City of Greensboro
North Carolina

Stormwater Management Manual

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Section 1: Introduction

1.1 Background

The current North Carolina Division of Water Quality's Stormwater Practices Manual (BMP Manual) was published on July 2, 2007 and revised on September 28, 2007. The City of Greensboro's requirements will follow the State's requirements and guidelines, but will also contain additional requirements to those listed in the State's Stormwater BMP Manual. The City of Greensboro's Stormwater Management Manual will serve as a supplement to the State's Stormwater BMP Manual and will additionally include the following requirements: stormwater quantity control, flood damage prevention, utilizing conveyance systems and minimizing erosive conditions (i.e. streams). In cases where City of Greensboro's requirements are more stringent than those of the State, they are provided in this Manual. In those cases, the City's requirements shall be applicable and replace those given in the State's Stormwater BMP Manual. Also, information or requirements unique or specific to City of Greensboro area is covered in this Manual. The State Stormwater BMP Manual primarily covers the water quality of stormwater runoff.

This manual also includes the requirements of the City of Greensboro's NPDES Phase II permit which was effective on June 1, 2009. The City of Greensboro is currently a NPDES Phase 1 Community but is required to adopt the minimum stormwater requirements for the NPDES Phase 2 regulations as part of the City's Comprehensive Stormwater Management Program.

This Stormwater Management Manual is to be used in conjunction with the State's Stormwater BMP Manual. It is intended to provide engineers, developers, property owners and managers, and interested citizens with information on stormwater management requirements, technical guidance on the methodology that can be used to meet the requirements, and guidelines for designing, implementing, and maintaining the Best Management Practices (BMPs) that may be used in the City of Greensboro to improve the quality of surface waters, and minimize the stormwater runoff volume and discharge rates from developed areas. This manual will describe the minimum design requirements and accepted methodology for meeting City ordinance requirements. The City reserves the right to limit the applicability of the State Stormwater BMP Manual on a site specific basis (water quality devices can not be dedicated to the City of Greensboro).

Each section of this Manual has a date on the header of each page so that users of this Manual can be sure which updated version they are using. This supplemental manual to the State Stormwater BMP Manual along with the City's current Storm Drainage Design Manual represent current drainage policy for the City.

<u>Stormwater Utility Credit Policy</u>

A stormwater utility fee is assessed on all properties within city limits. Stormwater Utility credit is available for Commercial Developments only. Residential Developments are not eligible for this credit. Stormwater Management measures that exceed the minimum requirements may also be eligible for credit under this policy. This manual provides guidelines for BMP's to be considered to receive credit. Refer to the City's *Stormwater Utility Credit Policy* (available on the City's

website) for more information regarding credit opportunities, including the actual credit that can be awarded for implementation of BMP's.

1.2.1 Non-Structural BMPs

Non-structural BMPs generally are techniques incorporated in site planning/design to promote low-impact development. These BMPs may be used to reduce the volume of runoff generated, reduce runoff discharge and provide partial pollutant removal. These practices are relatively inexpensive to implement, with the major cost usually being land area. But, with thoughtful site design, these practices can improve the stormwater management and aesthetic value of the development.

Non-structural stormwater BMPs can be implemented to help meet requirements for "low density" development in water-supply watershed areas and to reduce the amount of impervious area that is required to be treated for "high density" development. These BMPs can be incorporated in the site design to reduce stormwater runoff quantity and prevent adverse effects on the downstream property and receiving streams.

1.2.1.1 Public Education

1.2.1.1.1 Employee Education of commercial and industrial establishments.

Description

Employee education programs are designed to educate employees on the proper operational practices to minimize the potential for on-site pollutants to contact stormwater runoff. Through education, employees become more aware of potential stormwater pollutants, runoff characteristics, spill control measures, and methods to minimize off-site migration of polluted stormwater runoff from commercial and industrial properties. As a result, it is one of the easiest to implement and most beneficial pollution prevention BMPs available. In addition, a proper employee education program outlines methods by which employees can also reduce potential for stormwater pollution at their individual residences.

Applicability

Commercial, industrial or related facility that stores materials outside or is involved with receiving or shipping materials can benefit from employee education programs regarding on-site stormwater management practices.

Employee education programs are required by Federal law under *40 CFR Part 112 - Oil Pollution Prevention Regulations* and *40 CFR Part 122, 123, and 124 - National Pollutant Discharge Elimination System Regulations for Storm Water Dischargers*. As a result, all facilities conforming to these regulations should already be performing employee education.

To be eligible for stormwater utility credit for implementation of this BMP, organizations must meet the minimum criteria outlined in the table below. For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

Summary of Employee Education Requirements			
ACTIVITY	**DESCRIPTION**	**FREQUENCY**	**DOCUMENTATION**
Employee Briefings	Education sessions for all employees regarding proper water quality and environmental protection activities.	30 min./ quarter	Submit programs with agenda to SW for approval prior to briefings.
Employee Surveys	Conduct written surveys of each employee per EPA regulations	Once annually	Submit summary of survey responses in Annual Report.
Post/Distribute Information	Post and/or distribute periodic stormwater information provided by Stormwater Management Division	As received	Verify posting of Annual Report.

1.2.1.1.2 City of Greensboro Public Education Outreach

The City of Greensboro is committed to educate citizens on environmental awareness issues. The Stormwater Management Division, as part of its municipal NPDES permit, has developed educational programs to inform citizens on ways they can help protect the quality of Greensboro's streams and lakes. The City has produced several television and radio ads campaigning surface water quality protection. The City has also produced informational videos, brochures, etc., on various environmental topics for a wide range of audiences, including industries, businesses, schools and interested citizens.

The City also has helped form several volunteer groups to assist in educating citizens on water quality issues and to encourage citizens to get involved in cleaning up the City's surface waters. These groups include:

Environmental Business Partners
This program is setup to create a partnership with the City government and local businesses in order to provide the community with environmental/stormwater information.

"Green Heroes" (Includes Adopt-A-Stream, Adopt-A-Street, and Adopt-A-Park)
This program consists of volunteer groups that periodically remove litter along the stream section that they have adopted.

"Drain Markers" Program
This program involves placing the drain markers on storm water inlets that read "Don't Dump – Drains to Lakes and Creeks"

The City has also set up an "Environmental Helpline" (373-2812) to take calls on pollution problems from spills to excessive erosion problems from construction sites and to answer questions.

If you have an interest in obtaining any informational material, participating in the volunteer groups or have any other questions regarding environmental issues, please contact the Helpline.

1.2.1.1.3 On-Site Refuse Management

On-site refuse management programs include specific operating practices designed to minimize the potential for on-site litter and debris. The goal for these types of programs is to limit the amount of floatables and debris collecting in stormwater runoff and discharging off-site. In addition, on-site refuse management programs entail good housekeeping practices and help maintain a clean facility appearance.

Commercial and industrial facilities can benefit from an active on-site refuse management program. Many facilities already employ such a program either formally or informally as part of good housekeeping efforts to maintain a clean, aesthetically pleasing business environment.

Litter reduction and recycling activities are essential to improving solid waste management. Nearly 60% of North Carolina's municipal solid waste comes from local commercial and industrial businesses.

To be eligible for stormwater utility credit for implementation of this BMP, organizations must develop and implement an on-site refuse management plan which focuses on litter reduction, recycling, and proper disposal and storage. Organizations wishing to receive credit for on-site refuse management must prepare and submit an on-site refuse management plan. The plan should include the following items at a minimum:

1. A litter reduction program encouraging staff to properly dispose of waste materials. This program should outline the appropriate disposal options for all waste, including hazardous, non-hazardous and general solid waste material.
2. A comprehensive on-site waste material recycling program. This program should include all materials that could be reused or reclaimed either on-site or through the use of contractors of vendors. This may include paper wastes, waste treatment solids, and other materials.
3. Maintain area of refuse container covers designed to eliminate exposure to the environment (i.e. wind, rain, snow, etc.).

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Solid Waste Management

The City's Field Operations Department offers weekly waste collection and recycling services to its business customers. Business owners are responsible for providing city-approved trash and recycling dumpsters. Residential recycling services are offered every other week.

Businesses may recycle the following materials in the Team Recycle dumpster program:

Office and computer paper	**Newspapers**	**Steel cans (no lids)**
Plastic soda bottles	**Magazines**	**Empty aerosol cans**
#1 or #2 Plastic jugs	**Aluminum cans**	**Chipboard**
Cardboard (unwaxed & uncoated)		**Rigid Plastic**

The City does **NOT** allow the following to be disposed at the City landfill:

Aluminum cans	**Yard waste**	**Scrap whole tires**
Lead batteries	**Large appliances**	**Oil filters**
Anti-freeze	**Plastic Bottles**	**Wood pallets**
Beverage containers (from ABC permit holders)		

If you have any questions concerning the City's refuse and recycling program, or would like help setting up a recycling program for you business please contact the City of Greensboro Field Operations Department at 335-5444.

1.2.1.1.4 Stormwater System Maintenance

On-site stormwater system maintenance entails property owners or management companies regularly maintaining the stormwater system on their property. Often, it is very effective for individual facilities to periodically clean out on-site stormwater structures to assist in the City's effort in maintaining the stormwater system. By regularly maintaining on-site storm sewer systems and open channel conveyances, a facility may reduce the amount of sediment and other pollutants that can potentially migrate into the City's storm sewer system and downstream receiving waters. This helps the City meet the pollutant reduction goals associated with its Federal National Pollutant Discharge Elimination System (NPDES) Stormwater Permit. Also, periodic cleanings of the stormwater infrastructure can prevent water back ups in the system and potential damage from flooding due to a clogged system.

Owners of sites that have stormwater conveyance systems (pipe system, open channel, and water bodies) on their property that drain the site runoff are responsible for maintaining the conveyances. Storm sewer conveyances that cross through private property but receive public runoff will be maintained by the City of Greensboro. Inlet structures on public lines that collect runoff from private property are maintained as part of the public system.

To be eligible for stormwater utility credit for implementation of this BMP, organizations must prepare and submit an on-site stormwater system maintenance plan. This plan must meet the following minimum criteria:

1. Catch basins (e.g. curb inlets, grate inlets, etc.) and outfalls must be cleaned a minimum of 2 times per year.
2. Curb and gutter systems must be cleaned a minimum of 4 times per year.
3. Other implemented structural BMPs must be routinely maintained and inspected on an annual basis (minimum).

For more information regarding credit opportunities, refer to the City's Stormwater Utility Credit Policy document.

1.2.1.1.5 Paved Area Sweeping

The City of Greensboro Street Cleaning Division is responsible for periodically cleaning major and secondary public roads and public parking lots. The City uses a street sweeper that is equipped with a vacuum to pick up loose debris once it is swept to the curb. This prevents the debris from entering the storm sewer system.

A paved area sweeping program can significantly reduce sediment and other potential pollutants from migrating into the City's waterways. Paved areas are a source of various pollutants (especially hydrocarbons and heavy metals emitted by vehicles). Small pollutants attach to sediment and when it rains, the sediment, along with the attached pollutants, flow with the stormwater runoff to the nearest waterway. By employing a regular paved area sweeping program, a facility can dramatically reduce the amount of sediment entering the stormwater runoff. This not only helps the City maintain clean waterways but also improves general housekeeping efforts at individual facilities.

Essentially, every commercial and industrial facility that has paved areas can employ a sweeping program. Commercial and industrial facilities with large parking lots often receive the most benefit from paved area sweeping. In addition, it is often more cost effective to sweep large paved areas as compared to small paved areas. Many industries may already be employing routine paved area sweeping to comply with their NPDES Stormwater Permit.

To be eligible for stormwater utility credit for implementation of this BMP, organizations must develop, submit, and document implementation of a detailed paved area sweeping management plan. The plan should include at a minimum: sweeping frequency, name of sweeping contractor, sediment and debris disposal method, and areas regularly swept. For more information regarding credit opportunities, refer to the City's Stormwater Utility Credit Policy document.

1.2.1.1.6 Used Oil Recycling

Petroleum-based products are one of the major pollutants found in many urban surface waters. One of the major contributors is improperly managed used oil. Therefore, a used oil recycling program employed at facilities that utilize oil in their operations can be extremely beneficial with

respect to improving stormwater runoff quality. Many facilities that utilize oil should already have a used oil recycling practice in place as it has become relatively convenient and cost effective.

Commercial and industrial facilities that use oil in its operations can employ a used oil recycling program. There are many commercial vendors that collect used oil and haul it to a commercial recycling facility. This significantly reduces the amount of effort required by facilities to employ used oil recycling. Furthermore, by using a reputable used oil recycling company, a facility can reduce its potential liability regarding used oil contamination.

To be eligible for stormwater utility credit for implementation of this BMP, organizations must meet the following minimum criteria:

1. Offer and maintain on-site, used oil recycling collection area.
2. Utilize a registered commercial oil recycling company to collect, haul, and recycle the used oil, as necessary.
3. Provide upon request, to Stormwater Division, copies of all manifests for used oil collection performed each year.
4. Display City of Greensboro Used Motor Oil Recycling informational material in clearly visible and frequented on-site locations.

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

<u>City of Greensboro Household Hazardous Collection Center</u>

The U.S. EPA estimates that 50% of Americans change their own oil and only 35% of that oil makes its way into the recycling stream. This equates to some 200 million gallons of used oil being disposed of improperly (dumped on the ground, disposed in landfills, and poured down storm sewers and drains) in the U.S. every year. In North Carolina, over 20,000,000 gallons of oil are sold annually for light trucks and automobiles.

The City of Greensboro, Guilford County, and ECOFLO, Inc. provide a service to collect household hazardous waste (including used oil) from all households in Guilford County (no commercial or business waste is accepted). The Household Hazardous Waste Collection Center is located at 2750 Patterson Street, Greensboro.

The HHW program provides residents with a safe, economical, and environmentally sound disposal option for hazardous materials. The program also:

1. Decreases injury to solid waste workers
2. Diminishes the possibility of groundwater contamination
3. Assists in meeting state waste reduction goals.

1.2.1.1.7 Material Exposure Controls to avoid or limit exposure of materials to precipitation

Covering includes protecting certain areas of a facility from contact with precipitation. Covering dramatically reduces the contact of precipitation on potential stormwater pollutant sources, thereby reducing the pollutant levels in stormwater runoff from a particular property. Covering can include a building, canopy, or other structure that directs rainfall away from areas of concern. Areas at a facility that are commonly covered in some form are stockpile areas, hazardous material storage areas, maintenance areas (i.e. motor vehicle), and loading/unloading areas.

Covering is a common practice employed by many commercial and industrial facilities. The City recognizes that constructing coverings for large outdoor storage areas may not be cost effective for some facilities and therefore other BMPs may be utilized.

To be eligible for stormwater utility credit for implementation of this BMP, covering must be employed at all hazardous and petroleum-based material storage areas and any area that entails maintenance activities. Organizations must meet the following minimum criteria:

1. All hazardous and petroleum-based materials must be covered and protected from stormwater contact.
2. A Spill Prevention, Control, and Countermeasures (SPCC) plan must be developed and submitted to Stormwater Division for all hazardous and petroleum-based materials stored on-site (unless an exempt material or facility).
3. All maintenance activities must be performed under covered areas.
4. A site sketch with the covered areas must be submitted to the Stormwater Division with the credit application before final approval of a covered area can be granted.

1.2.1.1.8 Spill Prevention and Cleanup

Spill containment BMPs are provisions incorporated to prevent spilled materials which are potentially hazardous from migrating outside storage areas. The containment may be a dike or pit (for example, a concrete or steel berm) constructed around individual storage containers or a storage area. The dike or pit may have drain pipes with isolation valves to allow “clean” stormwater to discharge from the containment area; however, the valve is kept shut under normal conditions in cases of a leak or spill. It is preferred, if possible, to cover large volume storage areas to prevent rainfall from entering the containment area.

If the area to be contained is a large area with a storm drainage network, it may be appropriate to construct a basin at the storm sewer outfall. The basin can be designed to trap floating materials through the use of a retaining baffle, as shown in the following figure.

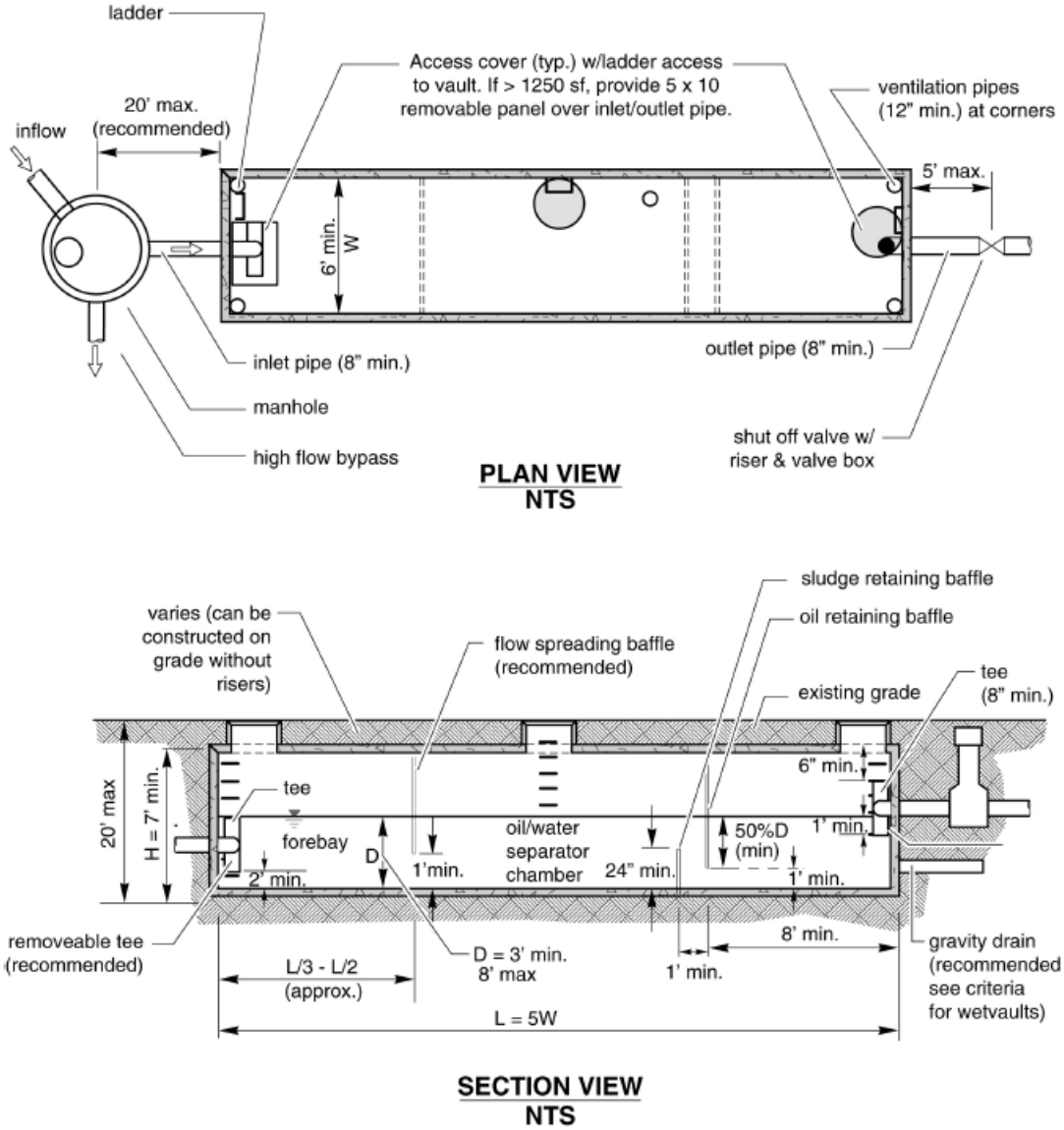
If a facility uses hazardous or petroleum-based materials (i.e. chemicals, wastes, oils, etc.) and stores them outside, they should employ spill containment around their storage areas. In many cases, however, if facilities do store hazardous materials outside, Federal law (40 CFR Part 112 - Oil Pollution Prevention Regulations and 40 CFR Part 264 - Hazardous Waste Regulations) require such facilities to have spill containment for these areas.

To be eligible for stormwater utility credit for implementation of this BMP, all hazardous and petroleum-based materials that are stored outside must have spill containment. Organizations wishing to receive credit for spill containment must meet the following minimum criteria:

1. All spill containment facilities must be capable of containing the contents of the largest tank in the applicable storage area with sufficient freeboard to contain precipitation.
2. For storage areas that contain hazardous materials, a secondary containment structure must be provided with an isolation valve. The valve must remain closed during normal facility operation. In the event of a rainfall event, the collected stormwater must be visually inspected (sight and smell) for any potential contamination. If no potential contamination is visible, the containment valve may be opened and the collected stormwater discharged. Any contaminated stormwater must be disposed in a proper manner.
3. For storage areas that contain potentially hazardous material that floats on water (e.g. oil), a structure using a retaining baffle as shown on the next page or other trapping provision may be used.
4. A site plan detailing the storage areas and spill containment measures must be submitted to Stormwater Division.
5. Display easily visible signage indicating a hazardous material storage area.
6. Implement a regular inspection program for all spill containment areas.
7. Document all inspection and maintenance activities associated with spill containment facilities (inspection and maintenance records should be available for review upon request).

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document which is available online.

API-Type (Baffle) Oil/Water Separator
Source: Washington Department of Ecology



1.2.1.1.9 Erosion and Sedimentation Control

Soil erosion has a major impact on the quality of surface waters. Erosion increases the sediment loading to surface waters causing adverse impacts such as increased turbidity, reduced light penetration, clogging of gills/filters of fish and aquatic invertebrates, and reduced spawning. Other impacts of increased sediment loading occur in low flow receiving waters, such as slow moving meandering streams, ponds and lakes, where the sediment has a chance to settle out. Impacts include smothering of aquatic habitat and more rapid filling of impoundments, increasing the need for costly cleanouts and decreasing the aesthetic value (Schueler, 1987).

The greatest amount of soil erosion occurs during development construction and related land disturbance, where grading activities expose the soil. Soil erosion can also occur on developed

sites where pervious areas are not well stabilized (for example, sparse grass cover), and in urban streams where increased flow velocities due to increased runoff has eroded the stream banks, and other places where runoff has been concentrated and the conveyance system is not adequately protected to resist erosion.

For all land disturbance activities erosion and sedimentation controls are to be implemented to prevent excessive sediment transport via stormwater runoff. After construction, it is important that property owners periodically inspect the construction site to check for any erosion problems or areas where earth is exposed due to poor grass cover or landscape cover.

City of Greensboro Soil Erosion and Sedimentation Control

As a result of the City's adoption of a local erosion and sediment control ordinance deemed equal to or more restrictive than the State's model ordinance and commitment of resources to implement the ordinance, the State Division of Land Resources has delegated program implementation and enforcement to the City. The City's program is based on the Soil Erosion and Sedimentation Control Act of 1973 and the City's National Pollution Discharge Elimination System (NPDES) Stormwater Permit.

The City of Greensboro enforces sedimentation and erosion controls on all new commercial and residential projects. The Engineering and Inspections Department's Sediment & Erosion Control Section is responsible for erosion control plan review, grading permits, erosion control inspections, and permanent stabilization of development.

For sites where land disturbances are greater than one (1) acre, a grading permit is required by City Ordinance. For sites where land disturbances are less than one (1) acre, no grading permit is required; however, the City still requires, manages and enforces erosion control on the site.

Refer to the City's Soil and Sedimentation Control Section Standards of Practice for more information on the City's regulations, policies, and procedures. Also, you may contact the Operations management Section of the Storm Water Management Division at 373-2055.

1.2.1.2 Land Use Planning and Management

Description

Cluster Development (Clustering) is a land development practice which can be implemented to concentrate development away from environmentally sensitive areas such as streams, wetlands, mature forests, etc. Because the idea of clustering is to compact development in one location, it will also reduce the amount of roadways, sidewalks and drives required compared to development that sprawls over the entire land area.

Applicability

Clustering and conservation of natural areas should be practiced at least to some extent for all developments, not only to reduce the impacts to our natural resources by minimizing disturbance and percentage impervious, but also to maintain some of the natural beauty of the site.
Clustering and conservation may be used for the following:

- ⇨ *Scoring points on the scoresheet for low density development in the General water-supply watershed area.* Points for clustering (Factor #1) can be received based on the criteria listed in the water-supply watershed ordinance (Chapter 30). Points can also be earned for conservation of stream buffers (Factor #7) and for conservation or re-creation of wooded areas (Factor #11). Also, by reducing built-upon surfaces, points may be gained for built-upon area (Factor #2).

- ⇨ *Protection of fragile areas in the watershed critical area.* The City ordinance requires development to conserve fragile areas in the undisturbed state. Fragile areas are steep slopes (>15%) lying adjacent and parallel to streams and drainageways, and wetlands.

- ⇨ *Reduction of stormwater utility fee.* Clustering and conservation practices are designed to reduce the impervious areas required for the site. Because the stormwater utility is directly based on impervious surfaces, the fee will be reduced for the site.

- ⇨ *Other considerations.* Reducing the amount of impervious area reduces the volume of runoff required to be treated by structural BMPs thus reducing the cost and size of the BMPs. Concentrating development away from environmentally sensitive areas will also likely reduce the amount of time and expense to get federal and state permits for impacts to jurisdictional waters.

Planning and Design Considerations

Concentrate development on the flattest part of the land away from environmentally sensitive areas such as steep slopes, streams, and wetlands. This will not only reduce the impacts to these areas but may reduce the amount of earth moving necessary.

Minimize the width of streets (in accordance with City standards).

Minimize the number of parking spaces and reduce the size of parking stalls and parking aisle widths (in accordance with City standards).

Reduce the amount of overflow parking to the minimum needed.

Take inventory and preserve mature trees and forests.

1.2.2 Structural BMPs

Structural BMPs are "engineered and constructed stormwater management structures" that can be designed to improve the quality of stormwater runoff and reduce stormwater runoff rates and/or volumes. These BMPs are designed to capture surface runoff from developed areas and improve the quality of the runoff from the site by removing pollutants through processes such as sedimentation, plant uptake, filtration, microbial activity, etc.

Structural BMPs are generally the costliest of the various BMPs to implement and to maintain. Most potential BMP owners are generally aware of the initial construction costs and land allocation that is required for structural BMPs, but some do not fully understand or appreciate the responsibility and costs associated with the maintenance of stormwater BMPs. This section supplements the State BMP Manual by providing design, installation, and maintenance guidelines for each of the structural BMPs.

1.2.2.1 Open Vegetated Conveyance / Grass Swale

Description

Open vegetated conveyances may be used instead of curb and gutter (where permitted) and hard piping to convey stormwater runoff where feasible. Open vegetative conveyances may be channels, swales, and, where runoff is in the form of sheet flow, any vegetated area that accepts runoff. Vegetated conveyances help to improve water quality by providing partial pollutant removal as the water is filtered by the vegetation and an opportunity for a portion of the water to infiltrate into the soil. They can also improve stormwater runoff quantity management by reducing the velocity of the flow through the conveyance and providing some infiltration into the soil.

Applicability

Vegetated conveyance systems can best be incorporated into moderate to low density development where land area is available and where the land surface is gently sloping (5% maximum). The site soils must be able to withstand erosion and a dense cover of strong rooted vegetation, such as tall fescue grass, must be established within the conveyance. Vegetated conveyances usually work best when the conveyance is "cut" into existing soils.

A benefit of using open vegetated conveyances is that they can save on construction costs by eliminating the need for stormwater sewer systems.

Open vegetated conveyances may be used for the following:

- ⇨ *Stormwater conveyance in the watershed critical area.* Section 30-7-3.2 (2) of the City's Ordinance (a) states that drainage shall be provided by means of open channels. Subsection (b) states that the drainage shall have protected channels.

- ⇨ *Scoring points on the "scoresheet" for low density development in the General water-supply watershed area.* (see Section 2 for an explanation and details on the Scoresheet) Use of open

vegetated conveyances will provide more points than piped conveyances (Factor #10). Also, vegetated conveyances that are used and are designed to resist soil erosion (10-year event), will classify as "protected drainageways" on the scoresheet (Factor #5).

- ⇨ *To provide stormwater quantity control.* Vegetated conveyance systems can provide temporary retention to reduce stormwater discharge rates. A hydrologic-hydraulic analysis will have to be performed to determine the design that will provide the desired reduction (for more information on design guidelines, see Section 14, Grass Swales, and Section 13, Filter Strips).

- ⇨ *Credit towards the stormwater utility fee.* Using vegetated conveyances instead of "hard" conveyances and are designed according to the guidelines given below, may be eligible for credit as specified in the *Stormwater Utility Credit Policy* document.

Planning and Design Guidelines

To improve its effectiveness as a stormwater BMP, open vegetated conveyance systems should be used in gently sloping areas to promote shallow, low velocity flow. This will maximize the channel filtering surface, and facilitate sedimentation and infiltration while increasing the travel time to the discharge point.

Channels and swales should be designed to promote shallow flow (i.e. trapezoidal). Conveyances designed with narrow cross sections will have higher velocities and deeper flow depths which allows for less pollutant removal, increased erosion potential, and higher quantity of flow at the discharge point.

The bottom width should be wide enough to maintain a shallow flow but narrow enough to prevent small rills from forming in the bottom during low flows.

Generally the side slopes should not be steeper than 3H:1V. The slopes should be flat enough to maximize the contact surface area (the water with vegetation) and prevent bank erosion while steep enough to reasonably contain the flow.

The permissible velocity for vegetated conveyances should be limited to prevent erosion within the channel. The permissible velocity varies depending on the soil type, the vegetation type, how well the conveyance is maintained, etc. Generally, the velocity should not exceed 4 ft/sec within the channel (10 year storm), for velocities greater than this, check dams may need to be constructed within the channel to slow the velocity.

It is recommended that the lining of open conveyances be a dense cover of erosion resistant grass, such as tall fescue. For channels and swales where relatively steep slopes exist (greater than 3:1), it may be beneficial to plant trees along the top of the slope. Tree roots will provide additional stabilization to the channel banks. It may be necessary to use temporary matting to get the grass established or to use sod.

1.2.2.2 Riparian Buffers

Description

Stream buffers are required to be implemented along streams, drainageways, and impoundments. The function of the buffers are to:

- ⇨ protect the overall stream quality by providing shading for the stream and provide wildlife habitat;
- ⇨ remove pollutants from stormwater runoff through infiltration and filtering of stormwater runoff from adjacent land areas;
- ⇨ help attenuate flow rates from developed areas;
- ⇨ provide a setback from the stream to prevent damage to structures or improved property due to flooding or changes in the stream channel.

The most effective stream buffers for protecting the overall quality of the stream are those that are left undisturbed including a tree line maintained along the stream bank.

Applicability

All major streams, drainageways, and water bodies are required to have buffer protection.

Stream buffers must be provided for the following:

Meet water-supply watershed and stormwater management requirements. Refer to Section 2.9.3 of this Manual for more information.

Stream buffers may be provided for the following:

- ⇨ *Scoring points on the scoresheet for low density development in the General water-supply watershed area.* Points on the scoresheet can be granted for buffers placed on drainageways and jurisdictional streams (Factor #7).

- ⇨ *Reduce the stormwater runoff that a site generates.* Stream buffers can serve to reduce the runoff rates that flow into the buffer. The actual reduction depends of the quantity of flow entering the buffer, the flow source (e.g. pipe discharge, sheet flow), the width of the buffer, buffer ground cover, etc.

1.2.2.3 Rooftop Runoff Management

Description

Disconnecting rooftop drainage can reduce the runoff flow rates from developed areas. Disconnecting means that runoff from rooftops will not be directed to storm drainage systems but

rather be directed toward pervious surfaces where it can filter through the grass or other landscape material, or infiltrate into the soil.

Applicability

This practice is applicable mostly for low density residential or commercial developments (less than 50% impervious). Disconnection is not applicable where the volume of runoff from rooftops will cause erosion or problems to adjacent downstream properties.

Disconnection practices may be used for the following:

- ⇨ *Scoring points on the scoresheet for low density development in the General water-supply watershed area.* Points on the scoresheet can be granted for dispersing flow instead of concentrating it (Factor #5). To receive points, the rooftop should disconnected as specified below (along with other impervious areas).

- ⇨ *Provide stormwater quantity control.* Disconnection of impervious areas can increase the time it takes for runoff to travel to the site outfall (increase time of concentration) and may allow a portion of the runoff to infiltrate into the soil. The effect that disconnection has on stormwater quantity depends on many factors, such as the storm event, the amount of impervious area that is being disconnected, whether the flow is concentrated or not, the soil type, the type of cover on the pervious surface, and the distance from where the runoff is "disconnected" to the nearest downstream area of imperviousness, stormwater conveyance system, or site outfall.

- ⇨ *Credit towards the stormwater utility fee.* Properties that disconnect rooftop drainage according to the guidelines below, may be eligible for credit as specified in the *Stormwater Utility Credit Policy* document.

Planning and Design Guidelines

Downspouts from rooftops should discharge to gently sloping, well vegetated or landscaped areas (mulched areas do a good job in storing and dispersing water as long as the inflow velocity is not great). Erosion control devices, such as splash blocks may be needed at the roof downspout discharge.

Rooftops should provide a downspout for every 5000 square feet of rooftop to reduce the erosion potential at the discharge location. The minimum distance between downspout discharge and the next impervious surface shall be 10 feet.

1.2.2.4 Grass Paving

Description

Grass paving technology allows for the reduction of paved areas by implementing grass paving in areas that are infrequently used such as fire lanes, overflow parking, golf cart paths, etc. A variety of grass paving units are available on the market. Grass paving units are designed to carry

vehicular loading and may be composed of different type materials. The pavers are usually covered with sod to make these areas practically indistinguishable from other grassed areas. Grass paving provides water quality benefits by allowing stormwater to infiltrate into the underlying soils and by filtering of the stormwater as it flows through the grass.

Applicability

Grass pavers can provide a more aesthetically pleasing site and reduce the "sea of asphalt" look. Grass paving should not be used for frequently traveled or parked in areas, since damage could be done to the grass and the grass needs sunlight to survive.

Grass paving may be used for the following:

- ⇨ *Scoring points on the scoresheet for low density development in the General water-supply watershed area.* Points can be received for "Other Measures" (Factor #12) for use of grass paving. Sites that incorporate 5% of their total impervious surface as grass paving will receive 10 points for this category.

- ⇨ *Reduce the runoff generated by a site.* Grass pavers can reduce the runoff volume generated and extend the time of concentration. Some units may provide enough infiltration to be considered a pervious cover; check with the manufacturer for more information on the runoff characteristics of the grass paving.

- ⇨ *Reduction of stormwater utility fee.* Grass paving is not considered an impervious surface (see note below) as it pertains to the fee, therefore the fee will be less.

*Note: Grass paving units are considered by the State and the City to be built-upon area, as it pertains to water-supply watershed regulations.

Design Considerations

Grass paving should not be used in high traffic areas or where vehicles will be permanently parked for long periods of time which may affect the growth of grass.

Refer to the manufacturer's guidelines for proper design considerations, installation, and maintenance of grass paving.

1.2.2.5 Natural Infiltration

Description

Natural infiltration is a method in which an undisturbed land area covered with natural vegetation accepts runoff from new development and infiltrates the runoff into the soil. Natural infiltration areas should only be used where the soils have a moderate to high infiltration rate (that is, soils in hydrologic group A or B). The area should be in the forested condition with the land surface

covered by leaves, needles, and organic matter and should only be used for passive recreation, such as hiking.

Applicability

A natural infiltration area that meets the State BMP Manual's design criteria may be used as stormwater quality control in the Watershed Critical Area (WCA) where the built-upon area is 6% or less in the Lower Randleman WCA or is 12% or less in any other WCA.

SECTION 2: NORTH CAROLINA'S STORMWATER REQUIREMENTS

Chapter 2.1 Overview of the City of Greensboro's Requirements

To address the adverse effects of urbanization on water quality, Federal, State and local regulations have been adopted to protect the quality of surface waters.

2.1.1 Stormwater Management Ordinance

Chapter 27 of the City Code of Ordinances is the Stormwater Management Ordinance. The main objective of this ordinance is to provide enforcement authority to meet the City's municipal NPDES Permit and associated Stormwater Management Plan. This plan is supplemented by additional portions of the Ordinance, particularly Chapter 30. Another key objective of this ordinance is to protect properties from potential stormwater quantity and quality problems. Potential problems include increased flooding and drainage problems due to inadequate or lack of conveyance systems and excessive stream bank erosion/channel widening due to increased runoff from developed areas. To control the adverse effects of increased stormwater runoff associated with newly developed or redeveloped sites, the City ordinance Chapter 27 requires all new development within the city limits to submit a *Stormwater Management (SWM) Plan.*

The SWM Plan must show stream buffers along (1) perennial streams, (2) intermittent streams and (3) channels. The SWM Plan must also include adequately sized detention or an *offsite stormwater conveyance system analysis* that shows the effects the development will have on the downstream properties including a determination if the development will cause or increase quantity or quality problems. If the analysis shows that negative impacts will result, stormwater management improvements including structural and/or non-structural BMPs are to be implemented to minimize the impact.

2.2.1 NPDES Discharge Permits

With the Clean Water Act, the EPA mandated that it is illegal to discharge any pollutant to "waters of the United States" without a National Pollutant Discharge Elimination System (NPDES) Permit. Refer to the NC State BMP Manual Section 2.2 for a description and explanation of this permit.

2.5 Water Supply Watershed Protection Requirements

The City of Greensboro depends on a series of lakes in the Reedy Fork Watershed in the northern region of the city for its drinking water supply. There are other protected drinking water supply watersheds besides the Reedy Fork watershed where a portion of the watershed is within the jurisdictional boundaries of the City. A portion of High Point, Randleman Lake, Polecat Creek, and Burlington watersheds are regulated by the City of Greensboro. To enforce Watersupply Watershed regulations, the City requires that before any new development or re-development activities begin on a site located within a protected water supply watershed, a *Watershed Development Plan* must be submitted to the City for approval. The Watershed Development Plan, when required, should be incorporated into the *Stormwater Management Plan* as described in the following section.

The Watershed Development Plan must show that built-upon surfaces do not exceed the maximum percentage of built-upon area allowed in that designated watershed. Built-upon area includes all impervious surfaces but also includes some areas that are partially impervious. The amount of built-upon area that is allowed on new development sites in a particular watershed is based on State Law and depends on the classification of the watershed. Refer to the tables below for built-upon density percentages for the designated watersheds.

For "high density" development sites, the Watershed Development Plan must show how structural BMPs will be implemented to improve the quality of runoff from the site. The structural BMPs must be proven facilities and at a minimum meet the design criterion of 85% removal of total suspended solids (TSS) from runoff resulting from the first one inch of rainfall. In addition, high density projects must discharge the storage volume at a peak rate equal to or less than the predevelopment peak discharge rate for the one year 24 hr storm.

For "low density" development sites in the General Watershed Area, the Watershed Development Plan must indicate that the site design will minimize impacts to the environment. A minimum score of 120 on the "General Watershed Area Performance Scoresheet" (see TABLE INSET: Ref. 30-7-2-2 chart below entitled "GENERAL WATERSHED AREA PERFORMANCE SCORESHEET") is required before a "low density" development can be approved for watershed protection. Low density development in the watershed critical area has different requirements.

Refer to the following density tables for designated watersheds.

DENSITY LIMITS IN UPPER AND LOWER RANDLEMAN LAKE WATERSHEDS IN DWELLING UNITS PER ACRE & % BUILT-UPON AREA[1]

TABLE INSET: Ref. Table 30-7-1-3

		Low Density Option		High Density Option
Watershed	**Overlay Zone & Tier**	**DU/AC**	**%BUA**	**%BUA***
Lower Randleman Lake (WS-IV Critical Water Supply)	GWA	1***	12	50
Upper Randleman Lake (WS-IV Critical Water Supply)	GWA	2**	24	70

[1] If, compared to the sidewalk installation requirements effective through December 31, 2002, the sidewalk installation requirements contained in Ordinance Number 02-239, effective January 1, 2003, increase the amount of sidewalk built-upon area, thereby exceeding the maximum built-upon area allowable under the High Density Option or necessitating additional stormwater control, treatment, or mitigation measures, the Technical Review Committee may approve reductions to required street pavement widths, sidewalk widths, driveway widths, or off-street parking area, so as to result in the same built-upon area as under the previous sidewalk installation requirements.

*In a subdivision, the BUA maximum applies to the subdivision as a whole, including streets, lots, etc. The maximum BUA allowed by this column (assuming engineered stormwater controls are large enough) shall be allocated among streets, lots, etc. In single-family detached development, the allocation to each house lot shall be uniform. In other development, the allocation may vary among lots. In all cases, the final plat shall clearly state each lot's allocation and restrictive covenants shall call attention to these allocations. On new or extended thoroughfare streets, allocate enough BUA to cover 5 foot sidewalks on both sides; and on all other new or extended streets allocate enough to cover a 5 foot sidewalk on one side.

**Alternatively, if total area minus area in street right-of-way, divided by number of house lots, equals 20,000 square feet or more, that is Low Density.

***Alternatively, if total area minus area in street right-of-way, divided by number of house lots, equals 40,000 square feet or more, that is Low Density.

DENSITY LIMITS IN WATER SUPPLY WATERSHEDS AND OTHER WATERSHED DISTRICTS
IN DWELLING UNITS PER ACRE & % BUILT-UPON AREA[1]

TABLE INSET: Ref. Table from 30-7-1-4

		Low Density Option		High Density Option
Watershed	**Overlay Zone & Tier**	**DU/AC**	**%BUA**	**%BUA***
Greensboro & Polecat Creek (WS-III)	GWA	2**	24	50(70#)
	WCA,1	See BUA	0.5	no HD option
	WCA,2	0.2	2.4	no HD option
	WCA,3,sewer	1***	12	30
	no sewer	0.33	4	no HD option
	WCA,4,sewer	2**	24	40
	no sewer	1***	12	no HD option
Lake Mackintosh (WS-IV)	GWA	2**	24	70
	WCA,1	See BUA	0.5	no HD option
	WCA,2	0.2	2.4	no HD option
	WCA,3,sewer	2**	24	34
	no sewer	0.33	4	no HD option
	WCA,4,sewer	2**	24	40
	no sewer	1***	12	no HD option
Other Watershed Districts [2]		2**	24	>24

[1] If, compared to the sidewalk installation requirements effective through December 31, 2002, the sidewalk installation requirements contained in Ordinance Number 02-239, effective January 1, 2003, increase the amount of sidewalk built-upon area, thereby exceeding the maximum built-upon area allowable under the High Density Option or necessitating additional stormwater control, treatment, or mitigation measures, the Technical Review Committee may approve reductions to required street pavement widths, sidewalk widths, driveway widths, or off-street parking area, so as to result in the same built-upon area as under the previous sidewalk installation requirements.

[2] According to Chapter 30-4-1.3(G) The Other Overlay District establishes regulation for protecting a watershed other than a water supply. These regulations are specified in Section 30-7-1 (Water Supply Watershed Districts and Other Watershed Districts) and Section 30-7-2 (General Watershed Areas and Other Watershed Districts)

#Watershed plans approved on and after October 31, 1997, collectively covering up to 10% of the WS-III GWA, may receive allocations permitting up to 70% BUA. An approved watershed plan constitutes a completed application for such an allocation. An allocation is granted to a lot when a building permit is issued thereon and to a part of a subdivision when the engineered stormwater control structure for it has been substantially completed. An allocation is lost if the building permit or plat approval expires or is revoked.
*In a subdivision, the BUA maximum applies to the subdivision as a whole, including streets, lots, etc. The maximum BUA allowed by this column (assuming engineered stormwater controls are large enough) shall be allocated among streets, lots, etc. In single-family detached development, the allocation to each house lot shall be uniform. In other development, the allocation may vary among lots. In all cases, the final plat shall clearly state each lot's allocation and restrictive covenants shall call attention to these allocations. On new or extended thoroughfare streets, allocate enough BUA to cover 5 foot sidewalks on both sides; and on all other new or extended streets allocate enough to cover a 5 foot sidewalk on one side.

**Alternatively, if total area minus area in street right-of-way, divided by number of house lots, equals 20,000 square feet or more, that is Low Density.

***Alternatively, if total area minus area in street right-of-way, divided by number of house lots, equals 40,000 square feet or more, that is Low Density.

In making determinations whether modification requests are minor or major, remember that all Greensboro's WCA Tier 4 and the portion of its Tier 3 lying more than 1/2 mile from normal pool elevation are beyond the minimum WCA required by EMC Rules.
(Ord. No. 99-206, § 8, 12-21-99; Ord. No. 02-239, § 16, 12-3-02)

GENERAL WATERSHED AREA PERFORMANCE STANDARDS

TABLE INSET: Ref. 30-7-2-1

Development Type		Schedule
1)	Low Density Option (see Tables 30-7-1-3 & 30-7-1-4 for density limits)	General Watershed Area and Other Watershed District Scoresheet (Table 30-7-2-2). A passing score is 120 or more points; or Engineer's Certification.
2)	High Density Option	Engineer's Certification.

GENERAL WATERSHED AREA AND OTHER WATERSHED DISTRICT PERFORMANCE SCORESHEET

TABLE INSET: Ref. 30-7-2-2

MAXIMUM POINTS	FACTOR	POINT VALUE	POINTS EARNED
25	**1. Clustering**		
	Minimal	10	
	Moderate	15	
	Major	20	

	Exceptional	25	
25	**2. Built-Upon Area**		
	0-3%	25	
	3.01-7%	20	
	7.01-10%	15	
	10.01-15%	10	
	15.01-20%	5	
25	**3. Proximity to Floodway as Defined by FEMA**		
	More than 2000 Feet	25	
	1000-2000 Feet	20	
	500-1000 Feet	15	
	100-500 feet	10	
	50-100 Feet	5	
10	**4. Soil limitations as Defined on Pg. 29 and Tbl. 7, Pg. 57 Guil. Co. Soil Survey**		
	Slight	10	
	Moderate	5	
25	**5. Drainage-Protect and Use Natural Drainageways**		
	Piped or Improved Drainage With Riprap	5	
	Dispersed Drainage or Protected Drainageways	10	
	Dispersed Drainage and Protected Drainageways (or Dispersed and No Drainageway)	20	
	Enhanced and Protected Natural Drainageways	25	
25	**6. Average Pre-development Slope of Land Subject to Grading or Filling**		
	0-6%	25	
	6.01-10%	20	
	10.01-15%	5	
25	**7. Stream Buffer Along Drainageways**		
	No Drainageway Present on Property or Within 50 Feet	25	
	50 Feet, All Wooded Except for Sewers and Required Streets	25	
	50 Feet, At Least Half Wooded	20	

	50 feet, No Grading or Fill Except For Sewers and Required Streets	15	
	40 Feet, Same Restrictions	10	
25	**8. Stormwater Runoff Control Strategies**		
	Divide the % of Stormwater (Runoff) Controlled by 4		
10	**9. Sewage Disposal**		
	Public Sewer Service	10	
10	**10. Street & Driveway Design**		
	With Vegetated Ditches	10	
	With Piped Drainage and/or Curb and Gutter and Energy Dissipators	5	
33	**11. Wooded Area**		
	Divide the % of Tract to Remain Wooded by 3 and To Be Thickly Planted in Tree Stands by 6		
	12. Grading Reduction and Other bonuses		
	NR:<1 Driveway per 300 Feet of Frontage	5	
	All: Creation of Wetlands	Up to 20	
	All: Other Measures	Up to 10	
	Total		

Notes: (1) All plans must have a minimum score of 120 points and meet all other requirements to be approved
(2) Use this table for low density option and only outside critical water supply watershed areas.
(3) See 30-7-2-2 for scoresheet timing of submittal, definitions, explanations and standards.

2.9 City of Greensboro's Requirements

2.9.1 City of Greensboro Stormwater Master Plans

It is the intent of the City of Greensboro to produce stormwater management master plans that will guide public and private development projects on various quantity and quality aspects of stormwater management for all of the major sub-watersheds in the city. Where such master plans are available, site development projects are to conform to the stormwater management guidance and standards available in said master plans.

2.9.2 Stormwater Management Plan

A Stormwater Management (SWM) Plan is required:

- ⇨ for all new development and redevelopment projects in the corporate limits and extraterritorial jurisdiction of the City, unless otherwise exempt.
- ⇨ to be approved by the City Technical Review Committee (TRC) prior to site plan or preliminary subdivision plat approval. It is preferred that the SWM Plan be submitted with the site plan or preliminary subdivision plat. For projects located in water-supply watershed areas or in other watershed district, a Watershed Development Plan should be incorporated into the Stormwater Management Plan.
- ⇨ to be approved prior to obtaining a grading or building permit except for grading plans submitted without corresponding TRC plans as allowed under City Ordinance.
- ⇨ to contain all items in section 2.9.2.1 below.

Site designers are encouraged to develop *comprehensive SWM plans* for the proposed development, including stormwater quantity and quality controls, non-structural and/or structural improvements, and pollution prevention programs for the site. Any proposed measures within commercial development that go beyond the requirements of Ordinance Section 27-22 may qualify for credits under the City's Stormwater Utility Fee Crediting Program.

2.9.2.1 Stormwater Management/Watershed Development Plan Components

<u>Site Plans, Group Development Plans and Construction Drawings</u>

The following information is required on all Stormwater Management (SWM) Plans:

1. On the coversheet label the Watershed Location of Proposed Site Development: Note the <u>watershed</u> (i.e., North Buffalo Creek, South Buffalo Creek, Horsepen Creek) for the proposed site development. Note <u>water-supply watershed name</u> (i.e., Greensboro Watershed) and <u>water-supply watershed designation</u> (i.e., WS-III, WS-IV, WCA), as applicable**.**

2. Approved Watershed Master Plan Available? – "Yes" or "No".

3. If the site was previously approved or part of a subdivision that was previously approved by the City or County for stormwater management or watershed development, provide the name of the plan and the date that the plan was approved.

4. Show existing built-upon area, if any, and note the amount (include % based on total site acreage)

5. Show the proposed built-upon area and note the amount (include % based on total site acreage)

6. Note the maximum amount of built-upon area (per watershed development restrictions, stormwater control design, etc.) (Include % based on total site acreage).
   - For development which includes a BMP, provide allocation table (onsite drainage area, offsite drainage area, total drainage area, onsite BUA, offsite BUA, total BUA, max BUA per stormwater control design and per watershed density)

7. Show the proposed disturbed (site development) area and note the amount. If site is located in the watershed critical area please include % of disturbance based on total site acreage.

8. Show the layout of existing and proposed stormwater conveyance system (pipes, channels, swales, catch basins, etc.) Label pipe size, material, elevations, slopes, lining material, and structure types (grate inlet, manhole, flumes, swales, energy dissipator devices, and roof drains). Show existing and proposed contours and label.

9. Label the amount of off-site drainage area and runoff quantities that discharge onto site.

10. Engineer's Certification of Stormwater Quantity Control (See Chapter 3 of Stormwater Management Manual)

11. Engineer's Certification of Stormwater Quality Control if applicable (See table 30-7-1-5)

<u>Stormwater Management Study – Analysis of Off-site System</u>

12. Map showing the limits of the off-site study; within the limits the map should show:
    - topography
    - stormwater conveyance system
    - properties and structures adjacent to the conveyance system
    - the total drainage area at the downstream limit of the study (at least 10 times greater than the site development area)
    - label site outlet and 10% point

13. Attributes of the off-site stormwater conveyance system including: structure types, materials, slopes, significant elevations, etc.

14. Provide supporting hydrologic and hydraulic calculations.

Stream Buffer and Related Information

15. Show the location of all perennial and intermittent streams and drainage ways.

16. Show the intermittent and perennial stream buffers and where measured from (top of bank and show and label top of bank). Label Drainage Maintenance and Utility Easement (DMUE). Ensure sheet flow is achieved prior to the undisturbed buffer.

17. Label the dimensions and restrictions within the buffer (that is, To Remain Undisturbed, 50% impervious, vegetated, etc)

18. Show the location of jurisdictional waters and wetlands.*

    *The U.S. Army Corps of Engineers and the N.C. Division of Water Quality regulate wetlands and waters of the United States through the 404 Corps Permit and 401 State Water Quality Certification process. The City encourages the protection and enhancement of wetlands and surface waters to promote improved water quality and water quantity management, as well as fish and wildlife biota and habitat preservation, and other benefits to local comprehensive watershed management. *Site designers/developers are responsible for obtaining all applicable Local, State, and Federal permits/certifications/approvals as necessary for proposed site development activities and submitting a copy of the applicable permits to the Stormwater Management Division as requested.*
    Please add the following note on the plan:" All the necessary approvals have been (will be) obtained from State and Corps for any wetland disturbance and/or stream crossing disturbance"

19. Indicate location of proposed stream crossing(s) showing the proposed grading and overall stream impact (includes culvert and outlet protection dimensions). (Alternative analysis may be required by the City to reduce and /or mitigate impacts).

FEMA Regulated Floodway/Floodplain Information

20. Show designated FEMA-regulated floodway and Special Flood Hazard Area (SFHA) boundaries on property as taken from the effective Flood Insurance Rate Map (FIRM). Note the 1% annual chance Base Flood Elevation (BFE) as provided in the Flood Insurance Study (FIS). Show and label cross sections and for limited detail studied streams, the non-encroachment area boundary.

21. If the site is located within a FEMA Special Flood Hazard Area (SFHA) the following additional requirements will apply:
    - Note the reference level (top of the lowest floor) elevations of all structures, also show flood proofing (non-residential facilities only) elevations of all structures. Note submittal of the required Elevation Certificates (EC) for structures located in the SFHA. The first EC must be submitted after the reference level is established and the final (as-built) EC must be submitted before the Certificate of Occupancy is issued. If

floodproofing is proposed, a floodproofing certificate must be submitted prior to the start of construction.

- Note that no encroachment / development into FEMA-regulated floodway or non-encroachment area boundary shall be made*.
- A Floodplain Development Permit Application must be submitted and a Floodplain Development Permit issued prior to or concurrent with Site Plan approval.
- If a FEMA-designated floodway or floodplain does not exist on the property/parcel, note the nearest distance to a FEMA-designated floodway, if within 2000 feet.

* In general, encroachment into a FEMA-regulated floodway is not permitted unless section 30-7-5.4(A) of the City of Greensboro Development Ordinance is met. Questions regarding development procedures within SFHA's may be directed to the Floodplain Administrator in the City's Stormwater Management Division.

Any proposed structures to be located adjacent to intermittent and perennial streams without an established Special Flood Hazard Areas (SFHA) require a BFE to be determined in accordance with Section 30-7-5.6(F) of the City of Greensboro Development Ordinance. Elevation or floodproofing certification is not required if the adjacent grade is five (5) feet or more above the Base Flood Elevation (BFE).

Low density development information

22. Provide completed watershed scoresheet. Refer to Chapter 2 of this manual or Section 30-7-2-2 of the Greensboro Development Ordinance.

23. For each factor where points are claimed, the requirements of that factor must be clearly depicted on the plans (for example, if 20 points for factor 7, "stream buffer along drainageways" are claimed, the plans need to show a 50' buffer on each side of the creek, the areas to remain wooded, and note the total buffer area amount and the wooded area amount).

Watershed Development in WCA (Watershed Critical Area)

24. Show location of natural slopes greater than 15% which are adjacent to streams and drainageways. Show drainageways carrying 17 cfs in the 100 yr storm. These areas and jurisdictional wetlands must remain undisturbed and either dedicated as drainageway and open space or platted as Undisturbed Easement (UDE) and common elements.

25. On the plan and plat please show limits of disturbance and label undisturbed areas as Undisturbed Easement.

26. Note that drainage will be provided by means of open vegetated channels.

27. Note the intended land use and SIC Industry Code. Show location of proposed storage tank(s) and indicate material to be stored. A secondary containment system must be constructed for the tank(s) and approved by the City.

Stormwater Control BMP Information

28. Indicate the type(s) of non-structural and/or structural stormwater control best management practices (BMPs) that are proposed. If proposing to use *existing* on-site or off-site controls, provide information to demonstrate that the controls have been approved by the City and can continue to meet quantity/quality control requirements.

29. If proposing to use off-site stormwater controls, indicate the location and owner(s) of the controls and provide information to demonstrate that the property owner will assist in maintaining the controls.

30. If proposing to use a public owned regional stormwater management facility, provide information to demonstrate that the municipality accepts participation from the property owner.

31. Show the location of the proposed stormwater controls and the location of the inlets and outlets of the control.

32. Show and label the 20' access easement to the stormwater control from the public R-O-W to the DMUE around the facility. Show the DMUE and label as "DMUE over and 15' around _____" DMUE must include all the components of the BMP (inlets, outlets, energy dissipators, etc). If access easement is not located in common elements a gravel access road is required.

33. Show the approximate size, configuration, and hydraulic structures for the stormwater control/improvement (with calculations). If proposing to use *existing* on-site or off-site controls, provide information to demonstrate that the controls have been approved by the City and can continue to meet quantity/quality control requirements.

34. Provide applicable maintenance agreements for proposed stormwater controls.

35. Note: The engineer's certification of completion will be required prior to the final plat or certificate of occupancy. The stormwater control is to be inspected to ensure it is functioning as designed and has full design volume prior to issuance of the final certificate of occupancy.

36. Note: The property owner (or homeowner's association) is responsible for maintaining the stormwater control(s) according to the approved maintenance plan and direction of the City of Greensboro.

37. Note: The City of Greensboro and their assigns have right to access the stormwater control(s) for inspections or maintenance, as necessary.

38. Note (for Underground Detention Systems only): The property owner or (or owner's Representative) is responsible for the inspection of the Underground Detention System

according to the approved maintenance plan and the City of Greensboro's Underground Detention System Policy.

Stormwater Control/Improvement Construction Plans

39. Show and label the layout of stormwater control, grading, and significant components (for example, primary outlet structure(s), dam, filter bed depth, bottom drain, etc.).

