WQ-02 WET DETENTION BASIN

1.0 Wet Detention Basin

1.1 Description

A Wet Detention Basin is intended to manage both the quantity and quality of stormwater runoff before discharging off-site. Stormwater runoff enters a Wet Detention Basin through one or more inlets that discharge into a forebay that is designed to settle out larger sediment. The runoff then passes over a forebay berm and into the main Wet Detention Basin, becoming part of a combined temporary and permanent pool. The temporary water quality pool drains from the Wet Detention Basin over a period of 24-hours. The permanent pool remains in the Wet Detention Basin, where natural processes facilitate both settling and nutrient reduction of the water contained within the Wet Detention Basin.

Wet Detention Basins are applicable where larger developments in a watershed substantially modify the hydrology and pollutant loading of a watershed. *The minimum required on-site drainage area for a Wet Detention Basin is **10 acres**. The optimum drainage area for a Wet Detention Basin is **25 acres or more**.* Applicable sites include:

- Large single family developments,
- Industrial facilities, and
- Large commercial facilities.

Wet Detention Basins are capable of removing metals, suspended solids, nitrogen and phosphorous, and other pollutants. Wet Detention Basins may also be used for water quantity control. The tendency of Wet Detention Basins to attract waterfowl has the potential for higher fecal coliform counts and may not be applicable in watersheds with fecal impairments. Wet Detention Basins also have the potential to raise the temperature of a receiving stream, and may not be applicable in watersheds with biota susceptible to thermal pollution.

1.2 Design

The required method to design an individual Wet Detention Basin or to design a Wet Detention Basin as part of a treatment train with other water quality BMPs is to use the Greenville County IDEAL Model to demonstrate overall site compliance with applicable County water quality standards. See County Design Manual for site-specific applicable water quality standards. In addition to the design requirements of this Specification, follow design requirements in Chapter 7 of the Greenville County Stormwater Management Design Manual.

The design of a Wet Detention Basin can be divided into three components:

1. Forebay (Section 1.2.5),
2. Permanent pool (Section 1.2.2), and
3. Temporary water quality pool (Section 1.2.3).

1.2.1 Flow Length

For maximum Wet Detention Basin water quality benefits, the optimal ratio of flow length to flow width is 3L:1W. Due to site constraints, the minimum allowable design ratio of flow length to flow width is 1.5L:1W. To increase the Wet Detention Basin's flow length to flow width ratio, the basin may be designed with baffles.

Optimizing the Wet Detention Basin flow shape and flow distance through the pond promotes better water quality treatment. Settling is the primary pollutant removal mechanism sought when addressing flow length as a water quality design feature. Wet Detention Basins designed with optimum flow lengths avoid the problem of dead storage or incoming runoff short circuiting through the pond. Optimum flow lengths also decrease the turbulence within the basin and minimize the re-suspension of deposited sediments.

Design Wet Detention Basins with a wedge-shape (when practicable), with the widest cross sections occurring at the downstream end of the basin. Design the deepest pools at the downstream end of the basins to help facilitate cooler effluent water temperatures.

1.2.2 Permanent Pool

The following are requirements for the permanent pool of the Wet Detention Basin:

- Design the permanent pool with an optimal depth between 4 and 6 feet, with a minimum depth of 4 feet and a maximum depth of 12 feet. The depth of the permanent pool prevents particles that have settled to the Basin bottom from re-suspending when runoff enters the Basin.
- Provide an aquatic safety bench around the perimeter of the permanent pool which is 4 to 6 feet wide and 1 to 2 feet below the permanent pool water surface. See Section 1.2.4 for additional information.

*The minimum required on-site drainage area for a Wet Detention Basin is **10 acres**. The optimum drainage area for a Wet Detention Basin is **25 acres or more**.* The permanent pool may be difficult to maintain if the contributing watershed is less than 25 acres, and/or if the ratio of drainage area to wet pond surface area is less than 6:1.

