

Flow Control - Detention Pond Example

Flow Control Definition

Flow control is Minimum Requirement 6 in the HRM. Unless an exemption applies (see section 2-3.6 of the HRM), any project that adds 5,000 square feet or more of net-new impervious surfaces in a drainage basin area project must provide flow control of stormwater runoff. The objective of flow control is to prevent increases in the erosion rates beyond those characteristics of natural or re-established conditions. The intent is to prevent cumulative future impacts from increased stormwater runoff volumes and flow rates on streams and off WSDOT ROW.

In addition, when the 10,000 square foot threshold is met or exceeded:

- Road/parking lot-related projects (including pavement, shoulders, curbs, and sidewalks) also need to apply Minimum Requirement 6 to any replaced (down to sub-grade) impervious surfaces within the drainage basin area if the total net-new impervious surfaces add 50 percent or more to the existing impervious surfaces, or
- Non-road-related projects (e.g., rest area, maintenance facility, ferry terminal buildings) also need to apply Minimum Requirement 6 to any replaced impervious surfaces within the drainage basin area if the value of the proposed improvements – including interior improvements – exceeds 50 percent of the replacement value of the existing site improvements.

Flow Control Design Guidance

Using a single event model, flow control design requirements for projects must limit the peak release rate of the post-developed 2-year runoff volume to 50 percent of the pre-developed 2-year peak, and maintain the pre-developed 25-year peak runoff rate. The 100-year event must be checked for downstream flooding and property damage.

(Previously, the peak rate of runoff for the completed conditions could not exceed the 10 and 100 year peak runoff from the existing conditions.)

Table 2-7. Eastern Washington flow control criteria.

| Facility Type | Criteria | Model |
|--|---|--|
| Detention and combination treatment and detention facilities | Provide storage volume required to match ½ of the 2-year pre-developed peak flow rate and match the pre-developed 25-year peak flow rate; last, check the 100-year peak flow for flood control and property damage. | Single Event Model (SCS or SBUH) Climate Region 1–4 Regional Storm; <u>OR</u> Type 1A storm for Climatic Region 2 & 3 only |
| Infiltration facilities | Size facility to infiltrate sufficient volume so that the peak overflow rates meet the discharge rates noted in the above criteria or infiltrate 100% of the runoff volume. | Single Event Model (SCS or SBUH) Climate Region 1–4 Regional Storm; <u>OR</u> Type 1A storm for Climatic Region 2 & 3 only |

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As noted in table 2-7, the pre- and post-development runoff volumes and flow rates must be estimated using the Regional Storm for Climatic Regions 1–4; OR Type 1A storm for Climatic Regions 2 and 3 only as described in Chapter 4. Pre-developed conditions are those that currently exist at the site.

In many instances, the 2-year pre-developed flow rate is zero cubic feet per second, or the flow rate is so small that it is impracticable to design a pond to release at the prescribed flow rate from an engineered outlet structure. In these cases, the total post-developed 2-year storm runoff volume must be infiltrated (preferred) or stored in a retention pond for evaporation, and the detention pond designed to release the pre-developed 10- and 25-year flow rates. See BMP FC.03 Detention Pond in Section 5-4.3.3 for pond and release structure design information.

Flow Control Requirements Not Met

In the event the flow control requirements are not met, a Down Stream Analysis is required as part of the Hydraulics Report. Appendix 4-C of the HRM provides details of the analysis. In the future, the Down Stream Analysis will be located in Chapter 4 of the Hydraulics Manual.

Detention Pond Definition

Detention ponds are open basins that provide live storage volume to enable reduction of stormwater runoff flow rates and matching of predeveloped flow durations discharged from a project site. Detention ponds are commonly used for flow control in locations where space is available for above ground facility but where infiltration of runoff is infeasible. Detention ponds are designed to drain completely after a storm event so that the live storage volume is available for the next storm.

Infiltration is the preferred method of flow control following appropriate runoff treatment. However, in areas where infiltration is not feasible, runoff detention must be implemented.

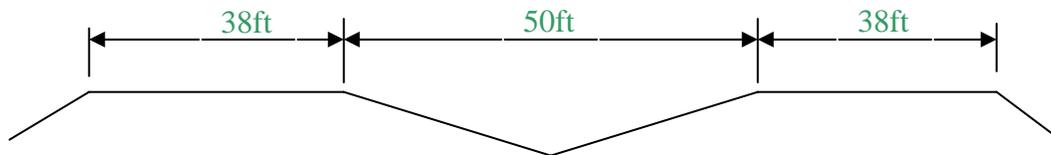
A primary overflow (usually a riser pipe within the outlet control structure) must be provided for the detention pond system to bypass flow, with a secondary emergency overflow should the primary inlet become plugged.

This tutorial will demonstrate a detention pond with 3 different outlets: a drywell, a weir and an orifice.

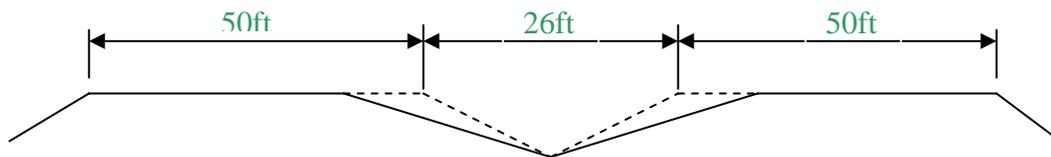
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Detention Pond Example

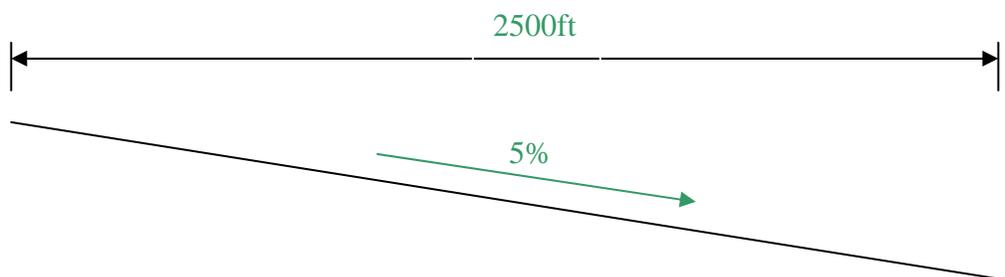
A section of highway near the city of Spokane (Region 3) is to be improved with an additional lane in each direction. The existing configuration consists of two 12-foot lanes with a 6-foot shoulder on one side and an 8-foot shoulder on the other in each direction. The northbound and southbound lanes are separated by an existing 50-foot grassed median. The pavement is sloped towards a “V” shaped median acting as the conveyance system.



There are ditches outside of the lanes preventing off-site drainage from entering the project area. The proposed project will add one 12-foot lane in each direction, while maintaining the current shoulder widths. Both lanes will be added inside of the existing lanes. The cross slope for the roadway is 2% with 4:1 side slopes



Using this information, design an infiltration pond for this 2,500-foot section of roadway that will meet the required release rates of Minimum Requirement 6. The roadway profile is on a continuous 5%.



The soil in the project vicinity has a NRCS identification as Spokane. The median area is grassed with no appreciable amount of brush. The rainfall amounts are noted on the next page.

