Section 8a is a perquisite to this tutorial. Before starting, designers should complete and understand the Infiltration Pond tutorial in section 8a.

In this example you will learn:

- The design criteria for bioinfiltration ponds.
- The design procedure for drywells.
- An introduction to the UIC guidelines in the HRM and how they apply to drywells.
- How to use StormSHED output to verify the design criteria's is met.

Biofiltration Swale Sample Problem Description

This tutorial will use the sample problem and StormSHED files from Section 8a.

Introduction to Bioinfiltration Swales

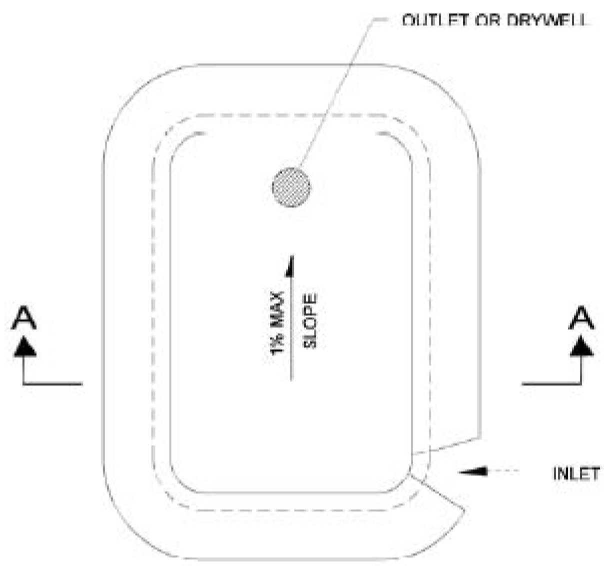
Bioinfiltration ponds aka bioinfiltration swales or grass percolation areas, are a combination of grasses and soils used to remove stromwater pollutants by percolation into the ground. These ponds are designed to contain the runoff treatment volume (6 month storm) below the first 6” in the pond. The remaining volume from the pond (25 year storm) will overflow into a higher permeability (flow control) infiltration BMP such as a drywell. *Pretreament should be considered in the design process, to prevent the bioinfiltration pond treatment soil from clogging.*

Bioinfiltration ponds can be utilized for runoff treatment and flow control. For runoff treatment BMP’s, bioinfiltration ponds meet the requirements for basic and enhanced runoff treatment objectives as well as oil control for high-use roads. In order for the flow control criteria to be met, there must be a large area with a shallow water depth otherwise flow control must be implemented using a different BMP.

Bioinfiltration Sizing Criteria

Bioinfiltration pond sizing is the same as for infiltration ponds including the design storm and precipitation values (see Section 8a of this tutorial) with the following exceptions:

- The pond should be designed to hold the volume of stormwater from the 6 month long duration or Type 1A storm in the first 6” of the pond. The remaining volume from the 25 year storm will overflow into a drywell or other infiltration or overflow facility.
- The swale bottom should be flat with a longitudinal slope of less than 1%.
- Bioinfiltration swales should be excavated to a minimum depth 6” below the bottom of the pond until after construction. Post construction the soil should be replaced with top soil that meets the minimum requirements:
    1. Contain sufficient organics and texture to ensure good vegetation growth. Also, SSC – 7 requirements for soil characteristics should be followed.
    2. For 6” of top soil, infiltration rates shall not exceed 1”/hr. A maximum infiltration rate of 2.4”/hr is allowed, however 18” of top soil must be provided at the bottom of the pond that meets the requirements of the SSC.
    3. If the infiltration rate of the native soil is less than that of the top soil, the native soil infiltration rate must be used for the design of the bioinfiltration pond.
- Grasses should drought tolerant or irrigation should be provided.
- Pretreatment should be considered to prevent clogging of the treatment soil and vegetation by debris, TSS, and oil and grease.
- When curb openings are used at the inlet, a concrete or riprap apron should be provided to prevent vegetation from blocking the inlet.



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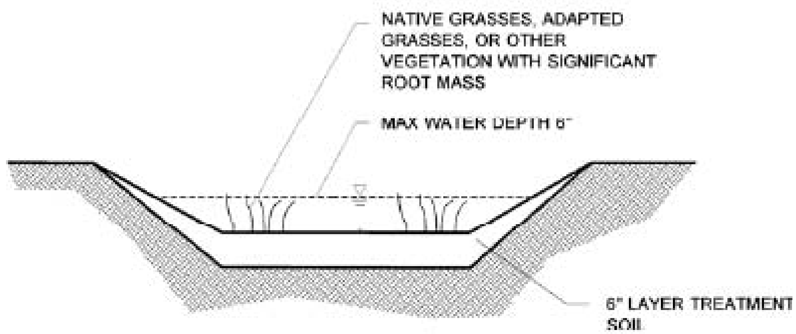