1.2.3 Temporary Water Quality Pool

The temporary water quality pool is stored above the permanent pool and released over 24 hours. The required method to design the temporary water quality pool component of the Wet Detention Basin is to use the Greenville County IDEAL Model to demonstrate overall site compliance with applicable County water quality standards. See County Design Manual for site-specific applicable water quality standards.

1.2.4 Aquatic Safety Bench

An aquatic safety bench around the permanent pool that is managed properly provides safety, aesthetic, bank stabilization and water quality benefits. The aquatic safety bench should be at least 4 to 6 feet wide and 1 to 2 feet below the permanent pool water surface. It should be planted with a minimum of 3 types of indigenous emergent wetland species at a minimum density of 50 plants per 200 square feet. The selection of the proper plant species and planting locations is an integral part in designing a successful aquatic bench in the Wet Detention Basin. Prepare a planting plan by a qualified landscape architect or wetland ecologist for the aquatic bench. Recommended aquatic vegetation for the aquatic bench is provided below.

Vegetation Common Name		
Alligator Flag	Lance-leaf Arrowhead	Swamp Hibiscus
Arrow Arum	Lizard's Tail	Swamp Lily
Caric Sedge	Louisiana Iris	Swamp Rose
Coastal Spikerush	Pickerelweed	Swamp Sunflower
Duck Potato	Pond Cyprus	Sweetflag
Flat Sedge	Rice Cutgrass	Switchgrass
Giant Bulrush	Soft Rush	Tickseed
Golden Canna	Softstem Bulrush	Three-square
Green Arum	Southern Blue-Flag Iris	Virginia Chain Fern
Jointed Spikerush	Smartweed	Wool Grass

Ensure vegetation near the basin meets requirements in ***Chapter 7, Section 7.2.3.4*** of the Stormwater Management Design Manual.

1.2.5 Forebay

The function of the forebay is to trap the majority of the coarse fractions of the suspended solids in the runoff before it enters the main wet detention area, therefore allowing the main pond to maintain its original design volume.

Provide a forebay for all inlets to a Wet Detention Basin and place forebays upstream of the main wet detention area. A forebay is not required for an outlet that contributes less than 10% of the total drainage area or to the basin.

Design forebay side slopes to be 2H:1V or flatter.

The forebay is separated from the larger Wet Detention Basin area by berms, barriers, or baffles that may be constructed of earth, stones, riprap, gabions, or geotextiles. The berm, barrier, or baffles act as a trap for coarse sediments and minimize their movement into the main detention basin. The forebay berm may incorporate a drain pipe or be constructed of riprap to facilitate equalization of the pond over time.

Design the top of the forebay barrier a maximum of 1-foot below the permanent pool elevation, and it may extend above the elevation of the permanent pool.

To minimize the re-suspension of settled particles, design the minimum permanent pool depth of water in the forebay 3-feet above the design sediment storage elevation.

Design the forebay in a manner that it is accessible for easy cleanout because it will eventually fill in with coarse particles. Design the access to the forebay with a maximum slope of 15-20 percent extending from the top of the embankment to the toe.

1.2.5.1 Forebay Sizing

Provide a forebay for each inlet which contributes 10% or more of the total drainage area to the basin. Size each forebay to provide approximately 75 percent of the required post-construction sediment storage volume based on a minimum cleanout cycle of 5 years. Size each forebay according to the specific basin inlet's contribution of sediment to the Wet Detention Basin. This is represented by the equation below:

$$Forebay\ Volume\ (cf) = \frac{Annual\ Sediment\ Load\ (\frac{lbs}{year})}{Bulk\ Density\ of\ Sediment\ (\frac{lbs}{cf})}\ x\ 5\ years\ x\ 0.75$$

Consider the following example:

A Wet Detention Basin has a total drainage area of 25 acres coming to the pond through multiple inlet pipes. One inlet drains 4 acres of drainage area. This is 16% of the total drainage area to that specific inlet. Inlets receiving greater than or equal to 10% of the total drainage area require a forebay, therefore a forebay is required. The annual post-construction sediment load from that 4-acre drainage area is 9,800 lbs of sediment (provided by the IDEAL model or other annual sediment load calculations). A typical bulk density for medium-graded sediment is 1.33 g/cm^3 (from USDA NRCS) which is equivalent to 83 lb/cf. As demonstrated below, the minimum forebay volume for this specific basin inlet is **443 cf**.

$$Forebay\ Volume\ (cf) = \frac{9{,}800\ (\frac{lbs}{year})}{83\ (\frac{lbs}{cf})}\ x\ 5\ years\ x\ 0.75 = \mathbf{443\ cf}$$

1.2.6 Principal Spillway

Design the principal spillway to safely pass, at a minimum, 10-year and 25-year, 24-hour storm events. Design the principal spillway with a trash rack, anti-vortex device, and pond drain valve incorporated into the riser structure.

1.2.7 Pond Drain Valve

The principal spillway riser structure must include a pond drain valve for maintenance that can be accessed safely from the riser structure without confined space entry. The pond drain valve must be made of galvanized metal or stainless steel that is resistant to rust and corrosion and have a minimum diameter of 3 inches.

The following information from the USEPA Stormwater Wet Pond and Wetland Management Guidebook provides guidance about pond valve maintenance and cautionary measures that should be taken.

Valves require annual exercising and lubrication. Most valves are hand-wheel valves that take several turns to completely open (often over thirty turns); however, exercising or temporarily opening a valve does not necessarily involve opening it completely. Staff need only rotate the wheel enough times to make sure the metal gate moves up and down. This procedure may involve two or three wheel rotations and a small amount of water may be released. After the valve is exercised, the staff should slowly close the valve, making sure the gate properly re-seats to a watertight closure position or to the appropriate opening dimension. If a valve gate won't move, it may need to be serviced or replaced. If the valve won't close after being opened a few turns, it will also need service.

Valve service typically means applying lubrication. Lubrication involves greasing the valve corkscrew stem and should only be done once it is determined that the valve will safely close again. Water will be released during this 5 to 15 minute operation as most valves must be completely open during lubrication.

Most valves draw water from, at, or near the pond bottom where sediment accumulates. Avoid the quick opening of valves as water released will be turbid and sediment will be introduced to downstream receiving areas. Open the valve slowly and allow the conditions at the permanent pool end to stabilize prior to complete opening.

Some valves are installed with extended stems to allow safer opening from well-above the actual valve itself. Some valve types do not have hand wheels and are more vandal-resistant but require either a cog or 'T' key to open. The key may or may not be present in the riser box. If it is, it should be securely stored in a place where it cannot be removed and preferably as far removed from running water as possible. If the key is stored off-site, this may pose a problem if the pond needs to be dewatered in an emergency.

Vandalism protection involves common sense measures such as chaining and locking valves and other mechanical components.

1.2.8 Low Flow Orifice

Use a low flow orifice to slowly release the temporary water quality pool over a period of 24 hours or longer depending upon the design criteria for the water quality structure. Wet Detention Basins with slow release rates for water quality control require small outlet control structures. These structures are prone to becoming clogged. Ensure the low flow orifice is protected from clogging by designing appropriate trash guards. Acceptable trash guards include:

- Floating Skimmers
- Hoods that extend at least 6-inches below the permanent pool water surface elevation.
- Reverse flow pipes where the outlet structure inlet is located below the permanent pool water surface elevation.
- Trash boxes made of sturdy wire mesh.

1.2.9 Emergency Spillway

Design emergency spillways to safely pass the post development 100-year, 24-hour storm event without overtopping any dam structures. Design the 100-year water surface elevation a minimum of 1 foot below the top of the dam embankment.

1.3 Other Design Requirements

Perform an infiltration test on the Wet Detention Basin bottom determined from site specific soil boring samples. If the infiltration rate exceeds 0.01 in/hour, a liner or clay pack is required.

Designer shall refer to DHEC Dam Safety Guidelines to ensure compliance with SC Regulation 49-11.