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Appendix 4B in the HRM, shows that Spokane soil is rated as NRCS Type B soil. A curve number can also be obtained from Appendix 4B in the eastern Washington section of the HRM. A curve number of 98 should always be used for paved areas and given the described conditions of the median, a curve number of 58 should be used.

Calculating the area contributing to the pond being designed indicates that there is a total of **7.23 acres**. The existing roadway configuration has **4.36 acres** of impervious and **2.87 acres** of pervious land contributing flow. After the project is completed, there will be **5.74 acres** of impervious and **1.49 acres** of pervious land contributing flow.

To best analyze this basin for the tri-storm requirement, the designer should define two basins within StormShed, an existing and a developed basin.

Getting Started

Start StormShed and create a new, untitled project using the menu sequence:

- Create a new StormShed project by selecting:
Start/Programs/StormShed/StormShed
- Create a new project by selecting: *File/New*
- Press the **I Fully Understand** button after reading the disclaimer.

We will immediately save this project under the project name “Widening”.

- Select the *File/SaveAs* menu item in the program menu.
- Enter the project name *Widening* in the “File name” input field.
- Press the **Save** button.
- Click in the Tree View to insure that it has focus.

Rainfall Setup

Open the options dialog box by selecting *Data/Option* from the program menu. Using values from the Isopuvials located in Appendix 4A of the HRM, the following rainfalls were determined for Spokane for the Type 1A storm.

- Change the precipitation for the 2 yr event to 1.4 inches.
- Change the precipitation for the 5 yr event to 1.7 inches
- Change the precipitation for the 10 yr event to 2.0 inches.
- Change the precipitation for the 25 yr event to 2.2 inches.
- Change the precipitation for the 100 yr event to 2.6 inches.
- Change the precipitation for the 6 mo. event to 0.97 inches (Appendix 4D notes that the 6 month storm for Spokane is $0.69 * 2$ yr storm or $1.4 * 0.69 = 0.97$)
- Click on the **OK** button to close the “Options” dialog box.

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Defining Drainage Areas

Create Existing Basin

First define the existing drainage area. Always work from left to right going through each TAB.

- Double Click on the “PROTOTYPE” record under the “Basins
- Click on the **New Basin** button
- Modify the AutoLabel Dialog to “Existing”
- Press the **OK** button to close the dialog box
- Change the “Rainfall Type” to Type 1A.

The screenshot shows the 'Basin Definition: Existing' dialog box with the 'Basin Data' tab selected. The 'Basin ID' is set to 'Existing'. The 'Select Rainfall Type' is set to 'TYPE1A'. The 'Hydrograph Method' is 'SBUH Method'. The 'Hyd Interval (min)' is 10, 'Peak Factor' is 484, and 'Tp Factor' is 4. The 'Summary Data' box shows: Perv TC: 11.05 min, Imperv TC: 0.84 min, Area: 7.2300 ac. Buttons for 'OK', 'Cancel', 'Apply', and 'Help' are at the bottom.

- Click on the “Perv CN” tab.
- Click on the “Prototype subarea” line.
- Modify per Figure below

The screenshot shows the 'Basin Definition: Existing' dialog box with the 'Perv CN' tab selected. It displays a table of subareas:

| Description: | Area (ac) | CN |
|-------------------|-----------|-------|
| Type B Soils | 2.87 | 58 |
| Prototype subarea | 2.5000 | 78.00 |

Buttons for 'Add', 'Update', and 'Delete' are on the right. At the bottom, 'Abs Coeff' is 0.2 and 'Total' is 2.5000 ac, 78.00.

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Basin Perv CN

- Click on the **Update** button.
- Make sure the Description in the box below is correct.

Both the north and south bound lanes drain inward toward the median. Then it drains down the center of the median to the point of analysis.

- Click on the “Perv TC” tab.
- Click on the “*Prototype..*” travel time reach to modify it.
- Make it *Shallow flow*, 25 feet in length with a slope of 25%. For the coefficient, use *High Grass surface* to depict the median.
- Click on the **Update** button.
- Modify the “Flow Type” drop down to *Channel*.
- Change the description to reflect drainage down the ditch.
- Change the length to 2500 feet with a slope of 5%.
- Select *Grass* for the coefficient.
- Press the **Add** button.

Basin Definition: Existing

Basin Data | Perv CN | **Perv TC** | Imperv CN | Imperv TC | Compute Design Event

Flow type: [] Descr: [] Len (ft): [0] Slope (%): [0] Kf: [0]

[Add] [Update] [Delete] Total TC: 11.05 min

| Type | Descrip | Len | Slope(%) | Kf | TT |
|---------|------------------------|-----------|----------|-------|-------|
| Shallow | half the median | 25.0000 | 25.00 | 9.00 | 0.09 |
| Channel | Channel down the ditch | 2500.0000 | 5.00 | 17.00 | 10.96 |

[OK] [Cancel] [Apply] [Help]

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Add the roadway drainage area and CN value of the project site.

- Click on the “Imperv CN” tab.
- Modify per Figure below
- Press the **Add** button.

The screenshot shows the 'Basin Definition: Existing' dialog box with the 'Imperv CN' tab selected. The table below shows the current data:

| Description: | Area (ac) | CN |
|------------------|-----------|----|
| Roadway Drainage | 4.36 | 98 |

The 'Add' button is highlighted in the original image. Below the table, the 'Total' values are 4.3600 ac and 98.00.

Modify Basin Imperv CN

Add the Sheet flow shown in the figure below.

The screenshot shows the 'Basin Definition: Existing' dialog box with the 'Imperv TC' tab selected. The table below shows the current data:

| Flow type | Descrip: | Len (ft) | Slope (%) | Kf |
|-----------|----------|----------|-----------|----|
| | | 0 | 0 | 0 |

The 'Add' button is highlighted in the original image. Below the table, the 'Total TC' is 0.84 min.

| Type | Descrip | Len | Slope(%) | Kf | TT |
|-------|------------------|---------|----------|--------|--------|
| Sheet | half the roadway | 38.0000 | 2.00 | 0.0110 | 0.8447 |

Modify the Imperv TC data

- Click on the “Imperv TC” tab..
- Make it *Sheet flow*, 38 feet in length with a slope of 2%. For the coefficient, use Smooth surface to depict the roadway
- Click on the **ADD** button

Flow Control - Detention Pond Example

Create Developed Basin

The “Existing” basin can now be used as a template for the developed basin.

- Double click on the “Existing” basin under the “Basins” node in the Tree View.
- Press the **New Basin** button.
- Enter Developed for the Basin ID.
- Press OK to close the “AutoLabel” dialog box.
- Click on the “Perv CN” tab.
- Modify the *Type B soils* area to 1.49 acres.
- Click the **Update** button

The screenshot shows the "Basin Definition: developed" dialog box with the "Perv CN" tab selected. The "Perv CN" tab is circled in red. The dialog contains a table with the following data:

| Description: | Area (ac) | CN |
|--------------|-----------|----|
| Type B Soils | 1.49 | 58 |

Below this table is another table with the following data:

| Description: | SubArea | CN |
|--------------|---------|-------|
| Type B Soils | 2.8700 | 58.00 |

At the bottom of the dialog, the "Abs Coeff:" is set to 0.2, and the "Total:" is 2.8700 ac and 58.00. Buttons for "Add", "Update", and "Delete" are visible on the right side.