40. Include the cross section of proposed BMP improvements showing the elevations of significant components and storage allocations (e.g. sediment storage, peak reduction storage, etc.) Label 1, 2, 10, 100 yr 24 hour storm elevations.

41. Details and material specifications of all significant components of the stormwater control. For dry ponds, wet ponds, stormwater wetlands please provide embankment seepage control details.

42. Provide Engineer's Statement of Pond and Dam Safety (if dam construction is proposed). "In accordance with the requirements in articles GS 143-215.25A and 143-215.26 of the NC Dam Safety Law and NC Administrative Code 15A NCAC 2K .0200, the Regional Engineer in the Winston-Salem Regional Office of the NC State's Land Quality Section has been / will be contacted for the determination of whether the proposed dam is governed by or exempt from the Dam Safety Law."

43. Provide hydrologic and hydraulic analysis/calculations, water quality and other pertinent calculations for design of the stormwater control.

44. Provide an inspection/maintenance plan for reference by the owner for long-term maintenance needs.

45. Provide the construction sequence for completing the stormwater control.

TRC Lite Plans

The following information is required on TRC Lite Stormwater Management (SWM) Plans:

1. On the coversheet, label the Watershed Location of Proposed Site Development: Note the watershed (i.e., North Buffalo Creek, South Buffalo Creek, Horsepen Creek) for the proposed site development. Note water-supply watershed name (i.e., Greensboro Watershed) and water-supply watershed designation (i.e., WS-III, WS-IV, WCA), as applicable.

2. Approved Watershed Master Plan Available? – "Yes" or "No".

3. If the site was previously approved or part of a subdivision that was previously approved by the City or County for stormwater management or watershed development, provide the name of the plan and the date that the plan was approved.

4. Show existing built-upon area, if any, and note the amount (include % based on total site acreage)

5. Show the proposed built-upon area and note the amount (include % based on total site acreage)

6. Note the maximum amount of built-upon area (per watershed development restrictions, stormwater control design, etc.) (Include % based on total site acreage).
   - For development which includes a BMP provide allocation table (onsite drainage area, offsite drainage area, total drainage area, onsite BUA, offsite BUA, total BUA, max BUA per stormwater control design and per watershed density)

7. Show the proposed disturbed (site development) area and note the amount. If site is located in the watershed critical area please include % of disturbance based on total site acreage.

8. Show the layout of existing and approximate location of the proposed stormwater conveyance system (pipes, channels, swales, catch basins, etc.) Label approximate pipe size and material. Show existing and proposed contours and label.

9. Label the amount of off-site drainage area and runoff quantities that discharge onto site.

10. Engineer's Certification of Stormwater Quantity Control (See Chapter 3 of Stormwater Management Manual)

11. Engineer's Certification of Stormwater Quality Control if applicable (See table 30-7-1-5)

<u>Stormwater Management Study – Analysis of Off-site System</u>

12. Map showing the limits of the off-site study; within the limits the map should show:
    - Topography
    - Stormwater conveyance system
    - Properties and structures adjacent to the conveyance system
    - The total drainage area at the downstream limit of the study (at least 10 times greater than the site development area)
    - Label site outlet and 10% point

13. Attributes of the off-site stormwater conveyance system including: structure types, materials, slopes, significant elevations, etc.

14. Provide supporting hydrologic and hydraulic calculations.

Stream Buffer and Related Information

15. Show the location of all perennial and intermittent streams and drainage ways.

16. Show the intermittent and perennial stream buffers and where measured from (top of bank and show and label top of bank). Label Drainage Maintenance and Utility Easement (DMUE). Ensure sheet flow is achieved prior to the undisturbed buffer.

17. Label the dimensions and restrictions within the buffer (that is, To Remain Undisturbed, 50% impervious, vegetated, etc)

18. Show the location of jurisdictional waters and wetlands.*

    *The U.S. Army Corps of Engineers and the N.C. Division of Water Quality regulate wetlands and waters of the United States through the 404 Corps Permit and 401 State Water Quality Certification process. The City encourages the protection and enhancement of wetlands and surface waters to promote improved water quality and water quantity management, as well as fish and wildlife biota and habitat preservation, and other benefits to local comprehensive watershed management. *Site designers/developers are responsible for obtaining all applicable Local, State, and Federal permits/certifications/approvals as necessary for proposed site development activities and submitting a copy of the applicable permits to Stormwater Management Division as requested.*
    Please add the following note on the plan: ”All the necessary approvals have been (will be) obtained from State and Corps for any wetland disturbance and/or stream crossing disturbance”

19. Indicate location of proposed stream crossing(s) showing the proposed grading and overall stream impact (includes culvert and outlet protection dimensions). (Alternative analysis may be required by the City to reduce and /or mitigate impacts).

FEMA Regulated Floodway/Floodplain Information

20. Show designated FEMA-regulated floodway and Special Flood Hazard Area (SFHA) boundaries on property as taken from the effective Flood Insurance Rate Map (FIRM). Note the 1% annual chance Base Flood Elevation (BFE) as provided in the Flood Insurance Study (FIS). Show and label cross sections and for limited detail studied streams, the non-encroachment area boundary.

21. If the site is located within a FEMA Special Flood Hazard Area (SFHA) the following additional requirements will apply:
    - Note the reference level (top of the lowest floor) elevations of all structures, also show flood proofing (non-residential facilities only) elevations of all structures. Note submittal of the required Elevation Certificates (EC) for structures located in the SFHA. The first EC must be submitted after the reference level is established and the final (as-

built) EC must be submitted before the Certificate of Occupancy is issued. If floodproofing is proposed, a floodproofing certificate must be submitted prior to the start of construction.

- Note that no encroachment / development into FEMA-regulated floodway or non-encroachment area boundary shall be made*.
- A Floodplain Development Permit Application must be submitted and a Floodplain Development Permit issued prior to or concurrent with Site Plan approval.
- If a FEMA-designated floodway or floodplain does not exist on the property/parcel, note the nearest distance to a FEMA-designated floodway, if within 2000 feet.

* In general, encroachment into a FEMA-regulated floodway is not permitted unless section 30-7-5.4(A) of the City of Greensboro Development Ordinance is met. Questions regarding development procedures within SFHA's may be directed to the Floodplain Administrator in the City's Stormwater Management Division.

Any proposed structures to be located adjacent to intermittent and perennial streams without an established Special Flood Hazard Areas (SFHA) require a BFE to be determined in accordance with Section 30-7-5.6(F) of the City of Greensboro Development Ordinance. Elevation or floodproofing certification is not required if the adjacent grade is five (5) feet or more above the Base Flood Elevation (BFE).

<u>Low density development information</u>

22. Provide completed watershed scoresheet. Refer to Chapter 2 of this manual or Section 30-7-2-2 of the Greensboro Development Ordinance.

23. For each factor where points are claimed, the requirements of that factor must be clearly depicted on the plans (for example, if 20 points for factor 7, "stream buffer along drainageways" are claimed, the plans need to show a 50' buffer on each side of the creek, the areas to remain wooded, and note the total buffer area amount and the wooded area amount).

<u>Watershed Development in WCA (Watershed Critical Area)</u>

24. Show location of natural slopes greater than 15% which are adjacent to streams and drainageways. Show drainageways carrying 17 cfs in the 100 yr storm. These areas and jurisdictional wetlands must remain undisturbed and either dedicated as drainageway and open space or platted as Undisturbed Easement (UDE) and common elements.

25. On the plan and plat show limits of disturbance and label undisturbed areas as Undisturbed Easement.

26. Note that drainage will be provided by means of open vegetated channels.

27. Note the intended land use and SIC Industry Code. Show location of proposed storage tank(s) and indicate material to be stored. A secondary containment system must be constructed for the tank(s) and approved by the City.

Stormwater Control BMP Information

28. Indicate the type(s) of non-structural and/or structural stormwater control best management practices (BMPs) that are proposed. If proposing to use *existing* on-site or off-site controls, provide information to demonstrate that the controls have been approved by the City and can continue to meet quantity/quality control requirements.

29. If proposing to use off-site stormwater controls, indicate the location and owner(s) of the controls and provide information to demonstrate that the property owner will assist in maintaining the controls.

30. If proposing to use a public owned regional stormwater management facility, provide information to demonstrate that the municipality accepts participation from the property owner.

31. Show the approximate location of the proposed stormwater controls and the location of the inlets and outlets of the control.

32. Show and label the 20' access easement to the stormwater control from the public R-O-W to the DMUE around the facility. Show the DMUE and label as "DMUE over and 15' around _____" DMUE must include all the components of the BMP (inlets, outlets, energy dissipators, etc). If access easement is not located in common elements a gravel access road is required.

33. Show the approximate size, configuration, and hydraulic structures for the stormwater control/improvement (with calculations). If proposing to use *existing* on-site or off-site controls, provide information to demonstrate that the controls have been approved by the City and can continue to meet quantity/quality control requirements.

34. Provide applicable maintenance agreements for proposed stormwater controls.

35. Note: The engineer's certification of completion will be required prior to the final plat or certificate of occupancy. The stormwater control is to be inspected to ensure it is functioning as designed and has full design volume prior to issuance of the final certificate of occupancy.

36. Note: The property owner (or homeowner's association) is responsible for maintaining the stormwater control(s) according to the approved maintenance plan and direction of the City of Greensboro.

37. Note: The City of Greensboro and their assigns have right to access the stormwater control(s) for inspections or maintenance, as necessary.

38. Note (for Underground Detention Systems only): The property owner or (or owner's Representative) is responsible for the inspection of the Underground Detention System

according to the approved maintenance plan and the City of Greensboro's Underground Detention System Policy.

Please provide preliminary design for the proposed stormwater control, drainage area, surface area calculations, etc.

Grading Plans

The following information is required on all Stormwater Management (SWM) Plans:

1. On the coversheet label the Watershed Location of Proposed Site Development: Note the watershed (i.e., North Buffalo Creek, South Buffalo Creek, Horsepen Creek) for the proposed site development. Note water-supply watershed name (i.e., Greensboro Watershed) and water-supply watershed designation (i.e., WS-III, WS-IV, WCA), as applicable**.**

6. Note the maximum amount of built-upon area (per watershed development restrictions, stormwater control design, etc.) (Include % based on total site acreage).
   - For development which includes a BMP provide allocation table (onsite drainage area, offsite drainage area, total drainage area, onsite BUA, offsite BUA, total BUA, max BUA per stormwater control design and per watershed density)

7. Show the proposed disturbed (site development) area and note the amount. If site is located in the watershed critical area please include % of disturbance based on total site acreage.

9. Label the amount of off-site drainage area and runoff quantities that discharge onto site.

Stream Buffer and Related Information

15. Show the location of all perennial and intermittent streams and drainage ways.

16. Show the intermittent and perennial stream buffers and where measured from (top of bank and show and label top of bank). Label Drainage Maintenance and Utility Easement (DMUE). Ensure sheet flow is achieved prior to the undisturbed buffer.

17. Label the dimensions and restrictions within the buffer (that is, To Remain Undisturbed, 50% impervious, vegetated, etc)

18. Show the location of jurisdictional waters and wetlands.*

    *The U.S. Army Corps of Engineers and the N.C. Division of Water Quality regulate wetlands and waters of the United States through the 404 Corps Permit and 401 State Water Quality Certification process. The City encourages the protection and enhancement of wetlands and surface waters to promote improved water quality and

water quantity management, as well as fish and wildlife biota and habitat preservation, and other benefits to local comprehensive watershed management. *Site designers/developers are responsible for obtaining all applicable Local, State, and Federal permits/certifications/approvals as necessary for proposed site development activities and submitting a copy of the applicable permits to Stormwater Management Division as requested.*

Please add the following note on the plan: ”All the necessary approvals have been (will be) obtained from State and Corps for any wetland disturbance and/or stream crossing disturbance”

19. Indicate location of proposed stream crossing(s) showing the proposed grading and overall stream impact (includes culvert and outlet protection dimensions). (Alternative analysis may be required by the City to reduce and /or mitigate impacts).

<u>FEMA Regulated Floodway/Floodplain Information</u>

20. Show designated FEMA-regulated floodway and Special Flood Hazard Area (SFHA) boundaries on property as taken from the effective Flood Insurance Rate Map (FIRM). Note the 1% annual chance Base Flood Elevation (BFE) as provided in the Flood Insurance Study (FIS). Show and label cross sections and for limited detail studied streams, the non-encroachment area boundary.

21. If the site is located within a FEMA Special Flood Hazard Area (SFHA) the following additional requirements will apply:
    - Note the reference level (top of the lowest floor) elevations of all structures, also show flood proofing (non-residential facilities only) elevations of all structures. Note submittal of the required Elevation Certificates (EC) for structures located in the SFHA. The first EC must be submitted after the reference level is established and the final (as-built) EC must be submitted before the Certificate of Occupancy is issued. If floodproofing is proposed, a floodproofing certificate must be submitted prior to the start of construction.
    - Note that no encroachment / development into FEMA-regulated floodway or non-encroachment area boundary shall be made*.
    - A Floodplain Development Permit Application must be submitted and a Floodplain Development Permit issued prior to or concurrent with Site Plan approval.
    - If a FEMA-designated floodway or floodplain does not exist on the property/parcel, note the nearest distance to a FEMA-designated floodway, if within 2000 feet.

    * In general, encroachment into a FEMA-regulated floodway is not permitted unless section 30-7-5.4(A) of the City of Greensboro Development Ordinance is met. Questions regarding development procedures within SFHA’s may be directed to the Floodplain Administrator in the City’s Stormwater Management Division.

    Any proposed structures to be located adjacent to intermittent and perennial streams without an established Special Flood Hazard Areas (SFHA) require a BFE to be determined in accordance

with Section 30-7-5.6(F) of the City of Greensboro Development Ordinance. Elevation or floodproofing certification is not required if the adjacent grade is five (5) feet or more above the Base Flood Elevation (BFE).

Low density development information

22. Provide completed watershed scoresheet. Refer to Chapter 2 of this manual or Section 30-7-2-2 of the Greensboro Development Ordinance

23. For each factor where points are claimed, the requirements of that factor must be clearly depicted on the plans (for example, if 20 points for factor 7, "stream buffer along drainageways" are claimed, the plans need to show a 50' buffer on each side of the creek, the areas to remain wooded, and note the total buffer area amount and the wooded area amount).

Watershed Development in WCA (Watershed Critical Area)

24. Show location of natural slopes greater than 15% which are adjacent to streams and drainageways. Show drainageways carrying 17 cfs in the 100 yr storm. These areas and jurisdictional wetlands must remain undisturbed and either dedicated as drainageway and open space or platted as Undisturbed Easement (UDE) and common elements.

25. On the plan and plat please show limits of disturbance and label undisturbed areas as Undisturbed Easements.

26. Note that drainage will be provided by means of open vegetated channels.

27. Note the intended land use and SIC Industry Code. Show location of proposed storage tank(s) and indicate material to be stored. A secondary containment system must be constructed for the tank(s) and approved by the City.

2.9.3 Stream Protection Requirements

The Stormwater Management Plan must also show buffers along streams that are required to be protected. The type of streams that are required to be protected and the development activity that is allowed in the buffer can differ in each watershed.

City Ordinance Section 30-7 incorporates NPDES Phase II and other State requirements to protect and preserve stream channels and floodplains from excessive disturbance and encroachment. Watershed master plans adopted by the City, if any, may identify sensitive floodplain areas that require additional conditions for development and/or buffers within floodplain/ flood prone areas in order to provide protection for citizens from identified existing/future flood risks and/or to meet other objectives.

Stream buffers protect the overall quality of the stream, by achieving pollutant removal as runoff flows through the buffer, by providing shade for the stream and habitat for wildlife. Although

stormwater BMPs may be allowed within a certain portion of required stream buffers, other alternative locations should be examined to avoid locating BMPs within stream buffers. Whenever there is practical alternative, structural BMPs should not be placed in stream buffers, but if encroachment into the stream buffer is needed, the amount of stream buffer area that is impacted and the distance between the impact and the stream should be minimized. Also, consideration should be given to the design of the BMP discharge to prevent erosion in the buffer zones and of stream banks.

2.9.3.1 Stream Channelization / Piping Restrictions

Generally, no perennial or intermittent stream is to be channelized or piped without first obtaining approval from the Technical Review Committee and receiving other applicable City, State and Federal permits and certifications. In general, **perennial and intermittent streams may not be channelized or piped** except where street, driveway and utility crossings and other activities are permitted by the ordinance and are shown to be necessary with minimized impacts. In a GWA, WCA, or Other Watershed Districts approval from the Technical Review committee, NC Division of Water Quality and U.S. Army Corps of Engineers shall be secured before any intermittent or perennial stream is channelized. Additionally if the stream is in a WCA it shall not be channelized without prior approval by the Planning Board. Evaluation of the channelization rquest shall be based on grounds for a modification in accordance with Section 30-9-11.7 of the Greensboro Development Ordinance.

2.9.3.2 Stream Buffers

Riparian areas shall be protected and maintained in accordance with the City ordinance on all sides of surface waters (intermittent streams, perennial streams, lakes, ponds other surface waters and ditches or manmade conveyance that delivers runoff) as indicated on the most recent version of The United States Geological Survey 1:24,000 scale topographic maps, the hardcopy soil survey maps developed by USDA-Natural Resource Conservation Service and other Environmental Management Commission (EMC) approved stream maps.

The City of Greensboro currently has an official Stream Map approved by the North Carolina Environmental Management Commission and the North Carolina Division of Water Quality (effective July 10, 2003). This map shows the origin points for intermittent and perennials streams in the watersupply watershed areas. This map is considered by DWQ and the City of Greensboro to be definitive for intermittent and perennial Streams, ponds and lakes in the Watersupply Watershed Areas. Any areas that have not been mapped on the Stream Map will have to be evaluated by a qualified professional. A third party stream determination must be evaluated and approved by the office having local jurisdiction. Intermittent and perennial stream are defined below.

In all watersheds, intermittent streams, lakes and ponds along them, that are indicated as being intermittent 1) on the most recent version of the US Geological Survey 1:24000 scale (7.5 minute quadrangle) topographic maps, 2) on the most recent version of the Soil Survey map developed by the USDA--Natural Resource Conservation Service, or 3) by an examination of site-specific evidence by the City Stormwater Services Management Division using criteria approved by the

NC Division of Water Quality or U.S. Army Corps of Engineers. However, if the above-mentioned map indicates an area as an intermittent stream but the Stormwater Managements Division finds no intermittent water body actually exists on the ground, that area shall not be deemed an intermittent stream. Ponds and lakes created for animal watering, crop irrigation, or other agricultural uses that are not part of a natural drainageway are not streams. If the City of Greensboro develops a detailed stream network map covering one or more watersheds, and that map is approved by the NC Division of Water Quality, then within the watersheds covered by that map intermittent streams shall thenceforth be as shown by that map. In the event of a conflict in stream determination, a NC Division of Water Quality or U.S. Army Corps of Engineers determination shall supersede any local designation.

Perennial streams and ponds along them, that are indicated as being perennial 1) on the most recent version of the US Geological Survey 1:24000 scale (7.5 minute quadrangle) topographic maps, 2) on the most recent version of the Soil Survey map developed by the USDA--Natural Resource Conservation Service, or 3) by an examination of site-specific evidence by the City Stormwater Services Management Division using criteria approved by the NC Division of Water Quality or U.S. Army Corps of Engineers. However, if the above-mentioned map indicates an area as a perennial stream but the Stormwater Management Division finds no perennial water body actually exists on the ground, that area shall not be deemed a perennial stream. Ponds and lakes created for animal watering, crop irrigation, or other agricultural uses that are not part of a natural drainageway are not streams. If the City of Greensboro develops a detailed stream network map covering one or more watersheds, and that map is approved by the NC Division of Water Quality, then within the watersheds covered by that map perennial streams shall thenceforth be as shown by that map. In the event of a conflict in stream determination, a NC Division of Water Quality or U.S. Army Corps of Engineers determination shall supersede any local designation.

Stream buffer requirements are summarized in the following tables. Stream buffers are most effective when the buffer remains in an undisturbed state. Therefore, it is encouraged that disturbance be minimized in the entire stream buffer, not just the portion that is required to remain undisturbed. Where the buffer is disturbed in accordance to the approved plan, it shall be promptly restored in accordance with Section 15 of the State BMP Manual.

TABLE 30-7-2
HIGH DENSITY STREAM BUFFER WIDTH* REQUIREMENTS
IN WATERSHED DISTRICTS

HIGH DENSITY OPTION

TABLE INSET:

Watershed District	Perennial Streams, Lakes & Ponds			Intermittent Streams		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
Greensboro	30	30--50	50--100	0--30	30--50	N/A
Lake Mackintosh	30	30--50	50--100	0--30	30--50	N/A

Polecat Creek	30	30--50	50--100	0--30	30--50	N/A
Randleman	30	30--50	50--100	0--30	30--50	N/A
Other Watershed Districts	30	30--50	N/A	0--30	30--50	N/A

*Distances on all sides of water bodies are in feet and are with reference to top of bank for streams and normal pool elevation for all other water bodies. Thus, "0" equals top of bank or normal pool elevation and "30" equals 30 feet landward from top of bank or normal pool elevation.

Intermittent and perennial streams without established Special Flood Hazard Area must meet stream encroachment requirements of Section 30-7-5.6(F)(1) of the Greensboro Development Ordinance
All the stream buffers must be measured from the top of stream bank; lake buffers are to be measured from the normal pool elevation.
Exemptions: Street crossings, utility crossings, water dependant structures.
Stream buffers in the critical area must remain undisturbed with some exemptions (see ordinance 30-7-3.2)

The City of Greensboro Development Ordinance does provide a mechanism for requesting a variance to stream buffer requirements. A stream buffer variance request is handled in the form of a modification to watersupply watershed standards which in themselves carry a significant documentation and justification requirement. Refer to Section 30-9-11.5 of the Greensboro Development Ordinance for additional information on minor and major watershed modifications. Randleman Lake watersupply watershed stream buffer variances are handled as a major watershed modification and as such are to be approved by The Environmental Management Commission via NCDENR Division of Water Quality.

Refer to APPENDIX 10 for the Buffer Bubble document developed by NCDENR Division of Water Quality. All stream buffers in the City of Greensboro must follow document guidelines and show the buffer bubble.

2.9.4 Modifications to Stormwater Requirements

2.9.4.1 Water-Supply Watershed Protection

City of Greensboro Ordinance Section 30-9-11, Modifications, describes the procedures for obtaining a modification to the water supply watershed standards of Chapter 30-7.

*2.9.4.*2 Stormwater Management Control

Quantity Control Requirements

A modification to the quantity control requirements of Section 27-22 (g) may be granted by the Enforcement Officer if it can be shown by detailed hydrologic and hydraulic engineering studies and analysis which are acceptable to the Enforcement Officer that one of the following applies:

1. the installation of stormwater management facilities would have insignificant effects on downstream flood peaks; or
2. stormwater management facilities are not needed to protect downstream developments and the downstream drainage system has sufficient capacity to receive any increase in runoff; or
3. it is not necessary to install stormwater management facilities to control developed peak discharge rates at the exit to a proposed development or redevelopment and installing such facilities would increase flood peak discharge rates at some downstream locations; or
4. the Enforcement Officer determines that stormwater management facilities are not needed to control developed peak discharge rates and that installing such facilities would not be in the best public interest.

Quantity control requirements may not be waived if the Enforcement Officer determines that not controlling downstream flood peak discharge rates would increase known flooding or drainage problems, or exceed the capacity of the downstream drainage conveyance system at any point between the exit of a proposed site development or redevelopment and the 10 percent downstream point.

2.10 Regulatory Requirements

2.10.1 Jurisdictional Streams and Wetlands

It is the intent in most cases to design stormwater management devices to remove pollutants before they have a chance to enter "waters of the United States." Stormwater BMPs should be constructed outside of perennial streams and natural wetland areas unless no practical alternative exists. Also, natural or existing lakes, ponds, and wetlands should not be considered for stormwater BMP retrofits until Federal and State Permits for such purpose have been obtained. The US Army Corps of Engineers (ACE) requires that all impacts to jurisdictional waters and wetlands be reported to their office. Depending on the impact, the US ACE and NC Division of Water Quality (DWQ) may require the applicant to obtain permits, prepare environmental documents, mitigate for the impact, etc. For Greensboro, the contacts are the US ACE Raleigh Regulatory Field Office at 919-876-8441 and NC DWQ Winston-Salem Division Office at 336-771-4608.

2.10.2 FEMA Floodway/Floodplain

Placement of structures including stormwater structural BMPs within a Special Flood Hazard Area (SFHA) as shown on the effective Flood Insurance Rate Map (FIRM), is strongly discouraged. In the event of a large flood, floodwaters could cause significant damage to the BMP. No structural BMP will be allowed in the designated "floodway" unless Section 30-7-5.4(A) of the Greensboro Development Ordinance is met and all applicable Federal and State permits have been obtained. Structures placed in the SFHA should be appropriately constructed to prevent damage from floodwaters. Structures (including structural BMP's) placed alongside intermittent and perennial streams without an established SFHA must meet the flood damage prevention set back requirements as listed in Section 30-7-5.6(F). Refer to Section 30-7-5 Flood Damage Prevention, for more information regarding this subject.

3.0 SECTION 3: STORMWATER MANAGEMENT CALCULATIONS

3.1 Stormwater Management Objectives

Stormwater quality and quantity control are required by City of Greensboro's Ordinance Sections 30-7 and 27-22. They are required as follows:

1. **Stormwater Quality Control (Sec 30-7 of City Ordinance)**:
   Applicable to high density development within the City's jurisdictional limits. *Required to* provide structural control that removes 85% Total Suspended Solids (TSS) associated with the runoff from the first one (1) inch of rain. In addition, high density projects must discharge the storage volume during the 1 yr 24 hr storm at a peak rate equal to or less than the predevelopment peak discharge. Runoff volume drawdown time shall be a minimum of fourty-eight (48) hours but no more than one hundred twenty (120) hours.

2. **Stormwater Quantity Control (Sec 27-22 of City Ordinance):**
   Applicable to all new development sites within the City that increase the net built-upon area of the site by more than 400 square feet or that result in a change to the predevelopment drainage patterns.
   Required to minimize off-site flooding, drainage and erosion problems.

The stormwater management (SWM) plan must indicate that these minimum control requirements are met, where applicable. An "ideal site SWM Plan" in most cases is one in which the complete pre-developed stormwater runoff characteristics of the site are maintained in the post-developed conditions, including emulation of the pre-developed runoff hydrographs and pollutant runoff characteristics, and is consistent with an approved watershed master plan. Low-impact or no impact developments which incorporate non-structural and/or structural stormwater management practices promote improved urban stormwater management programs and minimize adverse downstream impacts.

3.1.1 Quality Control for High Density Development in Water Supply Watershed Areas and Other Watershed District (Ordinance Section 30-7)

Section 30-7 requires an "engineered" stormwater quality control to improve the quality of stormwater runoff from new high density development sites. Exemptions to these rules can be found on Section 30-7-1.12(C) but only for Development in Other Watershed Districts. The stormwater quality control must be an acceptable structural BMP. The requirements and guidelines for designing these BMPs are presented in the State BMP Manual. Additional design guidelines (beyond the minimum State's Requirements) for BMPs are listed throughout this Manual.
The engineer's certification of stormwater quality control on the appropriate completed form, which is provided in Table 30-7-1-5 of the City's Ordinance, is required for proposed high density developments.

3.1.2 Quantity Control (Ordinance Section 27-22)

Section 27-22 requires a hydrologic and hydraulic engineering analysis to evaluate off-site impacts due to increased stormwater runoff from new development and/or redevelopment sites within city limits. Where impacts are determined, it is the developer's responsibility to provide stormwater improvements to minimize the potential problems.

Site Analysis

1. Evaluate the peak runoff from the property for the pre-development (existing) conditions (Qpre) during a 24-hour rainfall sequence with a recurrence interval of both 2 years and 10 years (where runoff discharges from the property at more than one location, evaluate each location). The 24-hour rainfall sequences for the 2 and 10 year recurrence storms, depth-duration-frequency table, and intensity-duration-frequency table, for the Greensboro area are provided in Appendix C. The rainfall values in the 24-hour rainfall sequence are based on "Type II distribution" (applicable to the Greensboro area, as excerpted from NWS TP-40 and HYDRO-35) of the 24 hour rainfall of 3.38 inches and 4.82 inches for 2- and 10-year recurrence rain storms, respectively.

2. Evaluate the peak runoff from the property for the post-development conditions (Qpost) during a 24-hour rainfall sequence with a recurrence interval of both 2 years and 10 years (where runoff discharges from the property at more than one location, evaluate each location).

3. Compare the peak runoff value(s) for post-development conditions (Qpost) with the pre-development conditions (Qpre) for both the 2-year and 10-year recurrence storms, 24- hour rainfall sequence. If either of the post-development peak flows are greater than the pre-development peak flows, the designer must perform a preliminary and/or detailed hydrologic and hydraulic analysis of the off-site stormwater conveyance system to indicate downstream impacts of any increased stormwater flows to determine if stormwater management improvements are necessary, or provide on-site stormwater control improvements that reduce post-development peak flows of the 2-year and 10-year recurrence storms, 24- hour rainfall sequence to the pre-development peak conditions, or participate in an approved downstream regional SWM facility, if available.

Off-site Analysis

For new development sites where on-site controls are not provided to reduce post-development flows to pre-development flows, an off-site analysis will be required, unless otherwise exempt (in writing) by the City. Where on-site quantity controls are provided to reduce post-development flows to pre-development flows, an off-site analysis may generally not be required, provided that conditions in an approved watershed master plan are satisfied. In some cases, however, it is possible that on-site stormwater controls may exacerbate system-wide drainage problems, and thus the designer should verify that the SWM Plan does not create new problems downstream. Therefore, it is recommended that an off-site analysis be performed prior to sizing a quantity control improvement to reduce post-development rates to pre-development rates as the analysis

may indicate that different on-site stormwater controls are needed for the given development (other than those developed based on a site-specific analysis only) or that minimal stormwater control measures are required for the site.

Downstream Limits of Analysis: In determining downstream effects from the proposed site development or redevelopment activity, hydrologic and hydraulic engineering studies shall extend downstream to a point where the proposed site development or redevelopment represents less than ten (10) percent of the total drainage area or watershed. This point is referred to as the "10% point."

For example, a 5-acre site located near the headwaters of a drainage basin is proposed for sustainable development of which 4 acres are proposed to be disturbed (that is, the runoff will increase on 4 acres of the site after it is developed). The 4 acres drain to one location before discharging from the site. The downstream limit of analysis would be where the contributory watershed equals 40 acres. In general, the area of interest for analysis is the property / site itself, the drainage exit point of the property, and each component (channel, pipe, culvert, overland flow etc.) of the downstream system to the 10% point in the watershed, at a minimum.

Design Storm Events for Analysis: The studies shall be based on an analysis of both 2- and 10-year design storm events.

Analysis Criteria: The analysis should examine whether the design storm events of interest cause or increase flooding, drainage, or erosion problems on off-site property. In determining downstream effects from the proposed development, studies shall extend downstream to the 10% point and should include:

a) routing of peak flows to the 10% point within the watershed using accepted hydraulic/hydrologic methods described in Section 4 of the State BMP Manual, and

b) if peak flow calculations indicate that adjacent development(s) or downstream properties might be adversely impacted by the proposed development, then hydraulic step-backwater calculations (Corps of Engineers' computer models HEC-2 or HEC-RAS are recommended where detailed hydraulic analysis is required) shall be performed and flood elevations determined for the areas impacted. *Detailed hydrologic and hydraulic engineering studies can be costly, thus the Guidance Manual recommends detailed studies only where peak flow hydrograph routing analysis indicates that drainage / flooding problems might be present.*

Land Use Conditions: Hydrologic / hydraulic studies should utilize the following land use conditions for analysis:

- use existing conditions for downstream areas of interest

- for development of watershed hydrographs (off-site drainage areas), existing conditions land use is the minimum requirement, but future land use conditions are recommended for a conservative analysis

- the effects of upstream stormwater detention facilities can be considered in the analysis only if such structures (i.e., regional facilities) have been accepted for maintenance by the City or otherwise approved by the City.

Implementation of Stormwater Control Improvements

All high density projects must discharge the storage volume at a peak discharge rate equal or less than the predevelopment peak discharge rate for the 1-yr, 24-hr storm to meet water quality requirements.

If it is determined that the proposed development of the site does contribute to flooding, drainage or soil erosion problems at any location between the proposed development site and the 10 percent downstream point, then onsite stormwater quantity control improvements must be implemented. **In addition, if downstream problems are known to exist, the proposed development cannot increase the runoff peak (2-yr and 10-yr storms) and therefore stormwater quantity control improvements must be implemented.** Improvements may consist of:

1. On-site peak reduction – The developer may choose to use nonstructural approaches such as natural or engineered swales, depressions in the land and other natural approaches, or structural approaches such as detention structures, extended detention facilities, and alternative Best Management Practices (BMPs) with provisions for stormwater quantity control. *A combination of nonstructural and structural approaches is encouraged.*

2. Off-site peak reduction – The developer may use a publicly or privately owned off-site facility where: the facility is functional (within 2 years for proposed public facilities); the owner/entity has accepted stormwater runoff from the site; it can be demonstrated that the facility is sized to handle the increased flow; the owner has participated and/or implemented a maintenance agreement for use of the facility; it is demonstrated that there are no quantity problems between the site and the off-site facility.

3. Improvements to the downstream stormwater sewer system – Where it is determined that downstream conveyance consist of a storm sewer system and the best solution is to upgrade the downstream sewer system, this may be done provided that the downstream property owner where the improvements will be made grants a temporary construction easement and the improvement will not cause other problems downstream. The site developer is to coordinate with the City on all proposed downstream improvements.

Design Storm Events: Storage volume must be released at a peak discharge rate equal to or less than the predevelopment peak discharge rate. For the Stormwater study the improvements shall be evaluated based on 1, 2- and 10-year 24-hour design storm events.

Method for Design: The designer should demonstrate that the proposed improvements are adequate to minimize downstream problems. Hydraulic/hydrologic methods presented in Section 3.2.4 of this Manual supplementing Section 3.2 of the State's Manual should be used to evaluate the proposed improvement. An example of an evaluation of a detention facility is provided in Appendix 2.

Land Use Conditions: For site specific design of SWM control structures / facilities, use fully developed land use conditions for the site and existing land use conditions for any upstream areas draining to or through the facility (future land use conditions are recommended, however, for a conservative analysis).

Details of Quantity Control Requirements

The following chart explains in detail the City's requirements of the 10% study. Each explanation reflects the potential requirements that Engineers and Developers must meet to address the Quantity Control Requirements. Cases not specified below will be analyzed on a case by case basis.

CASE 1	10% Study is submitted. The study shows that the existing storm drainage system can handle the 2 & 10 yr pre and post development conditions. The study provides the analysis of swales, pipes, etc. Project will be approved provided that all the required information related to Stormwater Management is submitted
CASE 2	10% Study is submitted. The study shows that the existing storm drainage system can handle the 2 & 10 yr pre development conditions. The study also shows that the downstream system cannot handle postdevelopment conditions. The developer/engineer has two options: option one is to detain the runoff on site and reduce the 2 and 10 yr storms to predevelopment conditions; option two is to upgrade the existing storm drainage system so it can handle the proposed development. If option two is chosen, future conditions (i.e. ultimate buildout conditions within the sub watershed) will have to be studied as well. Developer/engineer will not be responsible for upgrading the existing system to handle future conditions but the City will require that the analysis be submitted so the City can evaluate the option to pay for the incremental upsizing of existing storm drainage system between the proposed development and ultimate buildout. The study must include the analysis of swales, pipes, etc. Project will be approved provided that all the required information is submitted.
CASE 3	10% Study is submitted. The study shows that the existing storm drainage system cannot handle the 2 & 10 yr runoff in either the pre-development conditions or the post-development conditions. If the proposed development drains to an existing system that can not be upgraded (railroad, DOT road, etc) the Developer/engineer must provide a runoff detention facility and submit analyses showing that the proposed quantity control measure will handle the difference in the runoff peak values associated with the proposed development conditions and the existing system's capacity for the 2 and 10 yr storms. In addition, the City may require ultimate buildout conditions analysis. Developer/engineer will not be responsible for upgrading the existing system to future conditions. The study must include the analysis of swales, pipes, etc. Project will be approved provided that all the required information relating Stormwater Management is submitted.

Additional Stormwater Management for Public Benefits

Where the Enforcement Officer determines that additional storage capacity in a stormwater management facility beyond that required for on-site stormwater management is necessary in order to enhance or provide for the public health, safety, and general welfare, to correct undesirable existing drainage or flooding conditions or to provide greater protection for future development, the Enforcement Officer may:

1. require that the applicant grant necessary easements over, through or under the applicant's property to provide access to or drainage for such a facility;

2. require that the applicant attempt to obtain from the owners of property where the proposed stormwater management facility is to be located, any easements necessary for the construction and maintenance of same (and failing the acquisition of such easement(s) the City may, at its option, assist in such matter by purchase, condemnation, dedication or otherwise, and subject to item 3 below, with any cost incurred thereby to be paid by the City); and/or

3. Participate financially in the construction of such facility or improvement to the extent that such facility or improvement exceeds the required on-site stormwater management determined by the Enforcement Officer.

To implement this provision, both the City and owner/developer must be in agreement with the proposed stormwater management facility that includes additional storage capacity and jointly develop a cost sharing plan which is agreeable to all parties involved.

3.1.3 Engineer's Certification of Stormwater Quantity Control

For new development plans within the city limits of Greensboro, one of the following certifications should be made.

1. *The development shown on this plan is consistent with the provisions contained on the preliminary plan/site plan ____(name of plan)_____ , which was approved prior to July 1, 1999 and which approval has not lapsed, as specified in Section 30-6-12 of the Greensboro Development Ordinance, and therefore is exempt from compliance with Section 27-22 of the Stormwater Management Ordinance.*

2. *The net increase in built-upon area is less than 400 square feet;, therefore, this development is exempt from subsection (g)(2) "Quantity Control Requirements" of Section 27-22 of the Stormwater Management Ordinance.*

3. *The stormwater management study included with this plan indicates that that to the best of my knowledge, belief and information there will be no downstream flooding, drainage, or erosion problems as a result of the proposed development between the point where the runoff discharges from the property to where the site development area represents less than 10% of the total drainage area. Therefore, no quantity control improvement is proposed.*

4. *The stormwater management study included with this plan indicates that to the best of my knowledge, belief and information,* there *will be downstream flooding, drainage, or erosion problems associated with this development. The proposed stormwater management improvement(s) indicated on this plan is (will be) designed to minimize increased flooding, drainage and erosion problems from occurring between the point where the runoff discharges from the property to where the site development area represents less than 10% of the total drainage area.*

5. *The stormwater control structure(s) shown on this plan is (will be) designed to reduce the peak flow rates in the post-development 2-year 24 hour storm event and the 10-year 24 hour storm event to pre-development peak flow rates.*

6. T*he 10% point is located upstream of the site outlet; therefore no additional quantity control is required.*

3.2 Peak Flow Calculations

3.2.1 Hydraulic/Hydrologic Methods

The following hydraulic/hydrologic methods are accepted by the City for use to address quantity and quality requirements.

<u>Hydrologic Methods (hydrograph formulation and peak flow estimation)</u>

- NRCS (Natural Resources Conservation Service, U.S. Department of Agriculture) hydrologic methods (formerly known as the SCS, Soil Conservation Service) are preferred and acceptable for all applications. NRCS methods include those contained in the TR-55 publication and corresponding computer program.

    - The hydrograph formulation methodology - Tabular Hydrograph method is the preferred method. A summary of this method is given in Appendix 2.

    - Runoff flood peaks for small catchment areas or sub watersheds (approximately 50 acres or less) may be determined using the methodology presented in Chapter 4 of TR-55. However, as pointed out under Limitations in Chapter 4, if a hydrograph is needed or watershed subdivision is required, the Tabular Hydrograph method given in Chapter 5 should be used.

    - The NRCS routines applied within the US Army Corps of Engineers computer models HEC-1 and HEC-HMS are preferred and acceptable for most applications. (The Corps of Engineers HEC-1 / HEC-HMS models are preferred over the NRCS TR-20 model since Corps models are used by the City in watershed modeling and master planning.)

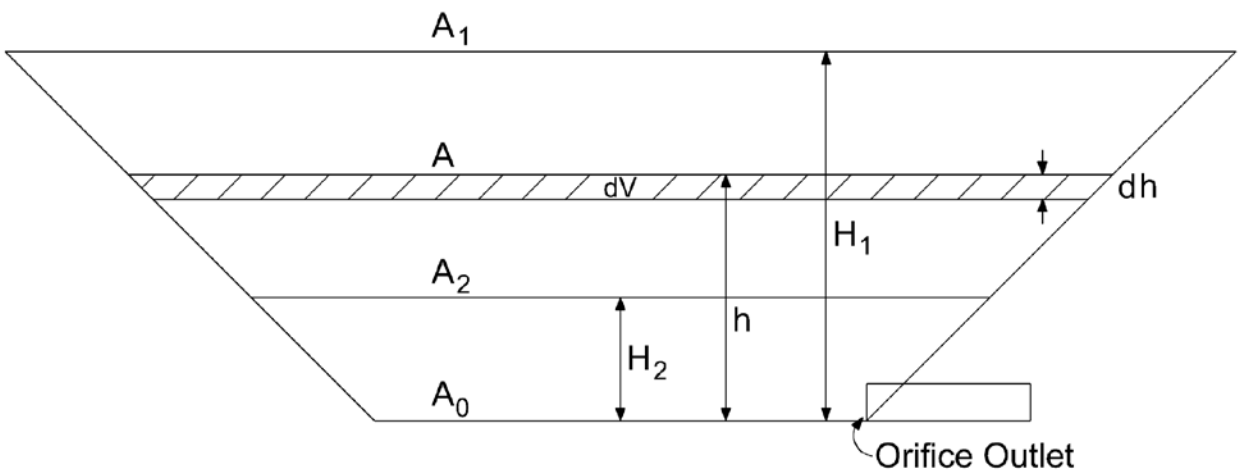
- The formula in the Rational Method, Qp = C I A, is acceptable for determining peak runoff from drainage areas of 200 acres or less.

- The "Small Watershed Method" developed by Dr. H.R. Malcolm, PE, is acceptable for most hydrologic analyses on small watersheds, based on Malcolm's procedures.

- Other hydrologic analysis methods may be allowed if the designer demonstrates that the alternatives are appropriate for the intended purpose subject to the City approval.

3.5.2 Orifice Equation

3.5.2.1 Drawdown Time Calculations for a Pond with an Orifice Outlet



In the above Figure,

$A_1 =$ Area of pond at the beginning of drawdown
$A_2 =$ Area of pond at the end of drawdown
$A =$ Area of pond at time, t during drawdown
$A_0 =$ Area of pond at the orifice outlet elevation
$T =$ Time for water level to fall from H1 to H2
$A =$ Reservoir Area
$Cd =$ Orifice coefficient of discharge
$a =$ Orifice area
$g =$ Acceleration of gravity
$H_1 =$ Maximum head (t=0)
$H_2 =$ Head when t = T ($H_2 = 0$)

Where

$$A = A_0 + \frac{(A_1 - A_0)}{H_1} \cdot h$$

$$dV = dt * q = Cd * a * \sqrt{2 * g * h} * dt = -Adh$$

Where:

$dV =$ Change in reservoir volume
$q =$ Outflow rate
$Cd =$ Orifice coefficient of discharge
$a =$ Orifice area
$g =$ Acceleration of gravity
$h =$ Head acting on orifice at time (t)

$$dt = \frac{-1}{Cd * a * \sqrt{2 * g}} * A * h^{-1/2} * dh$$

$$T = \frac{-1}{Cd * a * \sqrt{2 * g}} * \int_{H1}^{H2} A * h^{-1/2} * dh$$

$$T = \frac{-1}{Cd * a * \sqrt{2 * g}} * \int_{H1}^{H2} \left[A_0 + \left(\frac{A_1 - A_0}{H_1} \right) * h \right] * h^{-1/2} dh$$

$$T = \frac{-1}{Cd * a * \sqrt{2 * g}} * \int_{H1}^{H2} \left[A_0 * h^{-1/2} + \left(\frac{A_1 - A_0}{H_1} \right) * h^{-1/2} \right] * dh$$

$$T = \frac{-1}{Cd * a * \sqrt{2 * g}} * \left[2 * A_0 * h^{1/2} + \frac{2}{3} \left(\frac{A_1 - A_0}{H_1} \right) * h^{3/2} \right]_{H_1}^{H_2}$$

$$T = \frac{-1}{Cd * a * \sqrt{2 * g}} * \left[\left(2 * A_0 * H_2^{\ 1/2} + \frac{2}{3} \left(\frac{A_1 - A_0}{H_1} \right) * H_2^{\ 3/2} \right) - \left(2 * A_0 * H_1^{\ 1/2} + \frac{2}{3} \left(\frac{A_1 - A_0}{H_1} \right) * H_1^{\ 3/2} \right) \right]$$

Equation 1

$$T = \frac{1}{Cd * a * \sqrt{2 * g}} * \left[\left(2 * A_0 * H_1^{1/2} + \frac{2}{3}\left(\frac{A_1 - A_0}{H_1} \right) * H_1^{3/2} \right) - \left(2 * A_0 * H_2^{1/2} + \frac{2}{3}\left(\frac{A_1 - A_0}{H_1} \right) * H_2^{3/2} \right) \right]$$

For the specific case where $A_2 = A_0$ and $H_2 = 0$

$$T = \frac{1}{Cd * a * \sqrt{2 * g}} * \left[\left(2 * A_0 * H_1^{1/2} + \frac{2}{3}\left(\frac{A_1 - A_0}{H_1} \right) * H_1^{3/2} \right) \right]$$

Equation 2

$$T = \frac{1}{Cd * a * \sqrt{2 * g}} * \left[\left(\frac{2}{3} A_0 + \frac{1}{3} A_1 \right) * H_1^{1/2} \right]$$

For the case where the area of the pond is nearly constant with respect to depth, Equation 1 reduces to Equation 3 below.

Equation 3

$$T = \frac{2 * A}{Cd * a * \sqrt{2 * g}} * \left[\sqrt{H_1} - \sqrt{H_2} \right]$$

Downstream conditions should be examined to determine the effective head where the orifice is submerged (that is, cases where the tail water is higher than the orifice elevation.

3.6.3 Detention Storage Estimation Methodologies:

- The Storage-Indication (Puls method) is an acceptable method for routing hydrographs through a reservoir of any size. This method is incorporated into the US Army Corps of Engineers HEC-HMS and NRCS TR-20 computer models.

- The “Chainsaw Routing” method developed by Dr. H.R. Malcom, PE, NC State University, Raleigh, NC, is acceptable for most reservoir routing analyses on small reservoirs, as deemed appropriate by the designer based on Malcom’s procedures. The procedure and an example of an application of this method are given on Chapter 3.5 of the State BMP Manual and Appendix B.

- TR-55 as shown in the Storm Sewer Design Manual (page 26) and Dr. H.R. Malcom’s “Preliminary Design” (App. B) present methods to give the designer an approximate estimate of the storage required to provide the desired detention. These methods are good for preliminary design, but are to be followed up with an acceptable reservoir routing method for final design.

- Other reservoir routing analysis methods may be allowed if the designer demonstrates that the alternatives are appropriate for the intended purpose as approved by the City.

3.7.1 Hydraulic Methodologies (Open and closed conveyance analysis):

- Where step-backwater hydraulic computations are required for open stream channels including bridges and culvert roadway crossings, the US Army Corps of Engineers HEC-2 or HEC-RAS models are preferred and recommended for most applications. Where significant closed conduits represent the stormwater conveyance system, EPA's SWMM model is recommended, if a detailed hydraulic analysis is required for development of the SWM Plan.

- For simple hydraulic analyses, where applicable, the Manning's Equation and other hydraulic relationships (e.g., Hydraulic and Energy Grade Line calculations) may be applied where appropriate assumptions for use are satisfied and the results will be conservative.

- Other hydraulic analysis methods may be allowed if the designer demonstrates that the alternatives are appropriate for the intended purpose.

4 SECTION 4: SELECTING THE RIGHT BMP

4.4 Comparison of BMP Treatment Capabilities

Table 4-1 of the State BMP Manual presents the TSS, N, and P removal efficiencies of the various BMPs discussed in the State BMP Manual and in the City's supplement. Fecal coliform reduction is currently regulated as a narrative requirement and as part of the NPDES Phase II permit. After Phase II requirements are adopted by City Ordinance any proposed high density development within North and South Buffalo Creek Watersheds must be designed to drain to a high efficiency device for Fecal Removal Ability to the maximum extent practical.

Table 4-3 Sand filter construction cost is variable depending upon the type; ranges from low to high.

SECTION 5: COMMON BMP DESIGN ELEMENTS

5.5 Forebays

The forebay shall provide a means of drawdown for maintenance. For earthen baffles a ten foot (10') rip rap section has been successfully utilized on many wet detention ponds in Greensboro.

5.6 Earthen Impoundments, Embankments and Dams

Structural BMPs designed to impound water pose a potential hazard to downstream citizens and property. Because structural BMPs are mostly used in urbanized areas or rapidly growing areas, such as in Greensboro, potential hazards related to water impoundments and dams are increased.

The State of North Carolina Dam Safety Law of 1967 [as Amended through 1995] provides for the certification and inspection of dams in the interest of public welfare with respect to reducing the risk of failure to dams. The rules, which are provided in the North Carolina Administrative Code Title 15A, Subchapter 2K (see Appendix 3), entitled "Dam Safety," state that "no person shall begin the construction of any dam until at least 10 days after filing with the Department a statement concerning its height, impoundment capacity, purpose, location and other information required by the Department." It is important to note that the department requires notification for the construction of *any* dam even if the dam may be "exempt" from the State's regulation.

The Regulations (N.C.G.S 143-215.25A (a) (6)) exempt a dam "that is less than 15 feet in height or that has an impoundment capacity of less than 10 acre-feet, *unless the Department determines that failure of the dam could result in loss of human life or significant damage to property below the dam*." If the failure of a dam could result in the loss of human life or significant property damage the dam is classified as a High Hazard (Class C) structure. Although many structural BMP dams that are constructed in Greensboro are smaller than the size criteria for State regulation, the fact that they are being constructed in an urban or developing area could potentially have significant impacts to human life and property. The following Table shows the quantitative guidelines used by the State Dam Safety Office for dam hazard classification.

An additional five percent (5%) of the design height of an earthen embankment dam shall be added to the top of dam elevation during fill placement to negate future settlement.

To help ensure that stormwater BMP dams have met the State Dam Safety regulations and that the dams have been designed with public health, safety, and welfare in mind the **Engineer's Statement of Pond and Dam Safety** is required for dams proposed to be constructed for stormwater BMPs that temporarily or permanently store water.

Concrete dams and spillway structures shall be designed and built in accordance with the American Concrete Institute's (ACI) latest guidelines. Particular attention shall be paid to design and analysis, water tightness, concrete quality and construction practices. Structures shall be designed and constructed to maintain water tightness by controlling and limiting cracking with proper joint design and spacing. Documentation is to be submitted with pond certification.

Dam Hazard Classification		
HAZARD CLASSIFICATION	**CRITERIA**	**QUANTITATIVE GUIDELINES**
LOW	Interruption of Road Service, Low Volume Roads	Less than 25 Vehicles per Day
	Economic Damage	Less than $30,000
INTERMEDIATE	Damage to Highways, Interruption of Service	25 to Less than 250 Vehicles per Day
	Economic Damage	$30,000 to Less than $200,000
HIGH	Loss of Human Life*	Probable Loss of 1 or More Human Lives
	Economic Damage	More than $200,000
		250 Vehicles per Day at 1000 Feet Visibility
		100 Vehicles per Day at 500 Feet Visibility
		25 Vehicles per Day at 200 Feet Visibility
*Probable Loss of Human Life Due to Breached Roadway or Bridge on or Below the Dam		
NOTE: Cost of dam repair and loss of services should be included in economic loss estimate if the dam is a publicly owned utility, such as a municipal water supply dam.		

Engineer's Statement of Pond and Dam Safety

Engineer's Statement of Pond and Dam Safety

The stormwater pond and dam shown on this plan satisfies requirements of the North Carolina State Dam Safety Law of 1967 [As Amended Through 1995] and the Rules and Regulations as presented in the North Carolina Administrative Code Title 15A, Subchapter 2K - Dam Safety. Even in the case where the dam shown on this plan is determined by the State to be exempt from the above noted Dam Safety requirements, I, as the qualified design engineer, state that the pond and dam are designed to be safe and adequate for the protection of public health, safety, welfare, and downstream property. I understand that this statement as the design engineer shall not relieve the owner or operator of the pond and dam from the legal duties, obligations, and liabilities arising from such ownership or operation.

"In accordance with the requirements in articles GS 143-215.25A and 143-215.26 of the NC Dam Safety Law and NC Administrative Code 15A NCAC 2K .0200, the Regional Engineer in the Winston-Salem Regional Office of the NC State's Land Quality Section has been / will be contacted for the determination of whether the proposed dam is governed by or exempt from the Dam Safety Law."

When blasting is used to remove rock from the pool area, the blasted area should be over excavated to a sufficient depth below finish grade and brought back to finish grade with impervious soil material compacted in place or an alternate method can be submitted for approval. Documentation is to be submitted with pond certification.

5.6.1 Seepage Control

A filter diaphragm is a designed zone of filter material (usually well-graded, clean sand) constructed around a conduit. It has become a standard defensive design measure to prevent problems associated with seepage or internal erosion in earth fill surrounding the conduit. The use of a filter diaphragm is required around any conduit that extends through an embankment dam to the downstream slope. A drain system is required to collect the seepage at the bottom of the filter diaphragm and convey it to the downstream side of the embankment into a collection ditch or energy dissipater/stream channel. An acceptable filter diaphragm design is as given in Chapter 45, "Filter Diaphragms" National Engineering Handbook Part 628 (NEH-628), January 2007*, U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS).

The design and construction of the diaphragm shall be with suitable materials conforming to the recommendations given in Chapter 26, "Gradation Design of Sand and Gravel Filters," National Engineering Handbook Part 633 (NEH-633), Soils Engineering, October 1, 1994*, published by the Natural Resources Conservation Service (NRCS). In dams constructed of fine-grained (clayey) soils commonly encountered in Greensboro, fine aggregate used in concrete (concrete sand) meeting ASTM C-33 typically meets the requirements for the filter diaphragm.

The following paragraphs and figures provide acceptable design criteria.

The alignment of the filter diaphragm is perpendicular to the longitudinal alignment of the conduit and located in the downstream section of the dam such that it is

- Downstream of the key trench (or cutoff trench)
- Upstream of a point where the embankment cover (above the upstream face of the diaphragm to the downstream face of the dam) is at least one-half the difference in elevation between the top of the diaphragm and the maximum potential pond water level (see Figure 1).

The diaphragm shall extend horizontally and vertically into the adjacent embankment fill and foundation to intercept potential seepage/leakage through cracks, poorly compacted soil zones, or other discontinuities associated with the structure or its installation. Design the diaphragms to extend the following minimum distances from the surface of the conduit and into the trench excavation for the conduit, as illustrated in Figures 1, 2, and 3.

Extend the diaphragm horizontally and vertically upward 3 times the outside diameter of the conduit (as shown in Figure 2), except that

- Vertical extension need be no higher than the crest of the auxiliary (emergency) spillway, or higher than 2 feet below the embankment surface.
- Horizontal extension need be no further than 5 feet beyond the sides and slopes of any excavation made to install the conduit.
- Horizontal extension needs to provide for keying a minimum of 2 feet into the sides or side slopes of a sloped excavation for the conduit, as shown in Figure 3.

* Downloadable from NRCS's web site at: http://www.info.usda.gov/CED/.

If the filter diaphragm and adjacent embankment are founded on a "firm foundation" with a "settlement ratio" (refer to Chapter 45, "Filter Diaphragms" NEH-628 referred to above) of 0.7 or greater, the filter diaphragm should extend below the pipe to a depth of 2 feet or to bedrock formation, whichever is encountered first. If the foundation is softer (settlement ratio less than 0.7), extend the diaphragm vertically downward 1.5 times the outside diameter of the conduit or down to bedrock if encountered at shallower depth. Provide a minimum diaphragm thickness (in the direction of conduit length) of 3 feet. Use a larger thickness if needed for tying into the embankment or foundation drainage systems, accommodating construction methods, or other reasons. These dimensions are shown in Figures 2 and 3.

A suitably designed drain system shall be provided in the design to receive the seepage flow intercepted by the filter diaphragm and convey it to the downstream side of the dam into a ditch or energy dissipator for the conduit or the stream channel. Two acceptable designs are shown in Figures 1 and 4. Figure 1 shows a gravel drain (surrounded by filter sand – same as in the filter diaphragm). Figure 4 shows a 4 to 6 inch slotted Schedule 40 or 80 PVC underdrain collector pipe and 4 to 6 inch solid-walled Schedule 40 or 80 PVC pipes connected near the two ends to convey the water to the downstream side of the dam.

In the case where the conduit is tied to a downstream structure, an acceptable drain system design to receive the seepage flow intercepted by the filter diaphragm is shown in Figure 5. Figure 5 shows a 4 to 6 inch slotted Schedule 40 or 80 PVC underdrain pipe within the confines of the filter diaphragm. The underdrain pipes are connected to a 4 to 6 inch solid-walled Schedule 40 or 80 PVC pipes to convey the seepage flow to the downstream structure.