A Level Energy Dissipator (RC-05) or Level Spreader (WQ-13) may be installed at the Wet Detention Basin outlet structure to prevent destabilization of the receiving water body. A Level Energy Dissipator is appropriate when the desired function of the practice is to spread flow and dissipate energy. A Level Spreader is appropriate and required when additional water quality treatment is to be provided by a Vegetated Filter Strip (WQ-12) or Water Quality Buffer (WQ-11).

1.4 Installation

Perform the following for all Wet Detention Basin installations:

1. Route all channels and pipes conveying flow to the basin away from the basin area until the basin is complete and stabilized.
2. Clear, grub, and strip the area under the embankment of all vegetation and root material. Remove all surface soil containing high amounts of organic matter, and stockpile or dispose of it properly. Remove all unused fill material to the designated disposal area.
3. Ensure that fill material for the embankment is free of roots, woody vegetation, organic matter, and other objectionable material. Place the fill in lifts not to exceed 9 inches, and machine compact it. Over fill the embankment 6 inches to allow for settlement.
4. Install inlet and outlet control structures. Ensure principal spillway and emergency spillway installed to proper elevations as specified in the engineering drawings.
5. Grade the basin so that the bottom is level front to back and side to side and prepare subsoil.
6. Apply and grade planting soil for aquatic safety bench.
7. Install forebay and erosion control at points of inflow into the pond.
8. Install erosion control and energy dissipation at the pond outlet.
9. Seed, plant and mulch the embankments and the aquatic safety bench.
10. Route flow from contributing watershed to the basin as shown in the engineering drawings.
11. Follow required maintenance guidelines.

1.5 Inspection and Maintenance

Wet Detention Basins should be inspected semi-annually (every 6 months) and maintained at the appropriate intervals. Proper maintenance ensures the continued functionality of the Wet Detention Basin. Tables 1, 2 and 3 outline the various maintenance requirements after the installation of a Wet Detention Basin.

Table 1: Summary of General Maintenance Requirements

Required Maintenance	Frequency
General inspection of basin function and maintenance needs.	Semi-Annual (every 6 months)
Clean and remove debris from inlet and outlet structures.	After large storm events
Mow side slopes.	As needed
Removal of invasive vegetation.	Semi-Annual (every 6 months)
Inspect for damage to outlet control structure.	Semi-Annual (every 6 months)
Inspect for sediment accumulation in the basin and forebay.	Semi-Annual (every 6 months)
Inspect for operational inlet and outlet structures.	Semi-Annual (every 6 months)
Repair embankment, side slopes, undercut or eroded areas.	Annual, or as needed
Perform pesticide/nutrient management.	Annual, or as needed

Table 2: Summary of Maintenance Requirements for Individual Features

BMP Component	Maintenance	Frequency
Basin banks	Pruning and weeding.	As needed
	Remove trash and debris.	As needed
	Repair eroded areas, replant grass. If recurring problem, consider sodding.	Semi-Annual (every 6 months)
	Inspect trees and shrubs to evaluate their health.	Annual
Aquatic bench	Perform wetland plant management and harvesting.	Annual
	Survey the plant species, if monoculture developing, take appropriate action.	Annual
	Remove and replace dead or severely diseased vegetation.	Annual
Permanent pool	Remove accumulated sediment.	Per design cycle (typical 5-10 year maintenance interval), or after 25% of permanent pool volume is filled
	Apply algaecide.	When algal growth > 50% pond surface.
Forebay	Remove accumulated sediment.	Per design cycle (typical 5-year maintenance interval), or after 50% of total forebay capacity is filled
Outlet structure	Clean out outlet of all debris.	Semi-Annually (every 6 months)
	Check if bank needs stabilization downstream of outlet.	Semi-Annually (every 6 months)
	Exercise pond drain valve.	Annual, see Sec 1.2.7 for valve maintenance description and caution.