Modify Perv CN area for developed conditions

- Click on the “Perv TC” tab
- Modify half the roadway Shallow flow to 13ft
- Click the **Update** button

The screenshot shows the "Basin Definition: Developed" dialog box with the "Perv TC" tab selected. The "Perv TC" tab is circled in red. The dialog contains a table with the following data:

| Flow type | Descrip: | Len (ft) | Slope (%) | ns |
|-----------|-----------------|----------|-----------|----|
| Shallow | half the median | 13 | 25 | 9 |

Below this table is a table with the following data:

| Type | Descrip | Len | Slope(%) | Kf | TT |
|---------|------------------------|-----------|----------|-------|-------|
| Shallow | half the median | 25.0000 | 25.00 | 9.00 | 0.09 |
| Channel | Channel down the ditch | 2500.0000 | 5.00 | 17.00 | 10.96 |

At the bottom of the dialog, the "Total TC:" is 11.05 min. Buttons for "Add", "Update", and "Delete" are visible.

Modify Perv TC for developed conditions

Flow Control - Detention Pond Example

The last step is to modify the Impervious roadway for developed conditions.

- Click on the “Imperv CN” tab.
- Modify the Roadway drainage area to 5.74 acres.
- Click the **Update** button

The screenshot shows the 'Basin Definition: Developed' dialog box with the 'Imperv CN' tab selected. The 'Add' button is circled. The table below shows the current data:

| Description: | Area (ac) | CN |
|------------------|-----------|----|
| Roadway Drainage | 5.74 | 98 |

| Description: | SubArea | CN |
|------------------|---------|-------|
| Roadway Drainage | 4.3600 | 98.00 |

Abs Coeff: Total: 4.3600 ac 98.00

- Click on the “Imperv TC” tab
- Modify half the roadway Sheet flow to 50ft
- Click the **Update** button

The screenshot shows the 'Basin Definition: Developed' dialog box with the 'Imperv TC' tab selected. The 'Imperv TC' tab is circled. The 'Update' button is highlighted. The table below shows the current data:

| Flow type | Descrip: | Len (ft) | Slope (%) | Kf |
|-----------|------------------|----------|-----------|-------|
| Sheet | half the roadway | 50 | 2 | 0.011 |

Total TC: 1.05 min

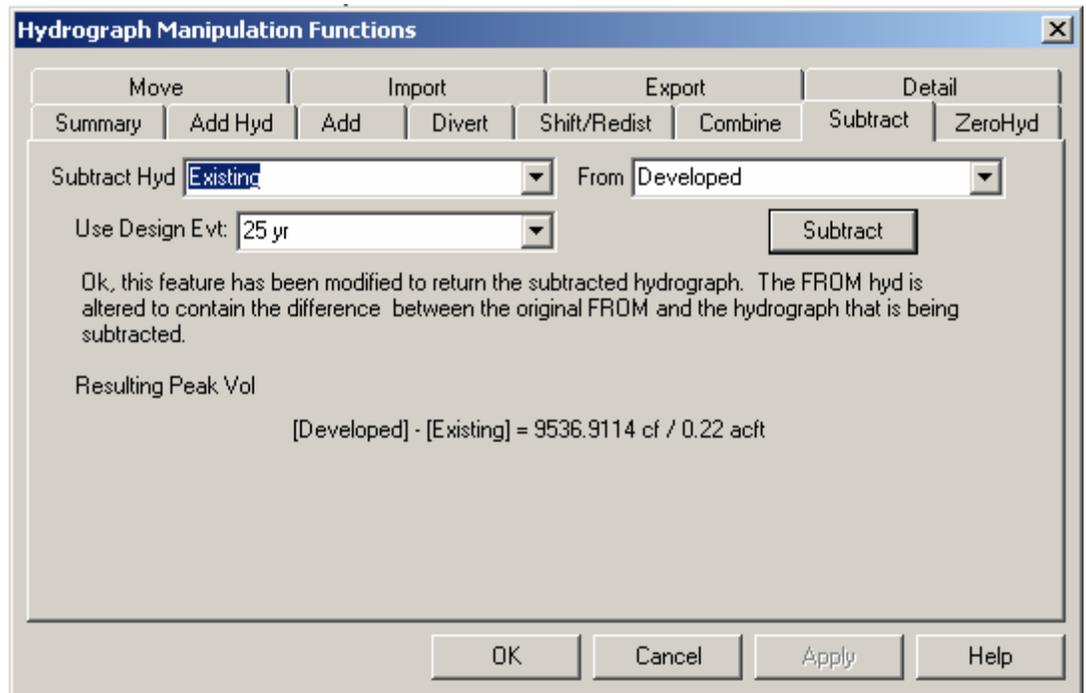
| Type | Descrip | Len | Slope(%) | Kf | TT |
|-------|------------------|---------|----------|--------|--------|
| Sheet | half the roadway | 50.0000 | 2.00 | 0.0110 | 1.0521 |

Modify Imperv Tc data for developed condition

Flow Control - Detention Pond Example

Estimate the Pond Size

- Click in the Tree View to make sure it has focus.
- From the program menu, select *Data/Hydrograph*
- Click on the “Subtract” tab.



Estimate detention volume for proposed pond

- Press the **OK** button to close the “Hydrograph Manipulation” dialog.

Now we have a volume of 0.22 acft to design our ponds as a starting point. Next run the 100-year and make certain the pond will not overtop. This is a good method to figure out what size of pond you will need to design.

Using this function does not create a hydrograph. The only way to store the information is to use Mr. Snappy and create a bmp file or do a Print Screen option..

Flow Control - Detention Pond Example

Define a Storage Element

For this project we are looking at different ponds that best fit our site. Our first choice is to design a Stage Storage pond since we have an area that already can be used for a pond with minor work involved.

- Double click on the node “PROTOTYPE” record.
- Click on the **New Node** button.
- Change the “AutoLabel” ID to Pond45.
- Press the **OK** button to close the “AutoLabel” dialog box.
- The Start El is the bottom pond elevation at 200ft

Node Definition

Node Data | Stage Storage Rating Curve

Node ID: Pond45 [New Node]

Descrip: Detention Pond

Start El (ft): 200 Max El (ft): 108

Contrib Area: [Clear]

Contrib Hyd: [Clear]