SECTION A-A
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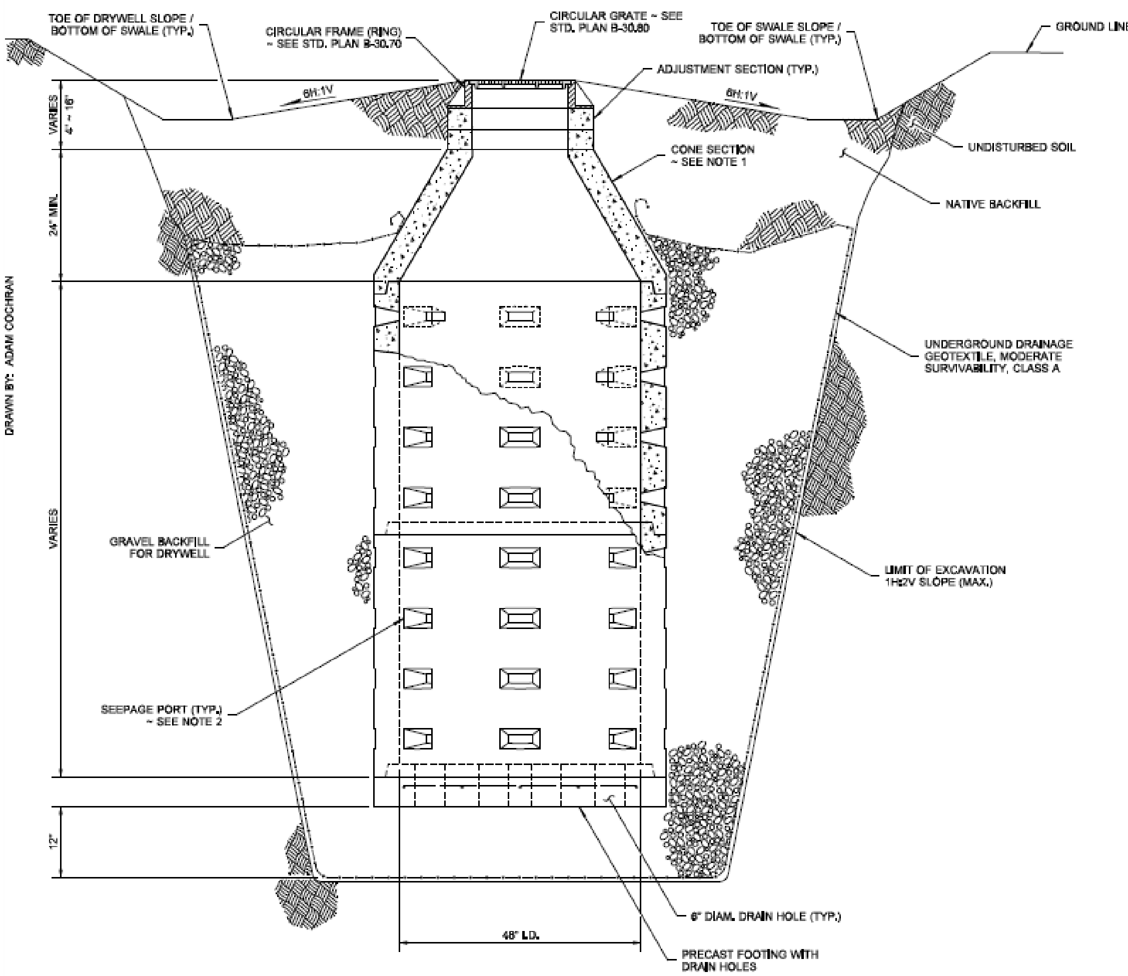
THIS DRAWING IS ONLY A TEMPLATE THAT NEEDS TO BE ADJUSTED AND REVISED FOR EACH PROJECT

INFILTRATION SWALE

Introduction to Drywells

Drywells are perforated pre-cast concrete manhole structures that are surrounded by drain rock. The primary purpose of a drywell is to discharge stormwater directly into the ground. Drywells can be used alone for flow control where runoff treatment is not required or in combination with a runoff treatment BMP. This tutorial will focus on the use of a drywell as an overflow structure in a bioinfiltration pond.



CUTAWAY ELEVATION VIEW

Standard Plan B-20.20.01 Drywell Type 1 (for Swales)

Drywells are considered a means of subsurface infiltrations and are designed based on the capacity of the subsurface soil conditions. Drywells are practical only in areas where groundwater tables are sufficiently below the bottom of the facility and in highly permeable soil conditions. The design of drywells is regulated by the Underground Injection Control (UIC) Rule, which is intended to protect drinking water. Infiltration systems regulated by the UIC include: drywells, pipe or french drains, drain fields, and other similar devices that are designed to discharge stormwater directly into the ground.