If perforated PVC underdrain pipe (or slotted PVC underdrain pipe with slot width greater than 0.5 mm) is used in lieu of slotted PVC underdrain pipe with slot width 0.5 mm or less, gravel that is filter-compatible with the sand in the filter diaphragm should be used as a jacket around the perforated pipe. The gravel must also be specified to be compatible with the size of perforations or slots in the collector pipe. The criterion is that perforations or slots in the collector pipe should have a diameter or slot width that is smaller than the D_{50} size of the gravel or sand filter surrounding the pipe. For further design details refer to Chapter 45, "Filter Diaphragms" NEH-628 referenced in the first paragraph of Section 5.6.1

The granular material (typically concrete sand) in the filter diaphragm should be <u>moderately compacted</u> after thoroughly wetting (saturating) it, using any of the compaction methods suited to granular materials such as walk-behind vibratory rollers or manually operated plate compactors. The <u>filter material should not be overly compacted</u> because that can reduce the filter's ability to "self-heal" or adjust to any movements in the underlying embankment and foundation. For guidance on compaction specifications, refer to NRCS's publication "Drainfill, National Engineering Handbook, Part 642*," Specification No.24.

* Downloadable from NRCS's web site at: http://www.info.usda.gov/CED/.

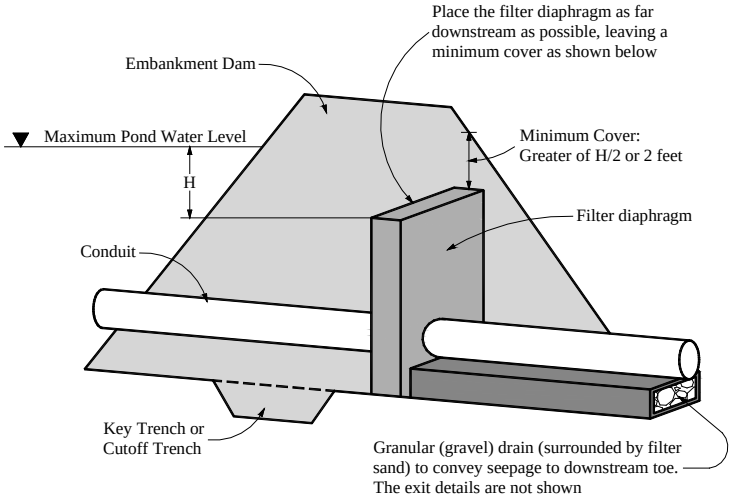


Figure 1 - Typical configuration for a filter diaphragm used in the design of an embankment dam. The figure shows the location of the filter diaphragm as far downstream as possible (downstream of key trench or cutoff trench), leaving adequate cover over it.

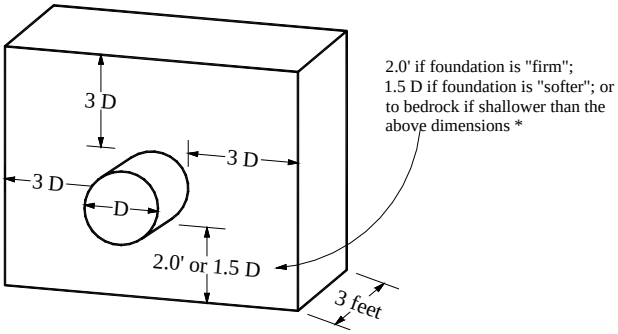


Figure 2 - Typical configuration of filter diaphragm used in the design of an embankment dam.

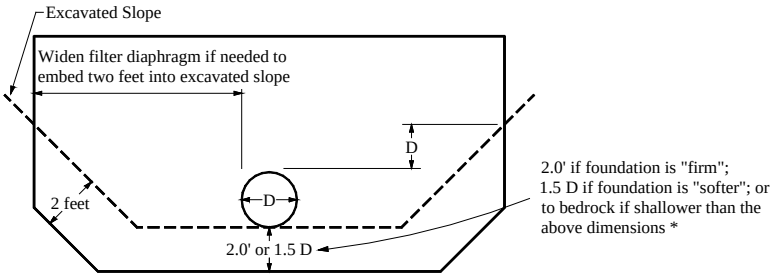
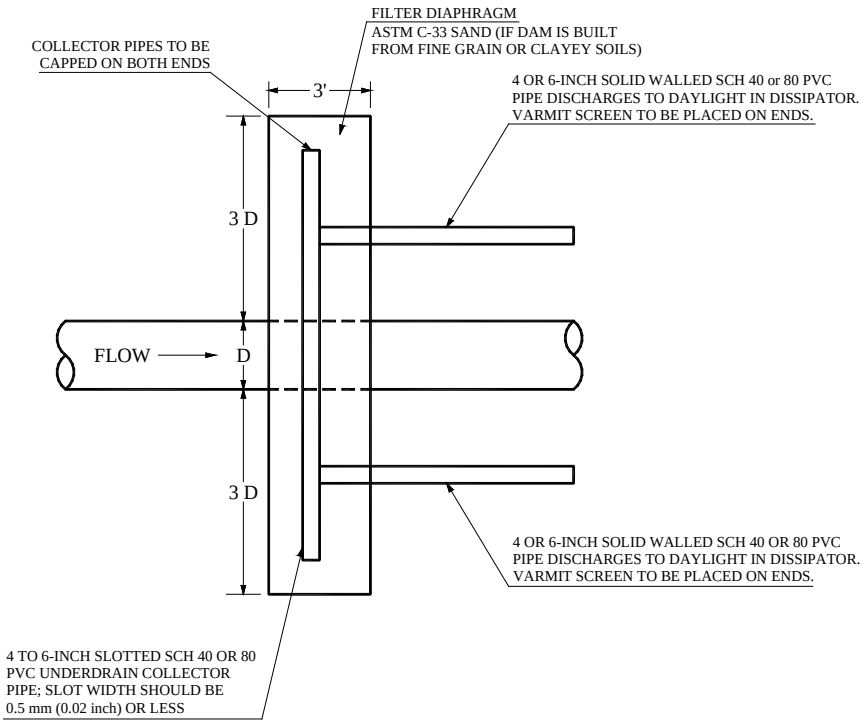
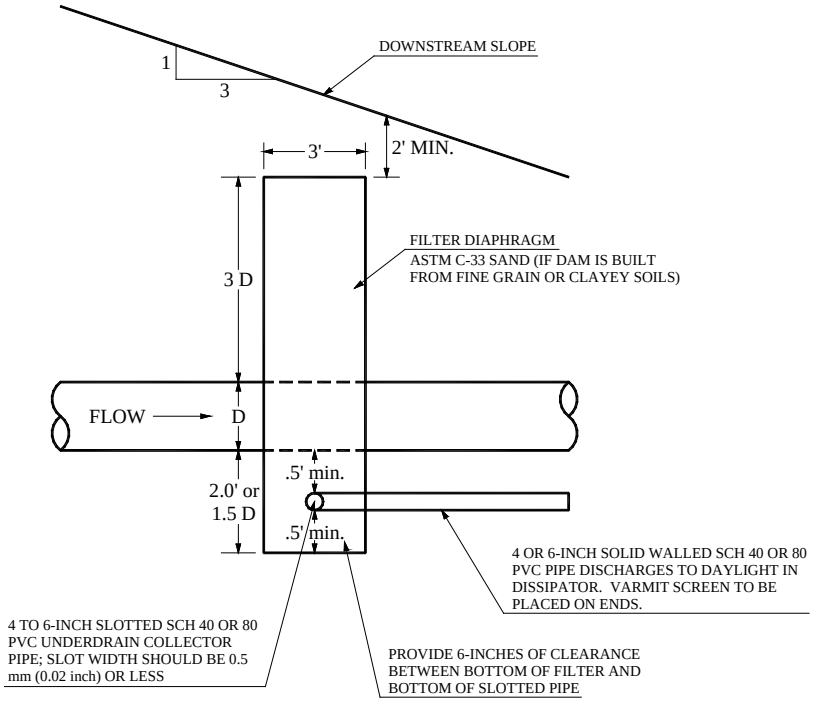


Figure 3 - Typical configuration for a filter diaphragm used in the design of an embankment dam. The filter diaphragm should extend into the foundation soils, where an excavation is made for the conduit.

***** Refer to Chapter 45, "Filter Diaphragms" National Engineering Handbook Part 628 (NRCS) for details of firm and soft foundations.



PLAN VIEW



SECTION VIEW

Figure 4

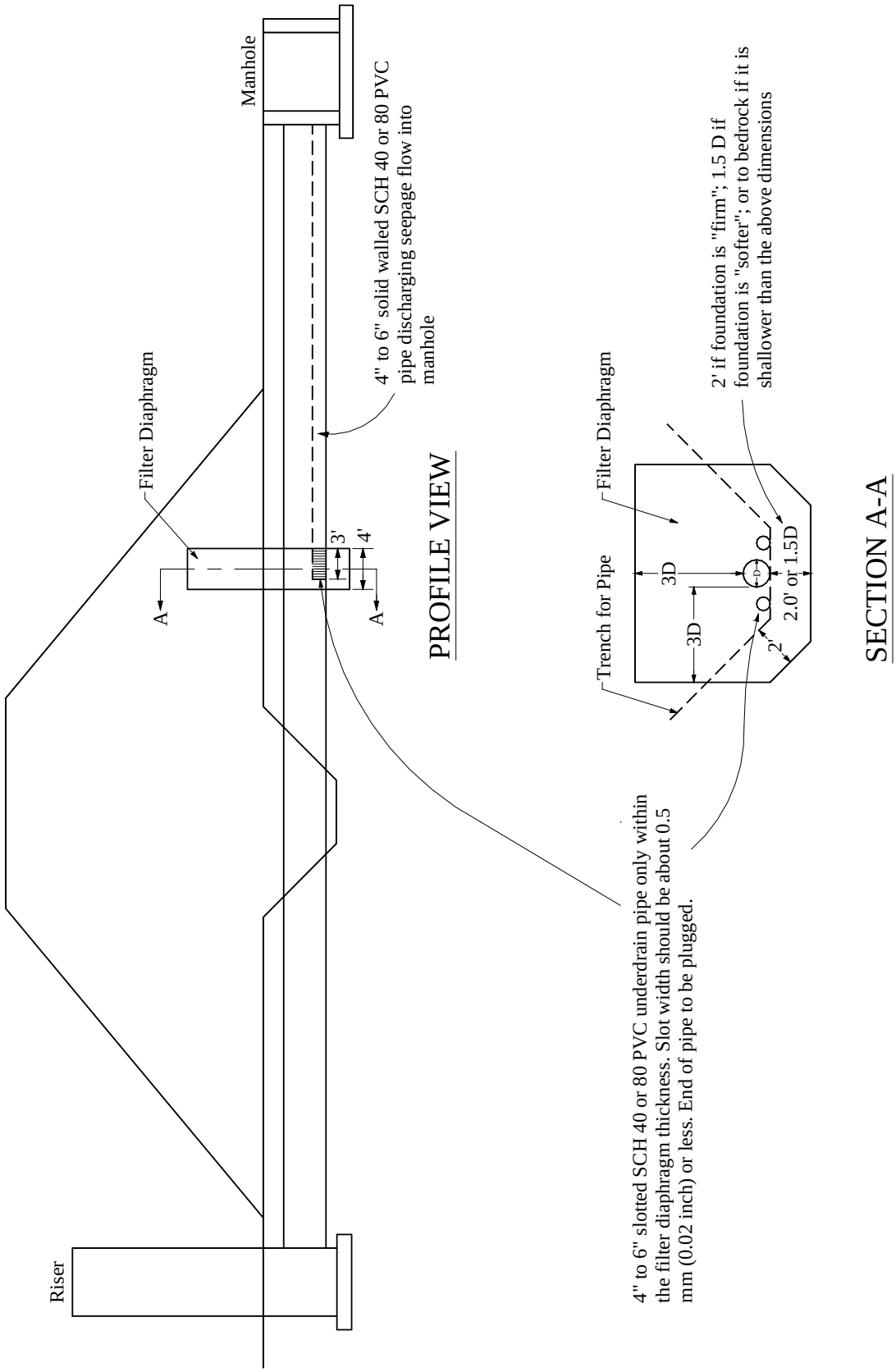


Fig. 5 Seepage Control for Outlet/Barrel Tied to Downstream Structure

5.7 Underdrain System

Other types of underdrain pipe can be utilized as long as pipe less than 10 inches in diameter has an equivalent area of openings (0.884 in^2/ft) and will handle all anticipated loading conditions.

Chocking stone is basically pea gravel. Choking stone is recommended in Chapter 12 Section 12.3.5 to be #8 or #89 washed stone. Refer to Chapter 26 "Gradation Design of Sand and Gravel Filters" National Engineering Handbook Part 633 published by the Natural Resources Conservation Service for guidance in selecting the proper gravel type.

5.8 Outlets

5.8.6 Spillways

5.8.6.1 Chute Spillways

A chute spillway typically consists of an approach (entrance) channel, a control structure, a discharge channel (chute), a terminal stilling basin structure, and an outlet channel. The control structure can be a concrete wall functioning as a broad-crested weir or an ogee-shaped spillway. The alignment of the control section (crest) in plan may be a straight, semicircular, or three sides of a rectangular box. The flow is normal to the crest alignment. The control structure is typically placed near or slightly upstream of the center-line of the earth embankment in one of the abutments of the dam or in a saddle in the topography adjacent to the dam.

The requirements listed below are provided to serve as guidelines for the design of concrete chute spillways:

1. The chute spillway should preferably be placed in the cut portion in the abutment of the dam or in a saddle in the natural topography adjacent to the pond, and not in the earth fill section of the dam. The fill portion of dam has the potential to undergo deformation and settlement over time resulting in cracking and breaking-up of spillway slab.

2. The chute, downstream of the crest control section, should consist of one or two segments of concrete channel of uniform bottom slope generally conforming to grade (with no abrupt changes in grade) until it terminates in the stilling basin (energy dissipater). If there is a change in slope, the transition in the bottom should be appropriately designed (with a curve) conforming to the underside of the jet of water (typically transitioning from subcritical to supercritical flow). If the width of the chute is contracted between the control section and the downstream portion of the chute, the flare angle of the contraction should be very small to avoid the ride-up of the flow on the side walls due to "cross waves" created in supercritical flow with flares in the side walls. If the chute is fairly long, significant air entrainment in the flow might occur and the side walls of the chute should be high enough to contain the increased flow depth due to "bulking" of flow due to air entrainment. A typical incremental depth to accommodate air entrainment is 20% to 25% of the calculated depth for normal flow depth (without air entrainment).

3. A “Filter Diaphragm” should be placed around the Water Quality drain pipe. Size of the filter diaphragm should be based on the pipe diameter and depth and width of the trench for installation of pipe (or pipe can be encased in concrete as part of chute). Refer to Section 5.6.1 Seepage Control for additional details.

4. Concrete slabs and side walls of the chute should be of reinforced concrete and should have a minimum thickness of 8 inches. This will provide a reasonable assurance of a watertight lining, protection from weathering and abrasion, and resistance against ordinarily experienced forces due to expansion, contraction, frost heave, and settlement of the foundation.

5. Where the chute is founded on soils that are not free-draining (as in the Piedmont area), the concrete slabs should be underlain by a pervious gravel blanket (minimum 9 inches thick) to facilitate underdrainage (of seepage flow under the slabs). Since concrete slabs can crack, hydraulic pressure (due to seepage) can uplift slabs in the absence of a drainage blanket that reduces the pore-water pressures. Pervious blankets should have drainage control with an underdrainage pipe system leading the collected flow to a suitable downstream outlet location.

6. Concrete joints: When the chute is founded on soils (not bedrock), “cut-off walls” should be provided under the joint, constructed integral with the downstream slab, and be deep enough to anchor into the foundation soil, to prevent the creep of the slabs down the slope and consequent failure of the slabs. The upstream slab should rest on a ledge built into the downstream cutoff wall/slab unit. When the chute is founded on bedrock, the floor should be adequately anchored into the underlying rock with suitably spaced anchor bars grouted into drilled holes in the rock foundation. See typical details below.

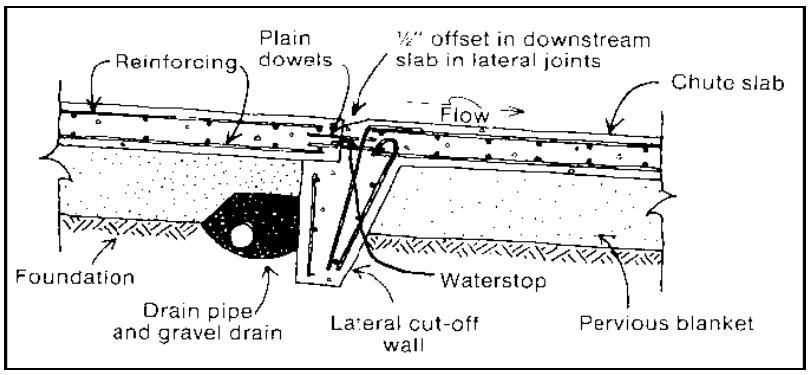


Figure 6 Typical Floor Lining on Earth (Soil) Foundations

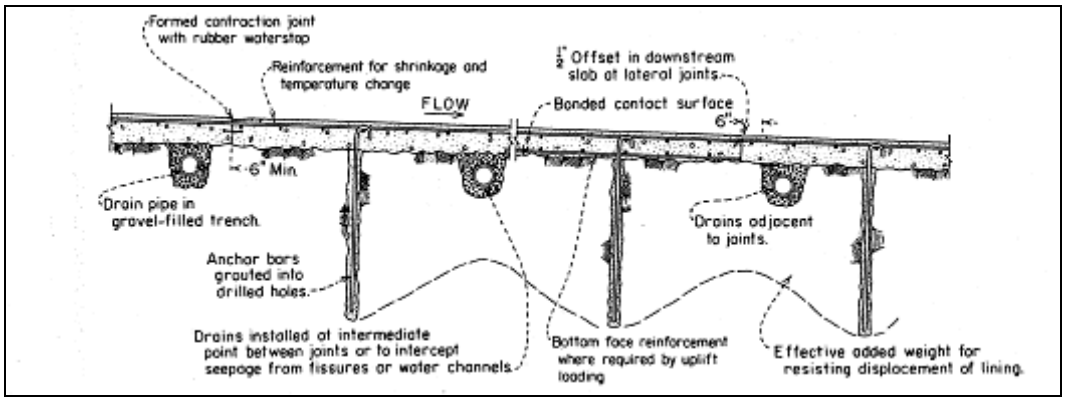


Figure 7 Typical Floor Lining on Rock Foundations

7. An appropriately designed and sized energy dissipator basin shall be located at the chute outlet. A SAF (St. Anthony Falls) stilling basin is generally considered the appropriate energy dissipator for chute spillways. Design methodologies provided in the chapter on Spillways in the book "Design of Small Dams" by the U. S. Bureau of Reclamation or in the chapter "Chute Spillways" in Section 14 of "National Engineering Handbook" by the U. S. Department of Agriculture, Soil Conservation Service (currently NRCS) are considered appropriate and acceptable. Use of riprap for spillway energy dissipation is inadequate and not recommended.

8. Ideal geometric shape for the spillway channel is rectangular. Trapezoidal channels can result in the development of secondary eddy flows and potential standing waves due to the supercritical flow conditions and make it difficult to provide adequate energy dissipation at the outlet.

The guidelines listed above conform to the standards/guidelines provided by State and Federal dam building agencies, such as NRCS (former Soil Conservation Service), Corps of Engineers and Bureau of Reclamation. As such, these guidelines represent reasonable expectations based on the documentation published by these agencies. If a proposed design deviates from these guidelines please include supporting documentation to justify the change.

The main consideration behind the implementation of these expectations is the head of water the structure is designed to hold, irrespective of the drainage area for the pond. For dams designed to have a relatively minor impoundment depth and head of water, deviation from these expectations will be considered on a case by case basis.

For additional information, refer to the "National Engineering Handbook – Section 14, Chute Spillways" published by the USDA Soil Conservation Service or "Design of Small Dams" published by the US Department of Interior Bureau of Reclamation.

5.8.6.2 Free Overfall (Straight Drop) Spillways

A "Free Overfall" (or "Straight Drop") Spillway is one wherein the flow freely drops from the crest of a weir wall that has a vertical or nearly vertical downstream face. The weir crest may be sharp-crested or broad-crested. In some designs, the crest may be extended in the form of an

overhanging lip to direct flows away from the downstream face of the wall. The underside of the nappe of the falling jet of water is ventilated to prevent pulsations in the jet. The wall in which the weir crest is located is typically a reinforced concrete retaining wall. This type of spillway shall be limited to situations in which the differential head between the upstream (pond) water level and the tail water level (in the downstream channel) is less than 20 feet.

A properly designed stilling basin shall be provided as a part of the spillway structure to dissipate the energy of the falling water downstream of the weir wall. Three acceptable stilling basin types are:

1. Plunge Pool Basin
2. Impact Blocks Basin
3. Hydraulic jump Basin

The Impact Blocks Basin typically is a more compact (shorter length) basin compared to the Hydraulic Jump Basin and its performance is not sensitive to the required tail water depth as in the case of a Hydraulic Jump Basin. Design methodologies given in the publications such as "Design of Small Dams" by the US Bureau of reclamation and Design Manuals of the US Department of Agriculture's Natural Resources Conservation Service (NRCS) or the US Army Corps of Engineers are acceptable. If other designs or design methods are used, calculations in support of such designs shall be submitted for City's review.

A Plunge Pool Basin consists of an open basin, lined with concrete or riprap (placed on a geotextile for soil separation), of adequate length and of a depth (relative to the tail water level) of the plunge pool that is equal to the maximum scour depth of a free-falling jet. The length of the basin should be based on the trajectory of the falling water jet for the maximum design discharge. An empirical equation (based on experimental data) for the maximum scour depth is given in "Design of Small Dams" as follows:

$$D_s = 1.32 * \left(H_t^{\,0.225}\right) * \left(q^{0.54}\right)$$

D_s = Maximum depth of scour below tail water level, in feet
H_t = Head differential between the head water and tail water levels, in feet
q = Discharge per foot width of the effective weir length, in cfs

The floor of the plunge pool basin would be provided at an elevation equal to or lower than the tail water elevation minus the maximum scour depth D_s. The tail water level should be determined based on the downstream channel flow characteristics (cross-section, slope, Manning's roughness coefficient, or other downstream hydraulic controls if they exist.

Detailed procedures for determining the dimensions of the Impact Blocks Basin and Hydraulic jump Basin, including an example of design, are given in the chapter "Spillways" in the book "Design of Small Dams." A summary of the procedures for Impact Block Basins (which is more compact/economical and less sensitive to variations in tail water level) is provided here, for ready reference. For the design procedure of Hydraulic Jump Basin (which is more complex), refer to the procedure and example given in the chapter on Spillways in the book "Design of Small Dams."

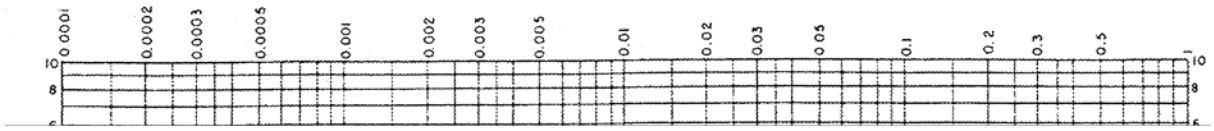
The dimensions of the basins are given by the curves in the charts reproduced from the "Design of Small Dams" in the attached Figure, as functions of two independent variables: the "Drop Distance" (Y) and the "Unit Discharge" (q). The dimensions of the basins are given in the charts on the ordinate (in terms of Y) for a given value of the dimensionless "Drop Number" (= q^2/gY^3) on the abscissa. Since q^2/g is equal to (d_c)^3 (where d_c = critical depth of flow over the spillway), the Drop Number is also equal to (d_c/Y)^3.

The linear dimensions of the elements of an <u>Impact Block Basin</u> are as follows:

L_p is read off the attached chart (upper one)
Minimum length of basin = $L_b = L_p + 2.55\ d_c$
Minimum length to upstream face of baffle block = $L_p + 0.8\ d_c$
Minimum tailwater depth = $d_{tw} = 2.15\ d_c$
Optimum height of baffle blocks = $0.8\ d_c$
Width and spacing of baffle blocks = $0.4\ d_c$ (+/-)
Optimum height of end sill = $0.4\ d_c$

In addition to determining the dimensions of the stilling basin from surface hydraulic considerations discussed above, the basin dimensions and thicknesses of the floor and walls of the basin structure shall also be designed based on considerations of the uplift and lateral pressures associated with the subsurface seepage flow beneath and adjacent to the spillway and stilling basin structure, as it affects the global stability and structural strength of the elements of the structure. The length of the spillway and stilling basin structure shall also be checked for insuring against high "exit gradient" of seepage flow immediately downstream of the structure to prevent "piping" problem of soil particles from the foundation or backfill against the walls being carried away with seepage flow.

SPILLWAYS


0.0001
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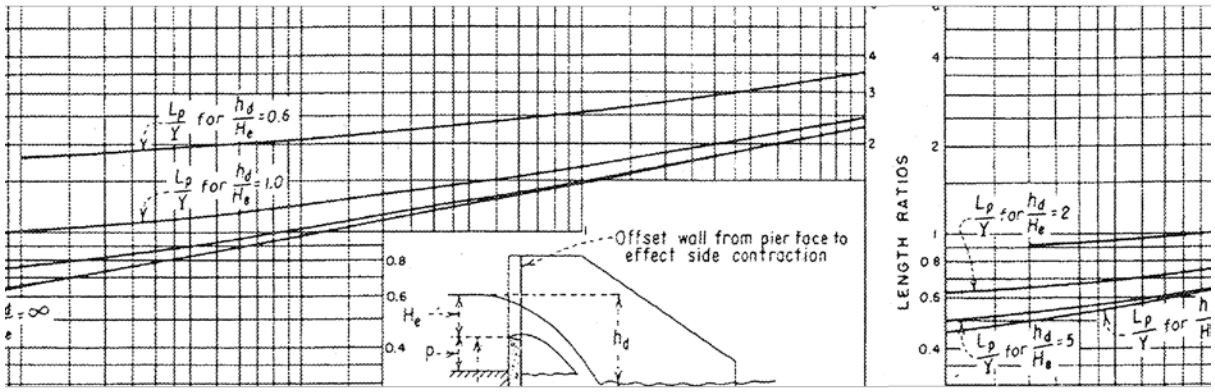
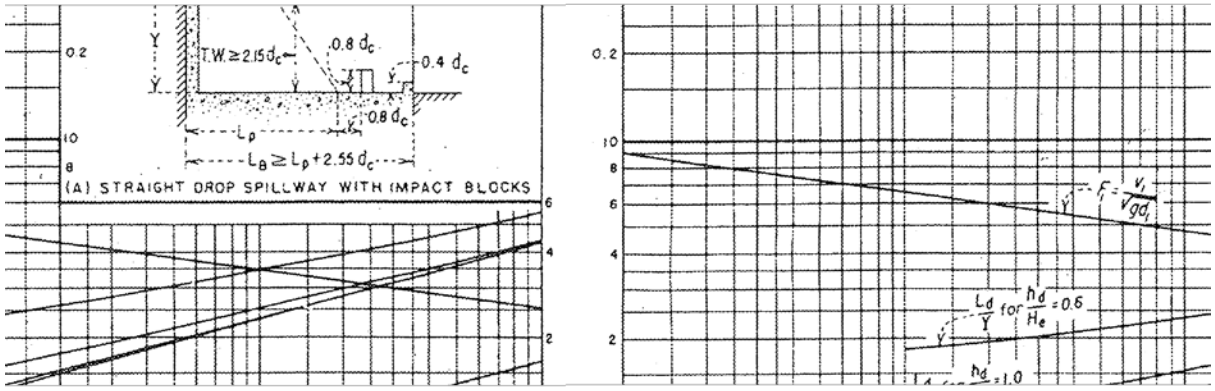
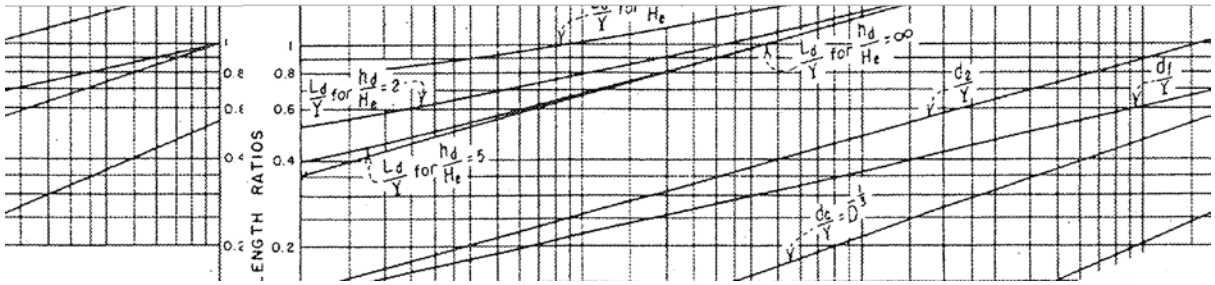

Offset wall from pier face to effect side contraction
LENGTH RATIOS


T.W. ≥ 2.15 dc
0.8 dc
0.4 dc
0.8 dc
Lp
LB ≥ Lp + 2.55 dc
(A) STRAIGHT DROP SPILLWAY WITH IMPACT BLOCKS


LENGTH RATIOS

5.8.8 Trash Racks

An underflow type trash guard is preferred over conical type trash guards. Experience has shown underflow type trash guards to be highly effective in preventing clogging and superior in preventing litter and debris from being transported downstream.

SECTION 6: BMP Facility Planting and Soil

6.4 Landscape Plans

The design of the following structural BMP's must include a landscape plan prepared in accordance with Section 6.4.1 and plantings placed in accordance with Section 6.4.2 of the State BMP Manual:

- Stormwater Wetlands
- Wet Detention Basin
- Bioretention Cell

A one year (1 yr) warranty period is customary and acceptable. A note on the plan must be added making reference to the one year warranty.

6.4.2 - Trees or shrubs shall not be planted on portions of water impounding embankments.

6.5.1 Soils Analysis

A soils analysis / report as outlined in Section 6.5.1 of the State BMP Manual will be prepared and submitted to the City of Greensboro Stormwater Division for the structural BMP's listed above. For wet detention basins and Stormwater wetlands the soils analysis must include an analysis of the viability of the soils to retain a permanent pool.

6.5.3 Soil Specifications

Soils used within any BMP proposed within the City of Greensboro must adhere to the specifications listed in Section 6.5.3 of the State BMP Manual.

SECTION 7: BMP INSPECTION AND MAINTENANCE

7.2. Legal and Financial Issues

7.2.2 Inspection and Maintenance Agreements

The City's water-supply watershed (Ch. 30) ordinance and the 1999 stormwater management (Ch. 27) ordinance require that BMPs which are constructed to meet these requirements must be maintained by the property owner or owners' association. The BMPs must be maintained to continue to function to meet the regulations it was designed for. The City has the authority to inspect these BMPs periodically and require the BMP owner to perform maintenance activities, when necessary.

7.3.10 Dam Safety

Preserving the structural integrity of the dam of a pond 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) Seepage

The downstream side of the dam should be inspected regularly for evidence of significant seepage. Seepage can emerge anywhere below the normal pool elevation, including the downstream slope of earth dams, areas beyond the toe of the dam, and around the spillway or pond outlet conduit. Indications of significant seepage include areas where the soil is saturated or where there is a flowing "spring" or leak. If "sinkholes" in the dam embankment are noticed, or if constant flowing water is noticed on the downstream side of the dam, then seepage has become excessive and professional engineering advice should be sought immediately to avert a major structural problem or a catastrophic failure of the dam.

(3) 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.

(4) 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.

7.3.11 Reduction of Pollutants Entering BMPs

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.

7.3.12 Stabilization of BMP drainage area

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.

For filtration practices such as sand filtration facilities and bioretention, maintaining a stabilized drainage area is especially important. Eroded sediment can quickly "seal" the filtration bed, drastically decreasing its filtration capacity.

Erosion Concerns

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, 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 a temporary erosion resistant matting or to use sod to repair these areas.

7.3.13 Blockage of Outlets

Wet 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.**

7.3.14 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.**

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.

SECTION 8: LEVEL SPREADER

The second paragraph in Section 8.3.3 in the State Manual states:

"One of the most important design criteria for the level spreader lip is that it must be constructed parallel to contour lines. Often, this will result in a level spreader that is curved, which is perfectly acceptable."
However if the curvature of the contours is significant and is likely to result in convergent and concentrated flow downstream of the lip (e.g. in swales of draws), construct the lip as a straight one or with a gentler curvature.

8.3.5 Level Spreaders in Series

8.3.5.1 Stream Buffer Widths

Refer to Section 2.9.3.2 for required stream buffer widths according to watersupply watershed requirements.

8.3.6 Options Where Level Spreaders are Not Appropriate

The Randleman Watersupply Watershed does not allow the outfall to be routed directly though the riparian buffer.

8.3.12 Stabilization of BMP drainage area

The area draining to the level spreader should remain stabilized to prevent excessive sediment from entering the level spreader. 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.

<u>Erosion Concerns</u>

Level spreaders must be inspected to make sure that they are functioning as designed. Standing water could cause issues to the lining material of the level spreader and therefore proper drainage is required.

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 a temporary erosion resistant matting or to use sod to repair these areas.

8.5 Maintenance

A Drainage, Maintenance and Utility Easement (DMUE) shall be placed over the Level Spreader and extend 15’ beyond its perimeter, including up to any associated stream or riparian buffers. A 20’ wide access easement will be required from the public street right-of-way to the Level Spreader.

See also Section 8.1 for additional information on outflow of a BMP through a Level Spreader.

9.0 STORMWATER WETLANDS

Example of Stormwater Wetland

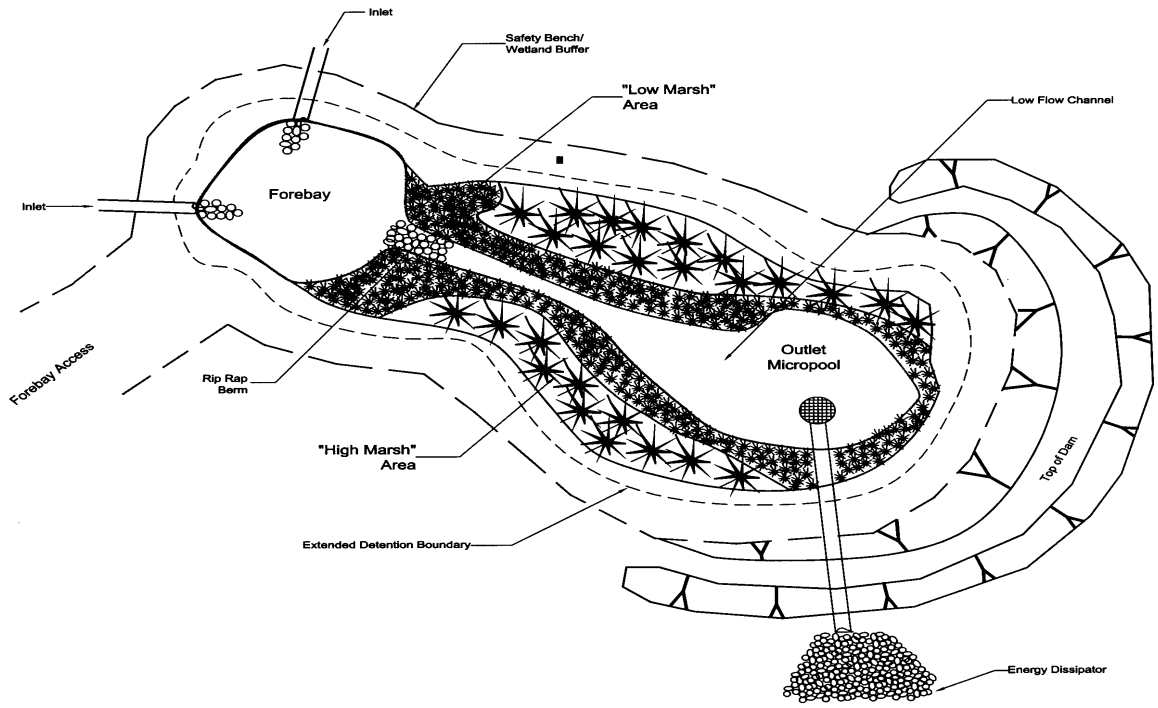


Figure Adapted from Schueler 1992

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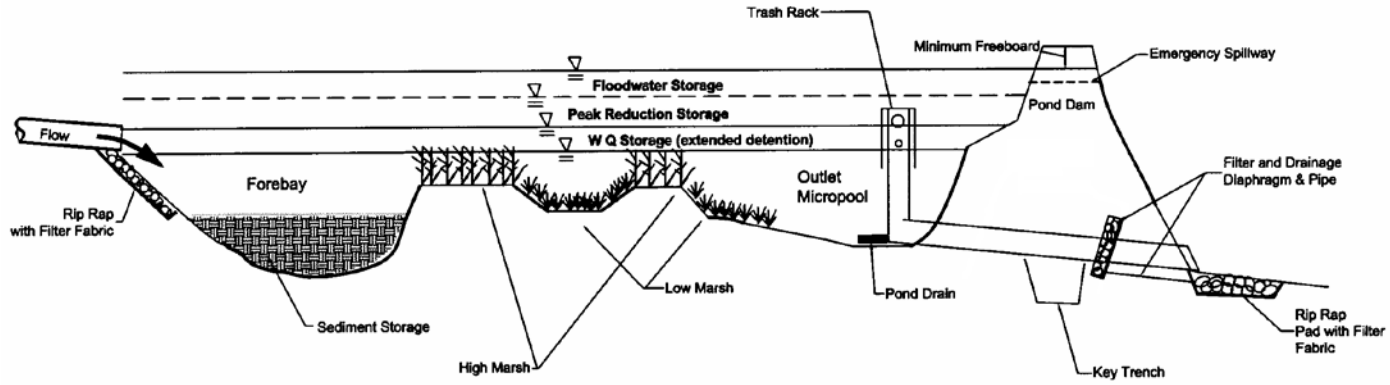


PROFILE

9.3 Design

9.3.1 Understanding Basic Layout Concepts

Siting Issues

Stormwater wetlands shall not be placed in jurisdictional wetlands, on intermittent or perennial streams. Also, Stormwater wetlands used to meet water-supply watershed regulations will be required to be designed to treat the total drainage area to the wetland, on-site and off-site, per the City's water-supply watershed ordinance.

When designing the dam and spillways, existing and potential future downstream development should be considered. Avoid placing the dam upstream of highly developed or traffic areas whenever possible. The discharge from the spillways should be directed to a conveyance system that can adequately handle the flow or if no conveyance is present, the discharge should be directed away from existing development.

Pretreatment and Inflow

Inverts for inlet pipes should be at the elevation of the normal (permanent) pool to allow the pool to dissipate the energy of the inflow to prevent erosion along the embankment slope. Inlets should be designed to discharge to the pond perpendicular to the pool surface to minimize potential erosion problems to the adjacent embankment. Riprap pads should be underlain with a gravel/sand filter or geotextile fabric and extend from the pipe invert to the pond bottom. For pond inlets that carry public runoff the invert must be designed to discharge above normal pool elevation to prevent water from backing up within the public storm sewer system.

9.3.2 Step 2: Determine the Volume to Treat

The minimum volume of 3630 ft^3 (1 ac.-in.) shall be based upon the runoff from a one inch (1") rainfall.

9.3.5 Step 5: Select the Appropriate Overflow Bypass

9.3.5.1 Outlet Design

Principal Spillway Capacity: 10 year 24 hour rain storm event

Emergency Spillway Capacity: Minimum 100 year 24-hour rain storm event (design to be consistent with the NC Dam Safety Requirements).

Dam freeboard: NC Dam Safety requires a one (1) foot minimum freeboard above the maximum flood pool elevation during the spillway design flood. The City encourages the designer to maximize the freeboard to the extent practicable.

An access to the forebay for future sediment cleanouts is to be provided. Access should have a maximum slope of 15-20% extending from the top of the embankment to the toe. This access

will allow construction equipment to get down in the forebay and will minimize disturbance to the vegetation.

Key trench should be installed and designed according to the requirements stated on section 5.6 of this supplement.

Principal Spillway

The principal spillway should be a riser/barrel, concrete free overfall weir, or concrete chute, with capacity to handle the 10-year, 24-hour rain storm event at a minimum. The riser/barrel material of construction shall be either reinforced concrete, ductile iron, PVC, HDPE, or corrugated aluminum piping. The use of aluminized steel or other type of corrugated metal is not allowed. Reinforced concrete (where the joints are sealed and specified watertight) and ductile iron pipes (being rigid pipes) are preferred for this application. To prevent distortion of flexible conduit, such as corrugated aluminum piping, special care (including construction oversight) must be taken during compaction of the soil around it and result in internal soil erosion problems potentially leading to failure of the embankment around and above the conduit

The spillway should be equipped with a trash rack and an anti-vortex device.

Emergency Spillway

The emergency spillway should be designed to safely convey discharges resulting from storms up to the 100-year, 24-hour storm, at a minimum. The spillway should be located where it will not adversely affect downstream property such as roadways and building structures. The emergency spillway may be incorporated into the principal spillway where accommodating the emergency spillway elsewhere is not feasible for the given site characteristics.

The emergency spillway should be cut into existing soils outside the fill section of the dam. Where this placement requirement cannot be met, the emergency spillway shall be designed to meet the chute or free overfall spillway requirements as listed in Section 5.8.6 of this supplement. The emergency spillway may be grass lined, when velocities permit, or lined with rip rap, concrete, or other erosion resistant materials. **Grass lined spillways are to be planted with a dense cover of erosion resistant grasses,** preferably incorporating turf reinforcement matting (TRM).

Wetland Pond Drain

A pond drain should be provided to drain the wetland for routine maintenance or structural repairs in an emergency situation. It is recommended that the pond drain be designated to have the discharge capability to completely drain the pond in less than 48 hours, in the event of an emergency posed by impending failure of the dam. The upstream slope of the pond dam should be designed to be flat enough to prevent slope failure due to “quick drawdown” of the pond (NC Dam Safety Code specifies a factor of safety of 1.25) in an emergency. Care should be taken to minimize transport of settled sediment from the pond during draining.

9.4 Construction

A concrete retaining wall may be used for the pond's dam provided the requirements listed under Section 10.3.2 of the State's Stormwater Best Management Practices Manual are met.

For earth dams, the top width of the dam shall be 10 feet minimum. A key trench shall be excavated under the entire length of the dam and located at or upstream of the centerline of the dam. The key trench should be filled with highly impervious and well compacted clay material. The key trench should have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations, with a minimum width of 4 feet. Side slopes should be no steeper than one horizontal to one vertical. The minimum recommended depth of fill material is 3 feet below the stripped grade (or shallower should bedrock be encountered). The fill material should be placed in lifts not to exceed 8 inches in loose thickness and compacted to at least 95% standard proctor. The fill material and compaction specification for the key trench shall be specified on the BMP design plans. Incorporating a drainage blanket (preferably with a chimney drain) should be considered to reduce the potential for seepage problems. Also refer to Section 5.6.1 of this manual.

A "filter and drainage diaphragm" shall be used to prevent piping along the barrel within the earth fill. Refer to Section 5.6.1 of the BMP Design Supplement for seepage control requirements for conduits that extend through an embankment dam.

9.5 Maintenance

9.5.1 Common Maintenance Issues

The wetland should be easily accessible for maintenance. A 20' wide access easement shall be provided from the public street right-of-way to the wetland's DMUE. A drainage maintenance and utility easement (DMUE) shall be paced over the wetland and extend 15' beyond the top of embankments and outside edges of erosion protection structures (energy dissipators concrete or riprap pads, etc). The access easement should be kept easily accessible for maintenance.

9.5.3 Reduction of Pollutants Entering Wetland

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

To assist the stormwater BMP in removing pollutants, every effort should be made to reduce the initial pollutant load entering the wetland. 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.

9.5.4 Stabilization of BMP drainage area

The area draining to the BMP 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.

Erosion Concerns
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 a temporary erosion resistant matting or to use sod to repair these areas.

9.5.5 Blockage of Outlets

Extended wetlands are designed for the ponded water to exit 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 wetland'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.**

9.5.6 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.**

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.

SECTION 10: WET DETENTION BASIN

10.1 General Characteristics and Purpose

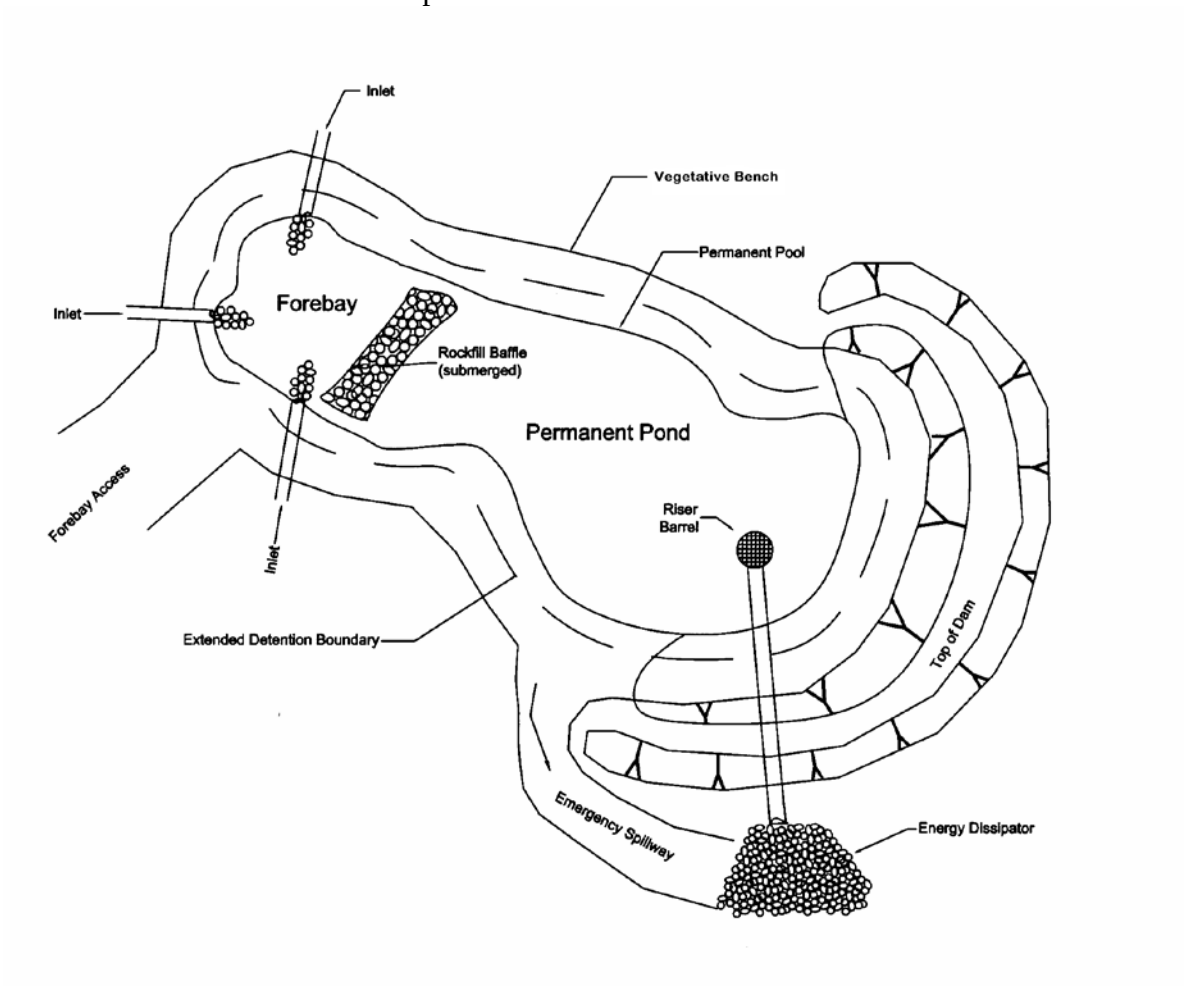
In Greensboro, the wet detention pond is currently the most commonly used BMP for meeting water-supply watershed protection requirements. This stormwater BMP improves stormwater quality primarily by detaining stormwater runoff for an extended period of time (usually 2 to 5 days) to allow pollutants that are suspended in the runoff to settle out. During a storm event, runoff enters the pond and replaces the "treated" water in the permanent pool that has been detained in the permanent pool from the previous storm event(s). As runoff enters the pond, its velocity is significantly reduced allowing suspended pollutants to begin settling. Many pollutant particles found in stormwater runoff are very small in size and, because smaller particles settle slower than larger particles, the pond is designed to provide adequate detention time so smaller particles have a chance to settle out.

The components of the wet detention pond that help increase the pond's pollutant removal efficiency are the permanent pool, temporary pool, and forebay (see Figure 10-1). The permanent pool helps reduce particles that have settled to the pond bottom from re-suspending when runoff flows into the pond. The temporary pool is storage above the permanent pool that is designed to control the WQV. To increase the detention time of the runoff, the temporary pool is slowly released through low flow orifice(s). A separate smaller pond, called a forebay, is placed upstream of the main pond to trap a majority of the coarser fractions of suspended solids in the runoff before it enters the main pond. Figure 10-1 illustrates the main features of a wet detention basin.

Wet detention ponds, based on findings from the City's periodic BMP inspection program, seem to function better when the pond is larger and receives flow from a larger drainage area. This may be attributed to several factors, such as, in larger drainage areas there is usually a better chance for seasonal or permanent surface or groundwater flow into the pond as opposed to smaller drainage areas. This flow may help the permanent pool to be "flushed" more often (as opposed to only during storm events), which may help to prevent undesirable conditions from developing (for example, stagnate water, fluctuating permanent pool elevation, etc.). It is suggested that owners of smaller properties cooperate to construct and maintain one relatively large pond to serve several properties, rather than several individual smaller ponds. Although the City generally recommends a drainage area of 10 acres or more, wet detention ponds may be used for smaller drainage areas.

Wet detention ponds have a higher tolerance for runoff with significant sediment concentration than the other BMPs. The wet detention pond BMP is most applicable for large industrial and commercial facilities and residential subdivisions where construction will take place in phases or in residential development where site disturbance will occur for a significant period after the BMP is installed. Also, properties where the land may remain fully or partially unstabilized or where sources of sediment remain on the property (e.g. stock yards, gravel/dirt areas, construction equipment storage, etc.), the wet detention pond is a good choice.

Figure 10-1
Example of Wet Detention Basin



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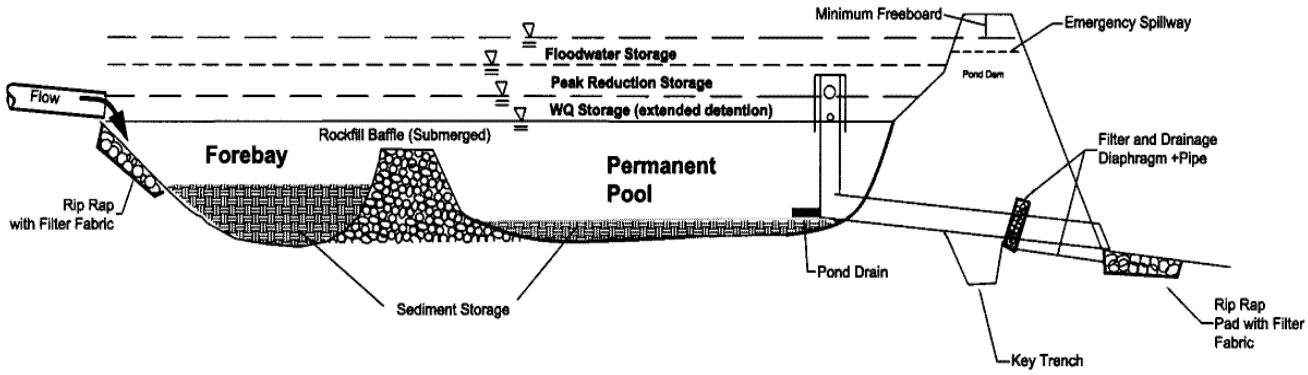

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10.3.2 Siting Issues

Wet detention basins shall not be placed in jurisdictional wetlands, on intermittent or perennial streams. Also, wet detention ponds used to meet water-supply watershed regulations will be required to be designed to treat the total drainage area to the pond, on-site and off-site, per the City's water-supply watershed ordinance.

When designing the dam and spillways, existing and potential future downstream development should be considered. Avoid placing the dam upstream of highly developed or traffic areas whenever possible. The discharge from the spillways should be directed to a conveyance system that can adequately handle the flow or if no conveyance is present, the discharge should be directed away from existing development.

10.3.3 Pretreatment and Inflow

Inverts for inlet pipes should be at the elevation of the normal (permanent) pool to allow the pool to dissipate the energy of the inflow to prevent erosion along the embankment slope. Inlets should be designed to discharge to the pond perpendicular to the pool surface to minimize potential erosion problems to the side embankment. Riprap pads should be underlain with a gravel/sand filter or geotextile fabric and extend from the pipe invert to the pond bottom. For pond inlets that carry public runoff the invert must be designed to discharge above normal pool elevation to prevent water from backing up within the public storm sewer system.

The top of the forebay baffle should be one foot below the normal (permanent) pool elevation. The baffle material may be earth, rip rap, etc. If earth baffles are used, provisions should be included to allow the forebay to drain out with the rest of the pond to facilitate sediment removal from the forebay. This could include a rip rap check dam in a section of the earth baffle or a perforated riser pipe connecting the forebay to the main pond.

10.3.4 Length, Width (Area), Depth, Geometry

For ease of maintenance and safety, the pond embankments should be sloped to a maximum of 3H:1V with flatter slopes preferred. The engineering design of a wet detention basin must include a 10' wide vegetated bench (max. slope 10%) placed around the perimeter of the basin pond at the normal pool surface. The inside edge of the shelf shall be no deeper than 6" below the permanent pool elevation, and the outside edge shall be 6" above the permanent pool elevation. The vegetated shelf provides a location for a diverse population of emergent wetland vegetation that enhances biological pollutant removal, provides a habitat for wildlife, protects the shoreline from erosion, and improves sediment trap efficiency.

The pond surface area shall have a minimum 1.5:1 length to width ratio, with 3:1 preferred. The distance between the inlets and outlets should be maximized to increase the pollutant removal capability of the pond.

It is encouraged to create a pond that fits within the natural contours of the land but care should be taken to prevent "dead storage zones" (areas outside the flow path between the inlet and outlet) within the pond. Generally, the pond should be narrower at the inlet forebay area and

become wider at the outlet. Whenever possible one forebay should be created and all pond inlet pipes discharge to the forebay area.

The bottom of the pond should be slightly sloped from the upstream end to the downstream end. This will allow the pond and captured sediments to drain better when cleanouts are necessary.

It is encouraged where appropriate to use educational signs at the pond describing the function of the pond and the purpose it serves.

To meet NCDWQ requirements, if the pond outlet ties into an existing storm drainage system then the pond surface area must be designed for 90% TSS. In this case, a filter strip would not be required or practical.

10.3.6 Sediment Accumulation

The engineering design of a wet detention basin must allocate additional volume for sediment accumulation between cleanouts. For design purposes, a sediment storage depth of a minimum of 0.125 inches of depth over the drainage area should be provided with approximately 75% of this volume allocated to the forebay. In no event should the depth of sediment storage be less than 1 foot in both the forebay and main pool. An access to the forebay for future sediment cleanouts is to be provided. The forebay access shall have a maximum slope of 15-20%, extending from the top of the embankment to the toe. This access will allow construction equipment to get down in the forebay and minimize disturbance to the vegetation.

10.3.7 Plant and Landscape Requirements

Earthen embankments for wet detention basins can be surfaced with turf grass, riprap or other protective measures. The use (or growth) of trees and shrubs is not permitted on earthen embankments due to their capability to undermine the embankment structural stability.

10.3.8 Surrounding Soils and Liners

When a wet detention basin is to be located in sandy or gravelly soils or in fractured bedrock, the BMP design shall incorporate an impervious clay or synthetic liner to sustain the permanent pool of water or alternatively incorporate designed features to cutoff seepage through the foundation and the abutments. The liner shall extend over the entire bottom surface of the permanent pool and water quality volume pool.

If, at the time of BMP certification in accordance with Section 30-7-1-6 of the Greensboro Development Ordinance, the pond does not have a permanent pool established per the approved plans, one of the following requirements must be met:

- Submit a performance bond to the City to cover all costs to upgrade the pond in the event it is determined that a permanent pool of water cannot be established.
- For non residential development, obtain a letter from the owner stating all necessary corrective measures will be undertaken to upgrade the pond in the event it is determined that a permanent pool of water cannot be established.

- Submit supporting technical analysis / soil investigative reports confirming the geotechnical composition of the pond bottom and embankments is conducive to holding a permanent pool.

10.3.9 Outlet Design

The principal spillway should be a riser/barrel, concrete free overfall weir, or concrete chute, with capacity to handle the 10-year, 24-hour rain storm event at a minimum. The riser/barrel material of construction shall be either reinforced concrete, ductile iron, PVC, HDPE, or corrugated aluminum piping. The use of aluminized steel or other type of corrugated metal is not allowed. Reinforced concrete (where the joints are sealed and specified watertight) and ductile iron pipes (being rigid pipes) are preferred for this type of application. To prevent distortion of flexible conduit, such as corrugated aluminum piping, special care (including construction oversight) must be taken during compaction of the soil around it and result in internal soil erosion problems potentially leading to failure of the embankment around and above the conduit. The minimum diameter of the principal spillway barrel section (horizontal pipe) shall be twelve inches (12”) to allow outflow to be limited to pre-developed peak for small sites.

For wet detention basin design purposes, the capacity of the principal spillway is the 10-year, 24-hour storm event. The 10-year, 24-hour storm event shall not activate the emergency spillway unless the spillway structure is integrally designed to handle both the 10-year, 24-hour and 100-year, 24-hour storm events. Riser/barrel assemblies shall be properly anchored to resist buoyancy forces.