North (ft): 0 East: 0

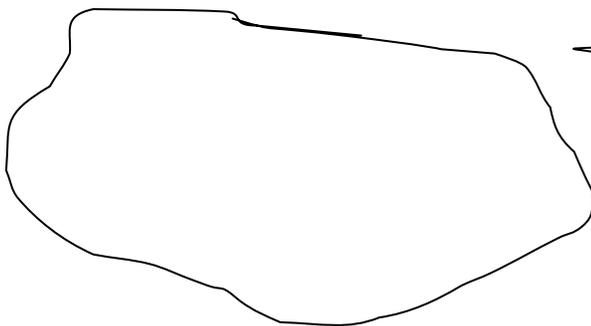
Incrim (ft): 0.1

Node Type

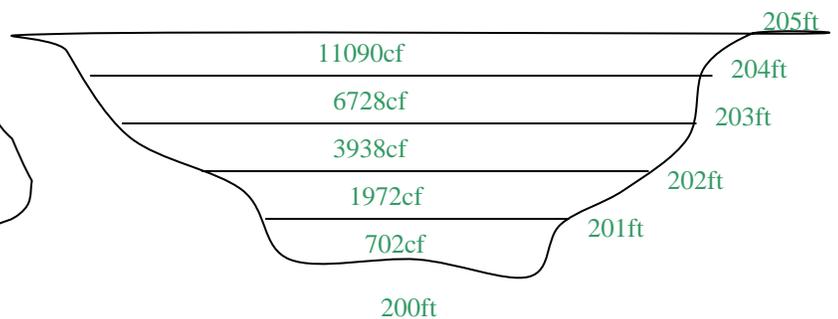
- Mh/CB/Inlet
- Vault
- Trap Pond
- Undg Pipe
- Stg-Sto
- RLPool
- Pipe Arch
- Ellipse Pipe
- Dummy Node

Defining the Stage Storage Pond

Plan View of Odd Shape Pond

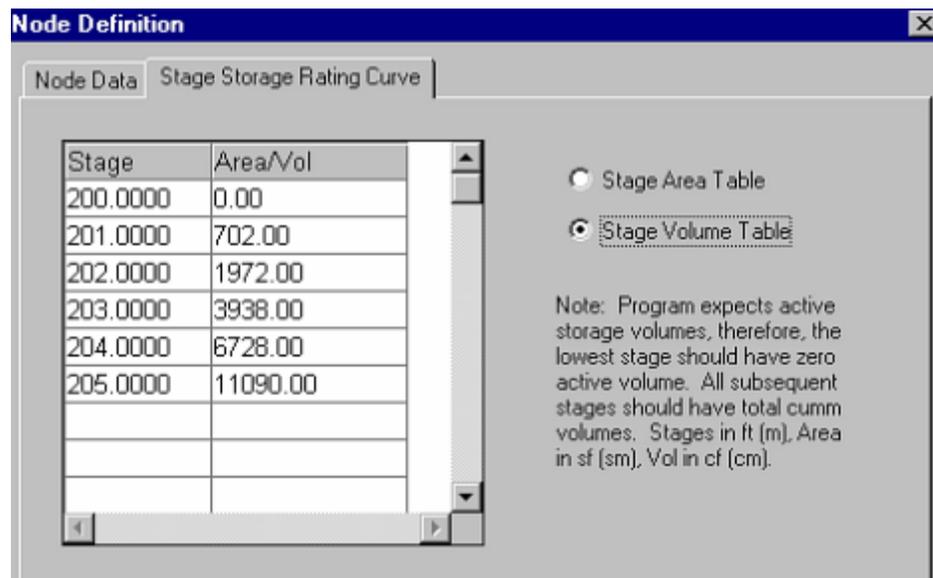


Cross Section View of Odd Shape Pond



Flow Control - Detention Pond Example

The dimensions are selected to provide a volume for the 100 year storm of about **11090 cubic**-feet with a depth of five (5) feet. **The volume per stage can be calculated using Caice for odd shape ponds.** On a real project, the process would be similar. Once an estimate of the pond volume would be made, the designer would look at the site and find a location that could accommodate the pond. In many cases the pond would be roughed in, and the bottom elevation determined before the data is even placed in the program.



Defining the Stage Storage Pond dimension

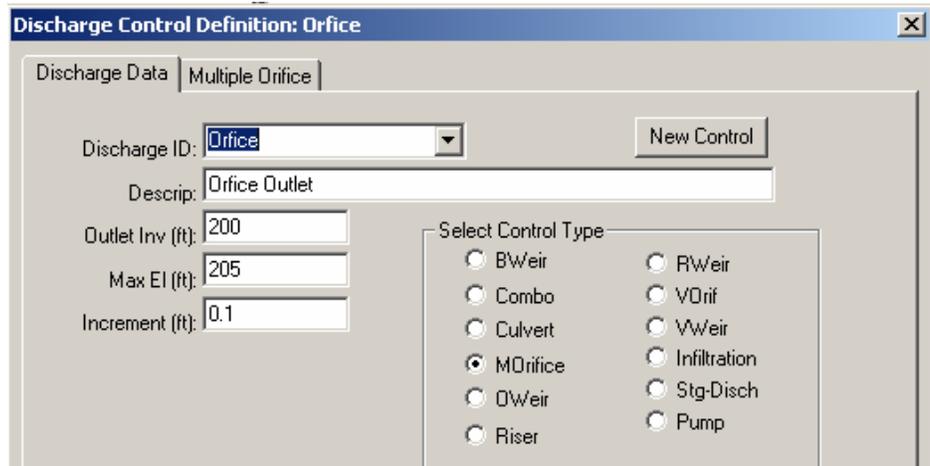
Define a Control Structure

We will start with a multiple orifice control structure and let the program size the orifice diameters.

- Double click on the PROTOTYPE record found under the “Discharge” node in the Tree View.
- Press the **New Control** button.
- Replace the “AutoLabel” ID with Orifice.
- Press **OK** to close the “AutoLabel” dialog box.
- Change the Control Type to “MOrifice”.
- Change the “Outlet Elev” to 200.
- Change the “Max Elev” to 205.

Flow Control - Detention Pond Example

- Click on the “Multiple Orifice” tab.
- Change the “Lowest Orif Elev” to 198.5 feet.
- Press **OK** to close the “Discharge Control Definition” dialog box.



Discharge Control Definition: Orifice

Discharge Data | Multiple Orifice

Discharge ID: Orifice [New Control]

Descr: Orifice Outlet

Outlet Inv (ft): 200

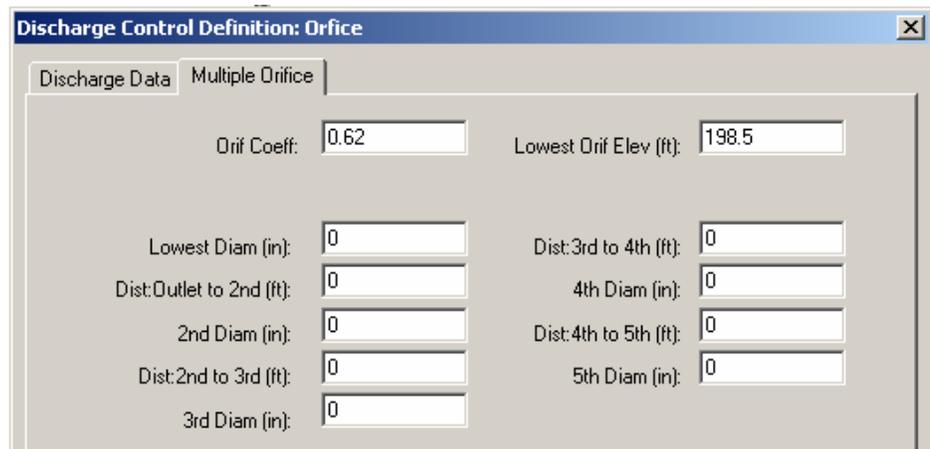
Max El (ft): 205

Increment (ft): 0.1

Select Control Type

- BWeir
- Combo
- Culvert
- MOrifice
- OWeir
- Riser
- RWeir
- VOrif
- VWeir
- Infiltration
- Stg-Disch
- Pump