Design Criteria for Drywells

Drywells should be designed with the following considerations:

- Drywells must meet the UIC requirements outlined in the HRM and be registered with the department of Ecology, see section 4-5.3 of the HRM for further guidance.
- The bottom of the drywell should be a minimum of 5’ above the seasonal high ground water level or impervious soil layers.
- Typically drywells are 48” in diameter and approximately 5’ (single barrel) to 10’ (double barrel) deep.
- A geotextile should be placed on top of the drain rock before the drywell is backfilled to prevent migration of fines into the drain rock.
- When more than one drywell is installed, spacing should be no closer than 30’ center-to-center.
- Drywells should not be built on slopes greater than 25% or above landslide hazards. For placement on slopes between 15%-25%, evaluation by a PE with geotechnical expertise is required.

Design Procedure for Drywells

The design procedure for drywells has recently (2004 HRM) changed based on research conducted by Massmann for eastern Washington. In the past, WSDOT followed the Spokane County design methods, which were based on soil types in Spokane County. Through Massman’s research, a more accurate design method was found that is based on soil types throughout eastern Washington. The design procedures for drywells are outlined in section 4-5.4.2 of the HRM and summarized below:

1. Estimate the volume of stormwater, V_{design}.

   This step was performed in Tutorial 8a on approximately page 7. The pond volume was determined from the **developed** basin condition and the release rates from the **existing** basin.

2. Follow steps 4 through 5 in the Detailed Approach.

   Both steps 4 and 5 involve conducting a geological investigation and collecting the soils data found in Tutorial 8a.

3. Determine the saturated hydraulic conductivity.

   This was calculated to be **42in/hr** on approximately page 22 of Tutorial 8a.

4. Estimate the uncorrected steady-state infiltration rate for drywells.

   Two equations were developed to estimate the steady-state infiltration rates, one double barrel drywells and the other is for single barrel drywells. The flow rates are based on the saturated hydraulic conductivity and the depth to ground water as shown below:

Double-barrel wells:

$$Q = K[3.5\ln(D_{wt}) + 12.32]$$

Single-barrel wells:

$$Q = K[1.34\ln(D_{wt}) + 8.81]$$

Where:

Q = the infiltration rate in cfs

K = the average saturated conductivity in fpm

D_{wt} = the depth from the bottom of the drywell to groundwater in feet

From Tutorial 8a, the ground elevation is 205' and the depth of groundwater is 191'. Given the 5' required separation between the groundwater depth and the bottom of the drywell, the maximum elevation of the bottom of the drywell is 196'. From that the drywell will need 5' for the single barrel (elevation 201) and 2'4" for the cone and adjustment section (elevation 203.33'). The top of the drywell will be set at elevation 203.33' and the bottom of the pond will be 6" below that or elevation 202.83'. Given the separation requirements, a Single-barrel well is the only option.

$$Q = K[1.34\ln(D_{wt}) + 8.81]$$

$$Q = 42\frac{in}{hr} x \frac{1hr}{60\min} x \frac{1\,ft}{12in}[1.34\ln(5') + 8.81]$$

$$Q = 0.6394cfs$$

5. Estimate the uncorrected, steady-state infiltration rate for drywells.

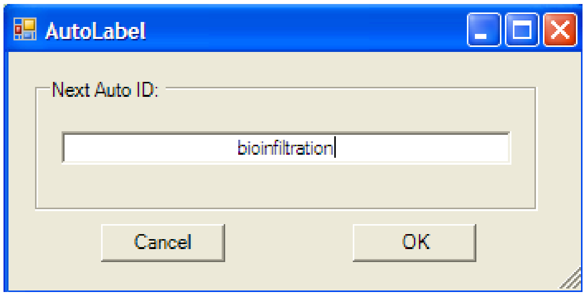
   If a pretreatment facility is used, then no correction factor is needed. If not, the long term effects of siltation and should be considered by reducing the infiltration rates by a factor of 0.5.

   $$Q = 0.6394cfsx0.5 = 0.32cfs$$

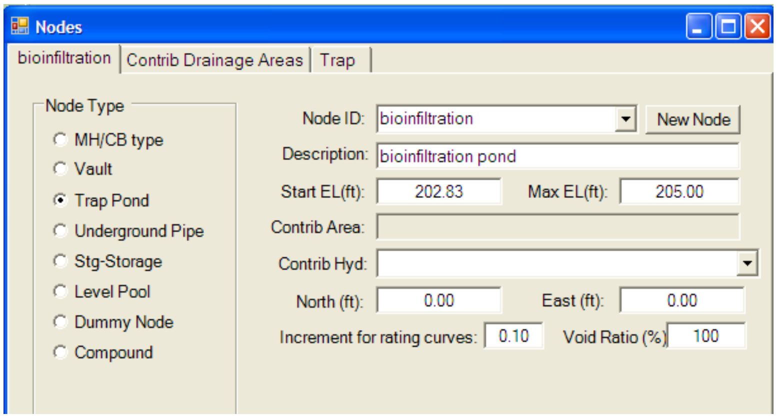
6. Size the facility.