The low flow orifices are to be protected from clogging due to floating debris using a trash guard. The trash guard should be durable and secure and should extend at least six inches below the normal pool surface. A common method when using a riser/barrel is to extend the principal spillway trash rack assembly below the normal pool. When the low flow orifice will be placed in a concrete dam or spillway, an inverted or submerged orifice can be used or a half aluminum pipe bolted to the concrete (see Section 5.8.8 for example trash protection devices). Refer to Section 3.5.2 for the preferred method for calculating the orifice drawdown time.

The capacity of the emergency spillway (in conjunction with the principal spillway) shall be based on the spillway design flood storm event per N.C. Dam Safety regulations and at a minimum be the 100-year, 24-hour rain storm event. The spillway should be located where it will not adversely affect the integrity of the dam and downstream properties such as roadways and building structures. As noted above, the emergency spillway may be incorporated into the principal spillway where accommodating the emergency spillway elsewhere is not feasible for the given site characteristics. **The emergency spillway shall be cut into existing soils outside the fill section of the dam.** Where this placement requirement cannot be met, the emergency spillway shall be designed to meet the chute or free overfall spillway requirements as listed in Section 5.8.6 of this supplement. The emergency spillway may be grass lined, when velocities permit, or lined with rip rap, concrete, or other erosion resistant materials. **Grass lined spillways are to be planted with a dense cover of erosion resistant grasses,** preferably incorporating turf reinforcement matting (TRM).

The City of Greensboro strongly recommends a minimum eight foot (8’) width emergency spillway be used for the 100-year flow if it can be placed in in-situ soil regardless of whether the

calculations indicated the principal spillway will pass the flow. The separate spillway provides an additional factor of safety that can be incorporated in the grading of the pond at a small cost and allows storm flow if a problem occurs with the riser/barrel assembly.

To meet NC Dam Safety requirements, a minimum freeboard of 1 foot above the maximum stage associated with the spillway design storm event is required. The City of Greensboro encourages BMP designers to maximize the freeboard to the maximum extent practicable. The Engineer's Statement of Pond and Dam Safety as listed in Section 5.6 of this Supplement shall be listed along with the BMP design elements.

10.3.11 Safety Considerations

Although not required by State Regulations or Local Ordinance, the use of fencing around wet detention basins is encouraged where safety risks are posed by children. The designer is encouraged to incorporate engineering design features (gentle contours, inlet and outlet screens, etc.) that minimize safety risks.

10.4 Construction

A concrete retaining wall may be used for the pond's dam provided the requirements listed under Section 10.3.2 of the State's Stormwater Best Management Practices Manual are met.

For earth dams, the top width of the dam shall be 10 feet minimum. A key trench shall be excavated under the entire length of the dam and located at or upstream of the centerline of the dam. The key trench should be filled with highly impervious and well compacted clay material. The key trench should have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations, with a minimum width of 4 feet. Side slopes should be no steeper than one horizontal to one vertical. The minimum recommended depth of fill material is 3 feet below the stripped grade (or shallower should bedrock be encountered). The fill material should be placed in lifts not to exceed 8 inches in loose thickness and compacted to at least 95% standard proctor. The fill material and compaction specification for the key trench shall be specified on the BMP design plans. Incorporating a drainage blanket (preferably with a chimney drain) should be considered to reduce the potential for seepage problems. Also refer to Section 5.6.1 of this manual.

A "filter and drainage diaphragm" shall be used to prevent piping along the barrel within the earth fill. Refer to Section 5.6.1 of the BMP Design Supplement for seepage control requirements for conduits that extend through an embankment dam.

For large ponds that have a considerable fetch, wind-generated wave action during storms shall be considered in the freeboard. Also protection (stone riprap layer laid on a gravel or geotextile bedding) against wave induced erosion should be provided covering the range of pool elevation above the minimum pool.

Appropriate energy dissipation shall be used at the spillway exit to prevent erosive velocities for up to the 10-year peak discharge rate, at a minimum. The basin discharge shall be evenly distributed across a minimum 30 foot long vegetated filter strip. Every effort should be made to discharge in defined conveyances and parallel to the existing flow to prevent bank erosion.

Downstream channels may need to be modified and lined with rip rap to prevent erosion of the channel. Modifications to the downstream channel should be minimized as much as possible to prevent excessive disturbance in the channel.

A pond drain is to be provided to drain the pond for routine maintenance or structural repairs in an emergency situation. The pond drain is to have the discharge capability to completely drain the pond in 24 hours, in the event of an emergency posed by impending failure of the pond dam. The upstream slope of the pond dam should be designed to be flat enough to prevent slope failure due to "quick drawdown" of the pond (NC Dam Safety Code specifies a factor of safety of 1.25) in an emergency. Care should be taken to minimize transport of settled sediment from the pond during draining.

Eliminating a conduit through the embankment eliminates the requirement for seepage control.

10.5 Maintenance

10.5.1 Common Maintenance Issues

The wet detention basin should be easily accessible for maintenance. A 20' wide access easement shall be provided from the public street right-of-way to the basin's DMUE. A drainage maintenance and utility easement (DMUE) shall be placed over the basin and extend 15' beyond the toe of embankments and outside edges of erosion protection structures (energy dissipators concrete or riprap pads, etc) so as to include all key components of the basin. The access easement should be kept easily accessible for maintenance.

The presence of some vegetation in ponds is desirable for aesthetic appearance and enhancement of fish habitat. Excessive growth of aquatic vegetation is, however, detrimental to the functional sustainability of ponds. Therefore, a good balance between aquatic vegetation and other aquatic life in ponds is desirable. Recommendations for the management of aquatic weeds are beyond the scope of this supplement. However, the owner of a pond experiencing excessive aquatic weed problems is advised to contact the NC State Fisheries & Pond Management Extension for assistance with the identification of the aquatic weeds and recommendations for appropriate management strategy. The website for the NC State Fisheries & Pond Management Extension is http://www.ces.ncsu.edu/nreos/wild/fisheries/index.html. Pond owners can also contact the local Guilford County Cooperative Extension Service at (336)375-5876 for advice and guidance.

10.5.10 Dam Safety

Preserving the structural integrity of the dam of a pond 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) Seepage

The downstream side of the dam should be inspected regularly for evidence of significant seepage. Seepage can emerge anywhere below the normal pool elevation, including the downstream slope of earth dams, areas beyond the toe of the dam, and around the spillway or pond outlet conduit. Indications of significant seepage include areas where the soil is saturated or where there is a flowing "spring" or leak. If "sinkholes" in the dam embankment are noticed, or if constant flowing water is noticed on the downstream side of the dam, then seepage has become excessive and professional engineering advice should be sought immediately to avert a major structural problem or a catastrophic failure of the dam.

(3) 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.

(4) 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.

10.5.11 Reduction of Pollutants Entering BMPs

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.

10.5.12 Stabilization of BMP drainage area

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.

For filtration practices such as sand filtration facilities and bioretention, maintaining a stabilized drainage area is especially important. Eroded sediment can quickly "seal" the filtration bed, drastically decreasing its filtration capacity.

Erosion Concerns
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 a temporary erosion resistant matting or to use sod to repair these areas.

10.5.13 Blockage of Outlets

Wet 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.**

10.5.14 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.**

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.

SECTION 11: SAND FILTER

Sand Filtration Facilities

11.1 General Characteristics and Purpose

Sand filtration systems used for stormwater treatment work similar to those that are used in the drinking water purification process. These systems remove pollutants through sedimentation, filtration, and microbial activity within the sand. Stormwater filtration systems consist mainly of a pretreatment or sedimentation basin, and the filter area. Runoff first enters the sedimentation basin where the runoff velocity is reduced allowing larger pollutant particles to drop out. When the stormwater exits the sedimentation area it is spread evenly over the filter bed where it then flows downward through the filter. As the stormwater flows through the filter, the filtration media trap and absorb pollutants present in the stormwater. Sand filtration systems are beneficial when land space is scarce or expensive, because they can be designed to be placed underground or to border the perimeter of a parking lot or other impervious surface.

Sand filtration facilities are best used for smaller sites (5 acres or less) where the percent imperviousness and the land value is high. Also, the facilities should be used on sites where the drainage area to the facility will remain well stabilized after the construction phase to prevent excess sediment and debris from prematurely clogging the filter. It is recommended that individual sand filtration facilities be sized to treat relatively small drainage areas (1 to 2 acres or less). Implementing multiple facilities on a site will prevent the entire site from being untreated if one filter facility happens to get clogged.

The cost of the construction of concrete underground sand filtration facilities is high in relation to other BMPs and the maintenance burden for the owner can be quite substantial. However, because the BMP can be placed underground, the construction and maintenance costs may be offset by the saving in land area.

To prevent loose debris such as grass clippings, landscape debris, etc from entering the facility, it is highly recommended that sand filtration facilities treat only runoff from impervious surfaces. It is a good idea to implement pollution prevention BMPs, such as paved area sweeping and covering, to minimize the sediment and other pollutants that enter the BMP.

Sand filtration BMPs differ from bioretention, in the fact that the hydraulic head above the filtration bed can be significantly higher than the 6 inches allowed for bioretention. Thus a smaller filter bed surface area will be required.

There are three basic sand filtration BMP types: (1) underground sand filter, (2) perimeter sand filter, and (3) surface sand filter. The underground BMP is ideal to treat stormwater in the ultra-urban environment where land costs are high. The perimeter sand filter and surface sand filter are good to treat parking lot runoff.

Description of Various Sand Filter Types

Underground Sand Filter

There are several different configurations for a sand filtration facility placed in an underground basin. The most widely known type is the District of Columbia (DC) sand filter developed by Mr. Hung V. Truong of the D.C, Environmental Regulation Administration. This type BMP is designed for use in the ultra-urban setting where the drainage area is small (less than one acre). The DC facility consists of three chambers: a wet sedimentation chamber, sand filtration chamber, and outlet chamber (see Figure 3.10).

The wet sedimentation chamber serves to dissipate the incoming velocity and settle out grit. The sedimentation chamber also has a submerged orifice that serves to trap floating debris and prevent it from entering the sand filtration chamber. Mr. Truong points out that the sedimentation chamber can be replaced by a commercial hydrodynamic BMP (see section 3.4.13, Proprietary Stormwater Treatment Facilities). The sand filtration chamber consists of the 24 inch sand bed layer underlain by a gravel bed with perforated PVC drain pipes. An optional layer of geotextile (plastic filter cloth) liner can be placed on top of the sand bed to prevent debris from getting into the sand layer. The outlet chamber collects the effluent from the underdrain pipes, and flow from the by-pass pipe when the volume of the basin is exceeded.

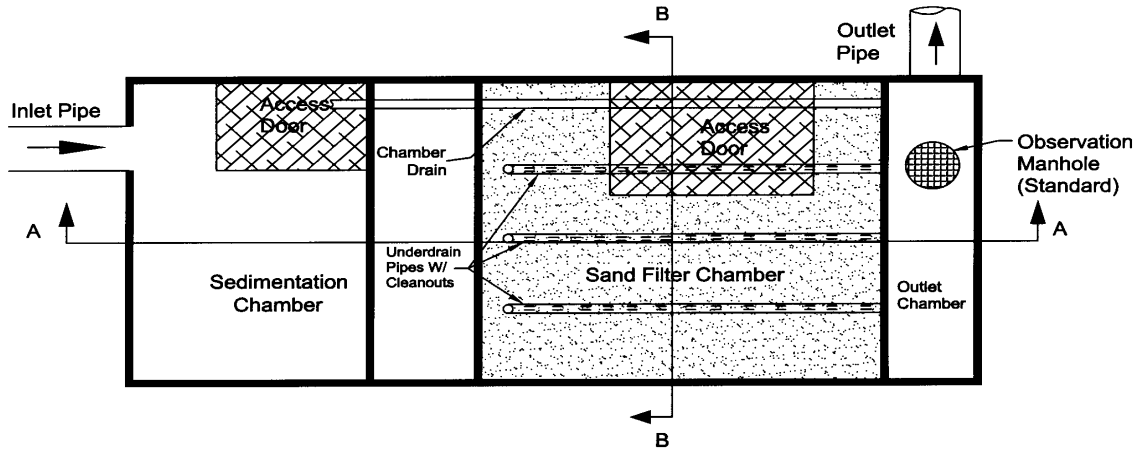
Perimeter Sand Filter (Delaware Sand Filter)

The perimeter sand filter was originally developed by Mr. Earl Shaver of the Delaware Department of Natural Resources and Environmental Control. This type of facility was primarily intended to border the perimeter of parking lots and treat the runoff from it. The facility consists of two parallel concrete chambers; a wet sedimentation chamber and a sand filtration chamber (see Figure below and Figures 12-a and 12-b of the State's Stormwater BMP manual) Runoff in the form of sheet flow enters into the wet sedimentation chamber where the energy is dissipated, flow is dispersed, and coarse sediments drop out. The flow then overflows into the sand filtration chamber where it percolates through the sand medium and is collected by an underdrain system. An overflow weir should be implemented to safely bypass storms larger than the water quality volume.

Surface Sand Filter (SSF)

The City of Austin, Texas first developed and used surface sand filtration systems for treating stormwater runoff (see Figure below and Figure 11-1 of State's Stormwater BMP Manual). The sand filter can be placed in a concrete or earth basin. A sedimentation basin is needed to pretreat the incoming runoff and to bypass larger storm events. The City of Austin found that it was important to size the sedimentation chamber to remove suspended solids to prevent excessive sediment loading on the sand filtration chamber. Since the SSF is an open basin, it will generally cost less than the other enclosed sand filter types and is usually practical to treat a larger drainage area.

Figure: Example of Underground Sand Filter (DC Filter)



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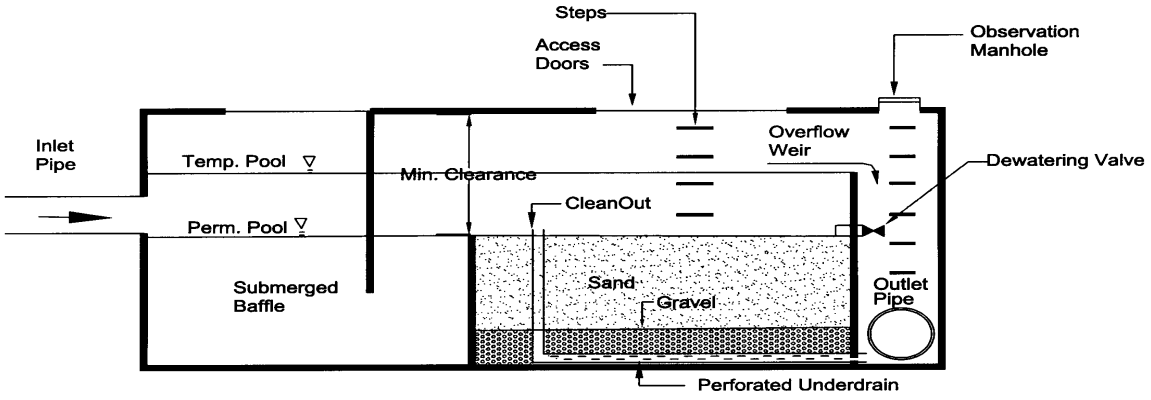
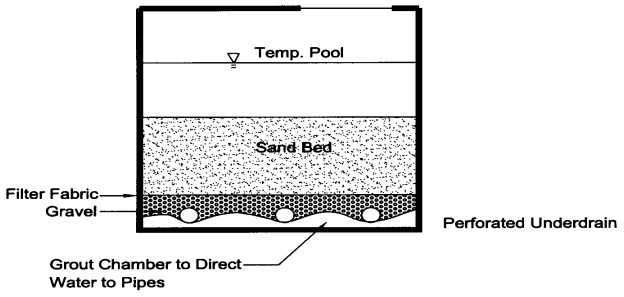
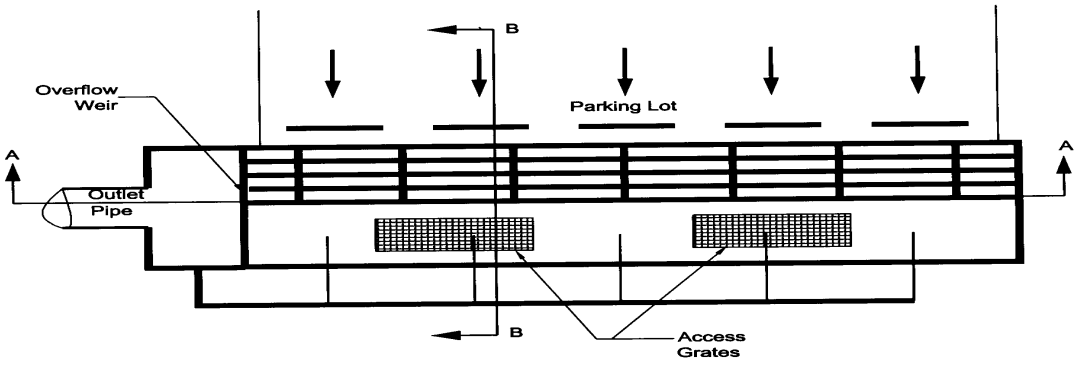


SECTION A-A



SECTION B-B

Figure: Example of Perimeter Sand Filter (Delaware Sand Filter)



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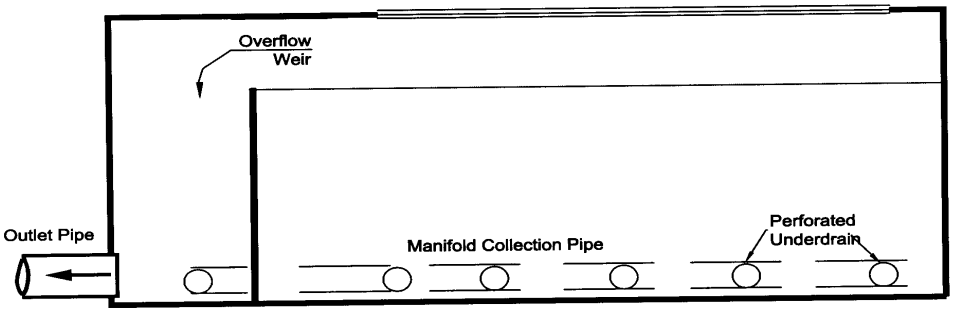

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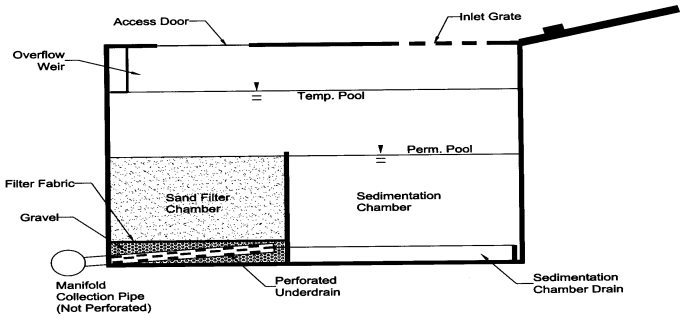
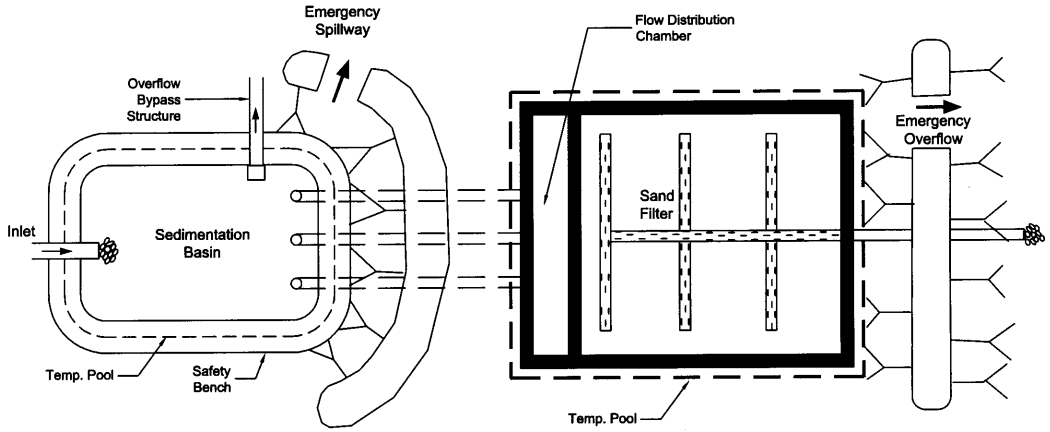


SECTION B-B

Figure: Example of Surface Sand Filter



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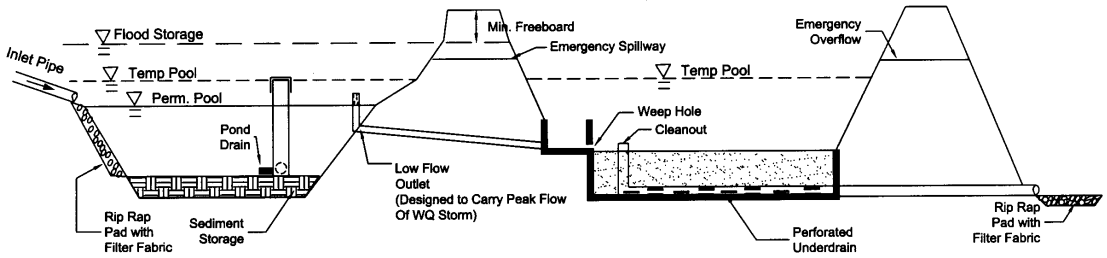

PROFILE

Figures 11-1 and 11-2a show a perforated pipe extending the length of the sand filter chamber and not merely just a solid pipe stubbing into it.

Since an underdrain is required to be incorporated into the device in Greensboro, the device does not require a one hundred feet (100') separation from water supply wells unless it is a community well. A community well has fifteen (15) or more connections and/or serves twenty five (25) or more people.

11.4 Maintenance

11.4.1 Common Maintenance Issues

A 20' wide access easement shall be provided from the public street right-of-way to the sand filtration and pretreatment areas. A drainage maintenance and utility easement (DMUE) shall be paced over the entire facility and extend 15' beyond its perimeter. The access easement should be kept to ensure the BMP is easily accessible for inspection and maintenance.

For sand filtration facilities that are underground, adequate access shall be provided into the facility for inspection and maintenance. It is preferred that large aluminum or steel doors be placed to access the sand filtration chamber. Steps will need to be provided for the underground facility. Also observation manholes or doors should be provided for underground overflow chamber and the sedimentation chamber. Maintenance to the underground sand filtration facility will involve entering a confined space and the appropriate provisions should be made to comply with OSHA confined space requirements.

For ease of maintenance and safety, the distance between manholes and/or access points shall be 100 linear feet maximum. 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.

Access to the sand or filter media for inspection and maintenance should be considered during design and ensured during construction. Sediment, debris, and other floatable trash commonly interfere with the proper function or effectiveness of sand filters. Proper grounds keeping and house keeping measures should be utilized throughout the drainage area to prevent these pollutants from entering the BMP in the first place.

11.4.3 Reduction of Pollutants Entering BMPs

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 BMP.
- ⇨ Trash and vegetative floatables (grass clippings, leaves, limbs, etc.) should be cleaned from the BMP surface and surroundings periodically to promote a healthy, aesthetically pleasing environment, and to prevent blockage of the outlets. Studies have shown that people are less likely to litter areas that are aesthetically pleasing.

11.4.4 Stabilization of BMP drainage area

The area draining to the BMP 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.

For filtration practices such as sand filtration facilities and bioretention, maintaining a stabilized drainage area is especially important. Eroded sediment can quickly “seal” the filtration bed, drastically decreasing its filtration capacity.

Erosion Concerns
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 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 a temporary erosion resistant matting or to use sod to repair these areas.

SECTION 12: BIORETENTION

12.3.1 Step 1: Understand Basic Layout Concepts

12.3.1.1 Pretreatment Options

Sheet flow must be achieved prior to entering the bioretention cell. Concentrated flow is not recommended. Therefore, a level spreader or a combination of gravel and grass or sod, with a minimum 10 feet in width needs to be in place for pretreatment. This is the City of Greensboro's requirement instead of 3-5 feet of sod stated in the State BMP Manual section 12.3.1.

12.3.6 Step 6: Size the Underdrain

All bioretention cells in the City of Greensboro shall have an underdrain system. Underdrain system are to be sized in accordance to provisions stated on Chapter 5.7.

Since an underdrain is required to be incorporated into the device in Greensboro, the device does not require a one hundred feet (100') separation from water supply wells unless it is a community well. A community well has fifteen (15) or more connections and/or serves twenty five (25) or more people.

12.3.8 Step 8: Select Plants and Mulch

The vegetation of choice for some bioretention cells is grass. Varieties, of centipede, Bermuda, and zoysia can survive in cells that are well drained. Bioretention cells with higher percentages of fines in the filter soil medium tend to be wetter making it difficult for these grasses to grow. Because of this, grass-only bioretention cells are not currently recommended for TN removal.

12.4 Common Maintenance Issues

Drainage, Maintenance & Utility Easement (DMUE) & Access Easement

A Drainage, Maintenance and Utility Easement (DMUE) shall be placed over the bioretention cell and extend 15' beyond its perimeter. A 20' wide access easement will be required from the public street right-of-way to the Bioretention cell's DMUE.

Reduction of Pollutants Entering BMPs

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.

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- ⇨ 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.

Stabilization of BMP drainage area

The area draining to the BMP 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.

For filtration practices such as sand filtration facilities and bioretention, maintaining a stabilized drainage area is especially important. Eroded sediment can quickly "seal" the filtration bed, drastically decreasing its filtration capacity.

Erosion Concerns

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 a temporary erosion resistant matting or to use sod to repair these areas.

SECTION 13: FILTER STRIP

13.5 Maintenance

For vegetated filter strips used to meet City regulations (water-supply watershed or stormwater management), a 20' wide access easement is required from the public street right-of-way to the filter strip's DMUE. A Drainage, Maintenance and Utility Easement (DMUE) shall be placed over the filter strip and extend 15' beyond its perimeter.

SECTION 14: GRASSED SWALE

14.2 Meeting Regulatory Requirements

Due to their limited pollutant removal capability, grass swales are not acceptable BMPs for meeting the requirements for "high density" development in the water-supply watershed.

14.5 Maintenance

For grassed swales to meet City regulations, a 20' access easement will be required from the public street right-of-way to the grassed swale's Drainage, Maintenance and Utility Easement (DMUE). A DMUE shall be placed over the swale and shall extend 15' beyond the top of the side slopes.

SECTION 15: RESTORED RIPARIAN BUFFERS

15.2 Meeting Regulatory Requirements

This BMP's design limitations are associated with the level spreader and the flow that the level spreader can handle. The flow in the level spreader cannot exceed 3 cfs as stated in Item 15.3.1 provided that the length of each level spreader does not exceed 130 lf.

It is required that the restored riparian buffer remain undisturbed and shall be dedicated and platted as Undisturbed Easement (UDE) in accordance with section 30-7-3.2(E)(1)(c). When a restored riparian buffer BMP is used to meet the water quality requirements (water quality credit), the buffer and/or device(s) can not be dedicated to the City of Greensboro even if the dedication is for Drainage Way and Open Space. In addition, an existing riparian buffer cannot be used for water quality credit and counted as a BMP, nor can an existing riparian buffer be disturbed during site development and then be "improved" or "restored" for water quality credit. In all cases, should local ordinance or other state regulation be more restrictive, i.e. Randleman rules or water-supply watershed rules, then the more restrictive requirements would apply.

SECTION 16: INFILTRATION DEVICES

16.2 Meeting Regulatory Requirements

This type of BMP has no application in The City of Greensboro based upon our soil types. A soil analysis must be provided if it is desired to prove otherwise. This type of request will be handled on a case by case basis.

A natural infiltration area that meets the State BMP design criteria, may be used a stormwater quality control in the Watershed Critical Area (WCA) where the built-upon area is 6% or less in the Lower Randleman WCA or is 12% or less in any other WCA.

The natural infiltration area is to remain permanently undisturbed and is to be covered by an Undisturbed Easement (UDE) and only maintenance should be performed.

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.

19.5 Maintenance

An inspection and maintenance plan as outlined in Section 19.5 of the State BMP Manual shall 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.

SECTION 20: Proprietary Systems

20.1 General Characteristics and Purpose

The need for urban BMPs that are more efficient in pollutant removal and present less impact to development has spawned the introduction of innovative stormwater BMP technologies. These technologies usually combine the processes of settling, filtration, and various biological processes into one controlled system housed in a modular unit. By combining different processes, these BMPs can be designed to focus on removing many different type pollutants and higher concentrations of these pollutants than conventional structural BMPs.

Proprietary stormwater treatment facilities apparently possess several beneficial attributes which make these BMPs a potential viable solution for future use in this area. For example, units can be usually be placed almost anywhere on a site where it can receive concentrated flows, such as from a storm drainage structure. Also, many of the innovative proprietary BMPs are relatively safe because the stormwater is treated inside the unit, and is not open to the environment like a wet detention pond or Stormwater wetland. Another benefit is that only minimal on-site construction is necessary since the units are usually assembled before they reach the site.

20.2 Meeting Regulatory Requirements

Proprietary BMPs have the potential to meet the quality control requirements for water-supply watershed protection provided their installation, operation and maintenance are closely monitored.

Proprietary systems proposed to treat runoff within the City of Greensboro water-supply watersheds must meet State requirements as listed in Chapter 20 of the State BMP Manual. This includes applying for and receiving a Preliminary Evaluation Period (PEP) permit from the Division of Water Quality. Through the PEP Program the Division of Water Quality determines the pollutant removal credit for the targeted pollutants.

Proprietary systems approved by the State for installation with the City of Greensboro must be accompanied by an operation, inspection and maintenance plan.

For proprietary systems used to meet City regulations, a 20’ wide access easement will be required from the public street right-of-way to the system’s DMUE. A Drainage, Maintenance and Utility Easement (DMUE) shall be placed over the system and extend 15’ beyond its outer perimeter.

APPENDIX A

Stormwater Links - City of Greensboro Links

- City of Greensboro link to Municode for City Ordinances:
  http://www.greensboro-nc.gov/departments/Water/developers/Municode.htm

  Chapter 30 (General Watersupply Watershed Requirements, Watershed Critical Area Requirements, Flood Damage Prevention, etc)
  Chapter 27 (Stormwater Management Ordinance)

- City of Greensboro Watershed Map online:
  http://www.greensboro-nc.gov/NR/rdonlyres/21771AC8-2E10-44A7-AFBD-8CAFF1F25A07/0/WaterSupplyWatersheds.pdf

APPENDIX 1

Depth-Duration-Frequency Table for Greensboro, NC

Precipitation Frequency Estimates (inches)

Rainfall Duration	Annual Exceedance Probability (1 in __ years)						
	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
5 min	0.38	0.45	0.53	0.57	0.63	0.66	0.69
10 min	0.61	0.72	0.85	0.91	1.00	1.06	1.1
15 min	0.76	0.91	1.07	1.16	1.27	1.34	1.39
30 min	1.04	1.26	1.52	1.68	1.88	2.01	2.13
60 min	1.3	1.58	1.95	2.18	2.51	2.73	2.93
2 hr	1.53	1.86	2.32	2.62	3.06	3.36	3.66
3 hr	1.64	1.99	2.48	2.81	3.28	3.62	3.95
6 hr	1.99	2.41	3.00	3.42	4.03	4.49	4.95
12 hr	2.36	2.86	3.57	4.1	4.9	5.52	6.16
24 hr	2.79	3.38	4.21	4.82	5.73	6.43	7.15

Intensity-Duration-Frequency Table for Greensboro, NC

Precipitation Intensity Estimates (inches/hour)

Rainfall Duration	Annual Exceedance Probability (1 in __ years)						
	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
5 min	4.57	5.44	6.34	6.87	7.55	7.96	8.31
10 min	3.65	4.35	5.08	5.49	6.02	6.33	6.6
15 min	3.05	3.65	4.28	4.63	5.09	5.35	5.56
30 min	2.09	2.52	3.04	3.35	3.77	4.03	4.26
60 min	1.3	1.58	1.95	2.18	2.51	2.73	2.93
2 hr	0.77	0.93	1.16	1.31	1.53	1.68	1.83
3 hr	0.55	0.66	0.83	0.94	1.09	1.21	1.31
6 hr	0.33	0.4	0.5	0.57	0.67	0.75	0.83
12 hr	0.2	0.24	0.30	0.34	0.41	0.46	0.51
24 hr	0.12	0.14	0.18	0.20	0.24	0.27	0.3

Source: NOAA Atlas 14, Vol. 2, Version 3 (2004) for Greensboro Pump Station 36.089 N 79.769 W

Note: Precipitation values for the 1, 2, and 5 year recurrence intervals were obtained from partial duration series and those for the 10, 25, 50, and 100 year recurrence interval were obtained from annual maximum series

Precipitation Distribution Table for Greensboro, NC

Storm Time (Hours)	SCS Type II Distribution Factor	1-Year 24-Hour Rainfall Distribution		2-Year 24-Hour Rainfall Distribution		10-Year 24-Hour Rainfall Distribution		100-Year 24-Hour Rainfall Distribution	
		Cumulative Rainfall Amount (inches)	Incremental Rainfall Amount (inches)	Cumulative Rainfall Amount (inches)	Incremental Rainfall Amount (inches)	Cumulative Rainfall Amount (inches)	Incremental Rainfall Amount (inches)	Cumulative Rainfall Amount (inches)	Incremental Rainfall Amount (inches)
0.0	0.000	0.000	0	0.000	0	0.000	0	0.000	0
0.5	0.0053	0.015	0.015	0.018	0.018	0.026	0.026	0.038	0.038
1.0	0.0108	0.030	0.015	0.037	0.019	0.052	0.027	0.077	0.039
1.5	0.0164	0.046	0.016	0.055	0.019	0.079	0.027	0.117	0.040
2.0	0.0223	0.062	0.016	0.075	0.020	0.107	0.028	0.159	0.042
2.5	0.0284	0.079	0.017	0.096	0.021	0.137	0.029	0.203	0.044
3.0	0.0347	0.097	0.018	0.117	0.021	0.167	0.030	0.248	0.045
3.5	0.0414	0.116	0.019	0.140	0.023	0.200	0.032	0.296	0.048
4.0	0.0483	0.135	0.019	0.163	0.023	0.233	0.033	0.345	0.049
4.5	0.0555	0.155	0.020	0.188	0.024	0.268	0.035	0.397	0.051
5.0	0.0632	0.176	0.021	0.214	0.026	0.305	0.037	0.452	0.055
5.5	0.0712	0.199	0.022	0.241	0.027	0.343	0.039	0.509	0.057
6.0	0.0797	0.222	0.024	0.269	0.029	0.384	0.041	0.570	0.061
6.5	0.0887	0.247	0.025	0.300	0.030	0.428	0.043	0.634	0.064
7.0	0.0984	0.275	0.027	0.333	0.033	0.474	0.047	0.704	0.069
7.5	0.1089	0.304	0.029	0.368	0.035	0.525	0.051	0.779	0.075
8.0	0.1203	0.336	0.032	0.407	0.039	0.580	0.055	0.860	0.082
8.5	0.1328	0.371	0.035	0.449	0.042	0.640	0.060	0.950	0.089
9.0	0.1467	0.409	0.039	0.496	0.047	0.707	0.067	1.049	0.099
9.5	0.1625	0.453	0.044	0.549	0.053	0.783	0.076	1.162	0.113
10.0	0.1808	0.504	0.051	0.611	0.062	0.871	0.088	1.293	0.131
10.5	0.2042	0.570	0.065	0.690	0.079	0.984	0.113	1.460	0.167
11.0	0.2351	0.656	0.086	0.795	0.104	1.133	0.149	1.681	0.221

Storm Time (Hours)	SCS Type II Distribution Factor	1-Year 24-Hour Rainfall Distribution		2-Year 24-Hour Rainfall Distribution		10-Year 24-Hour Rainfall Distribution		100-Year 24-Hour Rainfall Distribution	
		Cumulative Rainfall Amount (inches)	Incremental Rainfall Amount (inches)	Cumulative Rainfall Amount (inches)	Incremental Rainfall Amount (inches)	Cumulative Rainfall Amount (inches)	Incremental Rainfall Amount (inches)	Cumulative Rainfall Amount (inches)	Incremental Rainfall Amount (inches)
11.5	0.2833	0.790	0.134	0.958	0.163	1.366	0.232	2.026	0.345
12.0	0.6632	1.850	1.060	2.242	1.284	3.197	1.831	4.742	2.716
12.5	0.7351	2.051	0.201	2.485	0.243	3.543	0.347	5.256	0.514
13.0	0.7724	2.155	0.104	2.611	0.126	3.723	0.180	5.523	0.267
13.5	0.7989	2.229	0.074	2.700	0.090	3.851	0.128	5.712	0.189
14.0	0.8179	2.282	0.053	2.765	0.064	3.942	0.092	5.848	0.136
14.5	0.838	2.338	0.056	2.832	0.068	4.039	0.097	5.992	0.144
15.0	0.8538	2.382	0.044	2.886	0.053	4.115	0.076	6.105	0.113
15.5	0.8676	2.421	0.039	2.932	0.047	4.182	0.067	6.203	0.099
16.0	0.8801	2.455	0.035	2.975	0.042	4.242	0.060	6.293	0.089
16.5	0.8914	2.487	0.032	3.013	0.038	4.297	0.054	6.374	0.081
17.0	0.9019	2.516	0.029	3.048	0.035	4.347	0.051	6.449	0.075
17.5	0.9115	2.543	0.027	3.081	0.032	4.393	0.046	6.517	0.069
18.0	0.9206	2.568	0.025	3.112	0.031	4.437	0.044	6.582	0.065
18.5	0.9291	2.592	0.024	3.140	0.029	4.478	0.041	6.643	0.061
19.0	0.9371	2.615	0.022	3.167	0.027	4.517	0.039	6.700	0.057
19.5	0.9446	2.635	0.021	3.193	0.025	4.553	0.036	6.754	0.054
20.0	0.9519	2.656	0.020	3.217	0.025	4.588	0.035	6.806	0.052
20.5	0.9588	2.675	0.019	3.241	0.023	4.621	0.033	6.855	0.049
21.0	0.9653	2.693	0.018	3.263	0.022	4.653	0.031	6.902	0.046
21.5	0.9719	2.712	0.018	3.285	0.022	4.685	0.032	6.949	0.047
22.0	0.9777	2.728	0.016	3.305	0.020	4.713	0.028	6.991	0.041
22.5	0.9836	2.744	0.016	3.325	0.020	4.741	0.028	7.033	0.042
23.0	0.9892	2.760	0.016	3.343	0.019	4.768	0.027	7.073	0.040
23.5	0.9947	2.775	0.015	3.362	0.019	4.794	0.027	7.112	0.039
24.0	1	2.790	0.015	3.380	0.018	4.820	0.026	7.150	0.038

APPENDIX 2

POND DETENTION STORAGE COMPUTATIONS

Introduction

Computations for detention storage are done in two main steps:

(1) Computing Inflow Flood Hydrographs for the 2-year and 10-year recurrence interval 24-hour rainfall events, using the Soil Conservation Service's TR-55 Tabular Hydrograph Unit Discharges procedure. These will be done for both the pre-project and post-project conditions.

(2) Routing the Inflow Flood Hydrographs through the pond using a simplified spreadsheet-based computation procedure known as "Chain Saw Routing" (developed by Dr. H. R. Malcom of the North Carolina State University). In the routing computation procedure, the pond's spillway control design features (such as weir crest length or riser size) will be adjusted (through trials) to result in the outflow hydrograph peak to be no larger than the corresponding value for the pre-project condition.

The detailed steps in the computation procedures are described below.

Inflow Flood Hydrograph

Perform the following steps for the **pre-project and post-project conditions** for both the **2-year and 10-year rainfall events.**

(1) Compute the composite (weighted) Curve Number (CN) for the site area draining to the pond.

(2) Determine the Time of Concentration (Tc) for the site using any generally accepted methods.

(3) Using Figure 1, read the Direct Runoff (Q) in inches for the respective value of CN.

(4) Using Table 1, read the value of I_a (Initial Abstraction) for the respective value of CN.

(5) Using Table 2, for the known T_c and I_a/P values, read the values of Time (in hours) and Tabular Hydrograph ordinates (csm/in) and enter them in columns A and B of the "Chain Saw" Flood Routing spreadsheet described in the following section "Flood Routing." For Greensboro, P (the 24-hour rainfall) is 5.1 and 3.5 inches during 10-year and 2-year rain events respectively. To select the appropriate values of hydrograph unit discharges in Table 2, either round off the calculated value of I_a/P to the nearest value (0.1, 0.3, or 0.5) given in Table 2 or interpolate the values of the hydrograph unit discharges to correspond to the calculated value of I_a/P.

Inflow flood hydrograph ordinates for various times are given by the following equation.

$$q = A_m.Q.q_t = (A/640).Q.q_t$$

where, q = Inflow hydrograph ordinate value (in cfs),

A_m = Drainage area (including pond) in square miles,
A = Drainage area (including pond) in acres,
Q = Runoff in inches (from step 3),
q = Tabular hydrograph ordinate value

Inflow hydrograph ordinate values need not be computed in this step, since they will be computed as a part of the flood routing spreadsheet discussed in the following section.

Flood Routing

Perform the flood routing in the pond using the "Chain Saw" method that facilitates the computations using any commercial spreadsheet software (such as Excel or Lotus 123).

The basic continuity equation applicable to the flood routing process is

$\Delta S = (I - O).\ \Delta T$

where, ΔS = Change in storage during a time interval,
ΔT = Time interval,
I = **Average** inflow during the time interval,
O = **Average** outflow during the time interval

To enable computations using a spreadsheet, the Inflow and Outflow values at the **beginning** of a time interval, **instead of the average** values for the time interval, are used in the procedure for computing incremental storage. The governing equation thus becomes:

$\Delta S_{ij} = (I_i - O_i).\ \Delta T_{ij}$

This equation is used in the spreadsheet to compute incremental storage during various time intervals and the cumulative storage at the corresponding times.

Table 3 illustrates a typical spreadsheet used for storage routing computations for a 20 acre site, with pre-project CN=70 and post-project CN=90. The pond is assumed to be 160 ft. X 80 ft. (0.3 acre) in size, with side slopes of 3H:1V. The principal spillway is assumed to be a weir with crest at the normal pool level and C = 3.3. A 3-inch diameter drain, located 1 foot below the principal spillway crest level is assumed to function as an orifice with a discharge coefficient of 0.6. The spreadsheet shows the computations for the 10-year recurrence rain. Figure 2 shows the graph of the inflow and outflow hydrographs. The length of the weir required was found (as discussed in step 10 below) to be 0.9 ft. to match the post-project flood peak with the pre-project value of 42 cfs. The storage required, as may be seen in Table 3 (cell D20), is 94,942 cubic feet (2.18 acre-feet). The corresponding maximum stage (depth) is seen (in cell G20) as 5.8 feet.

Following are the steps in using the spreadsheet.

(1) Initialize the first row in the computations, say row # 10 (assuming rows 1 through 9 are used for title, descriptive text, and column headings), by entering 0 (zero) in all the cells. In the first cell for time (A10), you may alternatively enter the time

corresponding to one time interval before the start of the inflow (say, 10.5 hours if inflow values in Table 2 start at 11.0 hours).

(2) Enter the data for time and the corresponding inflow hydrograph unit discharges read from Table 2 in columns A and B respectively, starting with the second row (row # 11; cells A11 and B11).

(3) In the second row of computations, enter 0 or a small (nominal) value in the cell for outflow (G11), since outflow at the start is unknown.

(4) In cell C11, enter the formula for the Inflow (q) as given in step 5 under "Inflow Flood Hydrograph" above: =(value of A.Q/640)*(B11). Copy the formula from cell C11 and paste into all the cells below that in column C.

(5) In cell D11, enter: =(D10+(A11-A10)*3600*(C10-G10)). Copy the formula from cell D11 and paste into all the cells below that in column D.

(6) In cell E11, enter: =(D11-D10). Copy the formula from cell E11 and paste into all the cells below that in column E.

(7) In cell F11, enter the formula for the stage in terms of storage. For convenience, consider the zero value for stage as the crest elevation of the principal spillway, which in most cases would be the normal pool elevation in a pond. Develop data for the area (a) of the pond at the principal spillway (normal pool: zero stage) elevation and various stages (h) above the principal spillway elevation from the contour map or proposed grading plan. Calculate the storage volumes (V) for different stages (h) using prismoidal formula: $V = (d/3).((a_1 + (a_1.a_2)^{0.5} + a_2))$, where a_1 and a_2 are the areas of the pond at two stages and d is the vertical distance between the two stages.

The storage volume (V) versus stage (h) relationship for the pond above the normal pool (principal spillway crest elevation) can generally be approximated by an equation of the form:

$V = k\,h^n$

$\log V = \log k + n \log h$; For $h = h_1 = 1$, $\log h_1 = 0$; hence $k = V_1$, where V_1 = volume of storage at h = 1.0 ft. stage. Hence, $V = V_1.h^n$. Determine the values of n from the known pairs of values of V and h. Use the average of the values of n for computations. Alternatively, determine the value of n by plotting the V versus h pairs of values on a log-log paper. With the values of $k = V_1$ and n determined as above, the formula for the stage (h) can be written in terms of storage volume (V) as:

$h = (V/V_1)^{1/n}$

Enter the above formula for the stage in cell F11 of the spreadsheet: =(D11/value of V_1)^(value of 1/n). Copy the formula from cell F11 and paste into all the cells below that in column F.

(8) In cell G12, enter the formula for the total outflow as equivalent to the sum of the outflows through the various outflow facilities: =(H12+I12+J12). Copy the formula

from cell G12 and paste into all the cells below that in column G. Note that either 0 or a small value was entered in cell G11 in step 3 above.

(9) In cell H12, enter the formula for orifice discharge: =4.8*(value of orifice area)*(f12+value of the depth of center of orifice below the zero of stage)^0.5. Copy the formula from cell H12 and paste into all the cells below that in column H.

(10) In cell I12, enter the formula for the principal spillway discharge: (value of C)*(length of spillway)*(F12-stage of spillway crest)^1.5. In most cases, the stage of the spillway crest would be zero. Copy the formula from cell I12 and paste into all the cells below that in column I. Since the spillway length required is unknown, a few trial values for the spillway length may have to be entered, each resulting in a unique flood routing and peak outflow value (in column G). The final value to be accepted should be the one that results in the peak outflow value that closely matches or is less than the target value (such as the pre-project runoff peak discharge).

(11) In cell J11, enter 0. Copy the 0 from cell J11 and paste into all the cells below that in column J. Revise the values in column J only for routing floods larger than a 10-year flood, as given in the following steps.

(12) After performing the routing computations for detention storage required for the 10-year recurrence rain (no emergency spillway flows up to 10-year flood), the 10-year flood pool elevation would be known. Then, establish the crest elevation of the emergency spillway at or above the 10-year flood pool elevation.

(13) Revise the values in columns C and J to perform flood routing computations for the 100-year inflow flood, which would provide design information regarding the 100-year flood pool elevation and the discharges through the different outflow facilities. In column C, revise the formula in cell C11 and the ones below that to reflect the revised value of runoff (Q) for the 100-year rainfall. If the emergency spillway crest is set at the elevation of the maximum pool (highest stage) in a 10-year flood event, enter the formula for the emergency spillway discharge in the cell in column J and row corresponding to the highest value for the stage (column F) in the 10-year flood routing computation described in steps up to #11 above. If the emergency spillway crest elevation is set above the 10-year flood pool elevation, enter the formula in the cell in (column J) in the row below that having the highest value for stage in column F. Assuming that the emergency spillway would function as a broad-crested weir, enter the formula for the discharge as:
=2.65*(length of spillway)*(F11-stage of the crest of emergency spillway)^1.5. If the hydraulic characteristics of the spillway are different from that of a broad-crested weir, change the formula accordingly. Copy the formula from the cell in which the formula is entered and paste into all the cells below that in column J. The computations should be complete with this step. Obtain the design parameters from the values in the row in which the maximum stage and storage occurs.

FIGURE 1

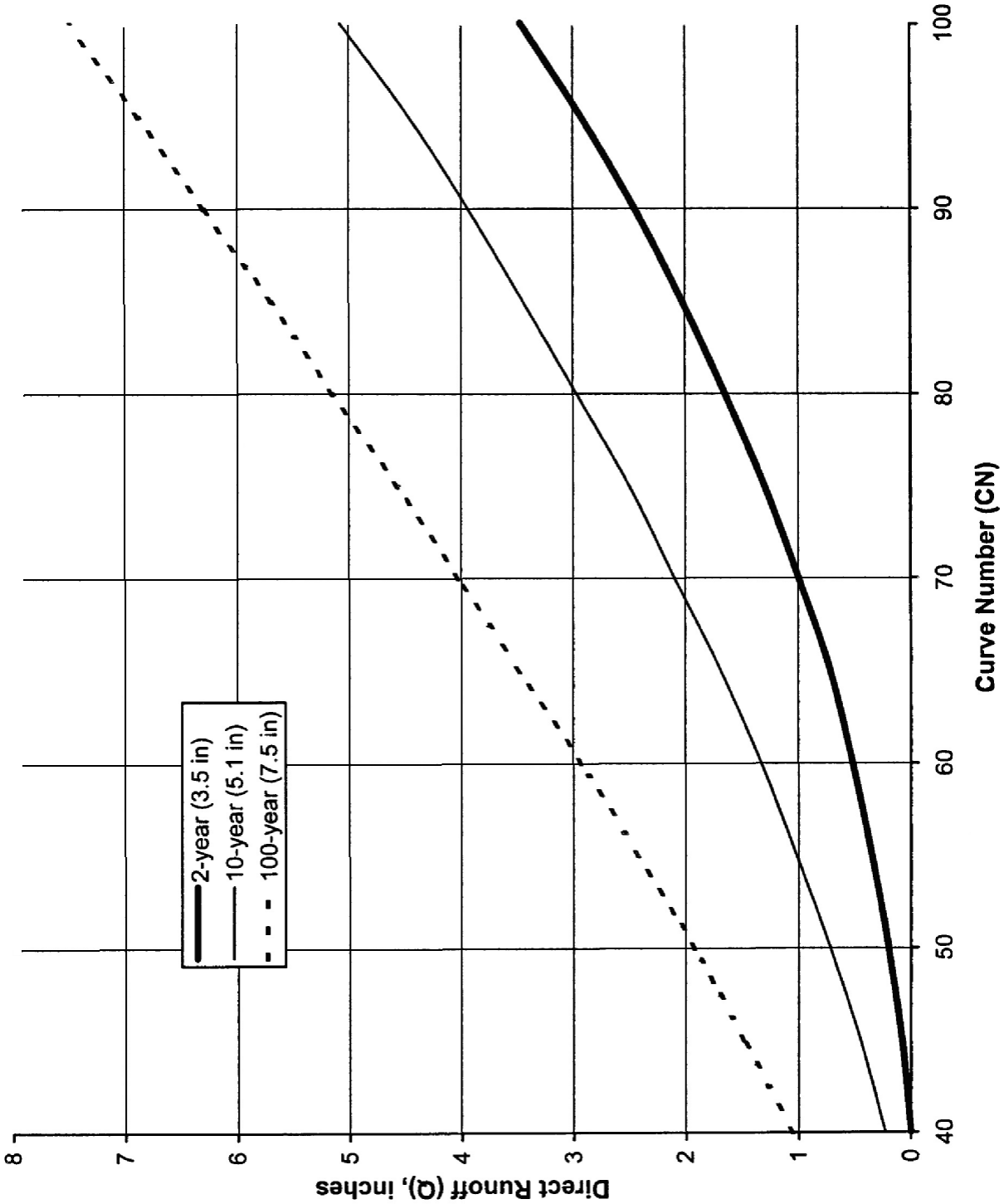

2-year (3.5 in)
10-year (5.1 in)
100-year (7.5 in)
Direct Runoff (Q), inches
0
1
2
3
4
5
6
7
8
Curve Number (CN)
40
50
60
70
80
90
100

TABLE 1

Values for Runoff Curve Numbers

Curve Number	I_a (in)	Curve Number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

TABLE 2

TABULAR HYDROGRAPH UNIT DISCHARGES (CSM/IN)
(Greensboro--Type II Rainfall Distribution)

T_c	I_a	Time (Hours)																													
(hr)	P	11.0	11.3	11.6	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.3	14.6	15.0	15.5	16.0	16.5	17.0	17.5	18.0	19.0	20.0	22.0
0.1	0.1	24	34	53	334	647	1010	623	217	147	123	104	86	76	66	57	51	46	42	38	34	32	29	26	23	21	20	19	18	15	13	12
	0.3	0	0	0	154	568	936	524	217	172	149	126	107	97	86	76	69	63	58	53	48	46	42	38	34	31	30	28	27	24	20	19
	0.5	0	0	0	0	70	539	377	196	171	154	134	117	108	99	89	83	77	72	67	61	59	56	51	46	43	42	40	38	34	30	28
0.2	0.1	23	31	47	209	403	739	800	481	250	166	128	102	86	70	61	54	49	44	40	35	33	30	27	24	21	20	19	18	16	13	12
	0.3	0	0	0	39	180	545	697	497	276	198	158	130	110	93	81	73	67	61	56	49	46	43	39	35	32	30	29	27	24	21	19
	0.5	0	0	0	0	7	98	371	322	221	182	158	137	120	104	94	86	80	74	69	62	60	57	52	47	44	42	40	39	35	30	28
0.3	0.1	20	28	41	118	235	447	676	676	459	283	196	146	114	80	66	57	51	46	42	37	33	31	28	24	22	20	19	18	16	13	12
	0.3	0	0	0	11	64	251	525	574	454	303	221	173	140	104	88	77	70	64	58	51	47	44	40	36	32	31	29	28	24	21	19
	0.5	0	0	0	0	1	25	151	299	277	219	187	162	141	113	100	90	84	78	72	65	61	58	53	48	44	42	41	39	35	31	28
0.4	0.1	18	25	36	77	141	271	468	592	574	431	298	216	163	104	77	63	55	49	44	38	34	31	28	25	22	21	20	18	16	14	12
	0.3	0	0	0	4	26	113	296	480	495	413	306	234	186	127	100	84	74	67	61	54	49	45	41	37	33	31	29	28	25	21	19
	0.5	0	0	0	0	0	7	59	168	245	527	213	186	163	128	109	96	88	81	75	67	62	58	54	50	45	43	41	39	35	31	28
0.5	0.1	17	23	32	57	94	170	308	467	529	507	402	297	226	140	96	74	61	53	47	41	36	32	29	26	23	21	20	19	16	14	12
	0.3	0	0	0	1	9	53	157	314	433	439	379	299	237	159	118	95	81	71	65	56	50	46	42	38	34	31	30	28	25	22	19
	0.5	0	0	0	0	0	2	26	89	170	217	229	200	179	144	119	104	93	85	78	70	64	59	55	51	46	43	41	40	36	32	28
0.75	0.1	13	18	24	36	46	68	115	194	294	380	424	410	369	252	172	123	93	74	61	49	41	35	31	27	24	22	20	19	17	15	12
	0.3	0	0	0	0	1	6	30	86	174	266	326	348	328	246	181	138	110	92	79	66	57	49	44	40	36	32	31	29	26	23	19
	0.5	0	0	0	0	0	0	2	16	45	92	137	166	185	170	146	125	110	98	89	79	70	63	58	53	48	44	42	41	37	33	28
1.0	0.1	11	15	20	29	35	47	72	112	168	231	289	329	357	313	239	175	133	103	83	63	50	40	33	29	26	23	21	20	17	15	12
	0.3	0	0	0	0	1	4	16	42	83	137	195	243	271	292	227	178	143	117	98	79	66	55	47	42	38	34	31	30	27	23	19
	0.5	0	0	0	0	0	0	1	7	21	42	71	101	126	160	154	138	123	110	100	87	77	67	60	55	50	46	43	41	38	34	28

TABLE 3

FLOOD ROUTING COMPUTATIONS (CHAIN SAW METHOD)
For 10-year, 24-hour Rain Event; Project: Typical Development

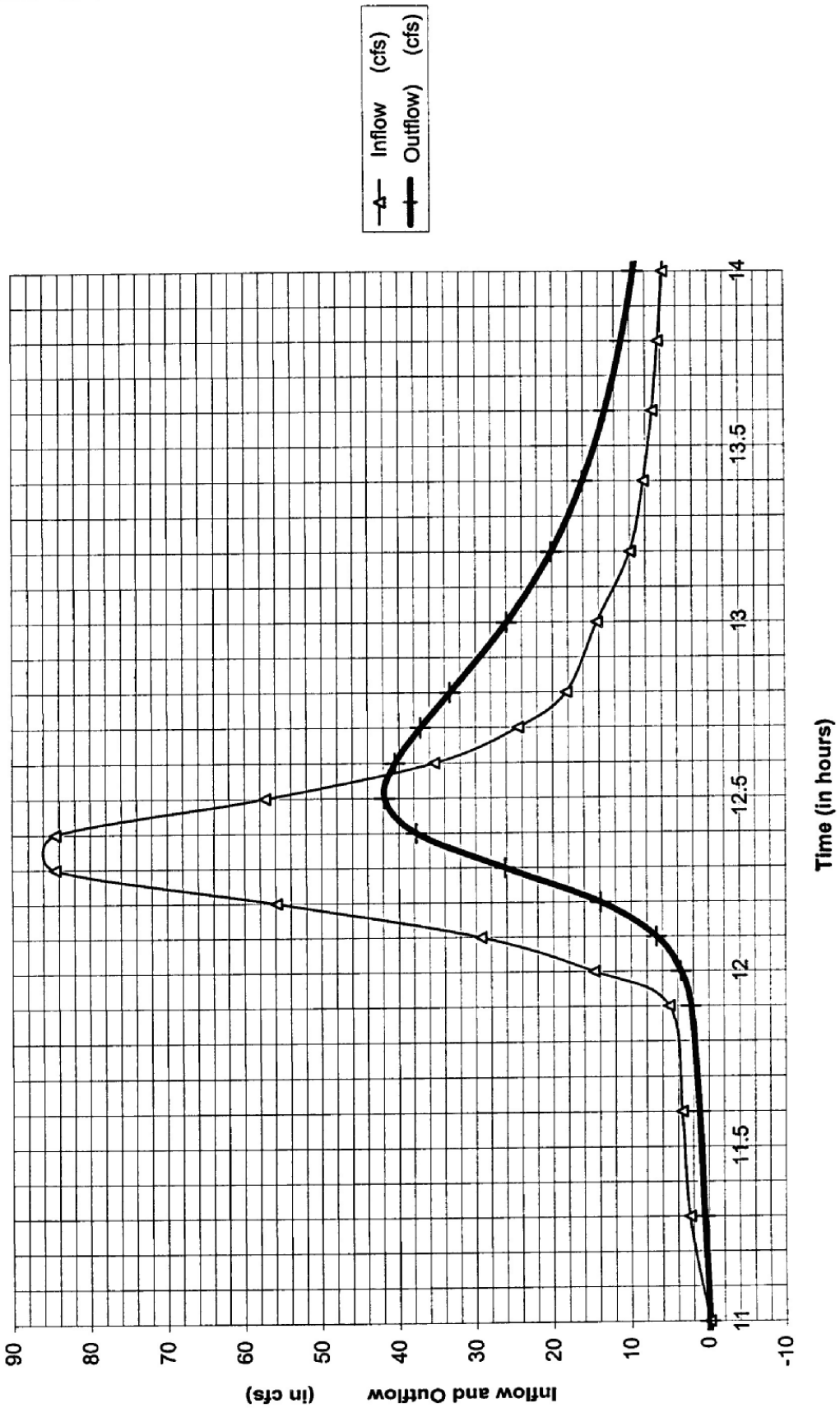
Site area = 20 acres; Post-develop. CN = 90; T_c = 20 Min.; 10-year Rain = 5.1 in.; Runoff = 4.0 in.