Defining Orifice



Discharge Control Definition: Orifice

Discharge Data | Multiple Orifice

Orif Coeff: 0.62

Lowest Orif Elev (ft): 198.5

Lowest Diam (in): 0

Dist:Outlet to 2nd (ft): 0

2nd Diam (in): 0

Dist:2nd to 3rd (ft): 0

3rd Diam (in): 0

Dist:3rd to 4th (ft): 0

4th Diam (in): 0

Dist:4th to 5th (ft): 0

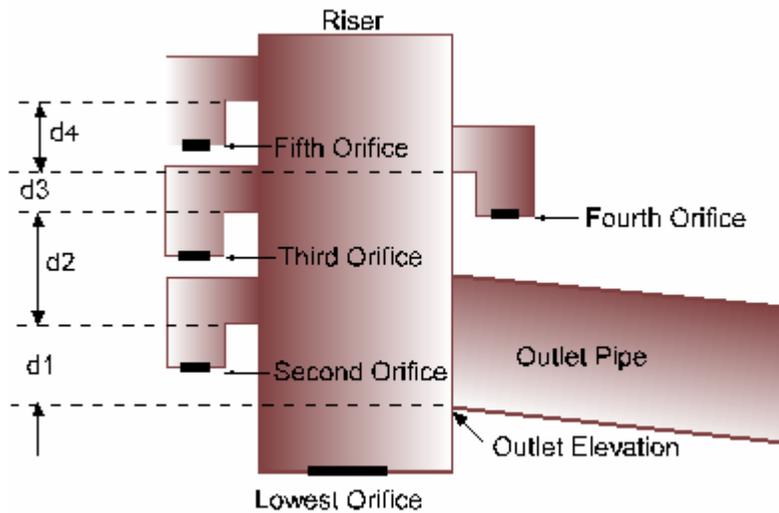
5th Diam (in): 0

Setting Lowest Orifice Elevation

It is assumed that the pond elevation is 200 ft and the maximum depth is five (5) feet. The program will size the orifice dimensions, so leave all control dimensions alone. The lowest orifice elevation is set at 1.5 feet below the outlet elevation, see the Multiple Orifice Structure on the next page. The lowest orifice elevation allows you to physically locate the orifice, but does not affect its discharge rate. For the lowest orifice elevation the discharge is always computed as the head on the outlet.

Note that the flow through the other orifices in the multiple orifice structure is based on the driving head from the water surface to the orifice, not the outlet elevation.

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Multiple Orifice Structure

Define the RLPool Node

- Double click on the PROTOTYPE node record found under the “Nodes” category in the Tree View.
- Press the **New Node** button.
- Change the “Next Auto ID” to MedianPond45.
- Press the **OK** button to close the “AutoLabel” dialog box.
- Change the “Node Type” to RLPool
- Change the description to pond and orifice.

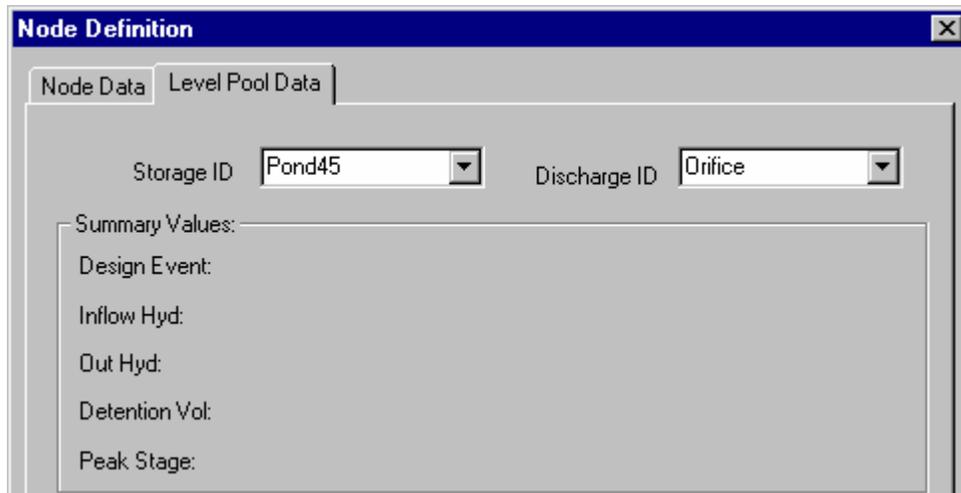
Notice that we have not changed the “Start EI” and “Max EI”.

The screenshot shows the Node Definition dialog box with the following settings:

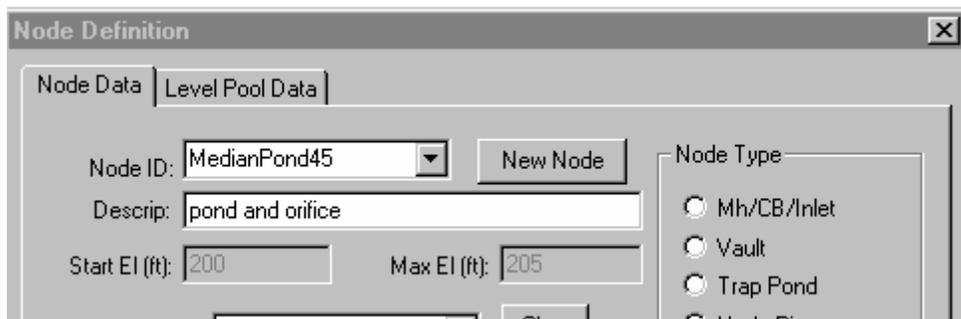
- Node ID: MedianPond45
- Descr: pond and orifice
- Start EI (ft): 100
- Max EI (ft): 108
- Contrib Area: [Empty]
- Contrib Hyd: [Empty]
- North (ft): 0
- East: 0
- Increment (ft): 0.1
- Node Type: RLPool

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- Click on the “Level Pool Data” tab.
- From the “Storage ID” drop down, select *Pond45*.
- From the “Discharge ID” drop down select *Orifice*.
- Click on the “Node Data” tab



Notice that the program has updated the start and max elevations to 200 feet and 205 feet.



- Click on the **OK** button to close the “Node Definition” dialog box.

The program will automatically design multiple orifice structures that meet the design requirements. Occasionally, orifice structures are not practical or constructible for a variety of reasons. Designers need to look at the dimensions and use some engineering judgment.

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Sizing the Control Structure

- Using the popup menu in the Tree View, open the *Pond Design* dialog box.
- Select *MedianPond45* from the “Level Pool Node Instruction Set” drop down.
- Fill out the pond design dialog box as shown in below.