   We now have all the information we need to size the biofiltration swale.

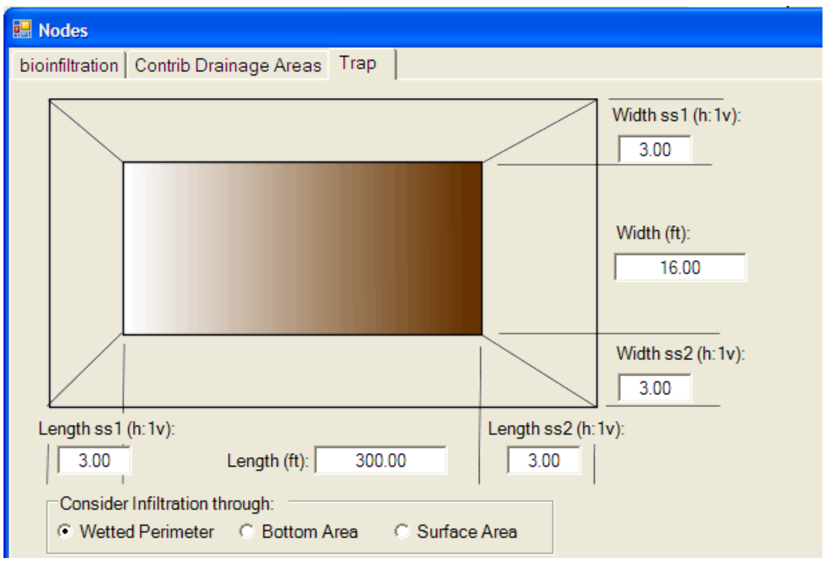
   - Using the same StormSHED file from Tutorial 8a, open **infiltration 8a and 8b.**
   - Create a new node called **bioinfiltration** and then select **OK**.



- Input the description and the elevations as shown below



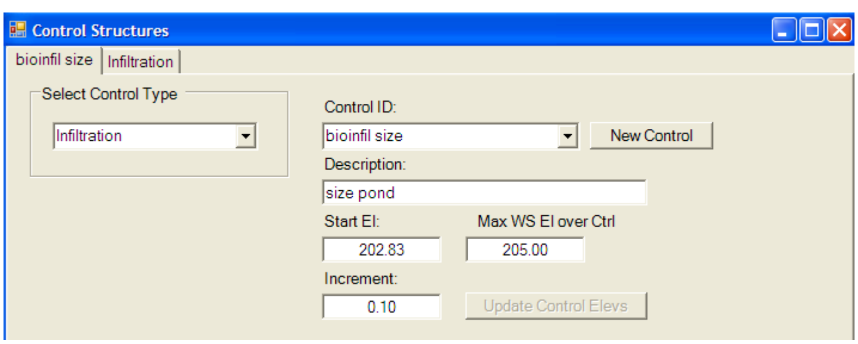
- Select the **<u>Trap</u>** tab and guess the pond dimensions to be **<u>300'x16'</u>** as shown below:



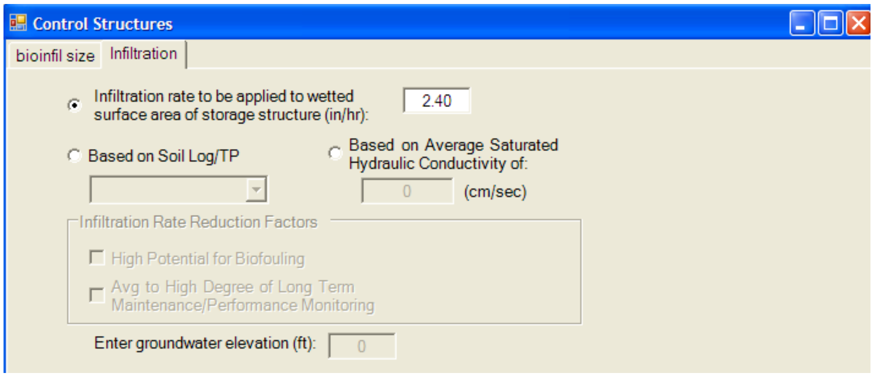
- Select the **OK** button to close the dialog box.