Pond area t normal pool – 0.3 acre; Stage-Volume: h=(V/13531)^0.9; Target Peak Outflow = 42 cfs

Time	Tab. Hydr. Value	Inflow	Storage	Change in Storage	Stage	Outflow	Outflow Facilities (Spillway sand Orifices)		
Hours	csm/in	cfs	cu.ft.	cu.ft.	ft.	cfs	Orifice	Prin. Spillway	Emerg. Spillway
10.7	0	0	0	0	0	0	0	0	0
11	20	2.5	0	0	0	0	0	0	0
11.3	28	3.5	2700	2700	0.234439	.598453	0.26132	.337133705	0
11.6	41	5.125	5833.67	3133.670294	0.468976	1.238921	0.285066	.953855593	0
11.9	118	14.75	10030.64	4196.965195	0.763833	2.295056	0.312368	1.982688547	0
12	235	29.375	14514.42	4483.779754	1.065179	3.603054	0.338	3.265054811	0
12.1	447	55.875	23792.32	9277.900411	1.661867	6.746569	0.383734	6.362834906	0
12.2	676	84.5	41478.55	17686.23514	2.740592	13.92971	0.454891	13.4748183	0
12.3	676	84.5	66883.86	25405.30461	4.213008	26.21996	0.537009	25.68294646	0
12.4	459	57.375	87864.67	20980.81606	5.385623	37.71455	0.594345	37.12020647	0
12.5	283	35.375	94942.43	7077.761302	5.77454	41.82502	0.612177	41.2128428	0
12.6	196	24.5	92620.43	-2322.007242	5.647278	40.46438	0.6064	39.85797537	0
12.7	146	18.25	86873.25	-5747.175161	5.3309	37.14768	0.591793	36.5558838	0
12.8	114	14.25	80070.09	-9803.16376	4.953662	33.31897	0.573891	32.74507541	0
13	80	10	66340.43	-13729.65581	4.182188	25.93706	0.535419	25.40164138	0
13.2	66	8.25	54865.75	-11474.68358	3.525123	20.15735	0.500325	19.65702749	0
13.4	57	7.125	46292.45	-8573.294042	3.025257	16.09976	0.471833	15.62787241	0
13.6	51	6.375	39830.63	-6461. 823732	2.6424	13.20605	0.448881	12.7571679	0
13.8	46	5.75	34912.27	-4918.355138	2.34684	11.10808	0.430284	10.6777951	0
14	42	5.25	31054.46	-3857.816651	2.112101	9.531426	0.41492	9.116506028	0
14.3	37	4.625	26430.52	-4623.939881	1.82683	7.728819	0.395446	7.333372544	0
14.6	33	4.125	23078.39	-3352.124024	1.616918	6.486928	0.380481	6.106447444	0
15	31	3.875	19677.22	-3401.176249	1.400782	5.288362	0.36443	4.923932248	0
15.5	28	3.5	17133.17	-2544.051319	1.236679	4.436282	0.351754	4.084528109	0
16	24	3	15447.86	-1685.307935	1.126638	3.894667	0.342992	3.551675376	0
16.5	22	2.75	13837.46	-1610.401491	1.020361	3.395479	0.334312	3.061167302	0
17	20	2.5	12675.59	-1161.862484	0.942919	3.047212	0.327842	2.719370219	0
17.5	19	2.375	11690.61	-984.9821635	0.876711	2.760251	0.322208	2.438043112	0
18	18	2.25	10997.16	-693.4516499	0.829766	2.563015	0.318152	2.244863045	0
19	16	2	9870.305	-1126.855293	0.752836	2.251418	0.311392	1.940025219	0
20	13	1.625	8965.202	-905.1034323	0.69041	2.009591	0.305797	1.703794382	0
22	12	1.5	6196.143	-2769.058659	0.495122	1.322316	0.287591	1.034725215	0
26	0	0	8754.786	2558.642973	0.675809	1.954506	0.304474	1.650032761	0

FIGURE 2

Flood Routing: 10-year Rain Event



APPENDIX 3

Dam Safety Law of 1967

(As amended through 1995)

§ 143-215.23. Short title.

This Part shall be known and may be cited as the Dam Safety Law of 1967. (1967, c. 1068, s. 1.)

§ 143-215.24. Declaration of purpose.

It is the purpose of this Part to provide for the certification and inspection of dams in the interest of public health, safety, and welfare, in order to reduce the risk of failure of dams; to prevent injuries to persons, damage to downstream property and loss of reservoir storage; and to ensure maintenance of minimum stream flows of adequate quantity and quality below dams. (1967, c. 1068, s. 2; 1977, c. 878, s. 1; 1993, c. 394, s. 1.)

§ 143-215.25. Definitions.

As used in this Part, unless the context otherwise requires:

(1) "Dam" means a structure and appurtenant works erected to impound or divert water.

(2) "Minimum stream flow" or "minimum flow" means a stream flow of a quantity and quality sufficient in the judgment of the Department to meet and maintain stream classifications and water quality standards established by the Department under G.S. 143-214.1 and applicable to the waters affected by the project under consideration, and to maintain aquatic habitat in the length of the stream that is affected. (1967, c. 1068, s. 3; 1973, c. 1262, ss. 23, 38; 1977, c. 771, s. 4; c. 878, ss. 2, 4; 1983, c. 306; 1987, c. 827, ss. 154, 175; 1993, c. 394, s. 2.)

§ 143-215.25A. Exempt dams.

(a) Except as otherwise provided in this Part, this Part does not apply to any dam:

(1) Constructed by the United States Army Corps of Engineers, the Tennessee Valley Authority, or another agency of the United States government, when the agency designed or approved plans for the dam and supervised its construction.

(2) Constructed with financial assistance from the United States Soil Conservation Service, when that agency designed or approved plans for the dam and supervised its construction.

(3) Licensed by the Federal Energy Regulatory Commission, or for which a license application is pending with the Federal Energy Regulatory Commission.

(4) For use in connection with electric generating facilities under the jurisdiction of the North Carolina Utilities Commission, except that a dam operated by a small power producer, as defined in G.S. 62-3(27a), shall be subject to the provisions of this Part even though the dam is constructed pursuant to a certificate of public convenience and necessity issues by the North Carolina Utilities Commission.

(5) Under a single private ownership that provides protection only to land or other property under the same ownership and that does not pose a threat to human life or property below the dam.

(6) That is less than 15 feet in height or that has an impoundment capacity of less than 10 acre-feet, unless the Department determines that failure of the dam could result in loss of human life or significant damage to property below the dam.

(b) The exemption from this Part for a dam described in subdivisions (1) and (2) of subsection (a) of this section does not apply after the supervising federal agency relinquishes authority for the operation and maintenance of the dam to a local entity. (1993, c. 394, s. 3.)

§ 143-215.26. Construction of dams.

(a) No person shall begin the construction of any dam until at least 10 days after filing with the Department a statement concerning its height, impoundment capacity, purpose, location and other information required by the Department. A person who constructs a dam, including a dam that is otherwise exempt from this Part under subdivisions (4) or (5) of G.S. 143-215.25A(a), shall comply with the malaria control requirements of the Department. If on the basis of this information the Department is of the opinion that the proposed dam is not exempt from the provisions of this Part, it shall so notify the applicant, and construction shall not be commenced until a full application is filed by the applicant and approved as provided by G.S. 143-215.29. The Department may also require of applicants so notified the filing of any additional information it deems necessary, including, but not limited to, stream flow and rainfall data, maps, plans and specifications. Every applicant for approval of a dam subject to the provisions of this Part shall also file with the Department the certificate of an engineer legally qualified in this State. The certificate shall state that the person who files the certificate is responsible for the design of the dam and that the design is safe and adequate.

(b) The Department shall send a copy of each completed application to the State Health Director, the Wildlife Resources Commission, the Department of Transportation, and other State and local agencies it considers appropriate for review and comment. (1967, c. 1068, s. 4; 1973, c. 476, s. 128; c. 507, s. 5; c. 1262, s. 23; 1987, c. 827, s. 176; 1989, c. 727, s. 163; 1993, c. 394, s. 4; 1995, c. 509, s. 80.)

§ 143-215.27. Repair, alteration, or removal of dam.

(a) Before commencing the repair, alteration or removal of a dam, application shall be made for written approval by the Department, except as otherwise provided by this Part. The application shall state the name and address of the applicant, shall adequately detail the changes it proposes

to effect and shall be accompanied by maps, plans and specifications setting forth such details and dimensions as the Department requires. The Department may waive any such requirements. The application shall give such other information concerning the dam and reservoir required by the Department, such information concerning the safety of any change as it may require, and shall state the proposed time of commencement and completion of the work. When an application has been completed it may be referred by the Department for agency review and report, as provided by subsection (b) of G.S. 143-215.26 in the case of original construction.

(b) When repairs are necessary to safeguard life and property they may be started immediately but the Department shall be notified forthwith of the proposed repairs and of the work under way, and they shall be made to conform to its orders. (1967, c. 1068, s. 5; 1979, c. 55, s. 1.)

§ 143-215.28. Action by Commission upon applications.

(a) Following receipt of agency comments the Commission shall approve, disapprove, or approve subject to conditions necessary to ensure safety and to satisfy minimum stream flow requirements, all applications made pursuant to this Part.

(b) A defective application shall not be rejected but notice of the defects shall be sent to the applicant by registered mail. If the applicant fails to file a perfected application within 30 days the original shall be canceled unless further time is allowed.

(c) If the Commission disapproves an application, one copy shall be returned with a statement of its objections. If an application is approved, the approval shall be attached thereto, and a copy returned by registered mail. Approval shall be granted under terms, conditions and limitations which the Commission deems necessary to safeguard life and property.

(d) Construction shall be commenced within one year after the date of approval of the application or such approval is void. The Commission upon written application and good cause shown may extend the time for commencing construction. Notice by registered mail shall be given the Commission at least 10 days before construction is commenced. (1967, c. 1068, s. 6; 1973, c. 1262, s. 23; 1987, c. 827, s. 154.)

§ 143-215.28A. Application fees.

(a) In accordance with G.S. 143-215.3(a)(1a), the Commission may establish a fee schedule for processing applications for approvals of construction or removal of dams issued under this Part. In establishing the fee schedule, the Commission shall consider the administrative and personnel costs incurred by the Department for processing the applications and for related compliance activities. The total amount of fees collected in any fiscal year may not exceed one-third of the total personnel and administrative costs incurred by the Department for processing the applications and for related compliance activities in the prior fiscal year. An approval fee may not exceed the larger of two hundred dollars ($200.00) or two percent (2%) of the actual cost of construction or removal of the applicable dam. The provisions of G.S. 143-215.3(a)(1b) do not apply to these fees.

(b) The Dam Safety Account is established as a non-reverting account within the Department. Fees collected under this section shall be credited to the Account and shall be applied to the costs of administering this Part. (1989 (Reg. Sess., 1990), c. 976, s. 1; 1991 (Reg. Sess., 1992), c. 1039, s. 15; 1993, c. 394, s. 5.)

§ 143-215.29. Supervision by qualified engineers; reports and modification during work.

(a) Any project for which the Commission's approval is required under G.S. 143-215.26, 143-215.27, and 143-215.28, and any project undertaken pursuant to an order of the Commission issued pursuant to this section or G.S. 143-215.32 shall be designed and supervised by an engineer legally qualified in the State of North Carolina.

(b) During the construction, enlargement, repair, alteration or removal of a dam, the Commission may require such progress reports from the supervising engineer as it deems necessary.

(c) If during construction, reconstruction, repair, alteration or enlargement of any dam, the Commission finds the work is not being done in accordance with the provisions of the approval and the approved plans and specifications, it shall give written notice by registered mail or personal service to the person who received the approval and to the person in charge of construction at the dam. The notice shall state the particulars in which compliance has not been made, and shall order immediate compliance with the terms of the approval, and the approved plans and specifications. The Commission may order that no further construction work be undertaken until such compliance has been effected and approved by the Commission. A failure to comply with the approval and the approved plans and specifications shall render the approval revocable unless compliance is made after notice as provided in this section. (1967, c. 1068, s. 7; 1973, c. 1262, s. 23; 1977, c. 878, s. 5; 1987, c. 827, s. 154.)

§ 143-215.30. Notice of completion; certification of final approval.

(a) Immediately upon completion, enlargement, repair, alteration or removal of a dam, notice of completion shall be given the Commission. As soon as possible thereafter supplementary drawings or descriptive matter showing or describing the dam as actually constructed shall be filed with the Department in such detail as the Commission may require.

(b) When an existing dam is enlarged, the supplementary drawings and descriptive matter need apply only to the new work.

(c) The completed work shall be inspected by the supervising engineers, and upon finding that the work has been done as required and that the dam is safe and satisfies minimum stream flow requirements, they shall file with the Department a certificate that the work has been completed in accordance with approved design, plans, specifications and other requirements. Unless the Commission has reason to believe that the dam is unsafe or is not in compliance with any applicable rule or law, the Commission shall grant final approval of the work in accordance with the certificate, subject to such terms as it deems necessary for the protection of life and property.

(d) Pending issuance of the Commission's final approval, the dam shall not be used except on written consent of the Commission, subject to conditions it may impose. (1967, c. 1068, s. 8; 1973, c. 1262, s. 23; 1987, c. 827, ss. 154, 177.)

§ 143-215.31. Supervision over maintenance and operation of dams.

(a) The Commission shall have jurisdiction and supervision over the maintenance and operation of dams to safeguard life and property and to satisfy minimum streamflow requirements. The Commission may adopt standards for the maintenance and operation of dams as may be necessary for the purposes of this Part. The Commission may vary the standards applicable to various dams, giving due consideration to the minimum flow requirements of the stream, the type and location of the structure, the hazards to which it may be exposed, and the peril of life and property in the event of failure of a dam to perform its function.

(b) The Department, consistent with rules adopted by the Commission, may impose any condition or requirement in orders and written approvals issued under this Part that is necessary to ensure that stream classifications, water quality standards, and aquatic habitat requirements are met and maintained, including conditions and requirements relating to the release or discharge of designated flows from dams, the location and design of water intakes and outlets, the amount and timing of the withdrawal of water from a reservoir, and the construction of submerged weirs or other devices intended to maintain minimum streamflows. The Commission shall adopt rules that specify the minimum streamflow in the length of the stream affected.

(c) The minimum streamflow in the length of the stream affected by a dam that is operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream shall be:

(1) The minimum average flow for a period of seven consecutive days that would have an average occurrence of once in 10 years in the absence of the dam, or ten percent (10%) of the average annual flow of the stream in the absence of the dam, whichever is less, if prior to 1 January 1995 the small power producer was either licensed by the Federal Energy Regulatory Commission or held a certificate of public convenience and necessity issued by the North Carolina Utilities Commission.

(2) The minimum average flow for a period of seven consecutive days that would have an average occurrence of once in 10 years in the absence of the dam, or ten percent (10%) of the average annual flow of the stream in the absence of the dam, whichever is greater, if subdivision (1) of this subsection does not apply.

(3) To protect the habitat of the Cape Fear Shiner and other aquatic species, 28 cubic feet per second for any dam that diverts water from 2,500 feet or more of the natural streambed of any stream on which six or more dams operated by small power producers were located on 1 January1995, notwithstanding subdivisions (1) and (2) of this subsection.

(d) Subsection (c) of this section establishes the policy of this State with respect to minimum streamflows in the length of the stream affected by a dam that is operated by a small power

producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream, whether the dam is subject to or exempt from this Part. In its comments and recommendations to the Federal Energy Regulatory Commission regarding the minimum streamflow in the length of the stream affected by a dam that is operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural streambed and where the water is returned to the same stream, the Commission and the Department shall not advocate or recommend a minimum streamflow that exceeds the minimum streamflow that would be required under subsection (c) of this section.

(e) The minimum streamflow in the length of the stream affected by a dam to which subsections (c) and (d) of this section do not apply shall be established as provided in subsection (b) of this section. Subsections (c) and (d) of this section do not apply if the length of the stream affected:

(1) Receives a discharge of waste from a treatment works for which a permit is required under Part 1 of this Article; or
(2) Includes any part of a river or stream segment that:
    a. Is designated as a component of the State Natural and Scenic Rivers System by G.S. 113A-35.1 or G.S. 113A-35.2.

    b. Is designated as a component of the national Wild and Scenic Rivers System by 16 U.S.C. § 1273 and 1274. (1967, c. 1068, s. 9; 1973, c. 1262, s. 23; 1987, c. 827, s. 154; 1993, c. 394, s. 6; c. 553, s. 80; 1995, c. 184, s. 1; c. 439, s. 1.)

§ 143-215.32. Inspection of dams.

(a) The Department may at any time inspect any dam, including a dam that is otherwise exempt from this Part, upon receipt of a written request of any affected person or agency, or upon a motion of the Environmental Management Commission. Within the limits of available funds the Department shall endeavor to provide for inspection of all dams at intervals of approximately five years.

(b) If the Department upon inspection finds that any dam is not sufficiently strong, is not maintained in good repair or operating condition, is dangerous to life or property, or does not satisfy minimum streamflow requirements, the Department shall present its findings to the Commission and the Commission may issue an order directing the owner or owners of the dam to make at his or her expense maintenance, alterations, repairs, reconstruction, change in construction or location, or removal as may be deemed necessary by the Commission within a time limited by the order, not less than 90 days from the date of issuance of each order, except in the case of extreme danger to the safety of life or property, as provided by subsection (c) of this section.

(c) If at any time the condition of any dam becomes so dangerous to the safety of life or property, in the opinion of the Environmental Management Commission, as not to permit sufficient time for issuance of an order in the manner provided by subsection (b) of this section, the Environmental Management Commission may immediately take such measures as may be

essential to provide emergency protection to life and property, including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir. The Environmental Management Commission may recover the costs of such measures from the owner or owners by appropriate legal action.

(d) An order issued under this Part shall be served on the owner of the dam as provided in G.S. 1A-1, Rule 4. (1967, c. 1068, s. 10; 1973, c. 1262, s. 23; 1977, c. 878, s. 3; 1987, c. 827, s. 154; 1993, c. 394, s. 7.)

§ 143-215.33. Administrative hearing.

A person to whom a decision or a dam safety order is issued under this Part may contest the decision or order by filing a contested case petition in accordance with G.S. 150B-23. A person to whom a decision is issued must file a contested case petition within 30 days after the decision is mailed to that person. A person to whom a dam safety order is issued must file a contested case petition within 10 days after the order is served. (1967, c. 1068, s. 11; 1973, c. 1262, s. 23; 1975, c. 842, s. 4; 1977, c. 878, s. 6; 1979, c. 55, s. 2; 1987, c. 827, s. 178; 1993, c. 394, s. 8.)

§ 143-215.34. Investigations by Department; employment of consultants.

The Department shall make such investigations and assemble such data as it deems necessary for a proper review and study of the design and construction of dams, reservoirs and appurtenances, and for such purposes may enter upon private property. The Department may employ or make such agreements with geologists, engineers, or other expert consultants and such assistants as it deems necessary to carry out the provisions of this Part. (1967, c. 1068, s. 12; 1973, c. 1262, s. 23; 1987, c. 827, s. 179.)

§ 143-215.35. Liability for damages.

No action shall be brought against the State of North Carolina, the Department, or the Commission or any agent of the Commission or any employee of the State or the Department for damages sustained through the partial or total failure of any dam or its maintenance by reason of any supervision or other action taken pursuant to or under this Part. Nothing in this Part shall relieve an owner or operator of a dam from the legal duties, obligations and liabilities arising from such ownership or operation. (1967, c. 1068, s. 13; 1973, c. 1262, s. 23; 1987, c. 827, s. 154.)

§ 143-215.36. Enforcement procedures.

(a) Criminal Penalties.

Any person who shall be adjudged to have violated this Article shall be guilty of a Class 3 misdemeanor and shall only be liable to a penalty of not less than one hundred dollars ($100.00) nor more than one thousand dollars ($1,000) for each violation. In addition, if any person is adjudged to have committed such violation willfully, the court may determine that each day

during which such violation continued constitutes a separate violation subject to the foregoing penalty.

(b) Civil Penalties.

(1) The Secretary may assess a civil penalty of not less than one hundred dollars ($100.00) nor more than five hundred dollars ($500.00) against any person who violates any provisions of this Part, a rule implementing this Part, or an order issued under this Part.

(2) If any action or failure to act for which a penalty may be assessed under this Part is willful, the Secretary may assess a penalty not to exceed five hundred dollars ($500.00) per day for each day of violation.

(3) In determining the amount of the penalty, the Secretary shall consider the factors set out in G.S. 143B-282.1(b). The procedures set out in G.S. 143B-282.1 shall apply to civil penalty assessments that are presented to the Commission for final agency decision.

(4) The Secretary shall notify any person assessed a civil penalty of the assessment and the specific reasons there for by registered or certified mail, or by any means authorized by G.S. 1A-1, Rule 4. Contested case petitions shall be filed in accordance with G.S. 150B-23 within 30 days of receipt of the notice of assessment.

(5) Requests for remission of civil penalties shall be filed with the Secretary. Remission requests shall not be considered unless made within 30 days of receipt of the notice of assessment. Remission requests must be accompanied by a waiver of the right to a contested case hearing pursuant to Chapter 150B and a stipulation of the facts on which the assessment was based. Consistent with the limitations in G.S. 143B-282.1(c) and G.S. 143-282.1(d), remission requests may be resolved by the Secretary and the violator. If the Secretary and the violator are unable to resolve the request, the Secretary shall deliver remission requests and his recommended action to the Committee on Civil Penalty Remissions of the Environmental Management Commission appointed pursuant to G.S. 143B-282.1(c).

(6) If any civil penalty has not been paid within 30 days after notice of assessment has been served on the violator, the Secretary shall request the Attorney General to institute a civil action in the Superior Court of any county in which the violator resides or has his or its principal place of business to recover the amount of the assessment, unless the violator contests the assessment as provided in subdivision (4) of this subsection. If any civil penalty has not been paid within 30 days after the final agency decision or court order has been served on the violator, the Secretary shall request the Attorney General to institute a civil action in the Superior Court of any county in which the violator resides or has his or its principal place of business to recover the amount of the assessment. A civil action shall be filed within three years of the date the final agency decision was served on the violator.

(7) The Secretary may delegate his powers and duties under this section to the Director of the Division of Land Resources of the Department.

(c) Injunctive Relief. - Upon violation of any of the provisions of this Part, a rule implementing this Part, or an order issued under this Part, the Secretary may, either before or after the institution of proceedings for the collection of the penalty imposed by this Part for such violations, request the Attorney General to institute a civil action in the superior court of the county or counties where the violation occurred in the name of the State upon the relation of the Department for injunctive relief to restrain the violation or require corrective action, and for such other or further relief in the premises as said court shall deem proper. Neither the institution of the action nor any of the proceedings thereon shall relieve any party to such proceedings from the penalty prescribed by this Part for any violation of the same. (1967, c. 1068, s. 14; 1973, c. 1262, s. 23; 1975, c. 842, s. 3; 1977, c. 771, s. 4; 1987, c. 827, ss. 154, 180; 1989 (Reg. Sess., 1990), c. 1036, s. 5; 1991, c. 342, ss. 10, 11; 1993, c. 394, s. 9; c. 539, s. 1021; 1994, Ex. Sess., c. 24, s. 14(c).)

§ 143-215.37. Rights of investigation, entry, access, and inspection.

The Commission shall have the right to direct the conduct of such investigations as it may reasonably deem necessary to carry out its duties prescribed in this Part, and the Department shall have the right to conduct such investigations, and for this purpose the employees of the Department and agents of the Commission have the right to enter at reasonable times on any property, public or private, for the purpose of investigating the condition, construction, or operation of any dam or associated equipment facility or property, and to require written statements or the filing of reports under oath, with respect to pertinent questions relating to the construction or operation of any dam: Provided, that no person shall be required to disclose any secret formula, processes or methods used in any manufacturing operation or any confidential information concerning business activities carried on by him or under his supervision. No person shall refuse entry or access to any authorized representative of the Commission or Department who requests entry for purposes of inspection, and who presents appropriate credentials, nor shall any person obstruct, hamper or interfere with any such representative while in the process of carrying out his official duties. (1967, c. 1068, s. 15; 1973, c. 1262, s. 23.)

North Carolina Administrative Code
Title 15A
Department of Environment and Natural Resources
Subchapter 2K

Dam Safety

SECTION .0100 - GENERAL PROVISIONS

.0101 DEFINITIONS
.0102 DAM SAFETY ORDERS

History Note: Statutory Authority G.S. 143-215.25; 143-215.32; 143-215.34;
Eff. January 22, 1977;
Amended Eff. November 1, 1978;
Repealed Eff. June 15, 1980

.0103 PURPOSE
The rules and regulations contained in this Subchapter are intended to carry out the purposes of the Dam Safety Law of 1967, as expressed in G.S. 143-215.24 which authorizes the implementation of a dam inspection and certification program in the interest of public health, safety and welfare.

History Note: Statutory Authority G.S. 143-215.31; 143-215.34;
Eff. June 15, 1980.

.0104 DEFINITIONS
As used in this Subchapter, the following terms have their stated meaning:
(1) "Applicant" means any person who has notified the department that he or she desires to construct, repair, alter, or remove a dam and requests approval by the department.
(2) "Appurtenance" means an accessory or integral subordinate structure associated with a dam, such as a spillway, conduit, walkway, valve, control gate, etc.
(3) "Articulation" means provisions for safe movement at the joint or juncture of sections of conduit.
(4) "As-built plans" means drawings, photographs, test data, and descriptions that clearly and accurately define the dam and its appurtenances after all construction is completed.
(5) "Conduit" means a natural or artificial channel or pipe through which water or other fluid is conveyed.
(6) "Critical circle" means the circle with the lowest factor of safety against mass movement in a circular arc analysis of slope stability.
(7) "Critical failure wedge" means the mass or block having the lowest factor of safety against mass movement in an analysis of slope stability along planar surfaces.
(8) "Director" means the Director of the Division of Land Resources, North Carolina Department of Natural Resources and Community Development.
(9) "Equipotential lines" means lines which represent points of equal energy level or head in a flow net.

(10) "Factor of safety" means the ratio of the forces or moments resisting mass movement to the forces or moments tending to produce mass movement.
(11) "Flow lines" means lines which represent the direction of flow in a flow net.
(12) "Flow net" means a graphical representation of flow lines and equipotential lines.
(13) "Hazard potential" means the probable damage that would occur if the structure failed, in terms of loss of human life and economic loss or environmental damage.
(14) "Maintenance plan" means written instructions prepared by the engineer that prescribe the proper servicing and repair of mechanical equipment, appurtenances, spillways, vegetative cover, and other aspects related to the safety of the dam.
(15) "Owner" means the individual or association of individuals owning the property on which the dam exists or is to be constructed, and the persons financially responsible for the construction.
(16) "Phreatic surface" means the free-water surface of a zone of seepage; it is represented by the uppermost flow line, or seepage line, in a flow net.
(17) "Qualified engineer" means a professional engineer legally qualified to practice in North Carolina pursuant to Chapter 89C of the General Statutes of North Carolina, and having appropriate specialty expertise for the particular dam engineering problem with which he is involved.
(18) "Qualified geologist" means an earth scientist experienced in applied geology with respect to the interaction of lithologies, soils, and geologic structures with dams and impoundments, who can provide professional credentials such as certification by the American Institute of Professional Geologists or registration as a geologist in the United States.
(19) "Quality control" means that combination of testing, observation, and monitoring provided during construction to confirm that requirements stated or depicted in the plans and specifications are being achieved.
(20) "Rapid drawdown" means removal of liquid from a reservoir at a rate that is significantly faster than the rate of drainage of the materials composing the portions of the reservoir exposed by the fluid removal.
(21) "Seepage" means the movement of water in a porous material and the water exiting at the visible surface of the material.
(22) "Sliding base analysis" means an analysis of the safety of a structure against lateral movement along its foundation.
(23) "Waste treatment and mine refuse dam" means a structure for impounding, restraining, storing, or disposing of liquids, slurries, or materials capable of liquification, produced from industrial, commercial, municipal, agricultural, or mining activities.
(24) "Construction" means any action, other than by natural causes, that creates a structure capable of impounding water or other liquids, or which increases the impoundment capacity of an existing structure. For the purposes of 15A NCAC 2K .0222, it shall also mean the reduction of the height or impoundment capacity of a dam when the effect of such reduction will be to exempt the dam from the North Carolina Dam Safety Law of 1967.

History Note: Filed as a Temporary Amendment Eff. November 1, 1990 For a Period of 180 Days to Expire on April 29, 1991;
Statutory Authority G.S. 143-215.25; 143-215.31;
Eff. June 15, 1980;
Amended Eff. July 1, 1988; November 1, 1984;
ARRC Objection Lodged November 14, 1990;
ARRC Objection Removed December 20, 1990;

Amended Eff. January 1, 1991.

.0105 CLASSIFICATION OF DAMS

(a) For the purposes of this Subchapter, dams shall be divided into three classes, which shall be known as class A (low hazard), class B (intermediate hazard), and class C (high hazard):

(1) Class A includes dams located where failure may damage uninhabited low value non-residential buildings, agricultural land, or low volume roads.

(2) Class B includes dams located where failure may damage highways or secondary railroads, cause interruption of use or service of public utilities, cause minor damage to isolated homes, or cause minor damage to commercial and industrial buildings. Damage to these structures will be considered minor only when they are located in back water areas not subjected to the direct path of the breach flood wave; and they will experience no more than 1.5 feet of flood rise due to breaching above the lowest ground elevation adjacent to the outside foundation walls or no more than 1.5 feet of flood rise due to breaching above the lowest floor elevation of the structure, the lower of the two elevations governing. All other damage potential will be considered serious.

(3) Class C includes dams located where failure will likely cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, primary highways, or major railroads.

(b) Classifications shall be proposed by the design engineer and are subject to approval by the Director.

(c) Probable future development of the area downstream from the dam that would be affected by its failure shall be considered in determining the classification.

(d) Dams will be subject to reclassification if the Director determines that the hazard potential has changed. Non-structural provisions of adequately demonstrated effectiveness and reliability such as flood plain zoning, and early warning systems may be considered by the Director in making this determination.

(e) When dams are spaced so that the failure of an upper dam would likely fail a lower dam, the consequence of the lower dam's failure shall be a determining factor for the upper dam's hazard classification.

(f) In assigning a hazard classification where a bridge or roadway is the only damageable property below a dam, consideration shall be given to the possibility of loss of human life, indirect economic impact through loss of service, and direct cost of damage to the bridge or roadway.

History Note: Statutory Authority G.S. 143-215.31; 143-215.34;
Eff. June 15, 1980.

SECTION .0200 - OBTAINING APPROVAL FOR DAM CONSTRUCTION: REPAIR OR REMOVAL

.0201 APPLICATIONS

(a) Any person(s) who proposes to construct, repair, alter or remove a dam must file with the Director a statement concerning the location of the dam, including the name of the stream and county, height, purpose, and impoundment capacity, 10 days before start of construction. If the Director determines that the proposed dam is exempt from the law, the applicant will be notified and he may then proceed with the construction.

(b) If the Director determines that the proposed dam is not exempt from the Dam Safety Law of 1967, the applicant will be so notified within 10 days of receipt of the statement described in (a) of this Rule and construction may not commence until a full and complete application has been filed and approved. This application must be filed at least 60 days before the proposed start of construction:

(1) When an application to construct a dam has been completed pursuant to Subsection (a) of this Rule, the department shall refer copies of the completed application papers to the Department of Human Resources, the Wildlife Resources Commission, the Department of Transportation, and such other state and local agencies as it deems appropriate for review and comment.

(2) Before commencing the repair, alteration, or removal of a dam, application shall be made for written approval by the department, except as otherwise provided by this Subchapter or in accordance with G.S. 143-215.27(b). The application shall state the name and address of the applicant; shall adequately detail the changes it proposes to effect; and shall be accompanied by maps, plans, and specifications setting forth such details and dimensions as the department requires. The department may waive such requirements in accordance with G.S. 143-215.27(a). The application shall give such other information concerning the dam and reservoir required by the department concerning the safety of any change as it may require, and shall state the proposed time of commencement and completion of the work. When an application has been completed, it may be referred by the department for agency review and report as provided by G.S. 143-215.26(b) in the case of original construction.

(c) The application for any dam shall include a preliminary report. (Filing of the preliminary report prior to filing the final design report, early in the site investigation and design schedule, is encouraged to assure the state's concurrence with the hazard classification, site investigation, and design concept. This is especially encouraged for class C dams.) The preliminary report shall be filed with the application and shall include the following information:

(1) a general description of the dam and appurtenances and a proposed classification as set forth in Rule .0105 of this Subchapter; The description shall include a statement of the purpose for which the dam is to be used;

(2) a description of properties located below the dam including number of homes, buildings, roads, utilities, and other property that, as determined by the engineer, would be endangered should failure of the dam occur;

(3) maps showing the location of the proposed structure that include the county, location of state roads, access to site, and outline of the reservoir; aerial photographs or USGS maps may be used;

(4) preliminary drawings or sketches that include cross-sections, plans and profiles of the dam, proposed pool levels, and types of all spillways;

(5) preliminary design criteria and basis for selection including a description of the size, ground cover conditions, and extent of development of the watershed, drainage area, spillway design storm, geology and geotechnical engineering, assumptions for the foundation and embankment materials, and type of materials to be used in the principal spillways(s).

(d) The Final Design Report. A "Certificate of Approval" to construct will not be issued until the final design report is received and approved. The preliminary report as described in (c) of this Rule and the final design report may be submitted as one document. The final design report shall include:

(1) a report of the investigation of the foundation soils or bedrock and the borrow materials, including the location of borrow areas, that are to be used to construct the dam;
(2) criteria to indicate that the dam will be stable during construction and filling and under all conditions of reservoir operations;
(3) computations indicating that the dam is safe against overtopping during occurrence of the inflow design flood and wave action; Wave action need not be considered when the design flood is based on the probable maximum precipitation (pmp);
(4) criteria, design data or references to indicate that seepage flow through the embankment, foundation, and abutments will be controlled so that no internal erosion will take place and so there will be no sloughing in the area where the seepage emerges;
(5) calculations and assumptions relative to design of the spillway(s);
(6) provision to protect the upstream slope, crest, and downstream slope of earth embankments and abutments from erosion due to wind and rain;
(7) other design data, assumptions, and analysis data pertinent to individual dams and site conditions;
(8) a proposed construction schedule;
(9) a proposed filling schedule for the reservoir;
(10) a maintenance and operation plan;
(11) the estimated design life of the dam and the reservoir;
(12) provision for maintaining minimum stream flow requirements.

(e) The Plans and Specifications. Five sets of plans and specifications must be submitted. The plans shall be a detailed engineering design that consists of drawings and specifications and that include the following as a minimum:

(1) Sheet one shall show the name of the project; name of owner; hazard classification of the dam; designated access to the project; and location with respect to highways, roads, streams, and any dam(s) that would affect or be affected by the proposed structure;
(2) Maps shall be included showing the drainage area and outline of the reservoir and the ownership of properties covered by the reservoir or flood pool;
(3) Geologic investigation, cross-section, profiles, logs of borings, location of borrow areas, drawings of principal and emergency spillways, and other additional sheets shall be included and drawn in sufficient detail to clearly indicate the extent and complexity of the work to be performed; The degree of detail required shall be determined by the applicable provisions of Rules .0204 through .0212 of this Section;
(4) The technical provisions, as may be required, to describe the method of construction and quality control for the project;
(5) Special provisions, as may be required, to describe technical provision needed to ensure that the dam is installed according to the approved plans and specifications;
(6) General provisions that specify the rights, duties, and responsibilities of the applicant, applicant's engineer and builder and the prescribed order of work.

(f) The Director, within 60 days following receipt of a completed application, shall notify the applicant, by mail, that the application is either approved or disapproved. An approved application shall conform to the requirements of Rule .0202 of this Section.

History Note: Statutory Authority G.S. 143-215.26,-27,-31;
Eff. June 15, 1980.

.0202 CERTIFICATE OF APPROVAL

(a) Approval of construction, repair, alteration, or removal of a dam will be contained in a certificate called a "Certificate of Approval" to be issued by the Director. A Certificate of Approval is a letter from the Director constituting approval subject to written general stipulations and specific written stipulations deemed necessary by the Director on a case by case basis.

(b) No construction shall be performed until the certificate is issued. The Certificate of Approval period shall be valid for the construction schedule specified in the approved final design report. Construction must commence within one year after the certificate is issued.

(c) Notice by registered or certified mail shall be given to the Director at least 10 days before construction is commenced. When repairs are necessary to safeguard life and property, they may be started immediately; but the department shall be notified forthwith of the proposed repairs and of the work under way, and they shall be made to conform to its orders.

(d) If construction does not commence within one year after the certificate of approval is issued, the certificate shall expire and a new application shall be submitted. Upon written application and for good cause shown, the Director may extend the time for commencing construction.

(e) Certificates of Approval are revocable in the event that the terms of the certificate, including the written stipulations and those terms stated in G.S. 143-215.23, are violated or in the event that conditions develop during construction that are hazardous to life and property. If the certificate is revoked due to development of hazardous conditions, the Director will issue an order requiring the owner or owners of the dam to make at his or their expense maintenance, alterations, or removal as deemed necessary within a time limited by the order; provided, any dam covered by a certificate issued under this Rule is considered to be within the definition of dams in G.S. 143-215.25 and .0104 of this Subchapter.

(f) Certificates of Approval are revocable in the event that the approved construction schedule is deviated from without prior written approval of a substitute construction schedule submitted in writing. Such approval of a substitute construction schedule shall be in the form of an Addendum to the Certificate of Approval to be issued by the Director.

History Note: Statutory Authority G.S. 143-215.26,-27,-31;
Eff. June 15, 1980.

.0203 PROFESSIONAL ENGINEER REQUIREMENTS

The design, preparation of the plans and specifications, inspection of the construction of or on the dam, and certification that the dam was constructed, repaired, altered, or removed according to the plans approved by the Director and that the dam or its remains are safe shall be done by a legally qualified engineer and shall bear his professional seal unless exempted under the provisions of G.S. 89C-25.

History Note: Statutory Authority G.S. 143-215.29,-31;
Eff. June 15, 1980.

.0204 INVESTIGATIONS

(a) General. The applicant shall be required to complete all investigations prior to submission of the final plans and application. The scope and the degree of precision that will be required for a specific project will depend on the conditions of the site and the hazard created by the proposed structure.

(b) Foundations and Abutments. The foundation and abutments investigation shall consist of borings, test pits, and other subsurface exploration necessary to assess the soil, rock, and

groundwater conditions. Geologic profiles and a geologic report prepared by a qualified geologist may be required for class B dams and shall be required for class C dams.
(c) Construction Materials. Specifications for construction materials shall establish minimum acceptance criteria so that design properties are achieved. If the use of on site borrow materials is specified, exploration, testing, and calculations should be performed to indicate that there are sufficient quantities of material available that meet the design criteria.
(d) Surveys. Surveys shall be made with sufficient accuracy to locate the proposed construction and to define the volume of the storage in the reservoir. The downstream area shall be investigated in order to delineate the area of potential damage in case of failure. Locations of centerlines, and other horizontal and vertical control points, shall be shown on a map of the site.
(e) Hydrologic Investigation. The drainage area shall be determined. Both present and projected future land use shall be considered in determining the runoff characteristics of the drainage area. The most severe of these two conditions shall be used in the design. All hydrologic assumptions and design calculations shall be included in the report.

History Note: Statutory Authority G.S. 143-215.26,-27,-31;
Eff. June 15, 1980.

.0205 SPILLWAY DESIGN

(a) All dams shall have a spillway system with capacity to pass a flow resulting from a design storm indicated in (e) of this Rule for a hazard classification appropriate for the dam, unless the applicant provides calculations, designs, and plans to show that the design flow can be stored, passed through, or passed over the dam without failure occurring.
(b) A vegetated earth or unlined emergency spillway will be approved when computations indicate that it will pass the design storm without jeopardizing the safety of the structure. The risk of recurring storms, excessive erosion, and inadequate vegetative cover will be considered acceptable in such a spillway when its average frequency of use is predicted to be no more frequent than once in 25 years for existing class B and for class A dams except for small class A dams designed in accordance with all design criteria established by the U.S.D.A, Soil Conservation Service, and as contained in Engineering Standard 378 of the U.S.D.A., Soil Conservation Service; once in 50 years for new class B, small and medium new class C, and existing class C dams; and once in 100 years for large and very large new class C dams. The dam sizes referred to in this Subsection are defined in (e) of this Rule.
(c) Lined Spillways and Channels. The design report shall include design data criteria for open channel, drop, ogee, and chute spillways and other spillway types that include crest structures, walls, channel lining, and miscellaneous details. All masonry or concrete structures shall have joints that are relatively water-tight and shall be placed on foundations capable of sustaining applied loads without undue deformation. Provisions must be made for handling leakage from the channel or underseepage from the foundation which might cause saturation of underlying materials or uplift against the undersurfaces.
(d) Within 15 days following passage of the design storm peak, the spillway system shall be capable of removing from the reservoir at least 80 percent of the water temporarily detained in the reservoir above the elevation of the primary spillway.
(e) It is recognized that the relationships between valley slope and width, total reservoir storage, drainage area, other hydrologic factors, and specific cultural features have a critical bearing on determining the safe spillway design flood. Rational selection of a safe spillway design flood for

specific site conditions based on quantitative analysis is acceptable. The spillway should be sized so that the increased downstream damage resulting from overtopping failure of the dam would not be significant as compared with the damage caused by the flood in the absence of dam overtopping failure. A design storm more frequent than once in 100 years will not be acceptable for any class C dam. In lieu of quantitative analysis, the following tables shall be used as criteria for spillway design storms and permissible velocities for vegetated earth spillways:

Criteria For Spillway Design Storm[1] Size Classification

Size	**Total Storage (Ac-Ft)[1]**	**Height (Ft)[1]**
Small	less than 750	less than 35
Medium	equal to or greater than 750 and less than 7,500	equal to or greater than 35 and less than 50
Large	equal to or greater than 7,500 and less than 50,000	equal to or greater than 50 and less than 100
Very Large	equal to or greater than 50,000	equal to or greater than 100

[1] The factor for determining the largest size shall govern.

Minimum Spillway Design Storms

Hazard	**Size**	**Spillway Design Flood (SDF)**
Low (Class A)	Small	50 year
	Medium	100 year
	Large	1/3 PMP
	Very Large	1/2 PMP
Intermediate (Class B)	Small	100 year
	Medium	1/3 PMP
	Large	1/2 PMP
	Very Large	3/4 PMP
High (Class C)	Small	1/3 PMP
	Medium	1/2 PMP
	Large	3/4 PMP
	Very Large	PMP

Permissible Velocities for Vegetated Earth Spillways

Permissible velocity[2] - feet per second				
	Erosion-resistant soils		**Easily erodable soils**	
	Percent slope of exit channel		**Percent slope of exit channel**	
Vegetation	**0 to 5**	**5 through 10**	**0 to 5**	**5 through 10**
Bermuda grass Bahia grass	8	7	6	5
Tall fescue Kentucky bluegrass Reed canary	7	6	5	4
Sod-forming grass mixture	5	4	4	3
Lespedeza sericea Weeping lovegrass Alfalfa Crabgrass	3.5	Do not use	2.5	Do not use

[2] Increase values 10 percent when the anticipated average use of the spillway is not more frequent than once in 50 years or 25 percent when the anticipated average use is not more frequent than once in 100 years.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0206 CONDUITS

(a) A conduit shall be provided to drain each reservoir. The conduit design shall include the computation of the minimum time required to drain the reservoir.

(b) All pipe conduits shall convey water at the design velocity without damage to the interior surface.

(c) Protection shall be provided to prohibit unsafe seepage along conduits through the dam, abutments, and foundation. The specific design for seepage protection along conduits shall be shown in the drawings and specifications.

(d) Adequate allowances shall be incorporated in the design to compensate for differential settlement and possible elongation of the pipe conduit.

(e) Trash racks shall be installed at the intake of conduits to prevent clogging the conduit.

(f) Pipe Conduit Spillway Materials

(1) Pipe conduits shall be designed to support the total external loads in addition to the total internal hydraulic pressure without leakage.

(2) Reinforced or Prestressed Concrete Pipe Conduits

(A) All conduits are to be designed and constructed to remain watertight under maximum anticipated hydraulic pressure and maximum probable joint opening, including the effects of joint rotation and extensibility.

(B) Provisions for safe movement of the barrel are to be provided at each joint in the barrel and at the junction of the barrel and riser or inlet. Cradles are to be articulated if constructed on a yielding foundation.

(C) The engineer shall submit the final design details of the proposed pipe to be used for all class A dams where the height of the dam exceeds 35 feet and all class B and C dams.

(3) Corrugated Metal Pipe Conduits

(A) Corrugated metal pipe shall not be used in class A dams over 35 feet high or in class B and C dams, except for special cases when the design engineer can adequately demonstrate satisfactory performance.

(B) Corrugated metal pipe may be used in class A dams which are less than 35 feet high.

(C) Corrugated metal conduits shall have watertight connecting bands designed and installed to remain watertight under maximum anticipated hydrostatic head and joint rotation.

(D) Flange type couplings shall not be used for corrugated metal pipe or corrugated steel pipe where the diameter exceeds 12 inches unless the applicant produces computations to verify that the flanges and the pipe conduit are of such design to safely support the total external loads in addition to the total internal hydraulic pressure without leakage.

(g) Dissipating Devices. All gates, valves, conduits and concrete channel outlets shall be provided with a dissipator designed and constructed to control erosion and prevent damage to the embankment or the downstream outlet or channel.

(h) In the case of repair to an existing dam, the engineer may determine that the conduit should not be repaired or replaced and shall submit reasoning to support this determination in the application for the Certificate of Approval to repair. The Director shall approve, disapprove, or approve in part this determination.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0207 SEEPAGE CONTROL

(a) All dams shall be designed and constructed to prevent the development of instability due to excessive seepage forces, uplift forces, or loss of materials in the embankment, abutments, spillway areas, or foundation. Seepage analysis for design shall identify areas having high internal uplift or exit gradients.

(b) The design may include an embankment internal drainage system, a zoned embankment, a foundation cut-off, an upstream blanket, a sufficiently wide homogeneous section, or other methods to protect against instability from excessive seepage forces or high hydraulic gradients.

(c) For class C dams, a flow net analysis shall be made to determine the location of the phreatic surface, flow lines, and equipotential lines within the embankment and its foundation. This analysis may be based on graphical construction, electrical or liquid analogs, soil prototype methods, or other accepted methods. The flow net and stability analysis shall use the maximum operating pool level with not less than five feet of clear water at the surface. Possible fluctuations in tail water elevation shall be included in the analysis. The flow net and seepage analysis shall be documented in the final design report, as required by .0201(d)(4) of this Section.

(d) Piezometers for confirming the location of the phreatic surface assumed for seepage and slope stability analyses should be considered by the design engineer for class A and class B dams and shall be required for class C dams. Where piezometers are required, their design, depths, and locations shall be provided as required in .0201(d) and .0212(b) of this Section.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0208 STRUCTURAL STABILITY AND SLOPE PROTECTION

(a) Design and construction of dams to assure structural stability shall be consistent with modern engineering practice. The scope and degree of precision that will be required for a specific project will depend on the conditions of the site and the damage potential of the proposed structure. Consideration in design for structural stability shall include, but are not necessarily limited to, the following:

(1) the hazard potential of the dam under present downstream conditions and under conditions which would likely develop during the life of the reservoir;
(2) foundation bearing capacity, compressibility, and permeability; the extent and reliability of the site investigation; and the predictability of the site and foundation conditions;
(3) the reliability of construction materials, such as borrow soils, in terms of sufficient volume to complete construction without unanticipated interruption and in terms of predictability of physical properties such as strength, permeability, and compressibility;
(4) durability of construction materials;
(5) construction conditions at the site;
(6) the degree of quality control to be exercised during construction;
(7) pore pressure build-up during construction;
(8) the rate of filling the reservoir and the rate of possible reservoir drawdown;
(9) tailwater conditions and the impact of tailwater drawdown;
(10) possible effects of landslides and subsurface solution activity on the structural stability of the dam and spillway structures;
(11) the extent of piezometers and other devices which will be used to monitor the completed dam and the degree of access for inspections.

(b) Slope stability analyses should be considered by the design engineer for all embankment dams and may be required for class B and class C dams. Where slope stability analyses are required, documentation in the final design report shall include the design cross section(s) showing the soil parameters assumed for analysis, the location of the phreatic surface assumed for analysis, stability computations, and the location and computed safety factor(s) for the most critical circle(s) or failure wedge(s). A minimum factor of safety of 1.5 for slope stability for normal loading conditions, and 1.25 for quick drawdown conditions and for construction conditions, shall be required unless the design engineer provides a thoroughly documented basis for using other safety factors.

(c) Foundation bearing capacity and sliding base analyses should be considered for all dams and may be required for class B and C dams. Where bearing capacity or sliding base analyses are required, documentation of assumptions, computations, and safety factors shall be included in the final design report. A minimum factor of safety against bearing capacity and sliding wedge failure of 2.0 shall be required unless the design engineer provides a thoroughly documented basis for using other safety factors.

(d) Resistance of appurtenant structures against flotation uplift shall be provided for all dams. If the structures are anchored by dead weight alone, the buoyant weight shall be used for analysis and the minimum factor of safety shall be 1.15. If the structures are anchored to soil or rock, the minimum factor of safety for that portion of the resistance provided by soil or rock anchorage shall be 2.0 unless the design engineer provides a thoroughly documented basis for using a lower safety factor.

(e) For concrete, masonry, or other similar dams of relatively narrow cross section, resistance against overturning under maximum design loading conditions shall be considered; overturning stability computations shall be required for class B and class C dams. Where overturning analyses are required, the computations shall be included in the final design report. The minimum safety factor against overturning under maximum design loading conditions shall be 1.5 unless the design engineer provides a thoroughly documented basis for using a lower safety factor.
(f) The anticipated reservoir and tailwater drawdown conditions shall be considered in all stability computations and shall be included in the design documents provided in the final design report.
(g) The slopes must be protected against erosion by wave action, and the crest and downstream slope must be protected against erosion due to wind and rain. Riprap and other erosion protection shall be provided over the full range in stage between the lowest drawdown elevation and at least two feet above full normal pool. Exceptions for slowly rising reservoirs, such as waste storage facilities, may be approved in writing by the Director.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0209 DESIGN LIFE OF A DAM AND RESERVOIR

(a) The selection of materials and equipment to be used in a dam and all of its appurtenant features shall either be based on sufficient quality and durability to satisfactorily function throughout the design life or shall provide for safe and economical replacement within the design life span.
(b) The design life of a dam and reservoir is the period of time the dam and reservoir can be expected to perform effectively as planned. The design life of a dam shall be determined by the following:
(1) the time required to fill the reservoir with sediment from the contributing watershed,
(2) the durability of appurtenances and materials used to construct the dam,
(3) the time required to permanently fill a waste treatment or storage facility with waste,
(4) the time required to perform the specific function for which the dam was designed.

History Note: Statutory Authority G.S. 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0210 SEDIMENT CONTROL

Sediment control related to earth moving activities involved in construction or repair of dams shall be provided in accordance with the North Carolina Sediment Pollution Control Act of 1973 (G.S. 113A-50 through 113A-66). Devices for sediment control during drainage of a reservoir shall be provided; exceptions for emergency drainage of a reservoir may be approved by the Director.

History Note:Statutory Authority G.S. 143-215.31, -113A-54;
Eff. June 15, 1980.

.0211 WASTE TREATMENT AND MINE REFUSE DAMS

(a) Waste treatment and mine refuse dams and reservoirs shall conform to all requirements of this Subchapter. In addition to the requirements of Rule .0105 of this Subchapter, a waste treatment or mine refuse dam may be classified A, B, or C on the basis of potential environmental damage.

(b) Mine refuse dams that are designed to be constructed in stages shall include an emergency spillway system that is capable of safely passing the required storm frequency below the top of the dam for each stage of construction. The refuse facility shall not be used until each stage of construction is completed and approved by the Director.

History Note: Statutory Authority G.S. 143-215.31;
Eff. June 15, 1980.

.0212 ADDITIONAL DESIGN REQUIREMENTS

(a) All elements of the dam and reservoir shall conform to good engineering practice. The safety factors, design standards, and design references that are used shall be included with the final design report.

(b) Monitoring or inspection devices may be required by the Director for use by inspectors or owners in the inspection during construction and filling and after completion of construction. The Director may also require that such monitoring or inspection devices, existing or installed by requirement, be read and documented at specified intervals and that copies of such be forwarded to his office.

(c) The plans, construction schedule, and construction specification shall assure that the downstream flow satisfies minimum quality and quantity standards as defined in G.S. 143-215.25(4) during the period of construction, filling, and life of the dam and reservoir.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0213 CONSTRUCTION SCHEDULE

The applicant shall submit a construction schedule that includes:

(1) Techniques and work force to be used to insure that the dam is constructed according to the plans and specifications;
(2) A construction schedule that includes the estimated time to complete the construction activities;
(3) Techniques to be used to divert the stream flow to prevent interference with construction and hazard to life, health, or property;
(4) The extent and method of quality control shall be subject to approval of the Director.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0214 PROPOSED CHANGES IN DESIGN

The owner shall notify the director of any proposed changes in design, plans, and specifications that will affect the stability of the dam. Approval must be obtained from the Director prior to installation. This approval shall be in the form of a written addendum to the Certificate of Approval.

History Note: Statutory Authority G.S. 143-215.26; 143-215.27; 143-215.31;
Eff. June 15, 1980.

.0215 AS-BUILT PLANS

Two complete sets of as-built plans shall be submitted to the Director within 30 days of completion of the project.

History Note: Statutory Authority G.S. 143-215.30; 143-215.31;
Eff. June 15, 1980.

.0216 ENGINEER'S CERTIFICATION

The engineer who has inspected the construction of or on the dam shall submit written certification bearing his professional seal, unless exempted under the provisions of G.S. 89C-25, that the dam and all appurtenances have been built, repaired, altered, or removed in conformance with the plans, specifications, and drawings approved by the Director and that the dam is safe.

History Note: Statutory Authority G.S. 143-215.30; 143-215.31;
Eff. June 15, 1980.

.0217 AUTHORITY FOR INSPECTION

Authorized personnel of the department may make inspection during construction as deemed necessary to ensure that the structure is being built in conformance with the Certificate of Approval issued. Said inspections do not relieve the engineer in charge from the responsibility of providing adequate inspection of the work.

History Note: Statutory Authority G.S. 143-215.29; 143-215.30; 143-215.31;
Eff. June 15, 1980.

.0218 EXEMPTIONS

History Note: Statutory Authority G.S. 143-215.21; 143-215.31;
Eff. June 15, 1980;
Amended Eff. November 1, 1985;
Repealed Eff. July 1, 1988.

.0219 ACCEPTABLE DESIGN: PROCEDURES AND TECHNICAL REFERENCES

The following represent acceptable design procedures and references:

(1) the design procedures, manuals, and criteria used by the United States Corps of Engineers;
(2) the procedures, manuals, and criteria used by the United States Soil Conservation Service;
(3) the procedures, manuals, and criteria used by the United States Department of Interior, Bureau of Reclamation;
(4) other procedures that are approved by the Director.

History Note: Statutory Authority G.S. 143-215.31; 143-215.34;
Eff. June 15, 1980.

.0220 GRANTING OF FINAL APPROVAL

(a) Unless the Director has reason to believe that the dam, as completed, is unsafe or not in compliance with any applicable requirement, regulation, or law, the Director, upon completion of construction and upon receipt of the engineer's certification pursuant to Rule .0215 of this Section, shall grant final approval of the work in accordance with the certificate, subject to such terms as he/she deems necessary for the protection of life and property.

(b) Pending issuance of final approval, a new dam or the addition to an existing dam shall not be used except on written consent of the Director and subject to conditions he/she may impose relating to safety of life and property and the satisfaction of minimum stream flow requirements.

History Note: Statutory Authority G.S. 143-215.3; 143-215.30;
Eff. June 15, 1980.