All data in the dialog box is selected from the associated drop downs except for the “Out Hyd” column. This column specifies the ID’s for the hydrographs that are routed through the pond.

| Design Event | Matching Hyd | % of Rate | Inflow Hyd | Out Hyd | |
|--|--------------|-----------|------------|---------|-------|
| 2 yr | Existing | 50 | Developed | 2 | Clear |
| Match Q: 0.6823 cfs Peak Out Q: 0.6823 cfs - Peak Stg: 202.62 ft - Active Vol: 3194.84 cf | | | | | |
| 25 yr | Existing | 100 | Developed | 25 | Clear |
| Match Q: 2.2578 cfs Peak Out Q: 2.2575 cfs - Peak Stg: 203.13 ft - Active Vol: 4292.44 cf | | | | | |
| 100 yr | Existing | 100 | Developed | 100 | Clear |
| Match Q: 2.6995 cfs Peak Out Q: 2.6991 cfs - Peak Stg: 203.35 ft - Active Vol: 0.1129 acft | | | | | |
| | | 100 | | | Clear |

- Press the **Size Outlet** button.

The program will automatically design multiple orifice structures that meet the design requirements. Occasionally, orifice structures are not practical or constructible for a variety of reasons. Select the Edit Control button above to view the orifice sizes. Designers need to look at the dimensions and use some engineering judgment. Examine the orifice discharge structure. Note that the lowest orifice is 3.94 inches in diameter and is located at our input elevation of 198.5 feet. The second orifice is 8.89 inches in diameter and is located a distance of 0.5 feet from the outlet elevation of 200 feet, see the multiple orifice diagram on the previous pages. The program uses the standard orifice equation to compute discharges through each orifice.

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| Parameter | Value |
|-------------------------|---------|
| Orif Coeff | 0.62 |
| Lowest Orif Elev (ft) | 198.5 |
| Lowest Diam (in) | 3.94043 |
| Dist:Outlet to 2nd (ft) | 2.63 |
| 2nd Diam (in) | 8.8916 |
| Dist:2nd to 3rd (ft) | 0.5 |
| 3rd Diam (in) | 2.87109 |
| Dist:3rd to 4th (ft) | 0.23 |
| 4th Diam (in) | 0 |
| Dist:4th to 5th (ft) | 0 |
| 5th Diam (in) | 0 |

Designers should change the orifice sizes to something nominal and since the 100 year orifice will not be needed (because we only need to match the 2 year and 25 year flows) it can be deleted.

| Parameter | Value |
|-------------------------|-------|
| Orif Coeff | 0.62 |
| Lowest Orif Elev (ft) | 198.5 |
| Lowest Diam (in) | 4 |
| Dist:Outlet to 2nd (ft) | 2.75 |
| 2nd Diam (in) | 9 |
| Dist:2nd to 3rd (ft) | 0 |
| 3rd Diam (in) | 0 |
| Dist:3rd to 4th (ft) | 0 |
| 4th Diam (in) | 0 |
| Dist:4th to 5th (ft) | 0 |
| 5th Diam (in) | 0 |

Then select OK and return to the pond design. This time select **Compute**. There are 4 things we need to check, that the Peak Out Q does not exceed the Match Q for both the 25 and 2 year storm, the 1' free board height for the 25 year storm and the Peak Storage does not exceed 205'.

Flow Control - Detention Pond Example

| Design Event | Matching Hyd | % of Rate | Inflow Hyd | Out Hyd |
|---|--------------|-----------|------------|---------|
| 2 yr | Existing | 50 | Developed | 2 |
| Match Q: 0.6823 cfs Peak Out Q: 0.6968 cfs Peak Stg: 202.58 ft - Active Vol: 3103.21 cf | | | | |
| 25 yr | Existing | 100 | Developed | 25 |
| Match Q: 2.2578 cfs Peak Out Q: 2.1746 cfs Peak Stg: 203.16 ft Active Vol: 0.1005 acft | | | | |
| 100 yr | Existing | 100 | Developed | 100 |
| Match Q: 2.6935 cfs Peak Out Q: 2.6081 cfs Peak Stg: 203.42 ft Active Vol: 0.1176 acft | | | | |
| | | 100 | | |

For the 2-year storm, the Peak Out Q slightly exceeds Match Q. For this tutorial the two numbers are close enough. To reduce the Peak Out Q, designers can change the orifice sizes and spacing and then re-compute the pond design until the Peak Out Q is less than the Match Q.

All the other requirements are met:

- The Peak Out Q is less than or equal to the Match Q for the 25 year storm.
- The 25 year Peak Storage is 203.16, so there is almost 2 feet of free board and only 1 foot is required.
- The 100 year storm Peak Storage is 203.42, almost a foot and a half lower than the top of the pond. The 100 year storm could reach to top of the 205' pond as long as it does not over top the pond.

At this point our detention pond design could be complete, in fact since there is an addition 1.5' of space from the top of the 100 year storm to the top of the pond, the pond size could be reduced. For learning purposes, we will repeat the pond design using a weir and the first orifice.

Orifices

We will set the weir elevation at the 25-year elevation from the pond design using the orifices, 203.16 and create a combination discharge structure to recognize both the weir and the orifice. Double click on the PROTOTYPE record under the "Discharge" node in the Tree View.

- Click on the **New Control** button.
- Label it Weir in the "AutoLabel" dialog box.
- Press the **OK** button to close the "AutoLabel" dialog box.
- Fill out the weir as shown in *Defining a Rectangular Weir*.
- Click on the "Rectangular Weir" tab.

Flow Control - Detention Pond Example

- Change the length to 5 feet.

This is an arbitrary number we are starting with on the weir length. The program will not size the weir. The only discharge structure that the program will size is the multiple orifices.

Discharge Control Definition: Weir

Discharge Data | Rectangular weir

Discharge ID: Weir [New Control]