Create a Discharge Structure for the first 6"

Next we need to size the pond to contain the 6 month storm in pond at a depth of 6", without the dry well.



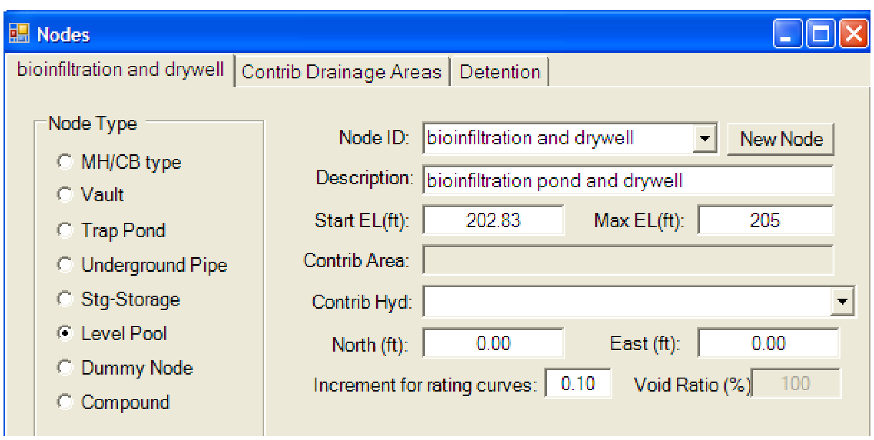
- Input the Control Structures data as shown on the last and next dialog box.



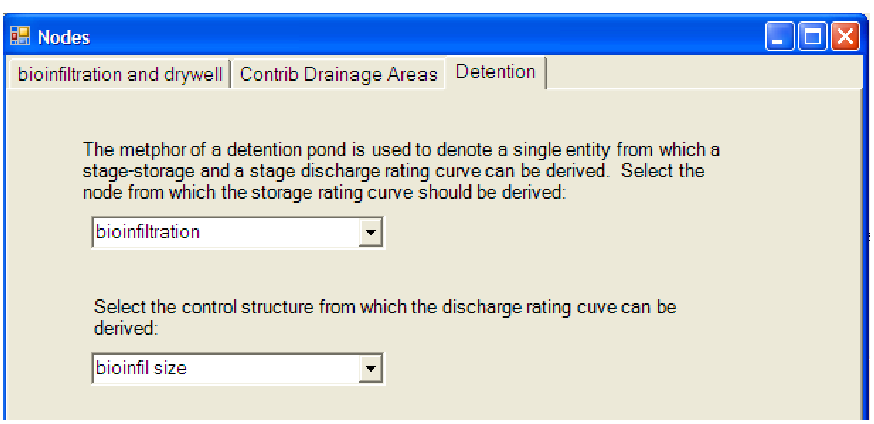
- **<u>Close</u>** the dialog box.

The lab tested the soil in the area where the bioinfiltration swale will be installed and calculated the infiltration to be 3.0 in/hr. However, per the bioinfiltration design criteria the maximum discharge is 2.4in/hr and this requires the bottom of the pond replace 18” of native soil with 18” of topsoil that meet the requirements in the SSC. Therefore in the Control Structures dialog box, 2.4in/hr overrides the calculated 3.0 in/hr. If only 6” of top soil were installed, the corresponding maximum infiltration rate would be 1.0 in/hr.

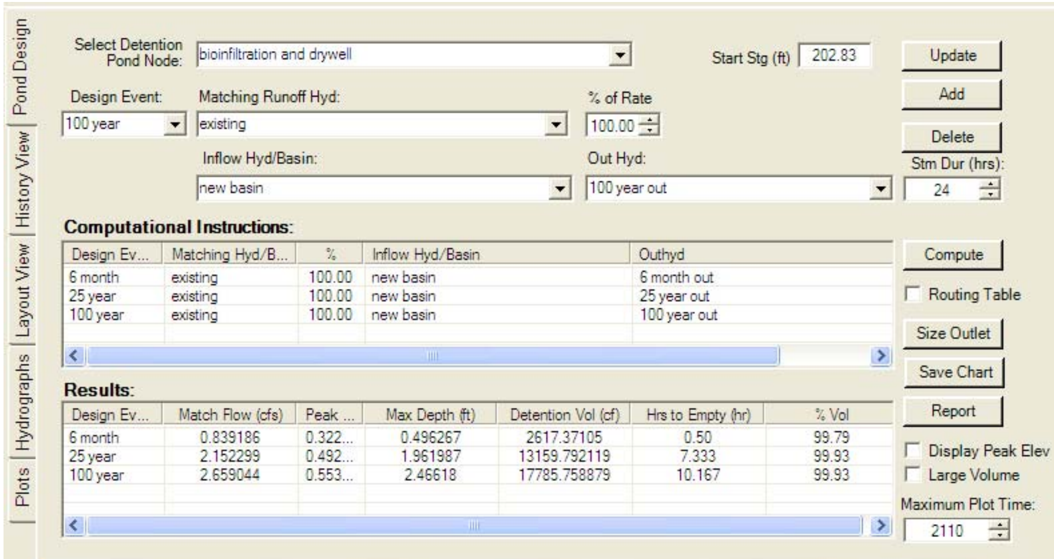
Create a Level Pool to define the trap pond and discharge structure.