.0221 DELEGATION OF AUTHORITY

The Director has the authority to:

(1) issue approval, disapproval, or approval subject to conditions for proposed construction, repair, alteration or removal of dams;
(2) require progress reports, issue notices of non-compliance and orders to comply, order a halt in construction in the event of non-compliance;
(3) receive notices of completion, specify details of description, grant final approval;
(4) assess civil penalties; and
(5) perform other related functions.

History Note: Statutory Authority G.S. 143-215.3; 143-215.3(a)(4); 143-215.28; 143-215.29; 143-215.30; 143-215.36(b);
Eff. June 15, 1980;
Amended Eff. November 1, 1982.

.0222 APPLICATION PROCESSING FEES

(a) A nonrefundable minimum application processing fee, in the amount stated in Paragraph (d)(1) of this Rule, shall be paid when an application for construction or removal of a dam is filed in accordance with 15A NCAC 2K .0201. Each application for construction or removal of a dam shall be deemed incomplete and shall not be reviewed until the minimum application processing fee is paid.

(b) A nonrefundable additional application processing fee, in the amount stated in Paragraph (d)(2) of this Rule, shall be paid when the as-built plans are submitted to the Director in accordance with 15A NCAC 2K .0215. Final approval to impound, pursuant to 15A NCAC 2K .0220, shall not be granted until the owner's certification and the accompanying documentation are filed in accordance with Paragraph (e) of this Rule, and the additional processing fee is paid.

(c) The application processing fee for the construction or removal of a dam shall be based on the actual cost of construction or removal of the applicable dam.

(1) The actual cost of construction or removal of a dam shall include all labor and materials costs associated with the construction or removal of the dam and appurtenances.
(2) The actual cost of construction or removal of a dam shall not include the costs associated with acquisition of land or right of way, design, quality control, electrical generating machinery, or constructing a roadway across the dam.
(d) Schedule of Fees:
(1) The minimum application processing fee shall be two hundred dollars ($200.00).
(2) The additional application processing fee shall be the following percentages of the cost of construction or removal:
(A) 2 percent of the actual costs between ten thousand and one dollars ($10,001) and one hundred thousand dollars ($100,000);
(B) 1.5 percent of the actual costs between one hundred thousand and one dollars ($100,001) and five hundred thousand dollars ($500,000);
(C) 1.0 percent of the actual costs between five hundred thousand and one dollars ($500,001) and one million dollars ($1,000,000);
(D) 0.5 percent of the actual costs over one million dollars ($1,000,000). In no case, however, shall the additional application fee be more than fifty thousand dollars ($50,000).
(e) Immediately upon completion of construction or removal of a dam, the owner shall file with the Director a certification, on a form prescribed by the Department, and accompanying documentation, which shows the actual cost incurred by the owner for construction or removal of the applicable dam.
(1) The owner's certification and accompanying documentation shall be filed with the as-built plans and the engineer's certification in accordance with 15A NCAC 2K .0215 and 15A NCAC 2K .0216, respectively.
(2) If the Director finds that the owner's certification and accompanying documentation contain inaccurate cost information, the Director shall either withhold final impoundment approval, or revoke final impoundment approval, until the owner provides the accurate documentation and that documentation has been verified by the Department.
(f) Payment of the dam application processing fee shall be by check or money order made payable to the "N.C. Department of Environment, Health, and Natural Resources". The payment should refer to the applicable dam.
(g) In order to comply with the limit on fees set forth in G.S. 143-215.28A, the Director shall, in the first half of each state fiscal year, project revenues for the fiscal year from fees collected pursuant to this Rule. If this projection shows that the statutory limit will be exceeded, the Director shall order a pro rata reduction in the fee schedule for the remainder of the fiscal year to avoid revenue collection in excess of the statutory limits.

History Note: Filed as a Temporary Rule Eff. November 1, 1990 For a Period of 180 Days to Expire on April 29, 1991;
Statutory Authority G.S. 143-215.28A;
ARRC Objection Lodged November 14, 1990;
ARRC Objection Removed December 20, 1990;
Eff. January 1, 1991.

.0223 DAM HEIGHT AND STORAGE DETERMINATION

(a) For the purpose of determining size classification, the height of a dam shall be measured from the highest point on the crest of the dam to the lowest point on the downstream toe.

(b) The total storage capacity of a dam shall be that volume which would be impounded at the elevation of the highest point on the crest of the dam.

History Note: Filed as a Temporary Rule Eff. November 1, 1990 For a Period of 180 Days to Expire on April 29, 1990;
Statutory Authority G.S. 143-215.31;
ARRC Objection Lodged November 14, 1990;
ARRC Objection Removed December 20, 1990;
Eff. January 1, 1991.

SECTION .0300 - INSPECTIONS: DAM SAFETY ORDERS

.0301 INSPECTION BY THE DEPARTMENT

(a) Schedule of Inspections
(1) All class A and B dams shall be inspected at least once every five years.
(2) Class C dams shall be inspected at least once every two years.
(b) At any time an inspection indicates that a dam may not perform satisfactorily or that the hazard classification has changed, the Director may require a detailed investigation at the owners expense to determine the required remedial action, if any.

History Note: Statutory Authority G.S. 143-215.31; 143-215.32;
Eff. June 15, 1980.

.0302 DAM SAFETY ORDERS

(a) The Director may issue an order directing the owner(s) of a dam to make, in not less than 90 days from issuance of the order and at the owner(s) expense, any maintenance, alteration, repairs, reconstruction, or change in construction upon a finding that the dam:
(1) is not sufficiently strong,
(2) is not maintained in good repair or operating condition,
(3) is dangerous to life or property, or
(4) does not satisfy minimum stream-flow requirements.
(b) The Director may issue an order directing the owner(s) of any dam to take such measures as may be essential, including lowering the level of the impounded water, drainage of the impoundment, and destruction of the dam or reservoir in whole or in part, immediately or within a time limited by the order if the condition of the dam is found to have become so dangerous to the safety of life or property, in the opinion of the Director, as not to safely permit sufficient time for issuance of an order in the manner provided by Subdivision (a) of this Rule.
(c) The Director may, if at any time the condition of any dam becomes so dangerous to the safety of life or property, in the opinion of the Director, as not to permit sufficient time for issuance of an order in the manner provided by Subdivision (a) or (b) of this Rule, immediately take such measures as may be essential to provide emergency protection to life and property including the lowering of the level of a reservoir by releasing water impounded or the destruction in whole or in part of the dam or reservoir. Costs of such measures may be recovered from the owner(s) of the dam by appropriate legal action by the Commission.
(d) Orders issued by the Director may be conditioned so as to require the dam owner, if he is required or given the option to remove the dam, to undertake the removal in such a manner as to minimize the amount of sediment transported from the impoundment downstream.

(e) Dam safety orders issued by the Director in no way relieve the owner(s) of the dam from duties and obligations imposed by regulations in Section .0200 of this Subchapter, nor do they relieve the owner(s) of the dam from any liabilities or other legal obligations.

History Note: Statutory Authority G.S. 143-215.32; 143-215.34;
Eff. June 15, 1980.

SECTION .0400 - ADMINISTRATIVE HEARINGS

.0401 OPPORTUNITY FOR HEARING
An administrative hearing before the N.C. Office of Administrative Hearings shall be granted to any person:
(1) whose application for dam construction, repair, alteration, or removal has been disapproved by the Director or has been approved by the Director subject to conditions which are unacceptable to the applicant pursuant to Rule .0202 of this Subchapter;
(2) who has been denied final approval of a completed dam by the Director or who has been granted final approval by the Director subject to conditions which are unacceptable to the applicant pursuant to Rule .0219 of this Subchapter;
(3) against whom a dam safety order has been issued requiring the maintenance, alteration, repair, reconstruction, change in construction or location, or removal of a dam within 90 days, pursuant to Rule .0302(a) of this Subchapter, or the lowering of the level of the water impounded by the dam within a time period prescribed by the Director pursuant to Rule .0302(b) of this Subchapter; or
(4) who has been assessed a civil penalty pursuant to G.S. 143-215.36(b) and Subchapter 2J of this Chapter.

History Note: Statutory Authority G.S. 143-215.33; 150B-23;
Eff. June 15, 1980;
Amended Eff. July 1, 1988.

.0402 PROCEDURES
(a) Administrative hearings shall be conducted pursuant to 15A NCAC 1B .0200 et seq., and Chapter 150B of the General Statutes. Any person entitled to an opportunity for a hearing by Rule .0401 of this Section must request a hearing within ten days after receipt of the notice of the action taken under Rule .0401 of this Section.
(b) Copies of 15A NCAC 1B .0200 may be inspected in the offices of the Division of Land Resources, Land Quality Section, 512 N. Salisbury Street, Raleigh, N. C. 27611. Copies may also be inspected in the Division of Planning and Assessment, 512 N. Salisbury Street, 8th Floor, Archdale Building, Raleigh, N. C. 27611. Copies may be obtained at the previous locations or from the Rules Division of the N.C. Office of Administrative Hearings, Blount Street, Raleigh, N.C. 27611.

History Note: Statutory Authority G.S. 143-215.33; 150B-23;
Eff. June 15, 1980;
Amended Eff. August 1, 1988; November 1, 1984.

.0403 DELEGATION OF AUTHORITY: APPOINTMENT OF HEARING OFFICERS

.0404 NOTICE: WAIVER

.0405 PLACE OF THE HEARING

.0406 PROCEDURES

.0407 HEARING OFFICERS: POWERS AND DUTIES

.0408 FINAL DECISIONS: JUDICIAL REVIEW

History Note: Statutory Authority G.S. 143-215.3(a)(4); 143-215.33; 150B-23; 150B, Article 3; 150B, Article 4;
Eff. June 15, 1980;
Legislative Objection (c) Lodged Eff. October 10, 1980;
Amended Eff. November 1, 1982;
Repealed Eff. November 1, 1984.

SECTION .0500 - MINIMUM STREAM FLOWS TO MAINTAIN AQUATIC HABITAT

.0501 DEFINITIONS

(a) Aquatic habitat shall be divided into three classes - "poor," "moderate," and "good."

(1) Streams with poor aquatic habitat are those which have a "poor" fish assemblage rating, and which are rated "poor" for at least two of the following three characteristics:
   (A) Substrate;
   (B) Cover; and
   (C) Macro-invertebrate organisms.

(2) Streams with moderate aquatic habitat are those which exhibit physical conditions and biota which are intermediate between the poor and good categories.

(3) Streams with good aquatic habitat are those which receive at least two "good" ratings when the substrate, cover, and macro-invertebrate organism characteristics are evaluated. The fish assemblage also must receive a "good" rating.

(b) Cover means objects within or overhanging the stream channel which provide shelter for aquatic organisms. "Good" cover occurs when cover is widespread and diverse. "Poor" cover occurs when the amount of cover is small or non-existent.

(c) Substrate means the predominant particle size of the material which makes up the stream bed. "Good" substrate is composed of at least 50 percent silt free substrate with gravel or cobble. "Poor" substrate is composed of at least 80 percent silt, sand, or smooth bedrock.

(d) The macro-invertebrate organisms of the affected reach are rated as "good" if the affected reach is rated good or excellent in the Division of Environmental Management's (DEM) biological monitoring database, or by a site-specific survey according to Standard Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b). Macro-invertebrates are rated "poor" if the reach is rated fair or poor in DEM's biological monitoring database, or by a site-specific survey according to Standard Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b).

(e) The fish assemblage rating shall be based on the North Carolina Index of Biotic Integrity (IBI). Existing ratings from the DEM biological monitoring database shall be used where available. If no rating exists, then a site-specific survey shall be conducted according to Standard

Operating Procedures for Biological Monitoring, 1995, Division of Environmental Management as defined in 15A NCAC 2B .0103(b). The fish assemblage shall be rated as "good" if the IBI rating is good, good-excellent, or excellent. The fish assemblage shall be rated as "poor" if the IBI rating is poor or lower.

(f) The affected reach of stream means that section of a stream downstream of a dam which experiences significant changes in hydrology. The exact delineation of the affected reach shall be site-specific and depend on factors including, but not limited to:

(1) volume of storage in the impoundment;

(2) upstream and downstream hydrologic characteristics of the stream;

(3) withdrawals from the impoundment; and

(4) downstream point source discharges to the stream. For the purpose of evaluating aquatic habitat, the affected reach of a stream does not include any portion which is in the backwater of a downstream dam when the level of that downstream impoundment is at normal pool.

(g) "Special case" streams are those which exhibit at least one of the following characteristics:

(1) supplemental classification as an Outstanding Resource Water as defined in 15A NCAC 2B .0101(e)(4) and .0216;

(2) populations of aquatic species listed as threatened or endangered by the U.S. Fish and Wildlife Service, or species which are listed as threatened or endangered by the N.C. Wildlife Resources Commission;

(3) self-sustaining populations of wild trout; or

(4) exceptional non-game or fishery resources as determined by the Wildlife Resources Commission.

(h) The use of the regression equations in Rule .0502 of this Section shall depend on the geographic region of the state in which the stream is located. The geographic region shall be determined from the North Carolina Atlas, edited by Clay, Orr, and Stuart, published by the University of North Carolina Press, 1975.

(i) A continuous stream gage record means a continuous record of daily flows from a stream gage which:

(1) has at least 15 years of continuous daily records;

(2) has no significant hydrological effects caused by upstream regulation, withdrawals, or discharges;

(3) is no less than one-half and no more than one and one-half times the drainage area of the site in question; and

(4) has low flow and average flow yields which are comparable to the site in question.

(j) A site-specific instream flow study conducted by the applicant or his consultants, which is subject to approval by the Department, means a study performed according to the following conditions:

(1) A plan of study shall be developed in consultation with the Department and submitted to the Department for review and approval prior to commencement of the study.

(2) The plan of study shall identify the aquatic habitat parameters to be evaluated by the study. The selection of these parameters shall depend on factors including, but not limited to:

(A) the aquatic species being evaluated;

(B) the habitat quality of the affected reach; and

(C) existing or potential water shortages or water use conflicts.

(3) The Department shall have the option of participating in the collection of all field data, and shall be notified prior to collection of any set of data.

(4) The results of the study shall accurately determine the parameters identified during study design.
(5) The Department may review the field data and results of these studies to determine the stream flow needed to maintain aquatic habitat.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33; 143-215.36; Eff. December 1, 1994;
Amended Eff. April 1, 1995.

.0502 REQUIRED MINIMUM FLOW FOR DAMS (NOT SMALL HYDRO PROJECTS)

(a) A dam operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural stream bed, shall be exempt from this Rule.

(b) A dam proposed for a small stream with a mean annual daily flow less than or equal to 3.0 cubic feet per second (cfs) shall be subject to the following review process in determining the required minimum flow:

(1) If the mean annual daily flow is less than or equal to 3.0 cfs and the 7-day, 10-year low flow (7Q10) is less than or equal to 0.2 cfs; and if there are no existing point source discharges of wastewater to the affected stream reach; then no minimum release will be required.
(2) If the mean annual daily flow is less than or equal to 3.0 cfs and the 7Q10 is less than or equal to 0.2 cfs; and one or more existing point source discharges of wastewater enter the affected stream reach; then the minimum release shall be equal to the 7Q10.
(3) If the mean annual daily flow is less than or equal to 3.0 cfs and the 7Q10 is greater than 0.2 cfs, then the minimum release shall be equal to the 7Q10.

(c) If the mean annual daily flow is greater than 3.0 cfs, then the following procedures shall be used to determine the minimum flow requirement:

(1) The minimum flow for a dam on a stream with poor aquatic habitat shall be the 7Q10 flow determined by using U.S. Geological Survey procedures.
(2) The minimum flow for a dam on a stream with moderate aquatic habitat in the piedmont, as defined in Rule .0501(h) of this Section, shall be determined using regression equations provided in this Subparagraph.

(A) All flows used in regression equations shall be measured in cubic feet per second, all drainage areas shall be measured in square miles, and all logarithmic expressions shall refer to base 10 logarithms.

(B) The regression equation used to determine the minimum flow for a stream in the piedmont which exhibits moderate aquatic habitat, and for which no continuous stream gage record, as defined in Rule .0501(i) of this Section, exists, shall be as follows:

LRF = (3.204 x M) - (2.618 x D)
LRF = LOG of regression flow
M = LOG of mean annual daily flow
D = LOG of drainage area

The regression flow (RF) is calculated by raising 10 to the power of the LRF. If the drainage area is greater than 95 square miles, the required minimum flow is 1.4 x RF. Otherwise the required minimum flow is equal to RF.

(C) The regression equation used to determine the minimum flow for a stream in the piedmont which exhibits moderate aquatic habitat, and for which a continuous stream gage record, as defined in Rule .0501(i) of this Section, does exist, shall be as follows:

LRF = (0.812 x M) + (8.111 x E92) - (4.806 x E85) - (3.275 x E95)
LRF = LOG of regression flow
M = LOG of mean annual daily flow
E85 = LOG of 85% annual exceedance flow
E92 = LOG of 92.5% annual exceedance flow
E95 = LOG of 95% annual exceedance flow

The regression flow (RF) is calculated by raising 10 to the power of the LRF. The required minimum flow is 1.1 x RF.

(3) The minimum flow for a dam on a stream with moderate aquatic habitat, located in a geographical region for which regression formulas are not provided, shall be determined by a site-specific instream flow study, as defined in Rule .0501(j) of this Section, conducted by the applicant or his consultants and subject to the approval of the Department.

(4) The minimum flow for a dam on a special case stream, or on a stream with good aquatic habitat, shall be determined by a site-specific instream flow study, as defined in Rule .0501(j). This study shall be conducted by the applicant or his consultants, and shall be subject to approval by the Department.

(5) If the applicant or owner disputes the minimum flow determined by the procedures described in Subparagraphs (c)(1) or (c)(2) of this Rule for streams with poor or moderate aquatic habitat, he may undertake a site-specific field study, as defined in Rule .0501(j) of this Section, subject to the review and approval of the Department. The final minimum release required will not exceed the amount determined by the procedures described in this Rule.

(6) The minimum release schedule for a water supply reservoir shall include provisions for reductions in the minimum flow which coincide with reductions in the usable water supply storage remaining in the impoundment and with reductions in the amount of water withdrawn from the reservoir.

(A) This system of tiered releases shall apply to new water supply reservoirs and any existing water supply reservoirs for which the minimum release is revised.

(B) The exact percentage of storage which triggers reductions in minimum flow will depend on several site-specific factors, including, but not limited to:

(i) size of the reservoir;

(ii) rate of the water supply demand;

(iii) hydrologic characteristics of the impounded stream; and

(iv) the impoundment levels which result in local efforts to reduce water usage through conservation measures.

(C) At least three levels of minimum releases shall be included in the release schedule for a water supply reservoir.

(D) When usable water supply storage has been reduced to a level which triggers the first reduction in minimum flow, then the average daily water withdrawal shall be reduced by at least 10 percent from the average daily withdrawal for the 60 day period immediately prior to the first reduction in the minimum flow. The water supply operator shall accomplish this reduction in withdrawal within two weeks of the reduction in the minimum release.

(E) When usable water supply storage has been reduced to a level which triggers the second reduction in minimum flow, then the average daily water withdrawal shall be reduced by at least 20 percent from the average daily withdrawal for the 60 day period immediately

prior to the first reduction in the minimum flow. The water supply operator shall accomplish this further reduction in withdrawal within two weeks of the second reduction in the minimum release.

(F) The water system operator shall document reduction in water withdrawals by submitting reports of daily water withdrawals to the Department. These shall be submitted every two weeks for as long as the minimum release is reduced below the amount normally required.

(G) An example is shown in the table below. (Note that the percentages of water supply storage which trigger the changes in minimum release are site-specific for this example and may vary according to the factors described in Part (B) of this Paragraph.)

Remaining Usable Water Level Supply Storage	Minimum Release	Water Use Reduction
between 70% and 100%	A	-------
between 40% and 70%	B	10%
below 40%	C	20%

A = Normal minimum release determined by a field study, regression equation, or use of the 7Q10
B = Intermediate reduction in minimum release
C = Low minimum release equal to no more than the 7Q10

(7) An existing dam which was built subject to review under the National or the State Environmental Policy Acts, and for which a minimum release has been established, will not have its minimum release changed under this Rule. However, the Department may review and adjust the minimum flow released by any other existing dam if there is evidence of any of the following conditions downstream of that dam:
(A) water quality standards not being maintained;
(B) water quality classifications which are being only partially supported or not being supported; or
(C) aquatic habitat not being maintained.

(8) If the minimum release required from an existing water supply reservoir is reviewed by the Department, any increase in minimum flow will be determined on a case-by-case basis in consideration of the following factors, including, but not limited to:
(A) availability of water to meet existing demands;
(B) rate of growth in water demand;
(C) planned development of alternative sources of water supply;
(D) structural difficulties;
(E) capital costs; and
(F) anticipated improvements in water quality and aquatic habitat in the affected reach resulting from the proposed change in minimum flow.

The change in minimum release shall be set no higher than an amount which would reduce the water supply safe yield, as determined by standard accepted engineering practices, by more than 10 percent.

(9) If a new minimum release requirement from an existing water supply reservoir is being delayed until a new source of water supply is developed, then this delay shall not exceed a period of five years from the written notification that a new minimum release will be required. This period may be extended by approval of the Environmental Management Commission in consideration of the following factors:
(A) delays in developing a new water supply source;
(B) changes in water quality and aquatic habitat in the affected reach; or
(C) availability of water to meet existing demands.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33; 143-215.36;
Eff. December 1, 1994;
Amended Eff. April 1, 1995.

.0503 REQUIRED MINIMUM FLOW FOR SMALL HYDROELECTRIC PROJECTS

(a) This Rule shall apply only to a dam operated by a small power producer, as defined in G.S. 62-3(27a), that diverts water from 4,000 feet or less of the natural stream bed. The length of the bypassed reach shall be measured from the toe of the dam to the point where the diverted water re-enters the natural channel, following the centerline of the natural channel.

(b) The minimum release for a hydroelectric project subject to this Rule shall be determined according to the procedures described in Subparagraphs (1)-(5) of this Paragraph. If at any time the inflow just upstream of the dam is less than the minimum flow required in the bypassed reach, then the minimum flow may be reduced to a level equal to this inflow.

(1) If the aquatic habitat in the bypassed reach is rated poor, then the minimum release to the bypassed reach shall be determined as follows:

(A) If the 7Q10 is less than or equal to 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be the 7Q10 flow.

(B) If the 7Q10 is greater than 10 percent of the mean annual daily flow, and there are no existing point source discharges of wastewater to the bypassed reach, then the minimum release to the bypassed reach shall be 0.8 times the 7Q10.

(C) If the 7Q10 is greater than 10 percent of the mean annual daily flow, and one or more existing point source discharges of wastewater enter the bypassed reach, then the minimum release to the bypassed reach shall be the 7Q10 flow.

(2) If the bypassed reach does not have an aquatic habitat rating of "poor," is not on a special case stream, and is located in the piedmont region, as defined in Rule .0501(h) of this Section, then the minimum release to the bypassed reach shall be determined as follows:

(A) If the 7Q10 is less than or equal to six percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 3.0 times the 7Q10 flow.

(B) If the 7Q10 is greater than six percent of the mean annual daily flow, and less than or equal to 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 2.2 times the 7Q10 flow.

(C) If the 7Q10 is greater than 10 percent of the mean annual daily flow, then the minimum release to the bypassed reach shall be 1.2 times the 7Q10 flow.

(3) The minimum flow determined by the procedures described in Subparagraphs (1) and (2) of this Paragraph may be adjusted downward by the Department if that adjustment would not result in significant loss of aquatic habitat. This adjustment may be based on factors including:

(A) the type of aquatic habitat present in the bypassed reach;

(B) the length of the bypassed reach.

(4) If the applicant or owner disputes the minimum flow determined by the procedures described in Subparagraphs (1) and (2) of this Paragraph, he may undertake a site-specific field study, as defined in Rule .0501(j) of this Section, subject to the review and approval of the Department. The final minimum release required will not exceed the amount determined by the procedures described in this Section.

(5) The minimum flow for a dam on a special case stream, or on a stream located in the mountain region, as defined in Rule .0501(h) of this Section, which does not exhibit poor aquatic habitat; shall be determined by a site-specific instream flow study, as defined in Rule .0501(j) of this Section. This study shall be conducted by the applicant or his consultants, and shall be subject to approval by the Department.

(c) A dam operated by a small power producer, as defined in G.S. 62-3(27a), which was operating to produce power as of October 13, 1994, and which is not under the jurisdiction of the Federal Energy Regulatory Commission, shall not be required by this Rule to increase its minimum flow above the amount required on October 13, 1994.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33; 143-215.36; Eff. December 1, 1994;
Amended Eff. April 1, 1995.

.0504 MONITORING OF MINIMUM FLOW REQUIREMENTS

(a) An owner of a dam with a minimum flow requirement greater than 1.0 cfs shall install, calibrate, and maintain one or more stream staff gages following procedures described in U.S. Geological Survey Water Supply Paper 2175, "Measurement and Computation of Stream flow." Plans for such gages shall be submitted to the Department for approval prior to installation. Staff gages shall be calibrated to indicate the water surface elevations which correspond to the required flows. Calibration shall be verified at least every two years. All initial calibration and re-calibration measurements, including field data, shall be provided to the Department within 30 days of completion.

(b) If the minimum release from a dam is less than or equal to 1.0 cfs, then an accurately calibrated release mechanism such as a gate or pipe opening shall be acceptable in lieu of a staff gage. Plans for making the required release shall be submitted to the Department for review and approval prior to construction, repair, or modification of the dam.

(c) An owner of a dam who does not comply with a minimum flow requirement may be required to install automated gaging which continuously monitors flow. Records from this type of gage shall be provided to the Department upon request, for the time period being investigated.

(d) Minimum release requirements may be modified or suspended for a term determined by the Department for reasons including pre-scheduled maintenance or construction involving the dam. The Department must approve a written request for such a change in the minimum flow requirement prior to any change in the minimum release.

(e) Reduction or cessation of the minimum flow as a result of emergency conditions or equipment failure shall not constitute a violation of the minimum flow requirement, so long as the event is reported to the Department within 48 hours. The Department may set forth a schedule for correcting the problem and restoring the required minimum flow. If the schedule is not met, and the problem continues to cause violation of the minimum flow requirement, then this violation may be subject to enforcement action.

History Note: Statutory Authority G.S. 143-215.24; 143-215.25; 143-215.31; 143-215.32; 143-215.33; 143-215.36; Eff. December 1, 1994.

APPENDIX 4

BMP Design Check List

The following checklists are provided as a guide for the designer / engineer in the design of a structural Best Management Practice (BMP) associated with the development of a watershed development plan. It is the sole responsibility of the designer / engineer to ensure all design, construction and certification requirements of the BMP as listed in the State BMP Design Manual and the City of Greensboro Stormwater Management Manual Supplement are met.

Wet Detention Basin Design Requirements

Item *	Design Requirement	Addressed in Design (Yes / No)
1	Basin sizing shall take into account all runoff at ultimate build-out, including off-site drainage.	
2	Vegetated slopes shall be no steeper than 3:1.	
3	BMP shall be located in a recorded Drainage Maintenance Utility Easement (DMUE over and 15' around BMP) with a recorded 20' wide access easement to a public ROW.	
4	Basin discharge shall be evenly distributed across a minimum 30 feet long vegetative filter strip unless BMP designed to remove 90% TSS.	
5	The design storage shall be above the permanent pool.	
6	Discharge rate following a 1-inch rainfall shall completely draw down the temporary storage volume between 2 and 5 days.	
7	The average depth of the permanent pool shall be a minimum of 3 feet.	
8	Permanent pool surface area determined using SA/DA tables 10-1, 10-2, 10-3, & 10-4	
9	Flow within the pond shall not short-circuit the pond.	
10	BMP shall be designed with a forebay.	
11	Basin side slopes shall be stabilized with vegetation above the permanent pool level.	
12	Pond side slopes shall be no steeper than 3:1	
13	BMP shall not be located to produce adverse impacts on water levels in adjacent wetlands.	
14	A minimum 10-foot wide vegetated shelf shall be installed around the perimeter. The inside edge of the shelf shall be 6” below the permanent pool elevation; the outside edge of the shelf shall be 6” above the permanent pool elevation.	
15	The forebay volume should be about 20% of the total permanent pool volume, leaving about 80% of the design volume in the main pool.	
16	Freeboard shall be a minimum of 1 foot above the maximum stage of the basin.	
17	Engineer's certification of BMP completion status box checked on watershed plan coversheet	
18	Final plat recordation status box checked on watershed plan coversheet	
19	Owners' maintenance responsibility note placed on watershed plan	
20	City of Greensboro right to access note placed on watershed plan	
21	BMP Construction completion note placed on watershed plan	

Wet Detention Basin Design Requirements (cont.)

Item *	Design Requirement	Addressed in Design (Yes / No)
22	Engineer's statement of pond and dam safety note placed on watershed plan	
23	BMP allocation table placed on coversheet	
24	Operation and Maintenance (O&M) plan included with BMP design	
25	Seepage control addressed in accordance with Section 5.6 of the Stormwater Management Manual	
26	Emergency spillway placed in cut portion of earthen embankment	
27	Spillway placed in fill portion of dam shall meet chute or free overfall spillway design requirements of Section 5.8.6 of Stormwater Management Manual	
28	Riser/Barrel spillway constructed of RCP, PVC, HDPE, ductile iron or corrugated aluminum. If RCP utilized, watertight joints specified	
29	Minimum sediment storage depth of 0.125 inches over the drainage area for the BMP	
30	Temporary storage volume calculated using the Simple Method as presented in Section 3.3.1 of the State BMP Design Manual	
31	Emergency spillway shall not be activated by 10 year / 24 hour storm event	
32	Top width of embankment dam ≥ 10'	
33	Trash guard provided on water quality orifice	
34	Earthen embankment key or cutoff trench provided along with fill and compaction specifications	
35	Invert of basin inlet pipes placed at or below permanent pool elevation	
36	Drain valve or other means to drain pond in 24 hour period	
37	Provide stage - discharge flow characteristics for principal spillway. For riser and barrel spillway designs, barrel discharge flows shall be analyzed for both inlet and outlet control.	
38	Pertinent water surface elevations shown on basin profile view (2, 10, 100 year storms)	
39	Energy dissipation details (size and material) include for all basin inlets and outlets	
40	Level Spreader is required if discharging to a stream buffer or adjacent property and 2 & 10 yr storm is not reduced to predevelopment levels	

* Items 1 -12 Required by the NC Administrative Rules of the Environmental Management Commission. Other specifications may be necessary to meet the stated pollutant removal requirements.

* Items 13 -16 Required by DWQ Policy

* Items 17 – 40 Required by City of Greensboro Stormwater Management Manual

Stormwater Wetland Design Requirements

Item *	Design Requirement	Addressed in Design (Yes / No)
1	Basin sizing shall take into account all runoff at ultimate build-out, including off-site drainage.	
2	Side slopes stabilized with vegetation shall be no steeper than 3:1.	
3	BMP shall be located in a recorded Drainage Maintenance Utility Easement (DMUE over and 15' around BMP) with a recorded 20' wide access easement to a public ROW.	
4	The wetland must be drawdown in 2-5 days	
5	Flow through the wetland shall not be short circuited. It shall be made as lengthy as possible.	
6	A forebay is required	
7	Overflows shall pass through a minimum 30 feet long vegetative filter, 50 foot filter is required for some projects.	
8	Wetlands require pretreatment	
9	Sizing of wetland is based on storage volume requirements and shall be as described in Section 9	
10	The minimum treatment volume for a stormwater wetland shall be 3,630 ft3 of drainage. Lesser volumes will be reviewed on a case by case basis .	
11	Maximum ponding depth shall be 1 foot	
12	Minimum length to width ratio shall be 1.5:1	
13	The wetland must be stabilized within 14 days of construction	
14	One of the following two criteria must be met, 1) The deep pools shall be at least six inches below seasonable water table, or 2) A clay liner shall be installed such that the minimum infiltration rate is 0.01 in/hr. Appropriate topsoil will be added to the clay liner to support plant growth.	
15	Cattails are not be planted	
16	Discharge rate following a 1-inch rainfall shall completely draw down the temporary storage volume between 2 and 5 days.	
17	Low Marsh zone, High Marsh Zone, Deep pools are provided	
18	Non forebay :5-10% of wetland surface, Forebay: 10% of wetland surface, Shallow Water (low marsh) 40% wetland surface, Shallow Land (high marsh) 30-40% of wetland surface, upland is optional	
19	Determine depth of the pools, shallow water, shallow land, etc.	
20	Landscape plan that clearly depicts the plantings, locations, quantities. The delineation of plantings of pondscaping zones, a minimum of 10 different species with no more than 30% of a single specie, 10 foot grass buffer is recommended as Centipede (see BMP manual for planting information)	
21	BMP shall not be located to produce adverse impacts on water levels in adjacent wetlands.	
22	Freeboard shall be a minimum of 1 foot above the maximum stage of the basin.	

Stormwater Wetland Design Requirements

Item *	Design Requirement	Addressed in Design (Yes / No)
23	Engineer's certification of BMP completion status box checked on watershed plan coversheet	
24	Final plat recordation status box checked on watershed plan coversheet	
25	Owners' maintenance responsibility note placed on watershed plan	
26	City of Greensboro right to access note placed on watershed plan	
27	BMP Construction completion note placed on watershed plan	
28	Engineer's statement of pond & dam safety note placed on watershed plan	
29	BMP allocation table placed on coversheet	
30	Operation and Maintenance (O&M) plan included with BMP design	
31	Seepage control addressed in accordance with Section 5.6 of the Stormwater Management Manual	
32	Emergency spillway placed in cut portion of earthen embankment	
33	Spillway placed in fill portion of dam shall meet chute or free overfall spillway design requirements of Section 5.8.6 of Stormwater Management Manual	
34	Riser/Barrel spillway constructed of RCP, PVC, HDPE, ductile iron or corrugated aluminum. If RCP utilized, watertight joints specified	
35	One of the following two criteria must be met, 1) The deep pools shall be at least six inches below seasonable water table, or 2) A clay liner shall be installed such that the minimum infiltration rate is 0.01 in/hr. Appropriate topsoil will be added to the clay liner to support plant growth.	
36	Temporary storage volume calculated using the Simple Method as presented in Section 3.3.1 of the State BMP Design Manual	
37	Emergency spillway shall not be activated by 10 year / 24 hour storm event	
38	Top width of embankment dam $\geq$ 10'	
39	Trash guard provided on water quality orifice	
40	Earthen embankment key or cutoff trench provided along with fill and compaction specifications	
41	Invert of basin inlet pipes placed at or below permanent pool elevation	
42	Drain valve or other means to drain pond in 24 hour period	
43	Provide stage - discharge flow characteristics for principal spillway. For riser and barrel spillway designs, barrel discharge flows shall be analyzed for both inlet and outlet control.	
44	Pertinent water surface elevations shown on basin profile view (2, 10, 100 year storms)	
45	Energy dissipation details (size and material) include for all basin inlets & outlets. Level Spreader is required if discharging to a stream buffer or adjacent property and 2 & 10 yr storm is not reduced to predevelopment levels	

* Items 1 - 7 Required by the NC Administrative Rules of the Environmental Management Commission. Other specifications may be necessary to meet the stated pollutant removal requirements.

* Items 8 - 15	Required by DWQ Policy
* Items 16 - 45	Required by City of Greensboro Stormwater Management Manual

Bioretention Design Requirements

Item *	Design Requirement	Addressed in Design (Yes / No)
1	Sizing shall take into account all runoff at ultimate build-out including off-site drainage.	
2	Side slopes stabilized with vegetation shall be no steeper than 3:1	
3	Drainage Area to the bioretention area is ≤ 5 acres (Sec.12.3.3)	
4	BMP shall be located in a recorded Drainage Maintenance Utility Easement with a recorded 20 ft wide Access Easement to a public right of way (ROW). (Label DMUE as "DMUE over and 15ft around Bioretention Area")	
5	Volume in excess of the design volume, as determined from the design storm, shall bypass the bioretention cell.	
6	Volume in excess of the design volume, as determined from the design storm, shall be evenly distributed across a minimum 30ft long vegetated filter strip. (A 50ft filter is required in some locations). If this cannot be attained, alternate designs will be considered.	
7	Bioretention facilities shall not be used where the seasonally high water table is less than 2ft below bottom of BMP.	
8	Media permeability of 0.52-6" per hour is required, 1-2 in per hour is preferred. (Sec.12.3.4)	
9	Mulch and plantings must meet requirements. (Sec. 12.3.8 & Table 12-1)	
10	Pretreatment is required prior to entering bioretention. See Section 12.3.1 under Basic Layout Concepts for pretreatment devices.	
11	The design shall be located a minimum of 100ft from water supply wells.	
12*	Bioretention facilities shall not be used where slopes greater than 20% or in non-permanently stabilized drainage areas.	
13	Inflow must be sheet flow (1ft/sec) or utilized energy dissipating devices.	
14	Ponding depth shall be 12 inches or less - 9 inches is preferred.	
15	Media depth shall be specified for the vegetation used. For grassed cells, use 2 feet minimum. For shrubs or trees use 3 feet minimum	
16	The geometry of the cell shall be such that no dimension is less than 10 feet (width, length, or radius)	
17	Media should be specified as listed in this section (Sec.12.3.4)	
18	The phosphorus index (P-index) for the soil must be low, between 10 and 30. This is enough phosphorus to support plant growth without exporting phosphorus from the cell. (Provide complete soil analysis) For complete requirements see Sec.12.3.4.	
19	Pipe inlet cannot have flared end section or any other type of heavy end section. This will cause unnecessary settling of the soil media.	
20	Ponded water shall completely drain into the soil within 12 hours. It shall drain to a level of 24 inches below the soil surface in a maximum of 48 hours.	

Bioretention Design Requirements

Item *	Design Requirement	Addressed in Design (Yes / No)
21	An underdrain shall be typically installed in in-situ soil drainage is less than 2 in/hr if there is in situ loamy soil (~12% or more of fines). This is usually the case for soil tighter than sandy loam or if there has been significant soil compaction from	
22*	Underdrains are required and clean-out pipes must be provided. (Sec.12.3.6) (See Sec. 5.7 for Underdrain System requirements)	
23	Engineer's certification of BMP completion status box checked on watershed plan coversheet	
24	Final plat recordation status box checked on watershed plan coversheet	
25	Engineer's certification of BMP completion will be required prior to final plat or certificate of occupancy	
26	Owners' (homeowners association) maintenance responsibility note placed on watershed plan	
27	City of Greensboro right to access note placed on watershed plan	
28	BMP Construction completion note placed on watershed plan	
29	A BMP allocation table placed on coversheet	
30	Operation and Maintenance (O&M) plan included with BMP design	
31	Overflow must be located at the upstream portion of the bioretention area. Level Spreader is required if discharging to a stream buffer or adjacent property and 2 & 10 yr storm is not reduced to predevelopment levels.	

* Items 1 -11 Required by the NC Administrative Rules of the Environmental Management Commission. Other specifications may be necessary to meet the stated pollutant removal requirements.

* Items 12 -21 Required by DWQ Policy

* Items 22 - 31 Required by City of Greensboro Stormwater Management Manual

Sand Filter Design Requirements

Item *	Design Requirement	Addressed in Design (Yes / No)
1	Basin sizing shall take into account all runoff at ultimate build-out, including off-site drainage.	
2	Vegetated side slopes shall be no steeper than 3:1.	
3	BMP shall be located in a recorded Drainage Maintenance Utility Easement (DMUE over and 15' around BMP) with a recorded 20' wide access easement to a public ROW.	
4	Seasonally high groundwater table must be at least 2 feet below the bottom of the filter for open-bottom designs	
5	Volume in excess of the design volume, as determined from the design storm, shall bypass the sand filter	
6	Volume in excess of the design volume, as determined from the design storm, shall be evenly distributed across a minimum 30 feet long vegetative filter, 50 foot filter is required for some projects. If this can not be attained, alternate designs will be considered on a case by case basis	
7	The design shall be located a minimum of 100 feet from water supply wells.	
8	Seasonally high groundwater table must be at least 1 foot below the bottom of the filter for closed-filter designs in order to prevent draining the water table and floatation. Exemptions will be made if these concerns are mitigated.	
9	Maximum contributing drainage basin is 5 acres	
10	Minimum width (parallel to flow) of a sedimentation chamber or forebay shall be 1.5 feet.	
11	Sand filters must completely drain within 40 hours	
12	Sand media shall be specified below and shall be a minimum of 18" deep (minimum 12" over the drainage pipes)	
13	For underground sand filters provide at least 5 feet of clearance between the surface of the sand filter and the bottom of the roof of the underground structure.	
14	Engineer's certification of BMP completion status box checked on watershed plan coversheet	
15	Final plat recordation status box checked on watershed plan coversheet	
16	Owners' maintenance responsibility note placed on watershed plan	
17	City of Greensboro right to access note placed on watershed plan	
18	BMP Construction completion note placed on watershed plan	
19	Engineer's statement of pond and dam safety note placed on watershed plan	
20	BMP allocation table placed on coversheet	

Sand Filter Design Requirements

Item *	Design Requirement	Addressed in Design (Yes / No)
21	Operation and Maintenance (O&M) plan included with BMP design	
22	Temporary storage volume calculated using the Simple Method as presented in Section 3.3.1 of the State BMP Design Manual	
23	Emergency spillway shall not be activated by 10 year / 24 hour storm event	
24	Drain valve or other means of dewatering the filter bed provided	
25	Pertinent water surface elevations shown on basin profile view (2, 10, 100 year storms)	
26	Energy dissipation details (size and material) include for all basin inlets and outlets. Level Spreader is required if discharging to a stream buffer or adjacent property and 2 & 10 yr storm is not reduced to predevelopment levels	

* Items 1 -7	Required by the NC Administrative Rules of the Environmental Management Commission. Other specifications may be necessary to meet the stated pollutant removal requirements.
* Items 8 -14	Required by DWQ Policy
* Items 15 – 26	Required by City of Greensboro Stormwater Management Manual

APPENDIX 5

BMP Certification Requirements

Certification (General)

All structural BMP's proposed to meet the requirements of Chapter 30 Article VII Environmental Regulations, within the City of Greensboro must be designed and certified by a professional engineer in accordance with Section 30-7-1.5(D) (Permanent Engineered Stormwater Controls) and Section 30-7-1.6(B)(3) (Construction of Watershed Protection Improvements) respectively.

The type of development proposed determines the timing and type of certification required as follows:

Single Family Subdivision

1. A BMP certification of design volume (at a minimum) is required prior to issuing the first Certificate of Occupancy (CO).
2. A final certification (of design volume, functionality, and construction IAW approved plans) is required prior to issuance of the final CO.

At the time of (initial or final) CO issuance, the BMP certification should be submitted to Sediment and Erosion Control Section whereby a copy is forwarded to the Stormwater Management Division. Upon receipt of the certification, the Stormwater Operations Management Section will perform a site evaluation to determine if the certification is acceptable.

Group Development and Site Plans

1. A BMP certification of design volume (at a minimum) is required prior to issuing the first CO.
2. A BMP certification is required prior to issuance of the final CO.

Deviation to this requirement may be made for multiple parcel commercial sites (see Case 1 below). At the time of (initial or final) CO issuance, the BMP certification should be submitted to Sediment and Erosion Control Section whereby a copy is forwarded to the Stormwater Management Division. Upon receipt of the certification, the Stormwater Operations Management Section will perform a site evaluation to determine if the certification is acceptable.

Commercial Subdivision

1. A BMP certification of design volume (at a minimum) is required prior to issuing the first CO.
2. A BMP certification (of design volume, functionality, and construction IAW approved plans) is required prior to issuance of any other CO (see Case 1 below).

At the time of (initial or final) CO issuance, the BMP certification should be submitted to Sediment and Erosion Control Section whereby a copy is forwarded to the Stormwater

Management Division. Upon receipt of the certification, the Stormwater Operations Management Section will perform a site evaluation to determine if the certification is acceptable.

In any case, final approval of installed engineered stormwater controls shall be required at finalization of the grading permit or at issuance of the final building certificate of compliance, whichever comes later. If neither a building permit nor a grading permit is required for a site, then any such engineered stormwater control shall be substantially completed and have full design volume available prior to installation of any built-upon area on the site. An Engineer's Certification of Stormwater Control Completion (Table 30-7-1-6) shall be required prior to final approval by the Enforcement Officer.

TABLE 30-7-1-6
ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

The engineer's certification, required according to Section 30-7-1.6(B) of the Greensboro Development Ordinance and Section 27-22(e) of the Stormwater Management Ordinance upon completion of permanent stormwater control structures, shall be of the following form:

ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG_____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on (approval date) , has its full design volume available, and is functioning as designed.

P.E. SEAL:_____

SIGNATURE:_____

DATE:_____

BMP specific certification forms can be found at the end of this Appendix.

Recertification (Specific Cases)

Case 1: Multiple Parcel Commercial Site Sharing a Common BMP

When multiple parcels within a commercial site are to be developed in phases, a recertification of the BMP is to be requested at the time each parcel is developed and a CO is requested. An exception to this requirement will be made if the site developer/owner submits a letter to the Stormwater Management Division stating the developer/owner will maintain development control on all parcels within the development and upon completion of development on the final parcel, the BMP will be recertified as to design function and full design volume.

Case 2: New Site Development using existing BMP

When new development is proposed for an established site and the new development will be treated by an existing BMP, a site inspection of the BMP will be performed by a representative of the Stormwater Management Division. If upon completion of the site inspection, the BMP is found to be functioning as designed and in relatively good (physical) condition (as determined by the Enforcement Officer) then a recertification of the BMP will not be required. In the case of underground detention systems older than one year, a recertification will be required.

When the new development will increase the BUA to the maximum design value for the BMP, a recertification of the BMP will be required in conjunction with plan approval.

Case 3: Redevelopment

For redevelopment on a site using an existing BMP, a recertification of the BMP may be required prior to issuance of the final CO (see Case #2 above).

When the new development or redevelopment increases the BUA to the maximum design value for the BMP, **Stormwater Management Division** will require a recertification of the BMP in conjunction with plan approval.

WQ BMP Inspection

Whenever a BMP inspection results in maintenance or repairs to an existing BMP and the maintenance / repairs deviate from the approved plans on file, a recertification by a professional engineer will be required in conjunction with the repair plan approval.

City (funded) Projects

1. A BMP certification is required prior to issuance of the final CO.

In this case, **Building Inspections** requests the BMP certification and forwards a copy to the Stormwater Management Division who's Operations Management Section performs a site evaluation to determine if the certification is acceptable.

Final Plat

In accordance with Section 30-6-11.3 (Required Improvements) of the Greensboro Development Ordinance, no subdivision final plat shall be approved until all required improvements have been installed and accepted by the City or surety has been provided as set forth in Section 30-3-9 (Sureties or Improvement Guarantees).

In accordance with Section 30-7-1.6(C) (Recordation of Permanent Improvements) all permanent engineered stormwater controls and associated access/maintenance easement(s) (specific or general, at the owner's option) shall be recorded on a Pond Plat, and a mechanism to ensure their maintenance shall be established concurrent with or prior to plat recordation.

Additional (Drought) Certification Requirements

If, at the time of final certification of a wet detention pond or Stormwater wetlands, a permanent pool is not established and thus cannot be checked for full functionality in accordance with City of Greensboro code of ordinance, one of the following additional requirements shall be met prior to the acceptance of the BMP certification by Stormwater Division:

1. Submission of a geotechnical analysis sealed by a licensed professional engineer concluding the composition of the underlying BMP surface is conducive to holding a permanent pool.
2. Submission of a performance and/or maintenance bond in an amount adequate to cover the cost of relining the BMP bottom with an impervious layer.
3. Submission of a letter of guarantee by the owner or owner's representative stating that in the event the BMP will not hold a permanent pool of stormwater runoff, the owner or owner's representative will take any or all corrective measures necessary to remedy the deficiency up to and including lining the pond surfaces with an impermeable barrier or liner. **This option is not available for single family subdivision development.**

In the event corrective measures are required to establish a permanent pool, the owner or owner's representative will submit a corrective action plan (to include all corrective measures proposed) to the City of Greensboro Stormwater Management Division for review and approval prior to commencing any corrective measures. Additionally, the owner or owner's representative shall complete all corrective measures within sixty calendar days of receipt of approval from the Stormwater Management Division of the corrective action plan. Regardless of any initial corrective actions taken or agreed to, the pond must ultimately meet the design specifications and full functionality as originally designed by the engineer of record, as required by city ordinance, and shown on the approved watershed plan.

Wet Detention Pond

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	**Design**		**As-built**	
1	Slope of embankments (3:1 or flatter)				
2	Elevations of the following:				
A	Bottom of clearing, grubbing, & stripping under dam footprint				
B	Bottom of key or cutoff trench				
C	Bottom of pond				
D	Bottom of riser				
E	Top of riser				
F	Water quality orifice				
G	Top of forebay baffle				
H	Invert of inflow & outflow pipe(s)				
3	Top of dam: elevation & width				
4	Bottom width of key or cutoff trench				
5	Compaction requirement of earth work in key or cutoff trench & embankments (e.g. 95% Standard Proctor)				
6	Normal pool depth (measured from top of sediment storage)				
7	Is 10-foot wide vegetated shelf provided around all sides of main pond?				
8	Forebay maintenance access provided (top of embankment to pond bottom)?				
A	Width of maintenance bench				
9	Barrel seepage control: type & size				
10	Size & material of riser/barrel				
11	Verification of volume:				
A	Permanent sediment storage (ft^3) allocation to forebay & pond				
B	Permanent pool surface area (ft^2)				
C	Temporary water quality volume (ft^3)				

Wet Detention Pond

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

12	Emergency Spillway: width & crest elevation				
13	Waterstops installed (if applicable)				
14	Size of riser footing (if applicable)				
a	Rebar installed (if applicable)				

Wet Detention Pond

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG _____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on _____, has its full design volume available, and is functioning as designed.

P.E. SEAL:

SIGNATURE: _____ DATE: _____

Stormwater Wetlands

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	Design		As-built	
1	Slope of embankments, excavations and/or cuts (3:1 or flatter)				
2	Elevations of the following:				
a	Bottom of clearing, grubbing, & stripping under dam footprint				
b	Bottom of key or cutoff trench				
c	Bottom of forebay & micropool				
d	Bottom of riser				
e	Top of riser				
f	Water quality orifice				
g	Invert of inflow & outflow pipe(s)				
3	Top of dam: elevation & width				
4	Bottom width of key or cutoff trench				
5	Compaction requirement of earth work in key or cutoff trench & embankments (e.g. 95% Standard Proctor)				
6	Width of maintenance benches				
7	Barrel seepage control: type & size				
8	Size & material of riser / barrel				
9	Verification of area & volume:				
a	Permanent sediment storage (ft^3)				
b	Total wetland surface area (ft^2)				
c	Permanent pool "high marsh" depth & surface area (ft^2)				
d	Permanent pool "low marsh" depth & surface area (ft^2)				
e	Forebay (perm. pool) surface area (ft^2)				
f	Micropool (perm.) surface area (ft^2)				
10	Wetland plantings (number and type)				

Stormwater Wetlands

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

11	Temporary water quality volume (ft^3)				
12	Pool elevation at principal spillway				
13	Emergency Spillway: width & crest elevation				

Stormwater Wetlands

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

ENGINEER'S CERTIFICATION OF STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG _____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on _____, has its full design volume available, and is functioning as designed.

P.E. SEAL:

SIGNATURE: _____ DATE: _____

Bioretention Area

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	**Design**		**As-built**	
1	Bioretention Surface Area				
2	Type & width of pretreatment				
3	Elevations of the following:				
a	Bottom of planting soil				
b	Top of planting soil				
c	Top of mulch layer				
d	Inlet of overflow / bypass structure				
4	Ponding depth				
5	Runoff volume captured (ft^3)				
6	Underdrain System Specifications:				
a	Size & type of perforated pipe				
b	Types and thickness of filter layers around the perforated pipe (#57 stone, choking stone, sand, etc.)				
c	Number of branch lines & spacing width of perforated pipe				
d	Invert elevation of underdrain				
e	Invert elevation of outflow pipe at outlet				
7	Invert elevation of receiving storm sewer / receiving stream water surface				
8	Planting Soil (attach soil test report):				
a	Planting soil depth				
b	Percentage clay				
c	Percentage sand				
d	Percentage organic material				
e	Percentage silt				
f	Soil pH				

Bioretention Area

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

9	Planting Specifications:				
a	Planting density (stems/acre)				
b	Number & type of trees				
c	Number & type of shrubs				
d	Number & type of herbaceous species				

Bioretention Area

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG _____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on _____, has its full design volume available, and is functioning as designed.

P.E. SEAL:

SIGNATURE: _____ DATE: _____

Sand Filter

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	Design		As-built	
1	Sand Filter Type				
2	Sediment Chamber Specifications:				
a	Sediment Chamber bottom elevation				
b	Sediment Chamber depth				
c	Sediment Chamber surface area (ft^2)				
d	Sediment Chamber volume (ft^3)				
3	Sand Filter Chamber Specifications:				
a	Elevation at top of filter media				
b	Depth of filter media				
c	Filter bed area				
d	Volume				
e	Type & size of filter media				
4	Percent of water quality volume stored in sediment chamber & facility				
5	Underdrain System Specifications:				
a	Size & type of perforated pipe				
b	Type (of stone) and thickness of filters around perforated pipe				
c	Number of branch lines				
d	Invert elevation of underdrain				
e	Invert elevation of outflow pipe at outlet				
f	Invert elevation of receiving storm sewer / receiving stream water surface				
g	Depth of gravel jacket				
6	Invert elevation of overflow / bypass structure				
7	Dissipator pad length & width				
8	Maintenance access provided (Yes / No)				

Sand Filter

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG_____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on _____, has its full design volume available, and is functioning as designed.

P.E. SEAL:

SIGNATURE: _____ DATE: _____

Dry Detention Basin

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	Design		As-built	
1	Slope of embankments (3:1 or flatter)				
2	Elevations of the following:				
a	Bottom of clearing, grubbing, & stripping under dam footprint				
b	Bottom of key or cutoff trench				
c	Bottom of Basin				
d	Bottom of riser				
e	Top of riser				
f	Low flow (WQ) orifice (if applicable)				
g	Invert of inflow & outflow pipe(s)				
3	Top of dam: elevation & width				
4	Bottom width of key or cutoff trench				
5	Compaction requirement of earth work in key or cutoff trench & embankments (e.g. 95% Standard Proctor)				
6	Sedimentation Basin surface area (ft^2)				
7	Maintenance access provided (top of embankment to bottom of basin)				
a	Width of maintenance bench				
8	Barrel seepage control: type & size				
9	Size & material of riser/barrel				
10	Verification of volume:				
b	Temporary water quality volume (ft^3)				
11	Emergency Spillway: width & crest elevation				
12	Waterstops installed (if applicable)				
13	Size of riser footing (if applicable)				
a	Footing rebar installed (if applicable)				

Dry Detention Basin

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG _____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on _____, has its full design volume available, and is functioning as designed.

P.E. SEAL:

SIGNATURE: _____ DATE: _____

Underground Detention System

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	**Design**	**As-built**
1	Detention tank or pipe length, width, depth (or diameter) & material of construction		
2	Elevations of the following:		
A	Bottom of excavation for detention system		
B	Depth of system bedding		
C	Invert of detention tank / pipe(s)		
D	Invert of inflow & outflow pipe(s) Inflow: Outflow:		
E	Invert of low flow orifice (if applicable)		
F	Invert of overflow weir or orifice (if applicable)		
G	Top of manhole cover(s)		
3	System access:		
A	Means of ingress / egress (i.e. access ladder or manhole steps)		
B	Number of access manholes & maximum distance between manholes		
C	Manhole covers locked or bolted (yes / no)		
D	Provisions to prevent unauthorized access via outlet pipes (yes / no)?		
4	Inlet / outlet pipes visible from access points (yes / no)		
5	Verification of volume:		
A	Temporary sediment storage volume (ft^3) and max. depth (ft)		
6	Low flow orifice material of construction		

Underground Detention System

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG _____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on _____, has its full design volume available, and is functioning as designed.

P.E. SEAL:

SIGNATURE: _____ DATE: _____

Infiltration Device

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	Design		As-built	
1	Side slope grade (no steeper than 3:1)				
2	Infiltration device (surface) grade (0.05% max.)				
3	Infiltration device area (length and width in feet)				
4	Depth to infiltration trench bottom liner				
5	Soil hydraulic conductivity (inches/hr)				
6	Distance to nearest surface waters (min. of 30')				
7	Distance to nearest water supply well > 100 feet?				
8	Distance to nearest structure (min. 15' downgradient)				
9	Elevations of the following:				
A	Bottom of infiltration device				
B	Top of infiltration drainage media				
C	Impervious soil horizon or bedrock (min. 2' below bottom of device)				
D	Seasonal high water table				
E	Upper edge of filter strip				
F	Surface of filter fabric protective layer				
G	Lower edge of filter strip				
10	Treatment storage (WQ) volume (ft^3)				
11	Number of observation wells (min. of one)				
12	Type of pretreatment device utilized				
13	Length of filter strip (min. length 30')				
14	Width (parallel to flow) of filter strip (min. 30')				
15	Is maintenance access provided (to infiltration device and filter strip)?				

Infiltration Device

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG _____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on _____, has its full design volume available, and is functioning as designed.

P.E. SEAL:

SIGNATURE: _____ DATE: _____

Filter Strip

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	Design	As-built
1	Grade (surface) slope (no greater than 15%; 5% or less preferred)		
2	Elevations on the following:		
A	Top of level spreader lip		
B	Upper edge of Filter Strip		
C	Lower edge of Filter Strip		
3	Length of Filter Strip (min. of 13' and max. of 130')		
4	Width of Filter Strip (30' minimum)		
5	Vegetation Plan Specifications:		
A	Percentage natural wooded		
B	Percentage planted wooded		
C	Percentage grass and thick ground cover		
6	Is maintenance access provided (to distribution device and filter strip)?		

