**ALTERNATIVE METHODOLOGY FOR DESIGNING WET DETENTION BASINS**

The methodology described below is intended for the design of wet detention basins to provide equal or better treatment of stormwater flows in comparison to the current methodology. The methods described herein are based on the fact that a hydraulic residence time of 14 days will achieve 90% TSS removal in a wet pond. This methodology does not reduce the requirements for calculating the design storm volume or change the required BMP draw down of 2 to 5 days.

In creating this methodology consideration was given to additional storm events other than a single design storm. In North Carolina rain events occur at a rate of every 3 to 5 days. Despite this fact it is not likely that we would see back to back design storms in a two week period. According to the National Weather Service data for the last five years, the average rainfall for a two week period would be 2.21 inches.

Furthermore, this methodology seeks to decouple the surface area and basin depth geometry so that the designer can be free to determine basin geometry to fit the needs of the site. The current methodology requires a relationship between surface area and basin depth that seems unsupported in the literature.

This methodology does not make a distinction between an 85% and 90% pond. The methodology treats all ponds as removing 90% TSS. This removal rate is supported in "Methodology for Analysis of Detention Basins for Control of Urban Runoff", Section 4.2.3 Figure 9 and Equation 13. This section talks about percent TSS removal with combined dynamic and quiescent effects. Using an HRT of 14 days the calculated removal is 88%. In addition the same document shows the long term average TSS removal of 100% for basins with a surface area to catchment area (SA/DA) ration of around 1% (Figure 12, pg 47). Note also that in another source entitled "Storm Water Technology Fact Sheet – Wet Detention Ponds" removal rates of up to 90 percent are shown in Table 1. These rates are for ponds without forebays and vegetated shelves.

The removal rate of a pond is determined by many factors and the rates are seen as an average of storm events over the lifetime of a BMP.

| **Major Design Elements** | |
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| **Required by the NC Administrative Rules of the Environmental Management Commission** | |
| 1 | Sizing shall take into account all runoff at ultimate build-out, including off site drainage. Portions of the project receiving runoff may direct runoff to on-site wetlands provided that the flow is directed over a 20' grassed buffer in a non-erosive fashion. This reduction in flow to the basin can be considered when sizing the basin but cannot be considered in determining whether the project is low or high density. |
| 2 | Vegetated slopes shall be no steeper than 3:1 |
| 3 | BMP in recorded easement with access to public ROW. |
| 4 | Basins shall be required to have a hydraulic retention time of 14 days. Basins draining to SA waters (1/2 mile) shall be designed with a secondary BMP in series with the basin. |
| 5 | Use as S&EC must be cleaned out etc. |

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| 6 | Design storage shall be above the permanent pool. This storage area shall compromise the volume between the permanent pool and the peak stage of the basin for the design storm. Note that this storage elevation may exceed the control structure elevation but not the emergency spillway elevation. |
| 7 | The volume of the design storm shall have an HRT of 14 days calculated by the following equation: Vpp = (HRT-Tdd)/14 x Vtp, Where HRT = hydraulic residence time in days, Vpp = volume of the permanent pool in cubic feet, Vtp = volume of the temporary pool in cubic feet, and Tdd = the draw down time for the permanent pool volume in days. |
| 8 | The minimum depth of the basin shall be 3 feet to impede algae growth and prevent scour. The maximum depth shall be 20 feet to avoid thermal upwelling. The depth of the basin shall be considered as the depth above the sediment storage elevation and below the permanent pool elevation. The contours of the basin should be designed to achieve this depth and reduce the velocity of flow through the basin to prevent scouring and resuspension of settled solids. The basin depth may be calculated by dividing the volume of the permanent pool below the below the bottom of the vegetated shelf by the surface area of the bottom of the vegetated shelf and adding 6 inches. |
| 9 | The permanent pool surface area shall be determined by the following equation: SA =IA/ DA * .03, Where SA is the permanent pool surface area in square feet, IA is the connected impervious area on site in square feet and DA is the drainage area in square feet. In no case shall the permanent pool surface area be less than 1% of the drainage area. |
| 10 | Flow shall not short circuit. |
| 11 | BMP shall be designed with a forebay. |
| 12 | Stabilize side slopes above waterline. |
| 13 | Slopes below the vegetated/safety shelf shall be no greater than shallower than 3:1 and no steeper than the soils or stabilizing materials will allow. |
| 14 | A minimum sediment storage depth of 1 foot shall be incorporated into the basin. |
| **Required by DWQ Policy** | |
| 15 | The BMP shall not be located to produce adverse impacts on water levels in adjacent wetlands. |
| 16 | A minimum 10 foot wide vegetated/safety shelf shall be installed on the perimeter of the basin. The top edge shall start 6 inches above the permanent pool elevation and extend at a 10: slope to a depth of 6 inches below the permanent pool elevation at the lower edge. |
| 17 | Forebay shall be 20% of the permanent pool volume. |
| 18 | Pond shall have a freeboard of 1 foot above the temporary pool elevation. |