Discrip: Weir to handle the 25 year events

Crest El (ft): 203.16

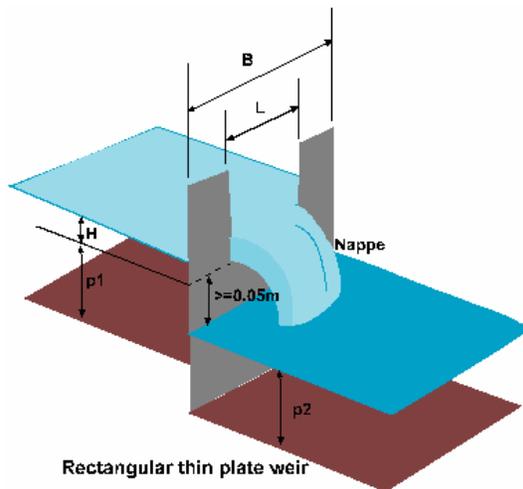
Max El (ft): 205

Increment (ft): 0.1

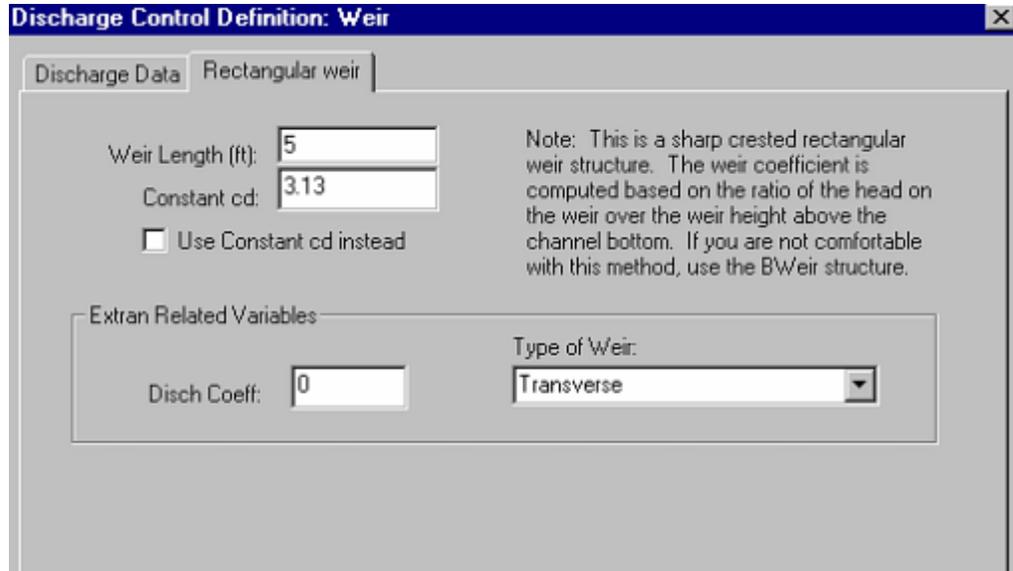
Select Control Type

- BWeir
- Combo
- Culvert
- MOrifice
- OWeir
- Riser
- RWeir
- VOrif
- VWeir
- Infiltration
- Stg-Disch
- Pump

Defining a Rectangular Weir



Flow Control - Detention Pond Example



Discharge Control Definition: Weir

Discharge Data Rectangular weir

Weir Length (ft):

Constant cd:

Use Constant cd instead

Note: This is a sharp crested rectangular weir structure. The weir coefficient is computed based on the ratio of the head on the weir over the weir height above the channel bottom. If you are not comfortable with this method, use the BWeir structure.

Extran Related Variables

Disch Coeff:

Type of Weir:

Defining a Rectangular Weir

- Click on the **OK** button to close the weir dialog box.

Since we have two discharge structures, we need to create a combination node to model the orifice and the weir.

- Double click under the PROTOTYPE “Discharge” node again.
- Press the **New Control** button.
- Enter the ID Combo.
- Press the **OK** button
- Change the description to “combination discharge structure”
- Change the “Control Type” to Combo.

Notice that the starting and max elevation input fields have been disabled and the elevations are not correct.

- Click on the “Combo” discharge structure tab
- Select *Orifice* for the first discharge structure.
- Select *Weir* for the second discharge structure.

Flow Control - Detention Pond Example

Discharge Control Definition: Combo

Discharge Data Combo discharge structure

Select from the list of previously defined discharge control structures. Do not select another combination control!

Outflow hydrograph for selected control structure. The design event will be appended to this ID.

Clear Orifice Orifice-OutHyd

Clear Weir Weir-OutHyd

Clear

Clear

Clear

Split total outflow hyd into control structure components.

Selecting this check box will result in the creation of outflow hydrographs for each discharge control structure. The hydrographs will have the predefined ID's shown above.

OK Cancel Apply Help

Define a combination discharge structure

- Click on the “Discharge Data” tab.

Notice that StormShed has updated the disabled fields for starting and maximum elevations.

- Press **OK** to close the dialog box.

There is more to change. The orifice structure still has a diameter for the 2nd orifice(s).

- Double click on the “Orifice” discharge structure.
- Click on the “Multiple Orifice” tab.
- Zero everything except the “Lowest Orifice Diameter”.
- Press **OK** to close the dialog box.

Discharge Control Definition: Orifice

Discharge Data Multiple Orifice

Orif Coeff: 0.62 Lowest Orif Elev (ft): 198.5

Lowest Diam (in): 4 Dist:3rd to 4th (ft): 0

Dist:Outlet to 2nd (ft): 0 4th Diam (in): 0

2nd Diam (in): 0 Dist:4th to 5th (ft): 0

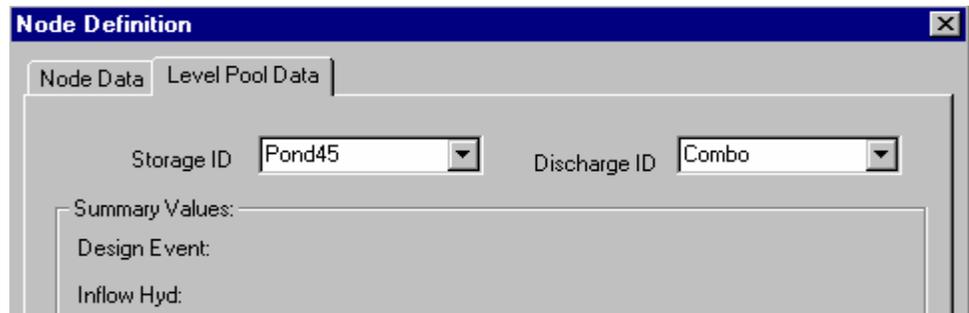
Dist:2nd to 3rd (ft): 0 5th Diam (in): 0

3rd Diam (in): 0

Flow Control - Detention Pond Example

One final step is needed before recomputing peak ponding elevations. Modify the RLPool node to let the program know that the discharge structure associated with the pond is no longer the “Orifice” structure, but the “Combo” structure.

- Open the “MedianPond45” node record.
- Click on the “Level Pool Data” tab
- Change the “Discharge ID” from “Orifice” to *Combo*.
- Press the **OK** button.



- Open the pond design dialog box by clicking the right mouse button in the white space of the tree view.
- Press the **Compute** button.

The “Size Outlet” button cannot be used because the discharge structure is no longer an orifice. Also, the discharge structures that makeup the Combo structure already have dimensions associated with them. The “Compute” button simply instructs the program to route flows through the storage and discharge structure with the intent of seeing if the pond performs as required.

Flow Control - Detention Pond Example

Pond design

Level Pool Node Instruction Set: MedianPond45 Starting Stage: 200 ft

| Design Event | Matching Hyd | % of Rate | Inflow Hyd | Out Hyd | |
|--|--------------|-----------|------------|---------|-------|
| 2 yr | Existing | 50 | Developed | 2 | Clear |
| Match Q: 0.6823 cfs Peak Out Q: 0.6968 cfs Peak Stg: 202.58 ft - Active Vol: 3103.21 cf | | | | | |
| 25 yr | Existing | 100 | Developed | 25 | Clear |
| Match Q: 2.2578 cfs Peak Out Q: 2.1912 cfs Peak Stg: 203.35 ft - Active Vol: 0.1131 acft | | | | | |
| 100 yr | Existing | 100 | Developed | 100 | Clear |
| Match Q: 2.6995 cfs Peak Out Q: 3.5320 cfs Peak Stg: 203.46 ft - Active Vol: 0.1200 acft | | | | | |
| | | 100 | | | Clear |

Send detailed routing to history.
 Exclude infiltration from control design.

Results

The table above meets all our design requirements. It releases the pre-developed flows and the peak stage in the pond did not go above the max. proposed elevation, in-fact the designer might consider reducing the pond size making certain the pond does not overtop during the 100 year storm.

If the Peak Out Q had been too high for the 25 year storm, designers could reduce the width of the weir to reduce the flow.