Filter Strip

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

ENGINEER'S CERTIFICATION OF
STORMWATER CONTROL COMPLETION

I certify that, pursuant to generally accepted engineering standards in the community, it is my professional opinion that the stormwater control(s) labeled as _____ on this plat (or on name of plat) as recorded in PB _____, PG _____ in the Office of the Guilford County Register of Deeds has been completed in conformance with the plans and specifications approved on _____, has its full design volume available, and is functioning as designed.

P.E. SEAL:

SIGNATURE: _____ DATE: _____

Restored Riparian Buffer

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
(336) 373-2055

Project: _____ Date: _____

	Description	Design	As-built
1	Riparian buffer slope (no greater than 6%)		
2	Elevations on the following:		
A	Top of distribution device (i.e. level spreader or equivalent) lip		
B	Upper edge of Riparian Buffer		
C	Lower edge of Riparian Buffer		
3	Flow to distribution device (one inch per hour storm)		
4	Length of distribution device (i.e. level spreader or equivalent; min. of 13' and max. of 130')		
5	Length of Riparian Buffer (min. of 13' and max. of 130')		
6	Width of Riparian Buffer (parallel to flow; 50' minimum)		
A	Width of grass zone (Zone 1)		
B	Width of forest vegetation zone (Zone 2)		
7	Zone 1 Planting Specifications:		
A	Tree planting density (stems/acre) and diameter breast height (dbh)		
B	Shrub planting density (shrubs/acre)		
8	Zone 2 Planting Specifications:		
A	Grass species (include plugging specifications if applicable)		
9	Is maintenance access provided (to distribution device & riparian buffer)?		

Restored Riparian Buffer

Record of Construction
Engineer's Certification of Completion

Water Resources Department
Stormwater Management Division
2602 S. Elm-Eugene St.
Greensboro, NC 27406
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P.E. SEAL:

SIGNATURE: _____ DATE: _____

APPENDIX 6

BMP Inspection and Maintenance Check List

Permanent Wet Detention Pond Maintenance Guidelines
City of Greensboro, Stormwater Management Division

Introduction

The purpose of this document is to provide owners of permanent wet detention ponds with a set of general guidelines to help maintain these structural stormwater best management practices. For owners to appreciate the need for routine and non-routine maintenance of their wet detention ponds, it is important that they are aware that these ponds provide value to the quality of our surface waters and in many cases can be an amenity to their property. Periodic inspections and maintenance are key factors in preserving the functionality of stormwater wet detention ponds. Wet detention ponds are not self-maintaining systems, and over time the efficiency of these structures to remove pollutants will diminish. Trapped sediments and other pollutants can potentially reduce the volume capacity of the ponds, therefore reducing their potential to treat stormwater runoff. The following guidelines are provided for the benefit of owners of wet detention ponds to help ensure that the pond will continue to meet the objectives for which it was designed. In addition to inspecting and maintaining components that sustain a wet detention pond's water quality functionality, attention must also be paid to the structural components that sustain its hydraulic functionality. Minimizing the risk of hydraulic malfunction (potentially leading to structural failure) is essential, especially for larger impoundment structures such as wet detention ponds. The majority of the wet detention ponds in Greensboro are located in urbanized settings, where structural failure may jeopardize downstream life and property. Maintenance is also important to prevent the decline in the appearance of the wet detention pond. Unhealthy conditions (such as noxious vegetation, stagnant water, etc.) may occur within and around the pond, which may affect the aesthetics and economic value of the surrounding property.

Wet Detention Pond Maintenance

The City of Greensboro's water-supply watershed (Ch. 30) ordinance and the 1999 stormwater management (Ch. 27) ordinance require property owner or owners' associations to meet certain maintenance requirements established for constructed wet detention ponds. The City has the authority to inspect these ponds periodically and require the pond owner to perform maintenance activities, when necessary. The City, as required by the State, will conduct periodic inspections of wet detention ponds implemented for water-supply watershed protection. The City will advise the owner of recommended and/or required maintenance actions needed to maintain the wet detention pond's functionality.

Dam Safety

Preserving the structural integrity of the wet detention pond's dam 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) *leakage and seepage*; (3) *dam material problems*; and (4) *vegetation growth* on the dam embankments.

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 proper engineering practices. The City has requirements concerning the maintenance of dams associated with required wet detention ponds. As new development occurs downstream of the pond, 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.

Leakage and Seepage

The downstream side of the dam should be inspected regularly for evidence of significant leakage or seepage. Seepage can emerge anywhere below the normal pool elevation, including the downstream slope of earth dams, areas beyond the toe of the dam, and around the spillway or pond outlet conduit. Indications of significant seepage include areas where the soil is saturated or where there is a flowing "spring" or leak. If "sinkholes" in the dam embankment are noticed, or if constant flowing water is noticed on the downstream side of the dam, then seepage has become excessive and professional engineering advice should be sought immediately to avert a major structural problem or a catastrophic failure of the dam.

Dam Material Problems

For earthen 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.

Vegetative Growth
Trees and other woody vegetation are not permitted on the top, slopes, or embankments of earthen dams. 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 groundhogs and muskrats. 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 from becoming established.**

Pollution Prevention Activities

To assist the wet detention pond in improving the quality of stormwater runoff, every effort should be made to reduce the pollutant load entering the pond system. The following onsite efforts should be made to reduce pollutants from entering the pond:

- 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 algal growth in the 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 algal 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.

Stabilization of Wet Detention Pond Drainage Area

The area draining to the wet detention pond should remain stabilized to prevent excessive sediment from entering the pond. When bare soil is directly exposed to precipitation, the sediment concentration in runoff is much higher than for soil that is covered and stabilized. A stabilized area is covered by impervious surfaces (pavement, buildings), grass cover, landscaping (mulch, pine straw), etc. It is in the best interest of the pond owner to reduce onsite sediment runoff to the pond, as this will reduce the life span of the pond and result in the need for more periodic, expensive dredging.

Embankments

If pond embankments are not kept well vegetated with grasses, erosion may occur. Erosion can be repaired by filling the small channels and gullies with suitable soil, compacting, and seeding. It may be necessary to install temporary erosion control (such as hay bales) along heavily eroded

areas to allow the repaired areas to stabilize. It is especially important to inspect for and immediately repair any erosion on the dam embankments.

Pipe Inlet and Outlet areas

Where erosion causes the undercutting of the downstream end of pipe, the undercut should be stabilized immediately to prevent the end pipe section from "breaking" off. Eroded areas should be filled with good compactable soil and covered with geotextile fabric and rip-rap.

Open Channel Flow

Eroded areas should be seeded/sodded and protected with temporary velocity dissipation (such as excelsior matting, straw bales, etc.). If erosion continues, a more robust lining should be used.

Blockage of Outlets

Wet 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 **monthly, or after every runoff-producing rainfall event.**

Principal and Emergency Spillway

Principal and emergency spillways are designed to safely convey one-inch rainfall events, and those larger storms that produce runoff which exceed the water quality volume of the wet detention pond. 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 **monthly, or after every runoff-producing rainfall event.**

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. The emergency spillway and outlet area where the barrel projects from the fill slope should be clear of woody vegetation, tree limbs, sediment accumulation, etc.

Sediment Accumulation

To preserve the wet detention pond's pollutant removal capability, sediment must be removed in areas where the capacity of the design sediment storage volume has been exceeded. The pond forebay helps to improve the removal efficiency of the pond system by trapping the majority of coarser suspended solids behind a rock baffle. When sediment deposition in the forebay exceeds the designed sediment storage capacity for the forebay, the forebay must be dredged. Typically, forebays will need to be dredged every 5 to 10 years. Depth measurements relative to the normal surface elevation (bottom of water quality orifice) should be taken at several locations around the pond. The sediment is to be removed when the measured depth is less than the design permanent water depth. Most wet detention ponds are designed for a three to four foot permanent water depth. As sediment accumulates in the pond, the permanent water depth is reduced along with the pond's ability to treat pollutants in the runoff. If a forebay is used at the inlet area of the pond and is regularly dredged, the frequency of dredging the entire pond could be greatly reduced. Check water depth at various points in the pond **semi-annually**. If depth is reduced to 75 % of the original design depth, sediment must be removed to at least the original design depth.

Sediment from most sources is usually not hazardous or contaminated, however, it is very "soupy" and is difficult to manage. It is good idea to provide a storage area near the wet detention pond to place sediment once it is dredged to allow it to dry. If desired, sediment may be land applied and seeded, while following all pertinent soil and erosion control regulations. If land applied on-site, it should be within the drainage area to the pond so sediment that runs off can be recaptured.

Wet Detention Pond Maintenance

Routine Maintenance
Routine maintenance shall include minor upkeep such as mowing; trash and debris removal; minor slope repair and stabilization; periodic structural inspections of the valves, gates, dam, etc.; and tree and brush removal from the dam, spillway, inlet(s), and outlet. These maintenance items may be performed by the owner without review of a Professional Engineer.

Non-Routine Maintenance
Non-routine maintenance shall include such items as sediment clean-out (dredging); channel stabilization; and problems regarding the principal spillway conduits, emergency spillway, dam failure, and seepage. These items require a Registered Professional Engineer to prepare a plan and/or details and to certify completion of the maintenance. All revisions and repairs to permanent runoff control structures shall be done in accordance with City of Greensboro guidelines and specifications.

Maintenance Schedule: estimated schedule - certain ponds may require more or less frequent attention.

I. **Monthly**, or after every runoff-producing rainfall event.
A. Remove trash and debris from the trash rack.
B. Check and clear the orifice of any obstructions.

C. Check the pond side slopes for erosion and remove trash from around the pond.
D. Inspect principal and emergency spillways for blockage.

II. **Quarterly**, or after major storm events (more than 2 inches of rain).
A. Inspect the collection system (e.g. catch basins, piping, grassed swales) for proper functioning. Clear accumulated trash from basin grates and basin bottoms, and check piping for obstructions.
B. Check pond inlet pipes for undercutting, replace rip-rap that is choked with sediment, and repair broken pipes.
C. Check the operation of the gate valve. All valves should be operated from the fully closed to the fully open position.
D. Remove woody vegetation (trees and brush) from dam embankment surfaces and spillway(s).

III. **Semi-Annually**
A. Remove accumulated sediment from the bottom of the outlet structure.
B. Check for presence of rip-rap at inlet pipes and replace if necessary.
C. Check pond depth at various points in the pond. If mean depth is reduced to 75 % of the original design depth, sediment will be removed to at least the original design depth.
D. Check riser and barrel for improper alignment, elongation and displacement of joints, cracks, leaks, loss of protective coating, corrosion, and blockage - repair as necessary.

IV. **General**
A. Mow side slopes according to the season. Maximum grass height should be nine (9) inches.
B. Riparian and aquatic vegetation (willows, alders, cattails, etc.) are encouraged along the perimeter of the pond at the water's edge. However, the dam, emergency spillway, inlet(s), and water control structure should be kept clear of all woody vegetation.
C. In case the ownership of the pond should change, the current owner should, within thirty (30) days of transfer of ownership, notify the City of Greensboro, Stormwater Management Division of such ownership transfer.
D. Excessive plant growth, algae blooms, odors, discoloration, perceived animal pests, etc. should be addressed with the Stormwater Management Division on an as-needed basis. Solutions to these problems should be non-chemical and deemed safe to our drinking water supply.

<u>Annual Inspections</u>
Annual maintenance inspections will be performed by the Stormwater Management Division. The owner of the pond will be notified of the results of the inspections and any maintenance that may be recommended or required.

* for additional information, please consult:

City of Greensboro, Stormwater Management Division. 2000. Stormwater Management Manual. First Edition.

Also available on the internet at:
www.ci.greensboro.nc.us/stormwater/Planning/TechnicalDocuments/SWM_update.pdf

BIORETENTION MAINTENANCE PLAN*

Routine and Non-Routine Maintenance of Bioretention Areas:

Paved Area Sweeping Program

A paved area sweeping program should be implemented for all properties that utilize bioretention areas. Sweeping paved areas on a periodic basis will help extend the life of this best management practice (BMP) by reducing the pollutant load and debris that enters it.

Mowing/Landscaping Activities

Mowing/landscaping activities on the property should to be conducted in such a way to prevent lawn and plant clippings as well as eroded sediment from entering the bioretention area. One way to prevent clippings from entering the cell is to use a mulching mower or bag, and remove clippings. This is especially important in areas that drain to the BMP.

Minimum Inspection and Maintenance Requirements

The following inspection/maintenance activities should be conducted on a **quarterly** (i.e., 4 times per year) basis, unless noted otherwise:
* This information is provided as a typical maintenance plan for bioretention areas in Greensboro. You may find that the specific maintenance needs or timeframe for maintenance of your bioretention area may be slightly different due to site-specific characteristics of your property and stormwater treatment device. For more information, please refer to the City of Greensboro's *Stormwater Management Manual (2000).*

Overall bioretention area

(a) Remove accumulated litter and debris should be removed from the bioretention area.
The bioretention area should remain clear of trash and debris to preserve the draw down rate and stormwater treatment function of the cell. The type of debris removed should be noted and their possible sources identified. Efforts should be made to reduce the amount of debris entering the bioretention area.

(b) Observe the filtration performance of the cell (every six months at a minimum).
After a storm event the bioretention area should hold several inches of standing water, but this water should drain within one to two days. If not, corrective maintenance to restore proper drawdown time and stormwater treatment performance of the filter bed should be performed in the following order:

1. Clean out the underdrain system.
2. Remove mulch and top few inches of planting soil and replace. The clogged material should be replaced with new material of the original specifications. Contaminated soil should be removed and disposed of at an approved site (landfill). Instead of replacing the top layer of planting soil, it may be possible to aerate or cultivate the first few inches to restore the draw down capacity of the cell.
3. If appropriate draw down time cannot be restored the owner will be required to remove and replace the filter bed and underdrain system.

Pretreatment Area

(a) Inspect energy dissipators for proper functionality.

Energy dissipators (rip-rap pads, check dams, etc) that are used to slow down and spread the runoff before it enters the bioretention area should be inspected for proper functionality. Sediment build-up should be removed. Once the voids become substantially filled with sediment, the rock must be removed, cleaned (away from bioretention area) and placed back in its original location. Larger rock or other measures may be required if the rock is being carried away by high flows.

(b) Inspect filter strips and channels for bare areas, rill or channel erosion.

A healthy stand of grass or similar ground cover for the pretreatment areas must be maintained. Bare areas and eroded areas should be stabilized, and seeded or sodded immediately.

Plantings

(a) Replace plantings that are dead, diseased, or otherwise have failed to establish.

If replacing plantings frequently, the planting soil may need to be tested. Make sure that the plantings used are to able withstand the bioretention environment (e.g. frequent inundation and drying).

(b) Prune and weed as needed or desired.

Make sure that all loose vegetation is removed from the bioretention cell so as not to interfere with the functionality of the cell.

Mulch Layer

(a) Inspect the cell for proper mulch cover.

Mulch needs to be reapplied in areas where erosion has displaced the mulch (mulch just may need spreading out). It will be necessary to replace the mulch layer once a year as the mulch decays. The thickness of mulch should be approximately 3-4 inches.

Soil Media

(a) Test the pH of the soil (annually).

To keep plantings healthy, the planting soil should be tested once a year to determine if the pH is in the acceptable range (5.5-6.5). Contact the Guilford County Cooperative Extension Service for advice on testing your soil and adjusting the pH.

(b) Test the toxicity of the soil (as needed, approximately once every 5 years).
After several years of service, the quantity of heavy metals and other pollutants that are collected by the cell may reach toxic levels, which may impair plant growth and the effectiveness of the cell. If the toxic levels are too high, the soil media must be replaced.

Outlet

(a) Verify that there is discharge from the drain pipe after storm events.
If there is no discharge from the outlet drain pipe, the underdrain system or soil media may be clogged. If so, corrective maintenance is needed immediately to restore the functionality of the bioretention area.
(b) Inspect the overflow grate and pipe to ensure it is not blocked with debris.
(c) Maintain access to the outlet pipe for inspection.
(d) *Inspect for and repair erosion problems at the outlet areas.*
The discharge area at the outlet pipe should be inspected to ensure there is no erosion. A rip-rap energy dissipator, if not already in place, may be needed if erosion continues to occur.

*The design engineer and/or developer should initially be responsible for providing pond owners with inspection and maintenance guidelines.

APPENDIX 7

Preliminary BMP Capital Cost Estimates
Quantity and Combined Quantity & Quality Control

When a wet or dry detention structural BMP is proposed to meet the requirements of Chapter 30 Article VII Environmental Regulations, the following procedure may be used to determine the preliminary construction costs. The preliminary construction cost is used as the basis for establishing the amount of surety that must be posted whenever an initial CO or final plat recordation is requested prior to BMP certification.

Preliminary estimates of capital costs of storm water ponds (water quantity and/or quality) are presented in the attachments for the following cases.

1. Ponds **inside** the Water Supply Watersheds
   - Cost of **wet detention ponds** without peak runoff control (Water Quality Control only)
   - Cost of **wet detention ponds** with peak runoff control (Water Quality and Quantity control)

2. Ponds **outside** the Water Supply Watersheds
   - Cost of **dry detention ponds** for peak runoff control (Water Quantity Control only)
   - Cost of **wet detention ponds** with peak runoff control (Water Quantity and Quality control)

In the Water Supply Watersheds, the incremental cost of providing for peak runoff (Quantity) control (in addition to the required water quality control storage), is approximately 17% of the base cost of the water quality wet pond.

Outside the Water Supply Watersheds, the incremental cost of providing for Quality control (in a wet detention pond) is approximately 45% of the base cost of peak runoff (Quantity) control in a dry detention pond.

Cost Estimate Methodology

Pond storage volumes (V_s) required for the different cases stated above were estimated based on Guilford County's "Water Quality Protection Manual" and data from selected projects in Greensboro. Capital Cost (CC) estimates for the required storage (V_s in cubic feet) in the ponds were then derived by using a formula (with a suitable adjustment to the constant in the formula) presented in a paper by the Center for Watershed Protection based on studies of a number of ponds in the Mid-Atlantic region: $\mathbf{CC = 30\ (V_s)^{0.7}}$. The cost estimate includes engineering and administration costs.

To determine the preliminary capital cost estimate perform the following:

1. Determine whether the BMP is located inside or outside the City of Greensboro watersupply watershed.
2. Determine the amount of drainage area and BUA to the BMP.
3. Locate the appropriate curve with the information gathered from the first two steps. Using the amount of drainage area as the entering argument read up until you intersect the curve that represents the BMP to be constructed (water quality only, quality and quantity combined or quantity only). Read across to obtain the preliminary capital cost estimate. For development with BUA values that do not fall directly on a plotted curve perform one of the following:
    a. Use the plot representing the next highest BUA value from the development proposed or
    b. Interpolate between the two plots that bracket the BUA value for the development proposed

Cost Escalation Determination

To provide a method for escalating the cost of BMP construction due to inflationary factors the following approach should be used.

1. Determine the preliminary capital cost estimate in accordance with the procedure outlined previously. The resulting cost is to be used as a 2007 fiscal year baseline.
2. Using the U.S. Army Corps of Engineers Civil Works Construction Cost Index System (CWCCIS) located at http://www.nww.usace.army.mil/cost/ and **Appendix A Table 2** Yearly Cost Indexes, find the composite cost index for reservoirs and dams (CWBS – Feature Code 03 and 04) in FY 2007 (baseline year) and the year construction is proposed.
3. Use the formula shown in the example below to determine the escalated construction cost.

The following formula is used for the purpose of updating/escalating an existing project cost.

$$\frac{Cost\ Index - Year\ A}{Cost\ Index - Year\ B} \times Cost\ in\ Year\ B\ (known) = Cost\ in\ Year\ A\ (Unknown)$$

Cost Index A - Cost index for the Year the project costs are updated to.
Cost Index B - Cost index for the Year the project costs are updated from.

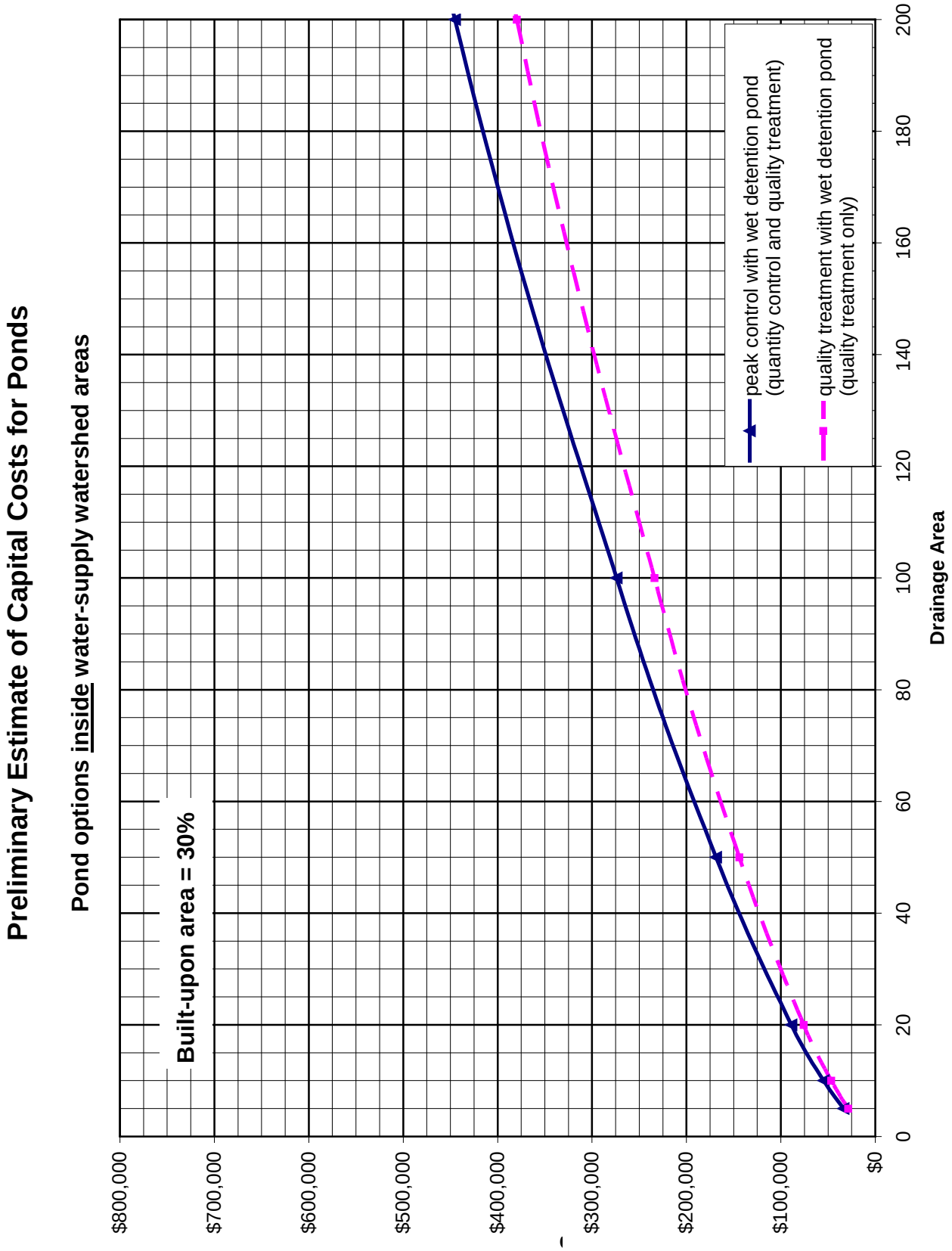
Example - Assume the following:
You have a wet detention pond cost of $75,000
Date of the project cost is FY 2007 (baseline year)

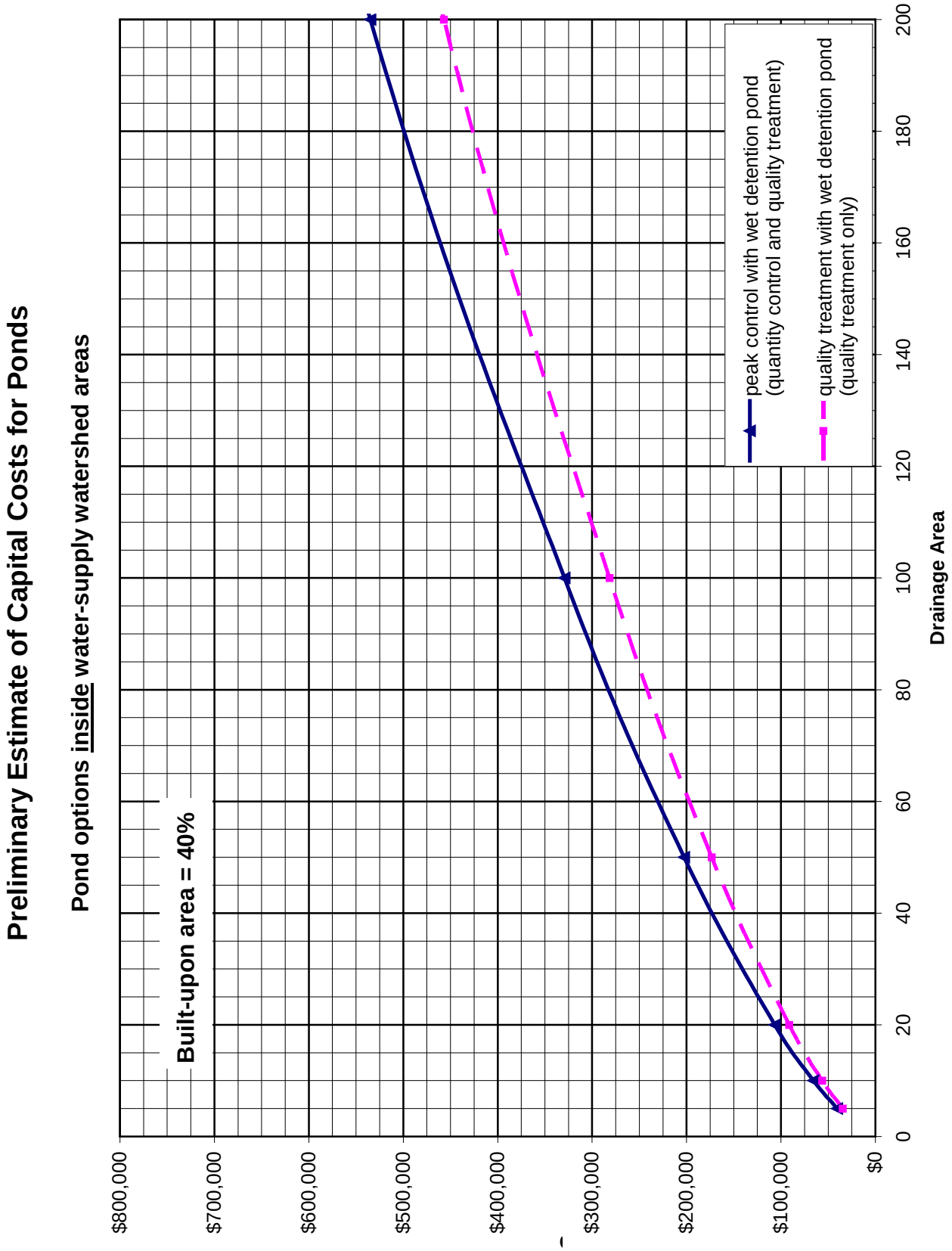
Feature Code is a composite of 03 - Reservoirs and 04 - Dams – Cost Index (for FY 2007) is the average of 700.34 and 663.57 or **681.96**

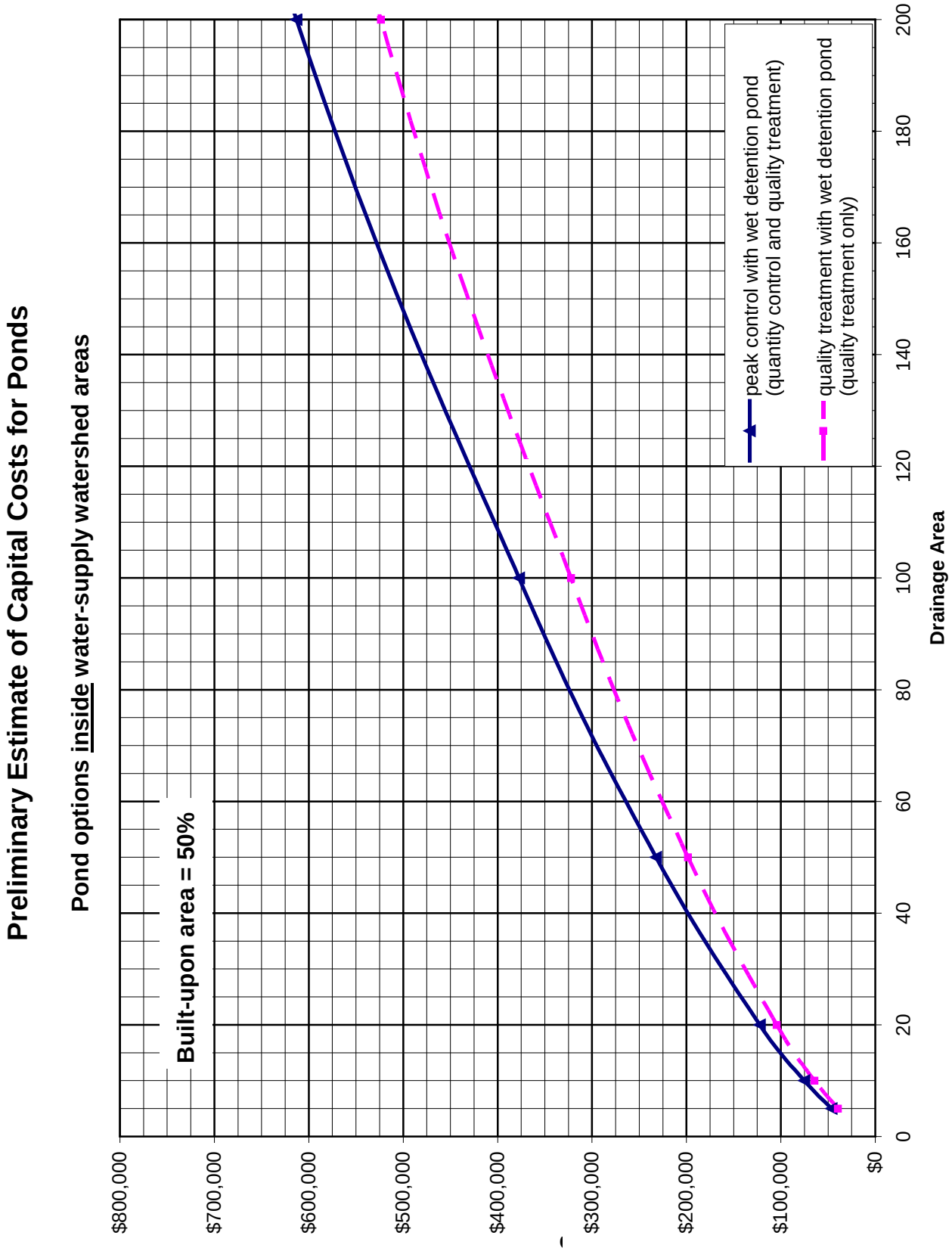
You want to escalate the project cost to FY 2009

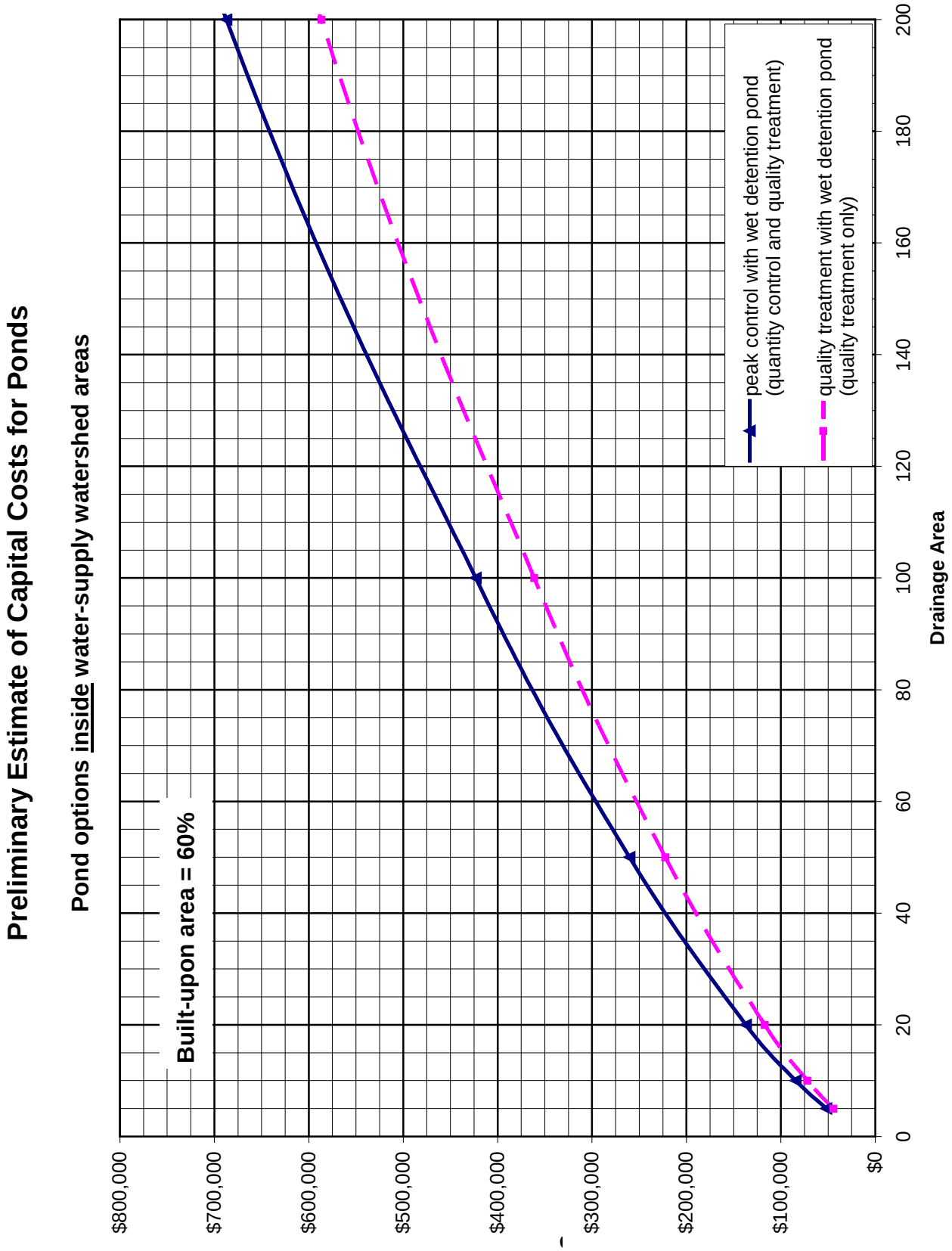
Feature Code is a composite of 03 - Reservoirs and 04 - Dams – Cost Index (for FY 2009) is the average of 731.65 and 694.76 or **713.21**

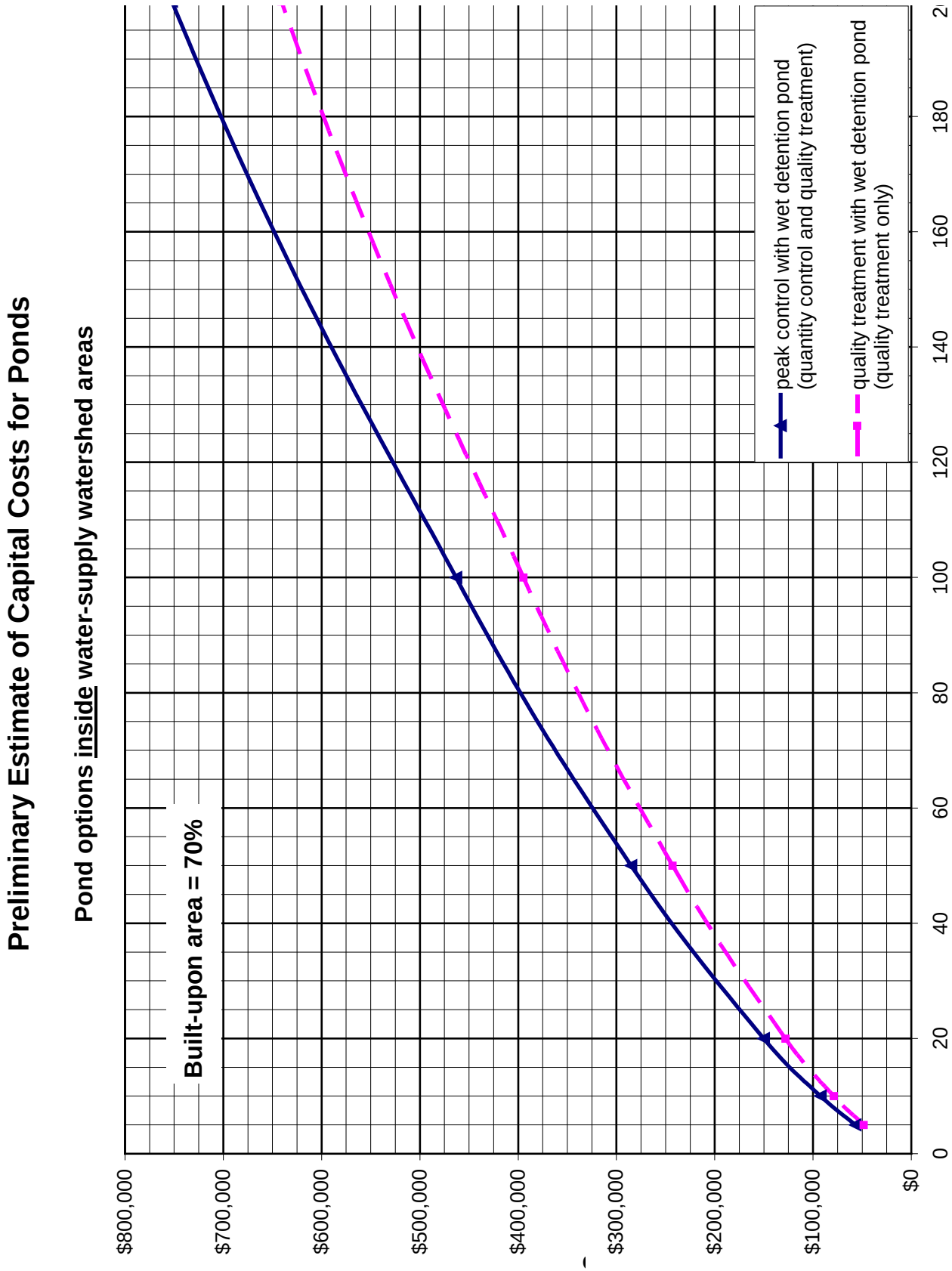
$$\frac{713.21}{681.96} \times \$75{,}000 = \textbf{\$78,437} \text{ in FY 2009}$$

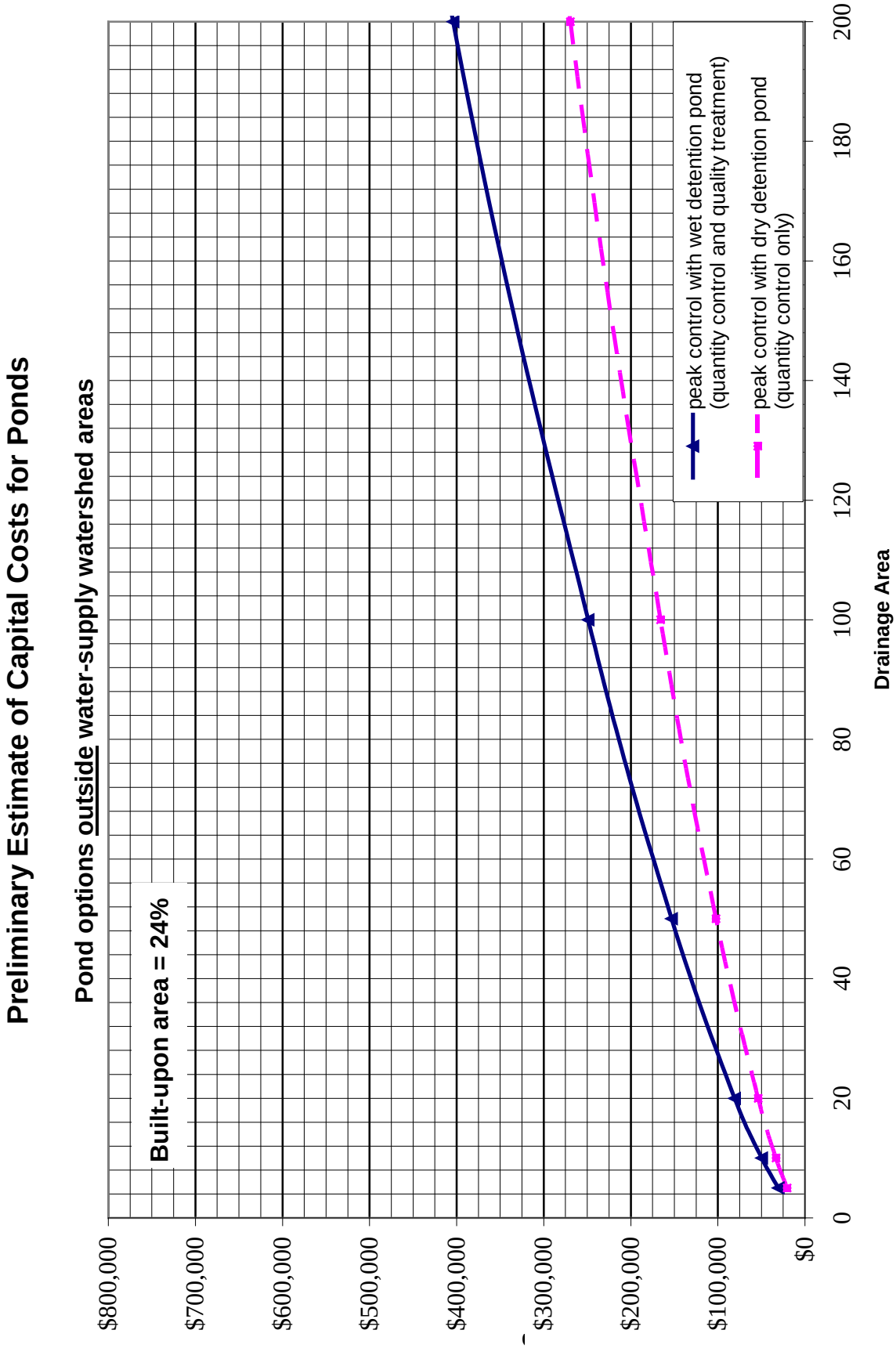

Preliminary Estimate of Capital Costs for Ponds
Pond options inside water-supply watershed areas
Built-upon area = 30%
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
quality treatment with wet detention pond (quality treatment only)

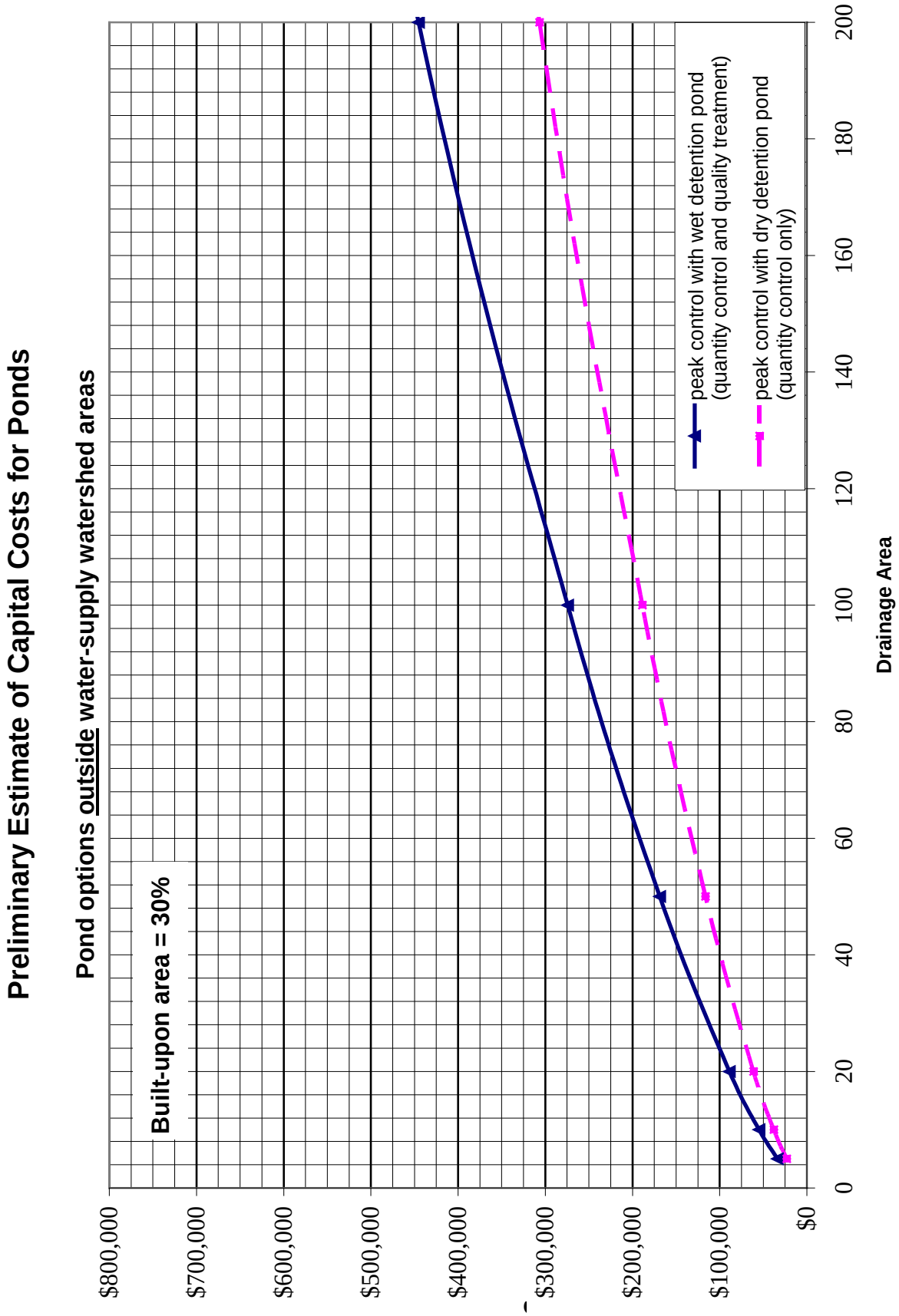

Preliminary Estimate of Capital Costs for Ponds
Pond options inside water-supply watershed areas
Built-upon area = 40%
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
quality treatment with wet detention pond (quality treatment only)


Preliminary Estimate of Capital Costs for Ponds
Pond options inside water-supply watershed areas
Built-upon area = 50%
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
quality treatment with wet detention pond (quality treatment only)


Preliminary Estimate of Capital Costs for Ponds
Pond options inside water-supply watershed areas
Built-upon area = 60%
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
quality treatment with wet detention pond (quality treatment only)


Preliminary Estimate of Capital Costs for Ponds
Pond options inside water-supply watershed areas
Built-upon area = 70%
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
peak control with wet detention pond (quantity control and quality treatment)
quality treatment with wet detention pond (quality treatment only)


Preliminary Estimate of Capital Costs for Ponds
Pond options outside water-supply watershed areas
Built-upon area = 24%
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
peak control with dry detention pond (quantity control only)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Pond options outside water-supply watershed areas
Built-upon area = 30%
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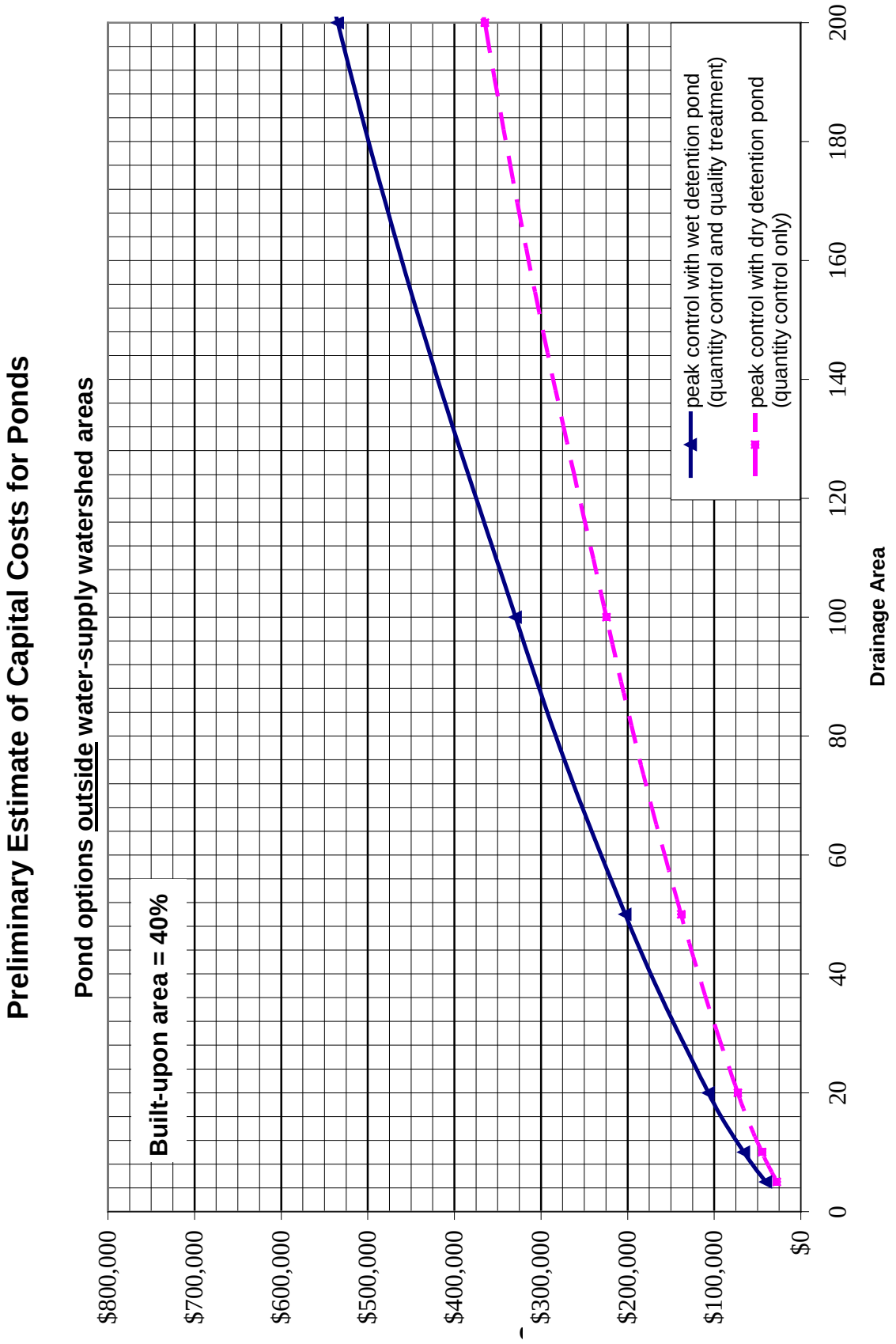
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
peak control with dry detention pond (quantity control only)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Pond options outside water-supply watershed areas
Built-upon area = 40%
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$700,000
$600,000
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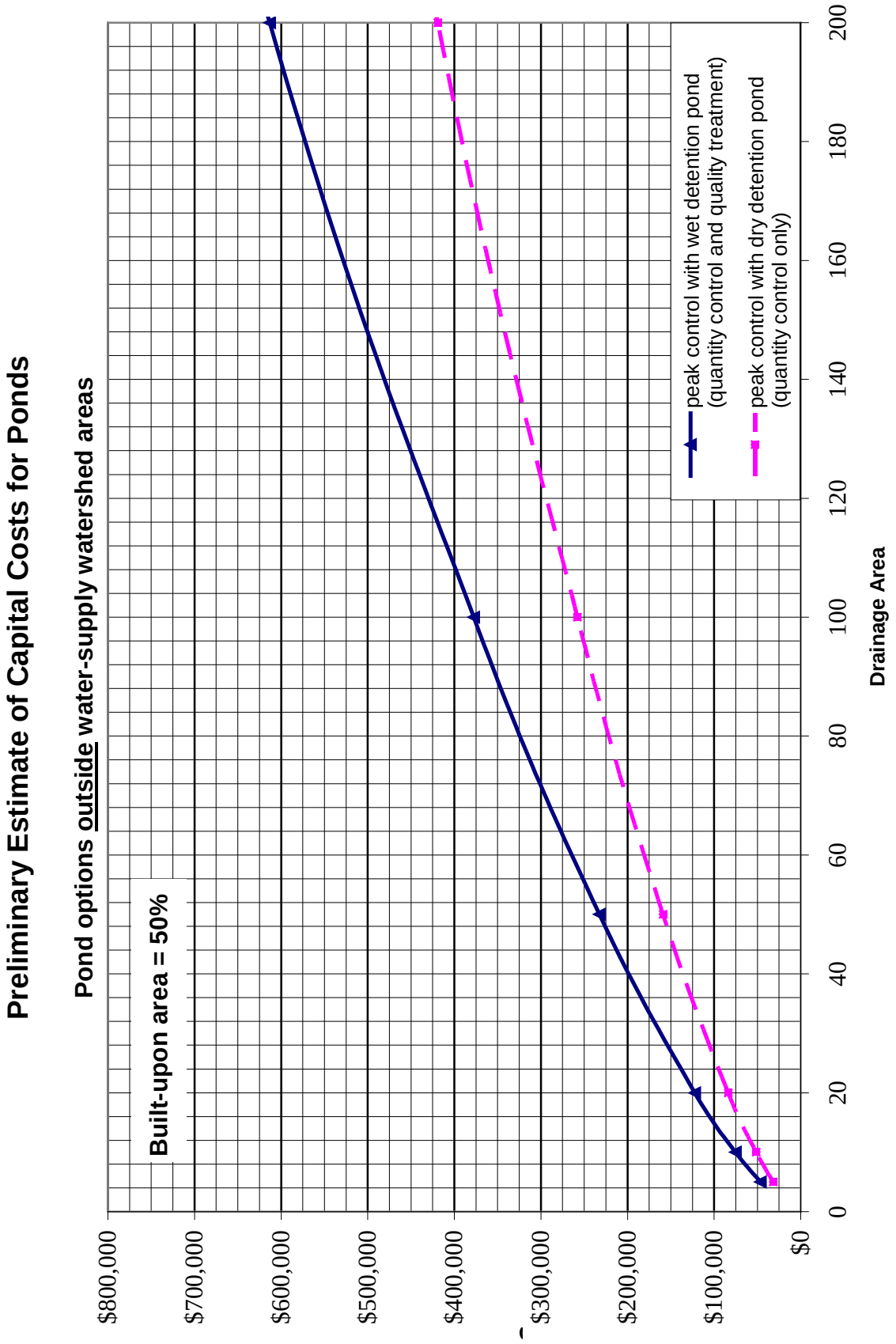
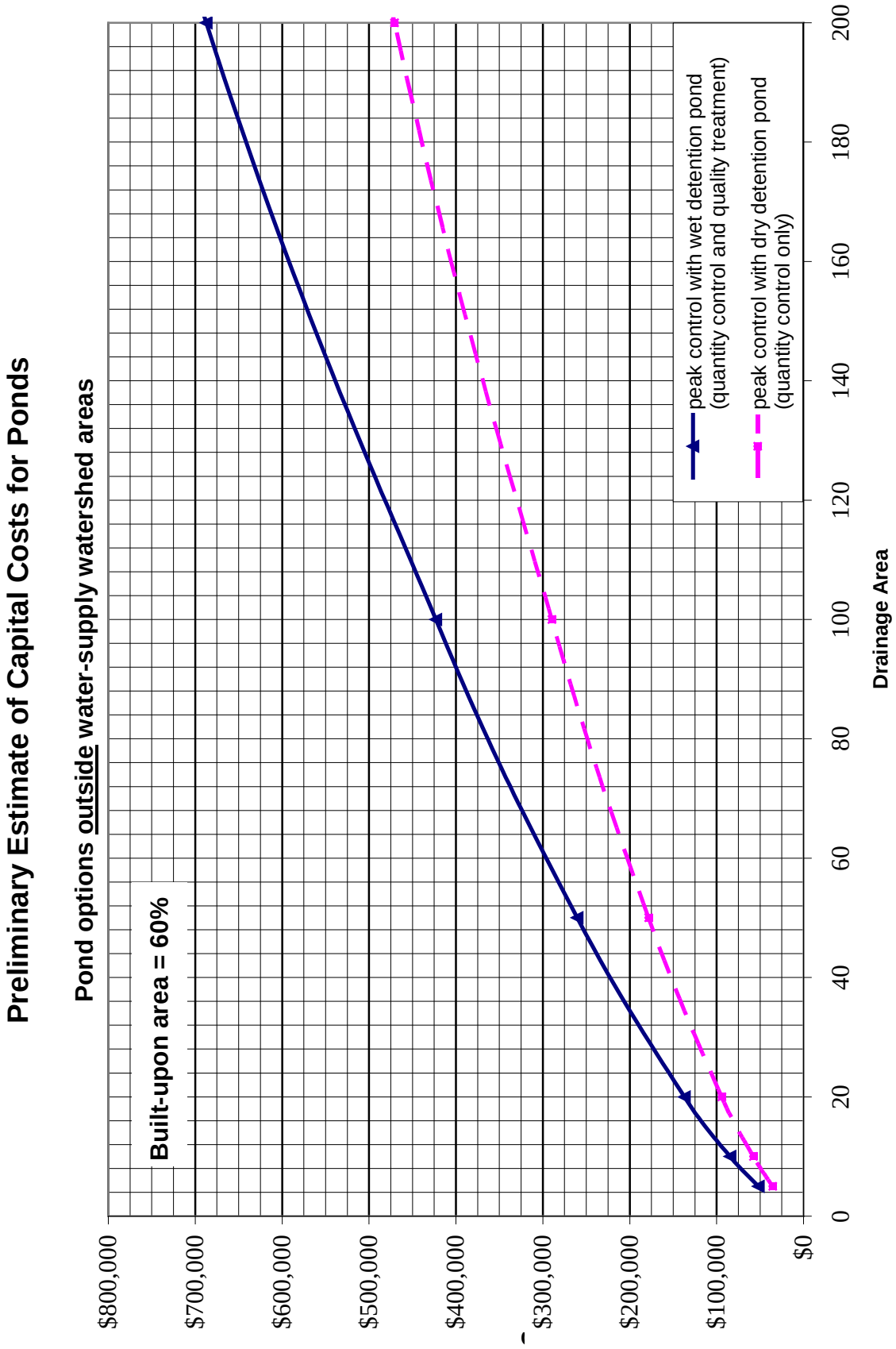
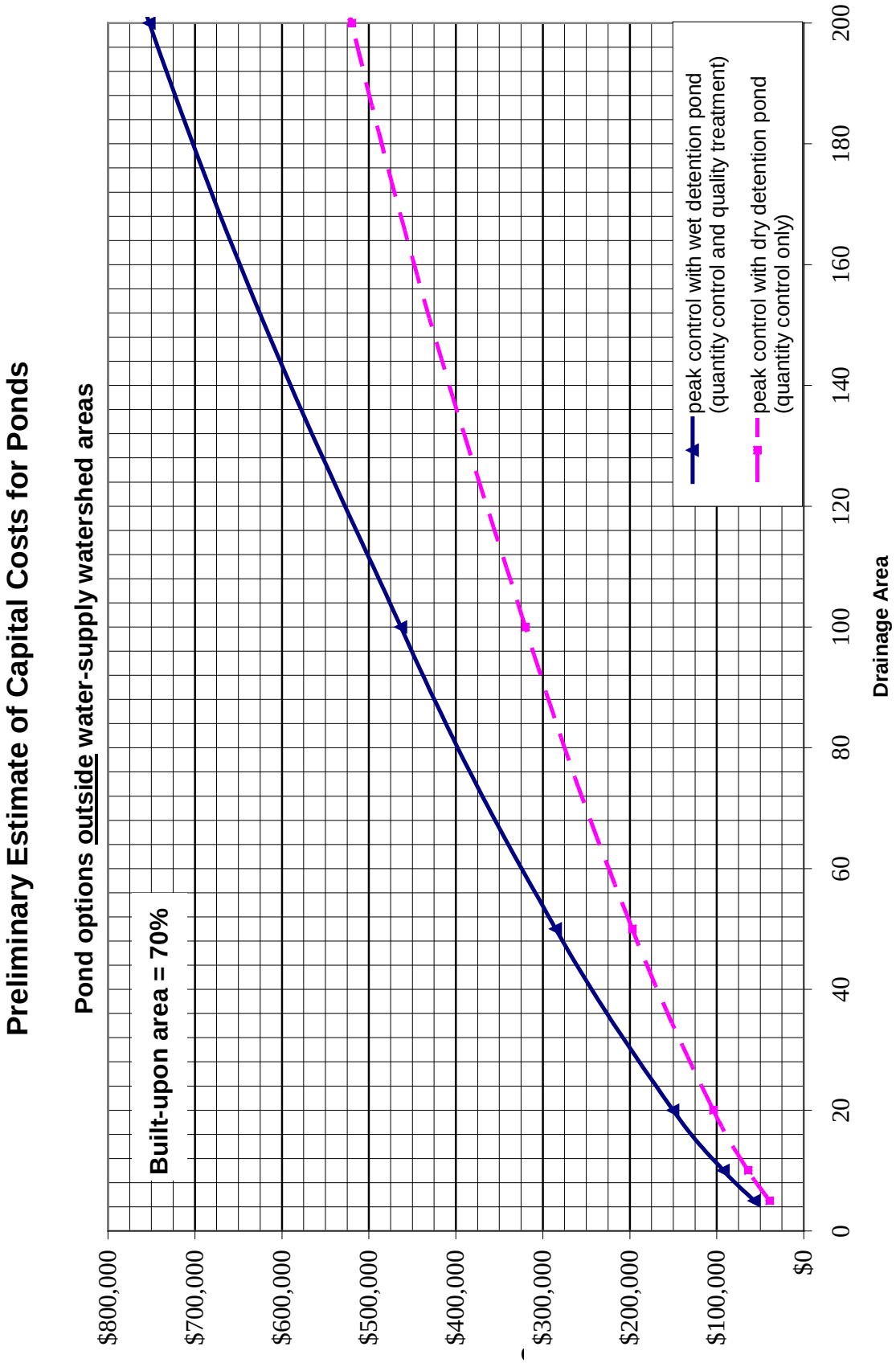
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
peak control with dry detention pond (quantity control only)


Preliminary Estimate of Capital Costs for Ponds
Pond options outside water-supply watershed areas
Built-upon area = 50%
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
peak control with dry detention pond (quantity control only)


Preliminary Estimate of Capital Costs for Ponds
Pond options outside water-supply watershed areas
Built-upon area = 60%
$800,000
$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
peak control with dry detention pond (quantity control only)


Preliminary Estimate of Capital Costs for Ponds
Pond options outside water-supply watershed areas
Built-upon area = 70%
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$700,000
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
0
20
40
60
80
100
120
140
160
180
200
Drainage Area
peak control with wet detention pond (quantity control and quality treatment)
peak control with dry detention pond (quantity control only)

APPENDIX 8

STORMWATER BMP BONDING PROCESS

The City of Greensboro ordinance requires that a BMP must be functioning as design and certified prior to plat recordation. In some instances, the Stormwater Management Division allows the placement of a surety or Bond as a temporary measure to comply with that requirement. The following is the Bonding process for any stormwater bonds.