- Input the data as shown on the dialog boxes as shown above and below.



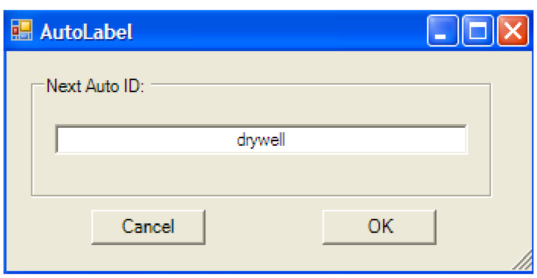
Verify the Pond Design meets the BMP requirements.



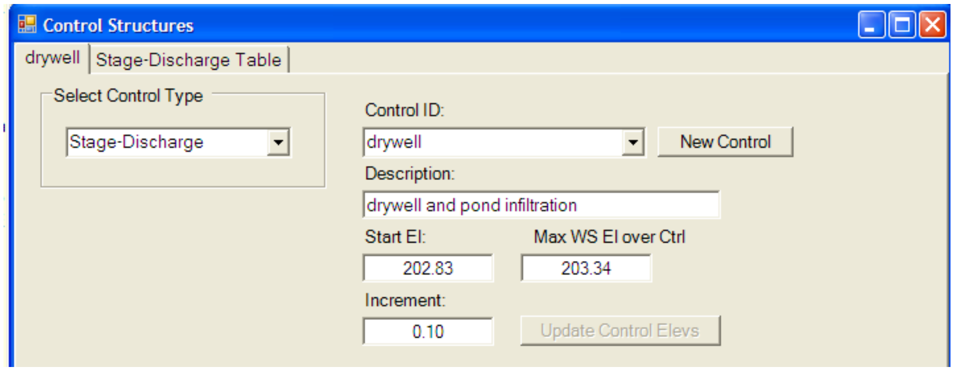
- Select the ***Pond Design*** tab and input the data as shown above.
- Click the **Compute** button and review the data to verify the design criteria is met.

Since the 6 month stormwater elevation is less than 6", the pond size of 300'x12' is sufficient. Now we will repeat the process adding the drywell to the infiltration rate to see if the pond meets the requirements for the 25 and 100 year storms.

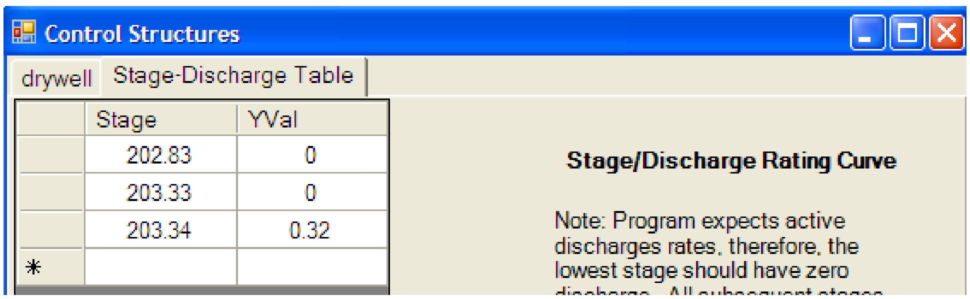
- Next create a discharge structure called drywell.



- Next input the drywell details as shown below, StormSHED will automatically input the elevations after the stage-discharge table is input.



- Select the **<u>Stage-Discharge Table</u>** tab and input the data as shown below.

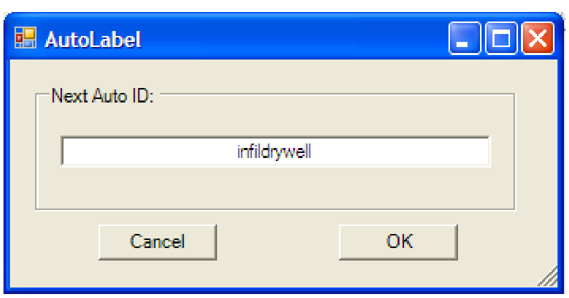


These values are only for the drywell. At the bottom of the pond, elevation 202.83 the discharge through the drywell is zero. At elevation 203.33, the top of the drywell there is still no runoff discharging into the drywell. However, once the runoff elevation just tops the drywell or elevation 203.34 runoff will begin to discharge through the drywell.