Table 3: Summary of Trouble Shooting Activities

BMP Component	Problem	Solution
Wet Detention Basin	Trash/debris is present.	Remove the trash/debris.
Perimeter	Areas of bare soil and/or erosion.	Re-grade the area as necessary, plant vegetation, and water until established.
Inlet device: pipe or swale	Pipe is clogged.	Unclog the pipe. Dispose of sediment properly.
	Pipe is cracked or damaged.	Replace the pipe.
	Erosion is occurring.	Re-grade as necessary to smooth and provide additional erosion protection as needed such as erosion control blankets and turf reinforcement matting to prevent future erosion problems.
Forebay	Sediment has accumulated and reduced the depth to 50% of the original design depth.	Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a proper location.
	Erosion has occurred or riprap is displaced.	Provide additional erosion protection such as turf reinforcement matting or riprap if needed to prevent future erosion problems.
	Weeds are present.	Remove the weeds, preferably by hand. If pesticides are used, wipe them on the plants rather than spraying.
Main treatment area	Sediment has accumulated to a depth greater than the original design sediment storage depth.	Search for source of sediment and remedy the problem if possible. Remove sediment and dispose of properly. Re-vegetate disturbed areas immediately with sod (preferred) or seed protected with erosion blankets.
	Pruning is needed to maintain optimal plant health.	Prune according to best professional practices
	Plants are dead, diseased or dying.	Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a one-time fertilizer application to establish the ground cover if a soil test indicates it is necessary.
	Weeds and noxious plants are growing in the main treatment area.	Remove the plants by hand or by wiping them with pesticide (do not spray).
Embankment	Shrubs or trees on the embankment.	Ensure vegetation is in Accordance with Design Manual Section 7.2.4.3
	Grass cover is unhealthy or eroding.	Restore the health of the grass cover – consult a professional if necessary.
	Signs of seepage on the downstream face.	Consult a professional.
	Evidence of muskrat or beaver activity is present.	Use traps to remove muskrats and consult a professional to remove beavers.
	An annual inspection shows that the embankment needs repair.	Make all needed repairs.
Outlet structure	Clogging has occurred.	Clean out the outlet device.
	The outlet device is damaged.	Repair or replace the outlet device.

1.6 IDEAL Modeling

The County's required method of demonstrating compliance with its water quality standards is to use the Greenville County IDEAL model. To facilitate use of this model, Table 4 shows how to represent this BMP and BMPs similar to this one in the IDEAL model. It lists the parameters needed to successfully run the model and the parameters that affect the sediment trapping efficiency of the BMP.

Table 4: IDEAL Modeling Guide

Wet Detention Pond Modeling in IDEAL		
What to Model as in IDEAL	Wet Detention Pond	
Similar BMPs	Retention or Irrigation Ponds	
	Extended Detention Wetland	
	Shallow Marsh Wetlands	
	Pond/Wetland System	
	Multiple Pond System	
	Wet Stormwater Detention/Extended Basins/Micropool Basins	
Specifications Needed for IDEAL	Soil texture and degree of saturation of the soil within the pond	
	At least 3 area measurements at varying stages of the pond	
	Type, shape, and size of the emergency spillway if applicable	
	Riser type, shape, and dimensions	
	Number of orifices with corresponding inverts and sizes	
	Size, slope, Manning's roughness coefficient, entrance loss coefficient, and invert height of the barrel	
	Direct loading of bacteria that will be entering the pond	
Parameters that Drive Performance	Feature	How Value Affects Sediment Trapping Efficiency (TE)
	Underlying Soil Texture	Soils with higher infiltration capabilities increase TE
	Surface Area	Increasing surface area increases TE
	Bottom Area	Increasing bottom area increases infiltration and TE

1.7 References

USEPA Stormwater Wet Pond and Wetland Management Guidebook, February 2009 (https://www3.epa.gov/npdes/pubs/pondmgmtguide.pdf).

USDA-NRCS Soil Quality Physical Indicator Information Sheet Series: Bulk Density, June 2008 (https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053256.pdf).