## Design Steps

**Step 1 Determine the Temporary Pool Volume, Vtp**

The design storm volume can be determined by using the simple method, the SCS method or any other applicable standard method. Consideration for low impact development (LID) practices upstream of the BMP can be used to reduce the volume of the design storm and would be encouraged.

The volume of the design storm is equivalent to the temporary pool volume, Vtp and should be expressed in cubic feet.

**Step 2 Determine the Permanent Pool Volume, Vpp**

The permanent pool volume should be determined by the following equation:

**Vpp = (HRT-Tdd)/14 x Vtp**

Where: HRT = 14 days (hydraulic residence time)
Vtp = Temporary pool volume in cubic feet
Tdd = Drawdown time for the BMP in days
Vpp = Permanent Pool Volume in cubic feet

Since the drawdown for the BMP may not be known at this time the designer should estimate the rate and return to this calculation in an iterative fashion to arrive at the final design.

**Step 3 Determine the Minimum Permanent Pool Surface Area**

The literature suggests a maximum surface area requirement of 3% the watershed area in designs where the watershed has a high percentage of impervious surfaces. To arrive at a minimum surface area the rational coefficient for the site should be multiplied by 3% of the connected impervious areas. Please note that in most cases pond geometry will dictate a larger surface area to achieve the volumes required.

**Step 4 Determine Permanent Pool Elevation**

The designer should select the permanent pool elevation to serve the project. This elevation should take into consideration the level of the water table on the site, the proximity to surface waters and wetlands and the impact the permanent pool level could have on these features. The permanent pool elevation of the basin must be at or above the elevation of the outlet pipe and or downstream BMP. The permanent pool should not be lower than 6 inches below the seasonal high water table.

**Step 5 Determine the Basin Geometry**

Using the values of temporary pool volume, permanent pool volume and minimum surface area the pond geometry can be designed to fit the site. Basin depth should be a minimum of 3 feet and a maximum of 20 feet. Average depth shall be calculated by dividing the surface area at the bottom of the vegetated shelf into the volume of the permanent pool below that elevation and adding 6 inches.

This is an iterative process and will require the designer to reevaluate the outlet structure and contours repeatedly to arrive at a final design. In most cases it is helpful to create a spreadsheet to tract the many dimensions and areas in the design process.  It is also prudent to use a spreadsheet to evaluate inflow and outflow hydrographs and basin peak stage elevations.

**Step 6 Design the Outlet Structure**

Given the volumes and areas calculated above, design the outlet structure to achieve the required draw down time and maximum stage elevations.

**Step 7 Check that the Design Meets the Design Criteria**

The designer should verify the typical design elements outlined in the table such as vegetated shelf requirements and forebay volumes.  In some jurisdictions local regulations may require additional design elements or requirements of the BMP.