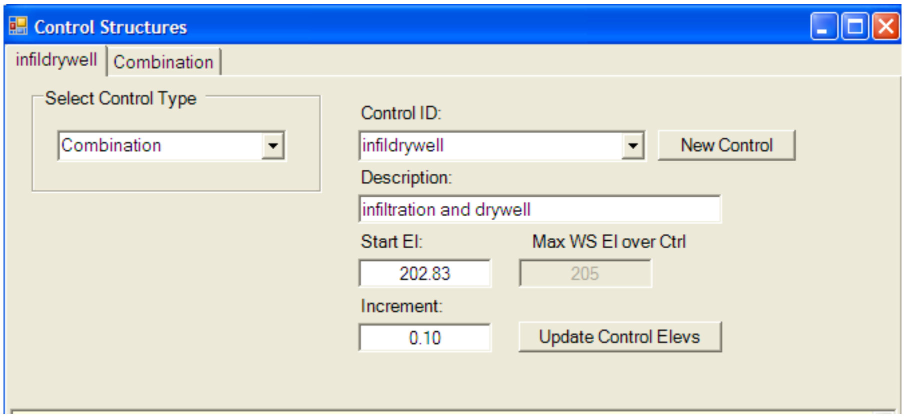
Create a Combo Discharge Structure

Next we need to create a combination discharge structure that will consider both the infiltration rate of the soil and discharge rate of the drywell.

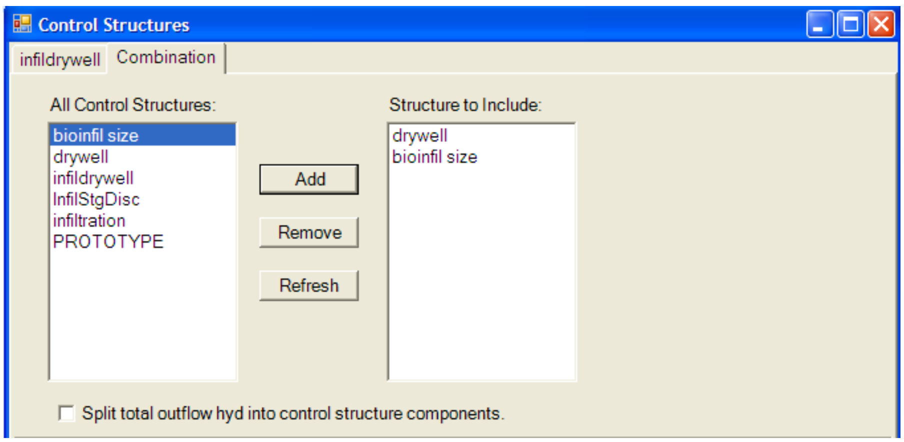
- Create a ***Control Structure*** named **<u>infildrywell</u>** and select the **<u>OK</u>** button.



- Create a ***Control Structure*** named **<u>infildrywell</u>** and select the **<u>OK</u>** button.

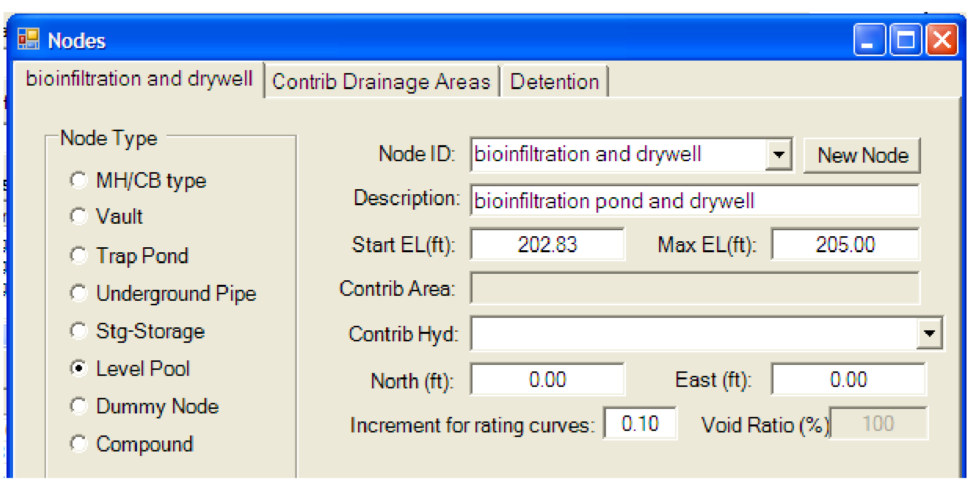


- For the <u>Control Type</u> select **<u>Combination</u>**.
- Input a **<u>description</u>** and **<u>Start El</u>** as shown above. The Max elevation will automatically update after the discharge structures are selected.