1.) Bonding process start at the Planning & Engineering Section.

2.) The Stormwater Engineer will advise the responsible party as to the steps required to properly construct/maintain the stormwater BMP and information for bonding. The Stormwater engineer will ask for a copy of the site plan and itemized estimate of construction costs signed by the developer's project engineer of record.

3.) The Stormwater Engineer will then forward to the Stormwater Utility Billing Specialist: a) copy of site plan, b) copy of itemized cost estimate, c) indication of specific type of BMP, d) bond cost factor (20% , 40% or greater depending on BMP type).

4.) The Billing Specialist will send a letter requesting a bond of adequate amount for the project, along with a sample bond form to ensure proper legal language. A hardcopy bond file will be created and maintained by the Billing Specialist.

5.) Once the bond is received, the Stormwater Billing Specialist will review the bond for proper language and dollar amount. The original bond document will be stored in the Water Resources Department fireproof vault. The pond bond tracker (excel file) will then be updated with new bond information. The Billing Specialist will send an e-mail message to the all Stormwater Engineers, Soil & Erosion, Operations Management and the Planning Department to inform them that an adequate bond was received for BMP construction. The project will then be clear to proceed.

6.) The Stormwater Billing Specialist will monitor the status of the bond and mail a letter to the responsible party at least one month prior to expiration of the current bonding period to request renewal of the bond. If bond renewal is not received by the current expiration date, the Stormwater division may choose to cash in the bond.

7.) When the project is complete and the responsible party believes the Stormwater Improvement has been completed in accordance with the approved design, the responsible party is required to notify the Stormwater Division in writing and schedule a final inspection of the site and the Stormwater Improvement. For all BMP's, the Stormwater division will notify Erosion Control so that an inspection can be scheduled by the Erosion Control Inspector. The Engineer's Certification of Stormwater Improvement Completion must be finalized prior to the City's final inspection of the Stormwater Improvement.

If the City Inspector observes any inconsistencies in the Engineer's Certification of Stormwater Improvement Completion or field review, then the engineer and responsible party will be promptly notified. **The bond will not be released until the Stormwater Improvement is fully functional and has been approved by the Design Engineers.**

8.) Once all approval criteria are met, the Stormwater Billing Specialist will send a letter to the responsible party to document the City's receipt of the Engineer's Certification of Stormwater Improvement Completion, the City's field inspection of completed Stormwater Improvement, and that the bond has been released. The original bond will be enclosed and returned to the responsible party.

SAMPLE

ADMINISTRATIVE HOLD ON CERTIFICATE OF DEPOSIT OR SAVINGS ACCOUNT

Date:

City of Greensboro
Stormwater Management Division
2602 S. Elm-Eugene Street
Greensboro, North Carolina 27406

Gentlemen:

<NAMED ACCOUNT HOLDERS> have requested <BANK NAME>Bank of N.C. to place an administrative hold on Certificate of Deposit (or Savings Account) # _____ and is authorizing the City of Greensboro to draw up to $_____but not exceeding $_____on the account should you fail to meet requirements of the watershed protection plan and perform in accordance with Chapter 30 of the Greensboro Code of Ordinances on the property more particularly described as

<NAME OF DEVELOPMENT>.

This confirms that the hold will be in force upon notification by the City of Greensboro and will remain in force for one year or until release in writing by an agent of the City of Greensboro.

_____Bank of N.C. has been informed by_____and the City of Greensboro that the right of the City of Greensboro to draw on this account will be exercised only if_____ fail to maintain the terms of the watershed regulations.

Respectfully,

Assistant Vice President
Branch Manager

Witnesses:

_____

STORMWATER L. O. C. SAMPLE
Letter of Credit #

Date:

ADVISING BANK
To be named by Beneficiary

APPLICANT

BENEFICIARY
City of Greensboro
Stormwater Management Division
2602 S. Elm-Eugene Street
Greensboro, NC 27406

MAXIMUM AMOUNT: $
* Dollars
And /100*

EXPIRATION DATE:
(Must be good for at least one year)

Gentlemen:

We hereby establish our Irrevocable Credit # _____ in your favor, for the account of and thereby undertake to honor your drafts at sight on us, not exceeding the aggregate of Dollars ($), each such draft to be accompanied by the following:

WHEREAS, the principal (applicant) has submitted a Watershed Protection plan, as required by the City of Greensboro Code of Ordinances. The condition of this obligation is such that if the principal (applicant) shall well and truly, do and perform the installation and maintenance of the watershed protection feature in said location <Name of development as listed on plan>___ as required in the City of Greensboro Code of Ordinances, and shall pay all labor and material bills incurred relative thereto, this obligation shall be void otherwise to remain in full force and effect.

This irrevocable letter of credit shall remain in full force for a period of one (1) year from the effective date hereof and shall automatically renew itself from year to year thereafter unless and until the issuing bank name shall give ninety (90) days prior written notice to the City of Greensboro, N.C., by certified mail, return receipt requested, of its intent to terminate the same at the expiration of the ninety (90) day period. During the last thirty (30) days during which the letter of credit is in full force and effect, the city may draw up to the full amount available under the letter of credit with a draft-accompanied by a document stating that applicant name has not completed the improvements and has not provided an acceptable substitute irrevocable letter of credit and that the drawing is for the explicit purpose of guaranteeing and/or providing for the completion of the improvements.

This irrevocable letter of credit sets froth in full the terms of our undertaking. This undertaking shall not in any way be modified, amended, or amplified, by reference to any document or contract referred to herein.

All drafts under this credit must be marked "Drawn under _____Bank's Letter of Credit # _____ dated _____."

We hereby agree with you that draft(s) drawn under and in compliance with the terms and conditions of this credit shall be duly honored if presented, together with document(s) as specified and the original of this credit at this office.

Except as otherwise expressly stated herein, this credit is subject to the Uniform Customs and Practice for Commercial Documentary Credits, fixed by the XIII Congress of the International Chamber of Commerce (International Chamber of Commerce Brochure No. 400, 1983 Revision).

Sincerely,

AMPLE
STORMWATER MANAGEMENT BOND

BOND NO. _____

STATE OF NORTH CAROLINA

CITY OF GREENSBORO

KNOW ALL PERSONS BY THESE PRESENTS: That we, <Developer>**,** a <Developer State> Corporation, authorized to do business in the state of North Carolina, as Principal, and <Bonding Company>, a corporation organized and existing under and by virtue of the laws of the state of <Bonding Company's State> and authorized to do business in the state of North Carolina as Surety, are held and firmly bound unto the City of Greensboro, in the penal sum of <Amount(printed)> ($_____) DOLLARS for the payment of which, well and truly to be made, we firmly bind ourselves, and each of our heirs, executors, administrators, and assigns, jointly and severally by these presents.

WHEREAS, the principal (applicant) has submitted a Watershed Protection Plan for <Name of development as listed on plan> as required by the City of Greensboro Code of Ordinances.

THE CONDITION of this obligation is such that if the Principal shall well and truly do and perform the installation and maintenance of the watershed protection feature in said location as required in the City of Greensboro Code of Ordinances, and shall pay all labor and material bills incurred relative thereto, this obligation shall be void otherwise to remain in full force and effect.

Signed, sealed, delivered and effective this<Day> day of <Month>,<Year> .

_____
(Developer)

Countersigned: **By:** _____
(Name and title – Typed)

_____
(Agency Name)

_____
(Bonding Company)

_____
Resident Agent (please type)

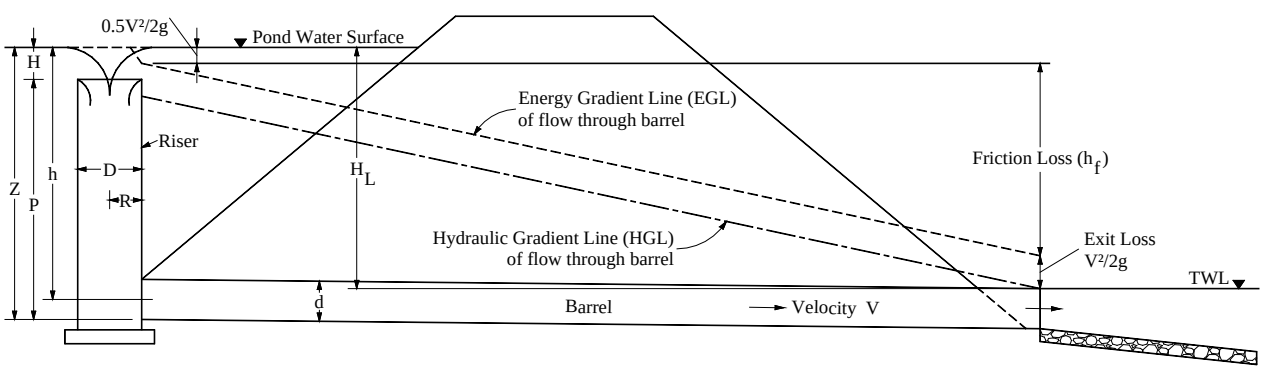
_____
Attorney-in-fact (Typed)

APPENDIX 9

Recommended Guidance for Riser and Barrel Spillway Discharge Characteristics and Flood Routing

Riser and Barrel type of spillway is widely used as the principal spillway in stormwater pond and wetland facilities. In the flood routing computations for ponds or wetlands using this type of spillway, the outflow discharge characteristics of the spillway is provided as input or is included in the computations. The computations for the design of ponds (or wetlands) submitted to the City for its technical review should include the details of the discharge characteristics (Outflow Discharge versus Pond Elevation or Stage) of the spillways, including the dimensions, elevations, and materials of the riser and barrel and the roughness coefficient (Manning's coefficient n or Darcy-Weisbach friction factor f) of the barrel (and riser if it is of small cross-sectional area relative to the barrel). The discharge characteristics of the Riser and Barrel Spillway, in terms of the outflow discharge varying with the pond water surface elevation (or "stage" above the crest of the riser), is somewhat complex since the flow is subject to varying hydraulic controls as the pond level rises above the crest of the riser. The following explanation and computation methodology is provided to serve as an acceptable general basis in either manual or computer-assisted computations submitted by Engineers to the City. Other methodologies and/or computer application software packages may be used if the formulas and discharge coefficients used in them are consistent with those recommended herein or enough justification is provided in support of those used.

A schematic sketch of a typical configuration of the Riser and Barrel Spillway, including notations used in the formulas in the following paragraphs, is shown in the following Figure.



RISER AND BARREL SPILLWAY - SCHEMATIC

As the pond water level rises above the crest of the riser with the incoming flood, water first flows over the rim of the riser as flow over a weir. The flow in this mode is controlled by the weir. The weir will be a sharp-crested weir if the crest is thin (as in a corrugated aluminum pipe and the bell end of a concrete pipe) and a broad-crested weir if the crest is of substantial thickness relative to the head over the weir as in a riser structure built of concrete or brick masonry. As the head on the riser crest increases, the control of flow into the riser will transition

from weir-controlled flow to orifice-controlled flow, with the open top of the riser functioning as an orifice. Based on observations in tests performed by the U.S. Bureau of Reclamation (USBR), the flow into the riser will be weir flow with free discharge (no downstream submergence) up to a H/R ratio of approximately 0.5 changing to submerged weir discharge for H/R ratios of 0.5 to 1.0, wherein H = head of pond water above the (riser) weir crest and R = D/2 = Radius of the circular (diameter D in feet) weir crest. USBR tests also show that as H/R ratio approaches 1.0, transition from (submerged weir) control to orifice control occurs and orifice control is established at an H/R ratio of approximately 1.0,. For H/R ratios higher than 1.0, orifice control (at the top of the riser) may be assumed to govern the flow into the riser. Independent of the flow control at the top of the riser, the barrel of the spillway will act as a culvert with head-water rising inside the riser with increasing flow passing through the culvert/barrel system. The water surface elevation in the riser may be governed either by "inlet control" at the entrance to the barrel acting as an orifice or by "outlet control" resulting from the tail water level and the head losses through the barrel, similar to flows through culverts. Initially (for small flows falling into the riser), with water depth in the riser above the barrel invert less than the height of the barrel, the flow in the barrel will be governed by inlet control with weir type of flow. This mode of flow in the barrel is not of practical significance in this context since the head water elevation under inlet weir control is typically below the crest of the riser and consequently does not affect the pond water surface elevation. With increasingly higher flows, however, the culvert flow shifts to either inlet control (acting as an orifice) or outlet (downstream) control. The head water depth and elevation inside the riser increase as a function of the orifice discharge characteristics if inlet control governs or tail-water elevation (downstream of barrel outlet) and the head losses due to (pipe) friction in the barrel and inlet and exit head losses if outlet control governs. For higher discharges during the passage of a flood, the outlet control of the flow in the barrel (rather than the inlet to the riser) could potentially govern the discharges of the spillway, especially if the barrel is long and is constructed of corrugated metal pipes with high friction factor. The hydraulic control of the discharge of the spillway during the complete passage of larger floods is typically a composite of the above modes of flow control. The computational approach is to calculate the discharge characteristics in the four modes of control separately and to determine the composite discharge characteristic relationship as the one that gives the minimum of the flows in the four control modes for a given pond water surface elevation or the maximum pond water surface elevation among the four modes for a given discharge. The following formulas may be used for computing the flows in the different hydraulic control modes.

<u>Weir Control of Riser</u>

$$Q = C_w L H^{3/2}$$

C_w = Discharge coefficient of weir.
L = Length (along perimeter) of weir crest
H = Head of water above riser crest = Elevation of water surface in pond – Elevation of riser crest = (Z – P)

The value of C_w for **sharp-crested circular weirs** (as distinguished from sharp-crested weirs in straight alignment for which C_w = 3.3) is given by the following approximate relationships (derived from the results of model tests on circular weirs reported in the "Spillways" chapter of

the publication "Design of Small Dams by the U.S. Bureau of Reclamation). Risers built of plain or corrugated sheet metal and manufactured concrete pipe with grooved (bell) end at the riser crest may be considered as sharp-crested circular weirs.

$C_w = 3.4 – 0.5(H/R)$ for $H/R < 0.5$; $C_w = 3.15 – 2.3(H/R – 0.5)$ for $H/R > 0.5$
L = 3.14 D for circular weir crest.

It may be noted that if riser crest weir control is confined to relatively low heads, with H/R ratio less than 0.5 (un-submerged outflow jet), the average value of C_w from the above formula (for H/R < 0.5) is 3.275, which is almost equal to the theoretical value of 3.3 that is generally used for straight sharp-crested weirs. Hence, **using a constant value of $C_w = 3.3$ (in lieu of the variable values in using the formulas above) is acceptable if the following combinations of riser and barrel diameters, that generally result in the weir control to occur in the range of heads with H/R below 0.5, are used in the design:**

12 inch Barrel: Minimum 30 inch Riser
15 inch Barrel: Minimum 36 inch Riser
18 inch Barrel: Minimum 42 inch Riser
24 inch and larger Barrel: Minimum 2 x Barrel Dia. for Riser

The value of C_w for **broad-crested straight weirs** (risers rectangular in plan form, built of straight walls of concrete or brick masonry) is given by the following approximate formulas, based on Plate No. 13 in the Army Corps of Engineers' Engineering Manual EM 1110-2-1602, App. III, 1993, and the values given in Table 5.3 in "Handbook of Hydraulics" by King & Brater.

Cw = 2.65 for H/B<0.5; Cw = 2.65 + 0.5 (H/B – 0.5) for <H/B<1.8; Cw = 3.3 for H/B>1.8,
where B = breadth of the weir crest (thickness of the weir wall at its top) in the direction of flow.

The above formulas are applicable for free discharging (into atmosphere) weirs, without submergence (with curtailed aeration) on the downstream side. Although published test data are not available, it is reasonable to assume that the flow over a broad-crested weir riser (with relatively short side lengths), with increasing head, will also be affected by the transition to downstream submergence as in a sharp-crested weir riser described above, with a gradual reduction in the discharge coefficient. The increase in Cw with increase in H/B (for H/B > 0.5) will thus be offset by a decrease in Cw due to downstream submergence effects with increasing head. In view of these considerations, **use a constant value of Cw = 2.65 for the full range of head.**

For **broad-crested circular weirs** (risers circular in plan form, built of concrete or brick masonry walls), use a modified value of Cw based on an approximately 10% reduction in the values of C_w used for broad-crested straight weirs, to account for the effects of converging radial flow toward and over circular weirs (lacking published data on circular broad-crested weirs). **Use a constant value of $C_w = 2.4$ for the full range of head.**

Orifice Control of Riser

This mode of flow control occurs typically for H/R values above 1.0.

$Q = C_d A (2gH)^{0.5}$ for orifices

C_d = Coefficient of discharge of submerged orifice = 0.5

This is based on the theoretical value 0.5 for "Reentrant or Borda's mouthpiece" (an experimental average value of 0.51 is reported on page 4-19 in "Handbook of Hydraulics" by King & Brater). Reentrant or Borda's mouthpiece is a short cylindrical tube projecting inward into a body of water, as distinguished from an orifice in the plane of the wall of the containing tank. The configuration and hydraulics of a riser projecting upward into a pool of water is similar to a Borda's mouthpiece. **Use Cd = 0.5**

For cylindrical risers, $\mathbf{Q = 3.15\ D^2\ H^{0.5}}$

H = Head of water above the crest of riser in feet
A = Area of orifice opening at riser crest in sq. ft.
D = Diameter of crest of cylindrical riser in feet

Transition from Weir Control to Orifice Control of Riser

It has been stated above that weir control of circular riser crest governs up to an H/R value of approximately 1.0, and orifice control of riser (top opening) governs for H/R values above 1.0. It is instructional to note that the same observations (based on tests by the U.S. Bureau of Reclamation) can also be deduced from the above stated formulae for the two modes of flow. To identify the transition, which is the point of intersection of the characteristic curves of the weir discharge relationship valid for H/R above 0.5 and the orifice discharge relationship, equate the discharge (Q) values from the two formulas.

$$3.14\ D\ (3.15 - 2.3(H/R - 0.5))\ H^{1.5} = 0.5\ (3.14\ D^2 / 4)\ (2gH)^{0.5}$$

Substituting 2R for D in the above equation and performing some algebraic steps, the equation reduces to the following.

$$1.15\ (H/R)^2 - 2.15\ (H/R) + 1.003 = 0$$

The solution of the above quadratic equation yields H/R = 0.98 (approximately 1.0)

Barrel Inlet Control

Use the following formula for the flow conditions with the water surface elevation in the riser above the top of barrel at its entrance (submerged orifice condition). The flow condition in the barrel with the head water below the top of the barrel is not of practical significance since it is below the crest of the riser and does not affect the pond water elevation. For submerged orifice

flow with water surface in riser above the top of barrel at its entrance, the following formula is applicable

$Q = C_d\ a\ (2gh)^{0.5}$; For circular pipe barrel, $Q = 6.3\ C_d\ d^2\ h^{0.5}$

C_d = Coefficient of discharge of submerged orifice, whose values are as listed in the following table.

Values of Coefficient of Discharge, C_d, of Orifices

Entrance Condition	**C_d**
Typical default value	0.60
Square-edged entrance	0.59
Concrete pipe, grooved end	0.65
Concrete pipe, mitred to slope	0.52
Corrugated metal pipe, projecting from fill	0.51

h = head of water above the center-line of the barrel entrance = (Z – d/2) in feet
d = diameter of (circular pipe) barrel entrance in feet
a = Area of cross-section of barrel at entrance in sq. ft.

Barrel Outlet Control

Barrel outlet control occurs when the water level in the riser required to drive a given flow through the barrel (differential head relative to the tail water at the downstream end of barrel) is higher than that under inlet (submerged orifice) control. The differential head relative to the tail water level is equal to the sum of head loss at entrance to the barrel, head loss due to friction in the barrel, and the head loss at the exit due to dissipation of the kinetic energy of flow. If the tail water levels for different flows are lower than the crown of the barrel outlet, assume the tail water elevation as equal to the top of the barrel at the outlet in considering the differential head. The formula for the differential head (total head loss, H_L) above the tail water level is as follows:

$H_L = (K_e + fL/d + 1.0)\ V^2/2g = (K_e + 185\ n^2\ L/d^{4/3} + 1.0)\ (Q^2/64.4\ a^2)$
$Q = 8.02\ a\ H_L^{0.5}/(Ke + 185\ n^2\ L/d^{1.333} + 1.0)^{0.5}$
$Q = 6.3\ d^2\ H_L^{0.5}/(Ke + 185\ n^2\ L/d^{1.333} + 1.0)^{0.5}$
K_e = Entrance loss coefficient, whose values are as follows:

Type of Entrance to Barrel	**K_e**
Square-cornered entrance flush with wall	0.5
Rounded-cornered entrance	0.25
Inward-projecting, square-cornered entrance	0.9

f = Darcy-Weisbach “friction factor” = $185\ n^2/d^{1/3}$
n = Manning roughness coefficient, whose values are as follows. Use the higher value in the range for head loss computations to conservatively account for aging of the barrel material.

Type of Pipe	Range of n
Ductile Iron Pipe	0.011 – 0.015
Concrete Pipe	0.011 – 0.015
Corrugated Metal (including Aluminum Pipe), including helical corrugated metal pipes shorter than 20 diameters or with annular corrugations at ends	0.022 – 0.026
Plastic Pipe (smooth interior)	0.011 – 0.015

L = Length of barrel in feet
d = Diameter of barrel in feet
a = Area of cross-section of barrel in sq. ft.
Q = Discharge through barrel in cfs.

The computations for inlet and outlet control of barrel may also be performed using the inlet and outlet control charts published by the Federal Highway Administration's Manual FHWA HDS-5, which are reproduced in the City of Greensboro's "Storm Drainage Design Manual" in the culvert design section. This method may be used only if manual (instead of computerized) calculations are performed for stage-discharge characteristics of the riser-barrel spillway. If spreadsheet computations are performed, the formulae given above can be used. The following example illustrates the computations using an Excel spreadsheet.

Example: Stage – Discharge For Riser/Barrel Spillway and Flood Routing

Data
Riser of Corrugated Aluminum Pipe (CAP) with annular corrugations; Barrel of Helically Corrugated Aluminum Pipe (CAP) segments with ("recorrugated") annular corrugations at ends (for joints).
Diameter of Riser, D = 4.0 ft; Radius, R = 2.0 ft
Diameter of Barrel, d = 2.0 ft
Elevation of Riser crest = 700.00 ft
Elevation of Invert of Barrel at Entrance = 690.00 ft
Elevation of Invert of Barrel at Outlet = 689.00 ft
Length of Barrel, L = 80 ft

Computations
Head over Riser Crest as Weir = H = Stage (elevation) of Pond Water Surface –
Elevation of riser crest = (Stage – 700.00)
Riser (weir) $C_w = 3.4 - 0.25\ H$ for $H < 1.0$; $C_w = 3.15 - 1.15\ (H - 1.0)$ for $H > 1.0$
Riser (weir) Discharge = $C_w\ 12.56\ H^{1.5}$
Riser (orifice) Cd = 0.5; Riser (orifice) Discharge = $50.4\ H^{0.5}$
Barrel (orifice inlet control) Cd = 0.6; Barrel (orifice) Discharge = $15.12\ (9.0 + H)^{0.5}$
Barrel (outlet control) $K_e = 0.5$; Manning n = 0.024
Barrel (outlet control) $Q = 6.3\ d^2\ H_L^{0.5}/(Ke + 185\ n^2\ L/d^{1.333} + 1.0)^{0.5} = 11.4\ H_L^{0.5}$
H_L = Pond Water Elevation – Elevation of Top of Barrel = Pond Water Elevation – 691.0

Computations for the Stage-Discharge characteristics of the spillway, using the data and formulae listed above, are presented in the Excel spreadsheet in Table 1 on the next page. A plot of the four potential controlling discharges and the actual composite controlling discharge of the spillway is also presented in Figure 1 on the page following the spreadsheet.

In this example of a riser-barrel spillway, it may be seen that the discharge is initially controlled by the riser crest acting as a sharp-crested weir for heads up to about 0.9 ft. The control shifts to Barrel outlet control at 0.9 ft head and continues for all heads above that value.

Summary of Results of Stage-Discharge Characteristics

Based on the results of computations in the spreadsheet in Table 1 on the next page and the curves in Figure 1, the stage-discharge characteristics for the spillway in this example are:

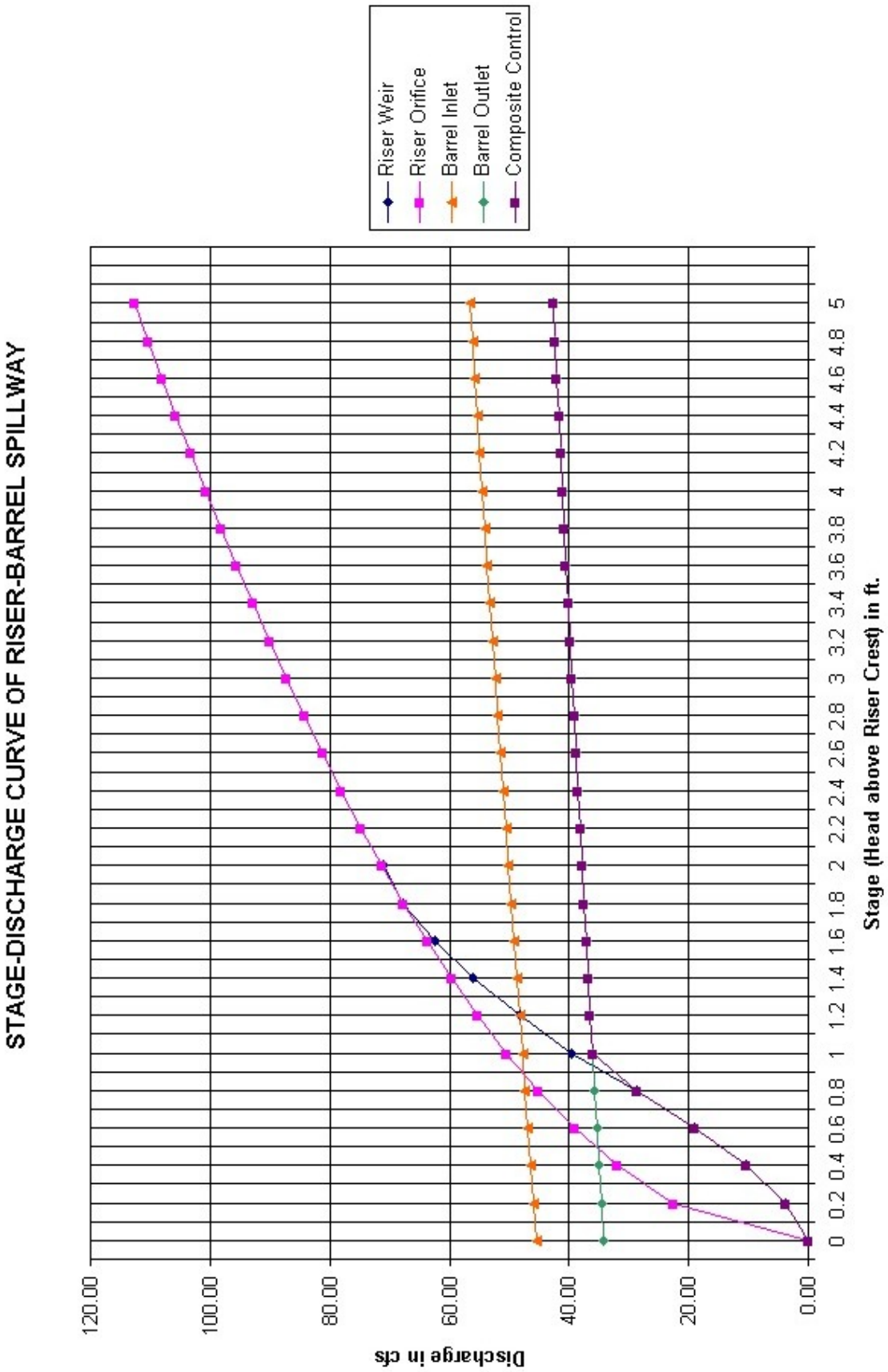
For Stage (Head on riser crest), H < 0.9 ft, $Q = 12.56\ (3.4 - 0.25\ H)\ H^{1.5}$
For Stage (Head above riser crest), H > 0.9 ft, $Q = 11.4\ H_L^{\ 0.5} = 11.4\ (9.0 + H)^{0.5}$

The above formulas can be entered as input to the cells in the column of Principal Spillway in the spreadsheet computations for flood routing, similar to the one included in Appendix 2, as detailed below.

TABLE 1

	A	B	C	D	E	F	G	H	I	J	K
1	STAGE-DISCHARGE CHARACTERISTICS OF RISER-BARREL SPILLWAY										
2											
3	Riser (CAP) Diameter = 4 ft; Riser Crest El = 700.0 ft;										
4	Barrel (CAP) Diameter = 2 ft; Barrel Invert El: Inlet 690.0 ft, Outlet 689.0 ft; Barrel Length = 80 ft										
5											
6											
7	Elev. of Pond	Barrel Tailwater Elevation	Riser Weir Head, H	Barrel Total Head Loss, HL	Riser Weir Cw	Riser Weir Discharge	Riser Orifice Discharge	Barrel Orifice (Inlet) Outlet Discharge	Barrel Outlet Control Discharges	Composite Discharge	Comments
8											
9	(ft)	(ft)	(ft)	(ft)		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
10											
11	700	691	0	9	3.4	**0.00**	0.00	45.36	34.20	**0.00**	Riser Weir Control
12	700.2	691	0.2	9.2	3.35	**3.76**	22.54	45.86	34.58	**3.76**	
13	700.4	691	0.4	9.4	3.3	**10.49**	31.88	46.36	34.95	**10.49**	
14	700.6	691	0.6	9.6	3.25	**18.97**	39.04	46.85	35.32	**18.97**	
15	700.8	691	0.8	9.8	3.2	**28.76**	45.08	47.33	35.69	**28.76**	
16	701	691	1	10	3.15	39.56	50.40	47.81	**36.05**	**36.05**	Barrel Outlet Control
17	701.2	691	1.2	10.2	2.92	48.21	55.21	48.29	**36.41**	**36.41**	
18	701.4	691	1.4	10.4	2.69	55.97	59.63	48.76	**36.76**	**36.76**	
19	701.6	691	1.6	10.6	2.46	62.53	63.75	49.23	**37.12**	**37.12**	
20	701.8	691	1.8	10.8	2.23	67.64	67.62	49.69	**37.46**	**37.46**	
21	702	691	2	11	2	71.05	71.28	50.15	**37.81**	**37.81**	
22	702.2	691	2.2	11.2			74.76	50.60	**38.15**	**38.15**	
23	702.4	691	2.4	11.4			78.08	51.05	**38.49**	**38.49**	
24	702.6	691	2.6	11.6			81.27	51.50	**38.83**	**38.83**	
25	702.8	691	2.8	11.8			84.34	51.94	**39.16**	**39.16**	
26	703	691	3	12			87.30	52.38	**39.49**	**39.49**	
27	703.2	691	3.2	12.2			90.16	52.81	**39.82**	**39.82**	
28	703.4	691	3.4	12.4			92.93	53.24	**40.14**	**40.14**	
29	703.6	691	3.6	12.6			95.63	53.67	**40.47**	**40.47**	
30	703.8	691	3.8	12.8			98.25	54.09	**40.79**	**40.79**	
31	704	691	4	13			100.80	54.52	**41.10**	**41.10**	
32	704.2	691	4.2	13.2			103.29	54.93	**41.42**	**41.42**	
33	704.4	691	4.4	13.4			105.72	55.35	**41.73**	**41.73**	
34	704.6	691	4.6	13.6			108.10	55.76	**42.04**	**42.04**	
35	704.8	691	4.8	13.8			110.42	56.17	**42.35**	**42.35**	
36	705	691	5	14			112.70	56.57	**42.65**	**42.65**	

FIGURE 1


STAGE-DISCHARGE CURVE OF RISER-BARREL SPILLWAY
Riser Weir
Riser Orifice
Barrel Inlet
Barrel Outlet
Composite Control
Discharge in cfs
0.00
20.00
40.00
60.00
80.00
100.00
120.00
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
Stage (Head above Riser Crest) in ft.

Flood Routing

Perform the flood routing in the pond using the "Chain Saw" method that facilitates the computations using any commercial spreadsheet software (such as Excel).

The basic continuity equation applicable to the flood routing process is

$\Delta S = (I\text{-}O).\Delta T$

where, AS = Change in storage during a time interval,
AT = Time interval,
I = Average inflow during the time interval,
0 =Average outflow during the time interval

To enable computations using a spreadsheet, the Inflow and Outflow values at the beginning of a time interval, instead of the average values for the time interval, are used in the procedure for computing incremental storage. The governing equation thus becomes:

$\Delta S_{ij} = (I_i — O_i).\ \Delta T_{ij}$

This equation is used in the spreadsheet to compute incremental storage during various time intervals and the cumulative storage at the corresponding times.

Table 2 illustrates a typical spreadsheet used for storage routing computations for a 20 acre site, with pre-project CN=70 and post-project CN=90. The pond at normal pool (orifice level) is assumed to be 160 ft. X 80 ft. (0.3 acre) in size, with side slopes of 3H:1V. The principal spillway is assumed to be a riser and barrel spillway of Corrugated Aluminum Pipe (CAP), riser of 4 ft diameter and barrel of 2 ft diameter, with crest at an elevation of 700.00 ft. A 3-inch diameter drain, located 1 foot below the principal spillway crest level is assumed to function as an orifice with a discharge coefficient of 0.6. The spreadsheet shows the computations for the 10-year recurrence rain. The inflow hydrograph values computed and shown in Table 3 of Appendix 2 are used in this example spreadsheet. The Figure 2 on the following page shows the graph of the inflow and outflow hydrographs. The proposed spillway was found (as discussed in step 10 below) to match the post-project flood peak with the pre-project value of 42 cfs. The storage required, as may be seen in Table 2 (cell D20), is 75,200 cubic feet (1.73 acre- feet). The corresponding maximum stage (depth) above the riser crest is seen (in cell G20) as 3.7 feet.

Following are the steps in using the spreadsheet.

(1) Initialize the first row in the computations, say row #10 (assuming rows 1 through 9 are used for title, descriptive text, and column headings), by entering 0 (zero) in all the cells. In the first cell for time (A10), you may alternatively enter the time corresponding to one time interval before the start of the inflow (say, 10.5 hours if inflow values in Table 2 start at 11.0 hours).

(2) Enter the data for time and the corresponding inflow hydrograph unit discharges read from Table 2 in columns A and B respectively, starting with the second row (row # 11; cells A11 and B11).

(3) In the second row of computations, enter 0 or a small (nominal) value in the cell for outflow (H11), since outflow at the start is unknown.

(4) In cell C11, enter the formula for the Inflow (q) as given in step 5 under "Inflow Flood Hydrograph" above: =(value of A.Q/640)*(B11). Copy the formula from cell C11 and paste into all the cells below that in column C.

(5) In cell D11, enter: =(D1O+(A11-A10)*36OO*(C10-H10)). Copy the formula from cell D11 and paste into all the cells below that in column D.

(6) In cell E11, enter: =(D11-D10). Copy the formula from cell E11 and paste into all the cells below that in column E.

(7) In cell F11, enter the formula for the stage in terms of storage. For convenience, consider the zero value for stage as the elevation of the orifice, which in most cases would be the normal pool elevation in a pond. Develop data for the area (a) of the pond at the principal spillway (normal pool: zero stage) elevation and various stages (h) above the principal spillway elevation from the contour map or proposed grading plan. Calculate the storage volumes (V) for different stages (h) using prismoidal formula: $V = (d/3).((a_1 + (a_1.a_2)^{.05} + a_2))$, where a_1 and a_2 are the areas of the pond at two stages and d is the vertical distance between the two stages.

The storage volume (V) versus stage (h) relationship for the pond above the normal pool (principal spillway crest elevation) can generally be approximated by an equation of the form:

$V=kh^n$

log V = log k +n log h; For $h = h_1 = 1$, $\log h_1 = 0$; hence $k = V_1$, where V_1 = volume of storage at h = 1.0 ft. stage. Hence, $V = V_1.h$. Determine the values of n from the known pairs of values of V and h. Use the average of the values of n for computations. Alternatively, determine the value of n by plotting the V versus h pairs of values on a log-log paper. With the values of $k = V_1$ and n determined as above, the formula for the stage (h) can be written in terms of storage volume (V) as:

$h = (V/V_1)^{1/n}$
In this example, $h=(V/13531)^{0.9}$

Enter the above formula for the stage in cell F11 of the spreadsheet: $(D11/13531)^{0.9}$. Copy the formula from cell F11 and paste into all the cells below that in column F. In cell G11, enter the function: If(F11 > 1.0, (F11 – 1.0), 0) and copy and paste it in the cells below G11 to enter the values of "stage" or head above the crest of the riser.

(8) In cell H12, enter the formula for the total outflow as equivalent to the sum of the outflows through the various outflow facilities: =(I12+J12+K12)). Copy the formula from cell H12 and paste into all the cells below that in column H. Note that either 0 or a small value was entered in cell H11 in step 3 above.

(9) In cell I12, enter the formula for orifice discharge: =4.8*(value of orifice area)*(F12)^0.5. Copy the formula from cell I12 and paste into all the cells below that in column I.

(10) In cell J11, enter the formulas for the principal spillway discharge stated in the Summary of Results of the analysis of Riser and Barrel Spillway, using the "IF" function as follows: IF(G11<0.9, (12.56(3.4 – 0.25 * G11)* G11^1.5), (11.4 * (9 + G11)^0.5)). In most cases, the stage of the spillway crest would be zero. Copy the formula from cell J11 and paste into all the cells below that in column J. Since the spillway dimensions required are unknown, a few trial values for the spillway riser and barrel diameters may have to be tried, each resulting in a unique flood routing and peak outflow value (in column H). The final design to be accepted should be the one that results in the peak outflow value that closely matches or is less than the target value (such as the pre-project runoff peak discharge).

(11) In cell K11, enter 0. Copy the 0 from cell K11 and paste into all the cells below that in column K. Revise the values in column K only for routing floods larger than a 10-year flood, as given in the following steps.

(12) After performing the routing computations for detention storage required for the 10-year recurrence rain (no emergency spillway flows up to 10-year flood), the 10 year flood pool elevation would be known. Then, establish the crest elevation of the emergency spillway at or above the 10-year flood pool elevation.

(13) Revise the values in columns C and K to perform flood routing computations for the 100-year inflow flood, which would provide design information regarding the 100-year flood pool elevation and the discharges through the different outflow facilities. In column C, revise the formula in cell C11 and the ones below that to reflect the revised value of runoff (Q) for the 100-year rainfall. If the emergency spillway crest is set at the elevation of the maximum pool (highest stage) in a 10-year flood event, enter the formula for the emergency spillway discharge in the cell in column K and row corresponding to the highest value for the stage (column F) in the 10-year flood routing computation described in steps up to #11 above. If the emergency spillway crest elevation is set above the 10-year flood pool elevation, enter the formula in the cell in (column K) in the row below that having the highest value for stage in column F or G. Assuming that the emergency spillway would function as a broad-crested weir, enter the formula in cell K20 for the discharge as:

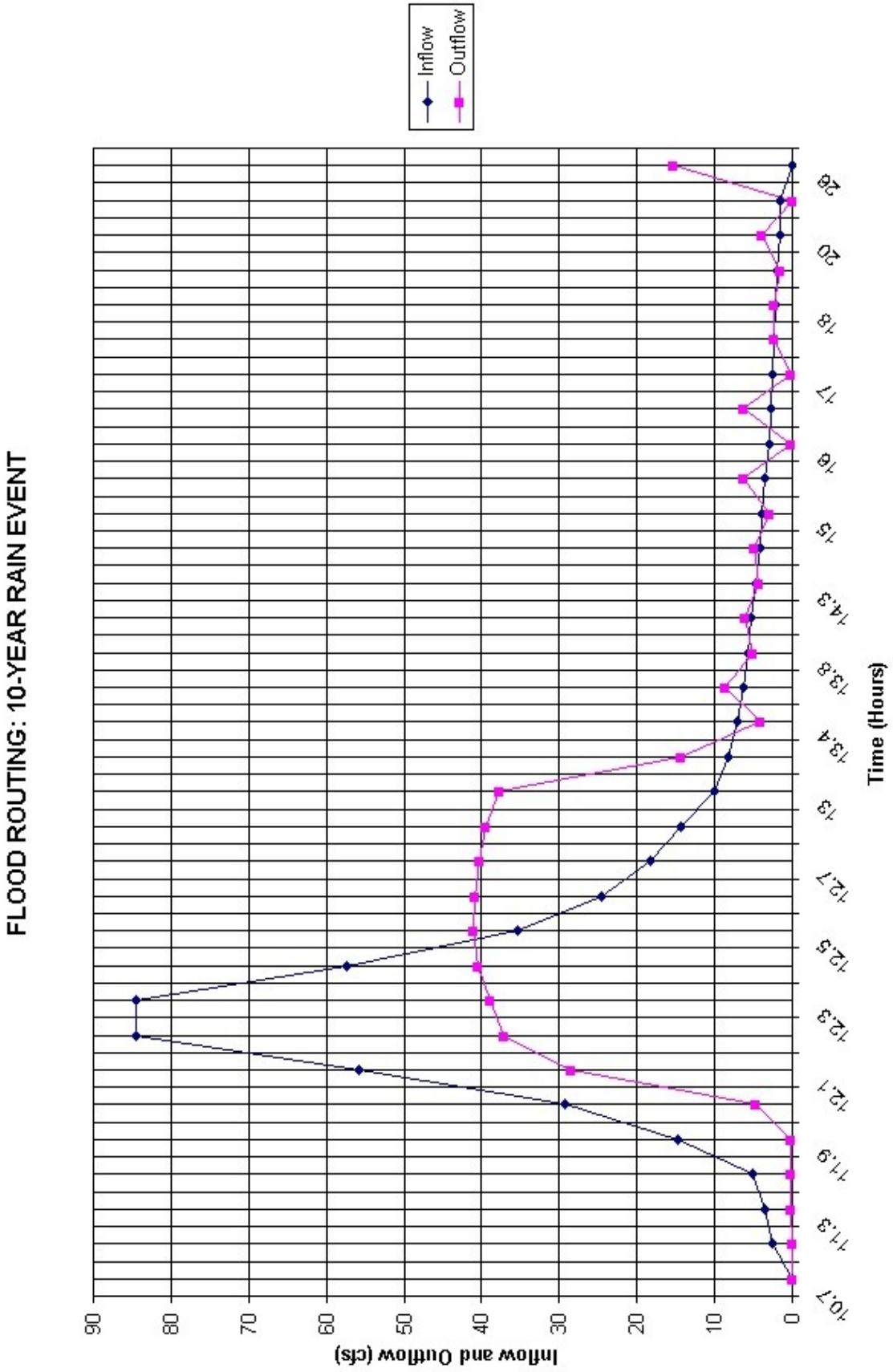
=2.65*(length of spillway)*(F20 minus stage (relative to the orifice) of the crest of emergency spillway)^1.5. If the hydraulic characteristics of the spillway are different from that of a broad-crested weir, change the formula accordingly. Copy the formula from the cell in which the formula is entered and paste into all the cells below that in column K. The

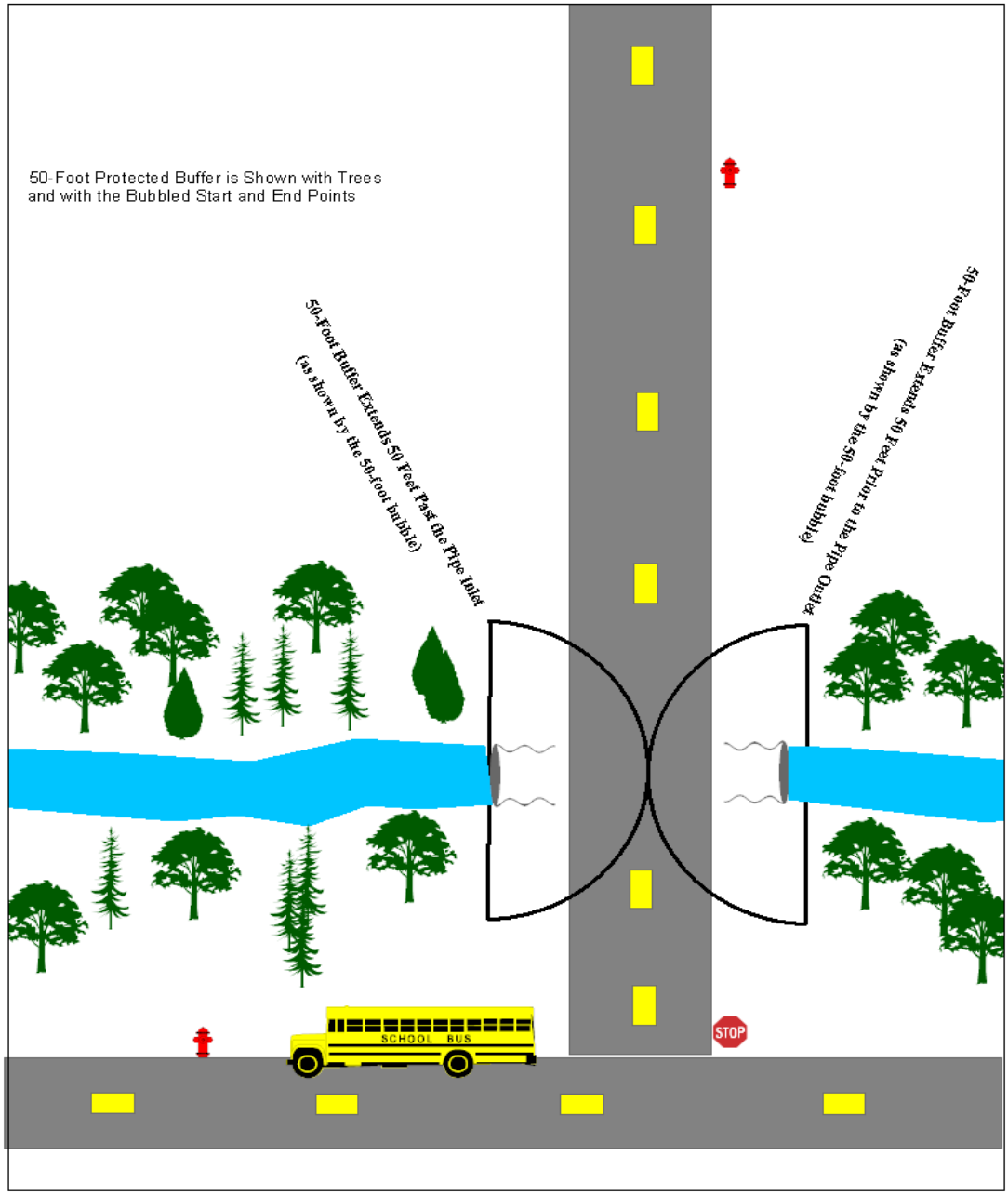
computations should be complete with this step. Obtain the design parameters from the values in the row in which the maximum stage and storage occurs.

TABLE 2

	A	B	C	D	E	F	G	H	I	J	K
1	**FLOOD ROUTING COMPUTATIONS (CHAIN SAW METHOD)**										
2	For 10-year, 24-hour Rain Event; Project: Typical Development										
3											
4	Site area = 20 acres; Post-develop. CN = 90; T_c = 20 Min.; 10-year Rain = 5.1 in.; Runoff = 4.0 in.										
5	Pond area t normal pool – 0.3 acre; Stage-Volume: h=(V/13531)^0.9; Target Peak Outflow = 42 cfs										
6											
7	Time	Tab. Hydr. Value	Inflow	Storage	Change in Storage	Head on Orifice	Head on Riser	Outflow	Outflow Facilities (Spillway sand Orifices)		
8	(hours)	(csm/in)	(cfs)	(cu.ft.)	(cu.ft.)	(ft.)	(cfs)	(cfs)	Orifice	Prin. Spillway	Emerg. Spillway
9											
10	10.7	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
11	11	20	2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
12	11.3	28	3.5	2700.00	2700.00	0.23	0.00	0.11	0.11	0.00	0
13	11.6	41	5.125	6356.59	3656.59	0.51	0.00	0.17	0.17	0.00	0
14	11.9	118	14.75	11710.17	5353.58	0.88	0.00	0.22	0.22	0.00	0
15	12	235	29.375	16940.56	5230.39	1.22	0.22	4.72	0.26	4.46	0
16	12.1	447	55.875	25816.87	8876.32	1.79	0.79	28.49	0.32	28.17	0
17	12.2	676	84.5	35676.24	9859.36	2.39	1.39	37.12	0.37	36.75	0
18	12.3	676	84.5	52734.25	17058.02	3.40	2.40	38.93	0.44	38.49	0
19	12.4	459	57.375	69139.87	16405.62	4.34	3.34	40.54	0.49	40.05	0
20	12.5	283	35.375	75200.79	6060.92	4.68	3.68	41.11	0.51	40.60	0
21	12.6	196	24.5	73137.05	-2063.74	4.57	3.57	40.92	0.50	40.41	0
22	12.7	146	18.25	67227.48	-5909.57	4.23	3.23	40.36	0.49	39.87	0
23	12.8	114	14.25	59268.97	-7958.51	3.78	2.78	39.58	0.46	39.13	0
24	13	80	10	41028.66	-18240.31	2.71	1.71	37.70	0.39	37.31	0
25	13.2	66	8.25	21082.33	-19946.33	1.49	0.49	14.43	0.29	14.14	0
26	13.4	57	7.125	16633.72	-4448.61	1.20	0.20	4.14	0.26	3.88	0
27	13.6	51	6.375	18782.98	2149.25	1.34	0.34	8.65	0.27	8.37	0
28	13.8	46	5.75	17146.10	-1636.87	1.24	0.24	5.12	0.26	4.86	0
29	14	42	5.25	17600.06	453.96	1.27	0.27	6.04	0.27	5.77	0
30	14.3	37	4.625	16746.21	-853.85	1.21	0.21	4.35	0.26	4.09	0
31	14.6	33	4.125	17044.05	297.84	1.23	0.23	4.92	0.26	4.66	0
32	15	31	3.875	15900.49	-1143.55	1.16	0.16	2.86	0.25	2.61	0
33	15.5	28	3.5	17723.19	1822.69	1.27	0.27	6.30	0.27	6.03	0
34	16	24	3	12685.90	-5037.29	0.94	0.00	0.23	0.23	0.00	0
35	16.5	22	2.75	17673.25	4987.35	1.27	0.27	6.19	0.27	5.93	0
36	17	20	2.5	11474.96	-6198.29	0.86	0.00	0.22	0.22	0.00	0
37	17.5	19	2.375	15580.52	4105.57	1.14	0.14	2.36	0.25	2.11	0
38	18	18	2.25	15613.67	33.15	1.14	0.14	2.41	0.25	2.16	0
39	19	16	2	15047.05	-566.62	1.10	0.10	1.59	0.25	1.35	0
40	20	13	1.625	16508.81	1461.76	1.20	0.20	3.91	0.26	3.65	0
41	22	12	1.5	46.22	-16462.59	0.01	0.00	0.02	0.02	0.00	0
42	26	0	0	21382.37	21336.15	1.51	0.51	15.24	0.29	14.95	0
43											
44	*Note: Principal Spillway: Riser and Barrel Spillway: Corrugated Aluminum Pipe (CAP) Riser and Barrel;										
45	Riser Dia. = 4.0 ft, Barrel Dia. = 2.0 ft, Barrel Length = 80 ft, Riser Crest El = 700 ft, Water Quality										
46	Orifice El = 699.0 Barrel Invert El = 690.0 at inlet and 689.0 at outlet; Tail Water below crown of barrel outlet.										

FIGURE 2


FLOOD ROUTING: 10-YEAR RAIN EVENT
Inflow
Outflow
Inflow and Outflow (cfs)
0
10
20
30
40
50
60
70
80
90
Time (Hours)
10.7
11.3
11.9
12.1
12.3
12.5
12.7
13
13.4
13.8
14.3
15
16
17
18
20
28

APPENDIX 10

Buffer Bubble