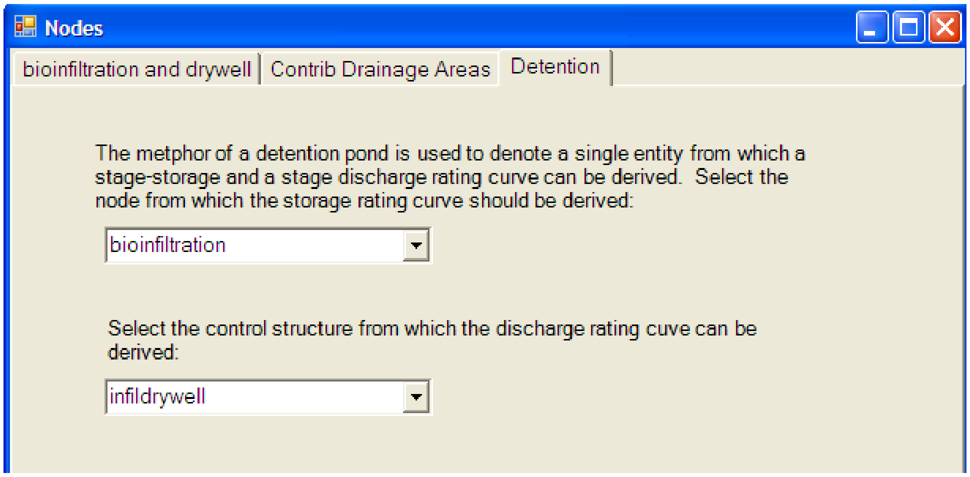
- Select the ***Combination*** tab and **<u>add</u>** both the **<u>drywell</u>** discharge structure and **<u>bioinfil size</u>** (infiltration rate). Both should appear in the right box titled '<u>Structure to include</u>'.

Define the RLPool



- Open the existing node called '**<u>bioinfiltration and drywell</u>**' as shown above.

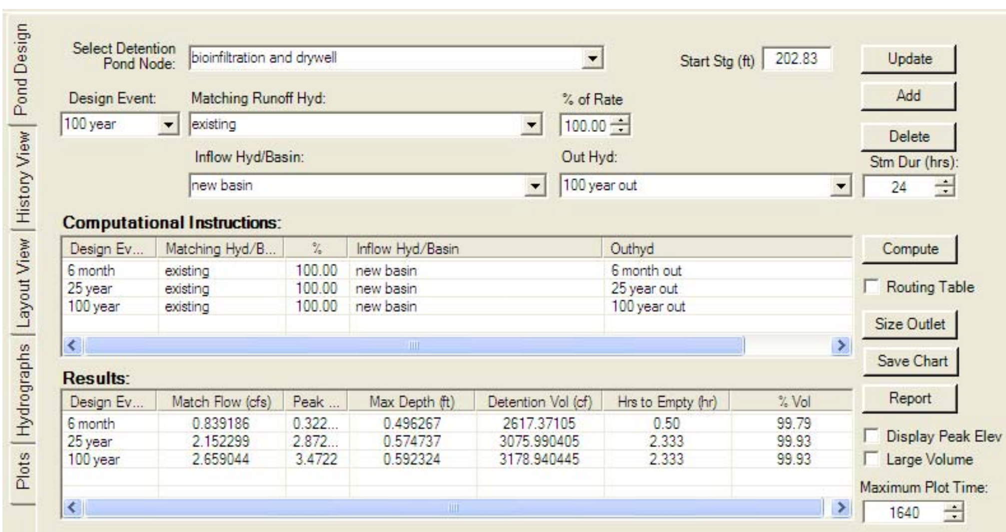
- Select the **Level Pool** for Node Type and input the description and Start El as shown above.
- Select the ***Detention*** tab and change the discharge structure to **infildrywell**.



- **Close** the dialog box.

Size the Biofiltration Pond

- Open the ***Pond Design*** tab and select the **Compute** button. The results should match the dialog box below.



Results

The bioinfiltration pond is required to have a 1’ of freeboard above the 25 year storm and with only a max depth of 0.57’ or approximately elevation 203.4, there is 1.6’ of freeboard. Checking the 100 year storm, the elevation is nearly identical. Therefore this pond size meets the requirement.