Flow Control - Detention Pond Example

Drywells

The last outlet for our detention pond is a drywell. For this tutorial we will use an discharge of 1 cfs, however the method for determining the discharge from a drywell is changing and we will notify designers how and when to use the new method.

- Double click on the PROTOTYPE record found under the “Discharge” node in the Tree View.
- Press the **New Control** button.
- Replace the “AutoLabel” ID with Drywell.
- Press **OK** to close the “AutoLabel” dialog box.
- Change the Control Type to “stg-disch” or staged discharge.
- Change the “Outlet Elev” to 200.
- Click on the “Stage-Discharge rating table” tab.

Discharge Control Definition: Drywell

Discharge Data | Stage - Discharge rating table

Discharge ID: Drywell

Descrip: drywell

Start El (ft): 200

Increment (ft): 0.1

Select Control Type

BWeir RWeir

Combo VOrif

Culvert VWeir

MOrifice Infiltration

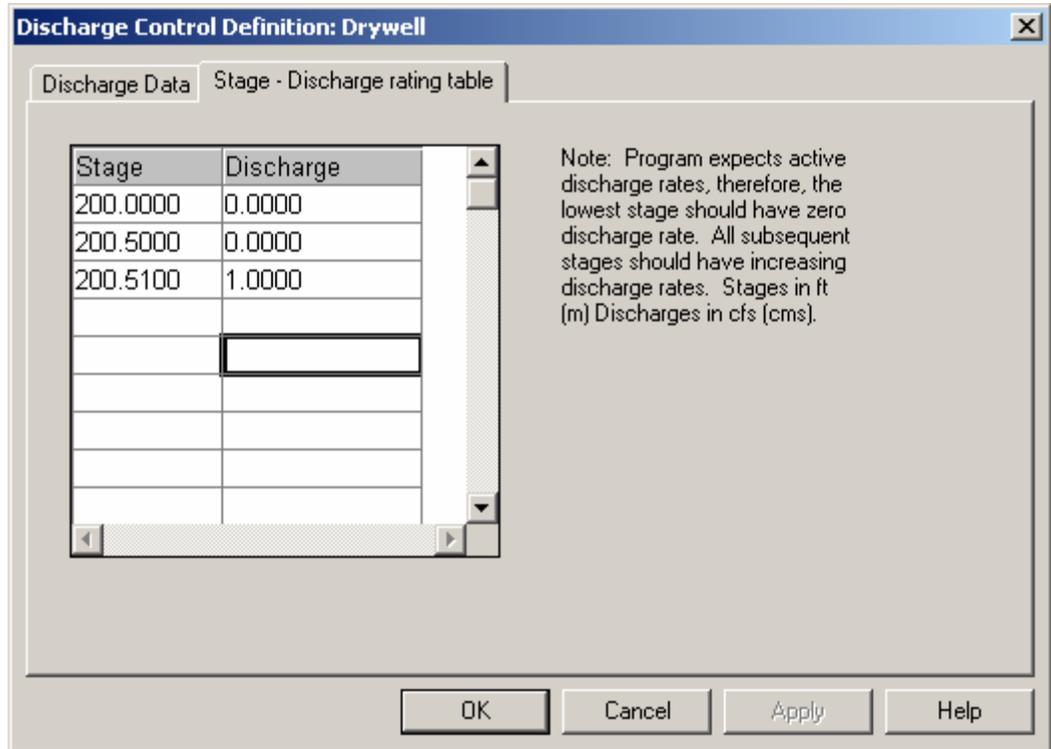
OWeir Stg-Disch

Riser Pump

Treat as secondary discharge structure.

Flow Control - Detention Pond Example

- Change the stage and discharge to match below.
- Press **OK** to close the “Discharge Control Definition” dialog box.

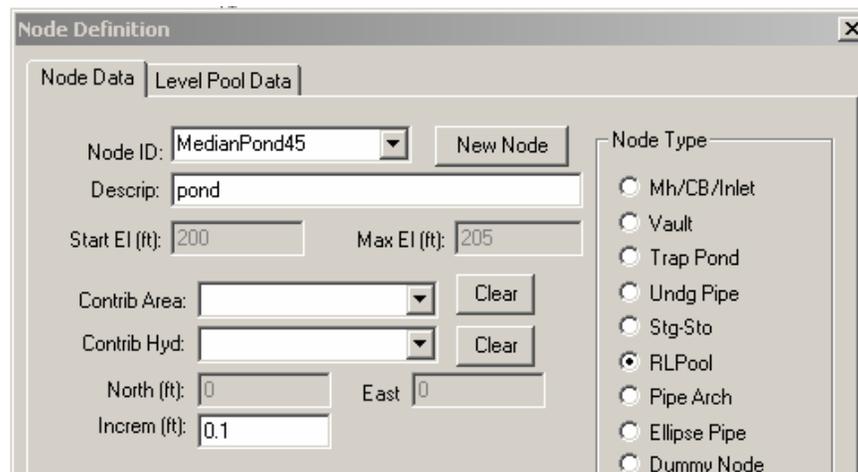


The dialog box titled "Discharge Control Definition: Drywell" has two tabs: "Discharge Data" and "Stage - Discharge rating table". The "Stage - Discharge rating table" tab is active, showing a table with two columns: "Stage" and "Discharge". The table contains three rows of data, with the third row highlighted. A note on the right side of the dialog box states: "Note: Program expects active discharge rates, therefore, the lowest stage should have zero discharge rate. All subsequent stages should have increasing discharge rates. Stages in ft (m) Discharges in cfs (cms)." At the bottom of the dialog box are four buttons: "OK", "Cancel", "Apply", and "Help".

| Stage | Discharge |
|----------|-----------|
| 200.0000 | 0.0000 |
| 200.5000 | 0.0000 |
| 200.5100 | 1.0000 |
| | |
| | |
| | |
| | |
| | |

One final step is needed before recomputing peak ponding elevations. Modify the RLPool node to let the program know that the discharge structure associated with the pond is the “drywell” structure.

- Open the “MedianPond45” node record.
- Click on the “Level Pool Data” tab

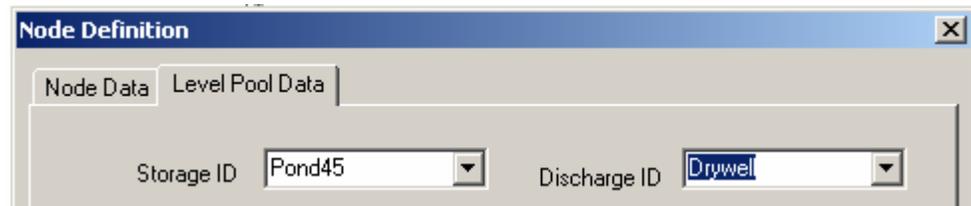


The dialog box titled "Node Definition" has two tabs: "Node Data" and "Level Pool Data". The "Level Pool Data" tab is active. The "Node ID" is set to "MedianPond45" and the "Descrip" is "pond". The "Start EI (ft)" is 200 and the "Max EI (ft)" is 205. The "Node Type" is set to "RLPool". Other options include "Mh/CB/Inlet", "Vault", "Trap Pond", "Undg Pipe", "Stg-Sto", "Pipe Arch", "Ellipse Pipe", and "Dummy Node".

Flow Control - Detention Pond Example

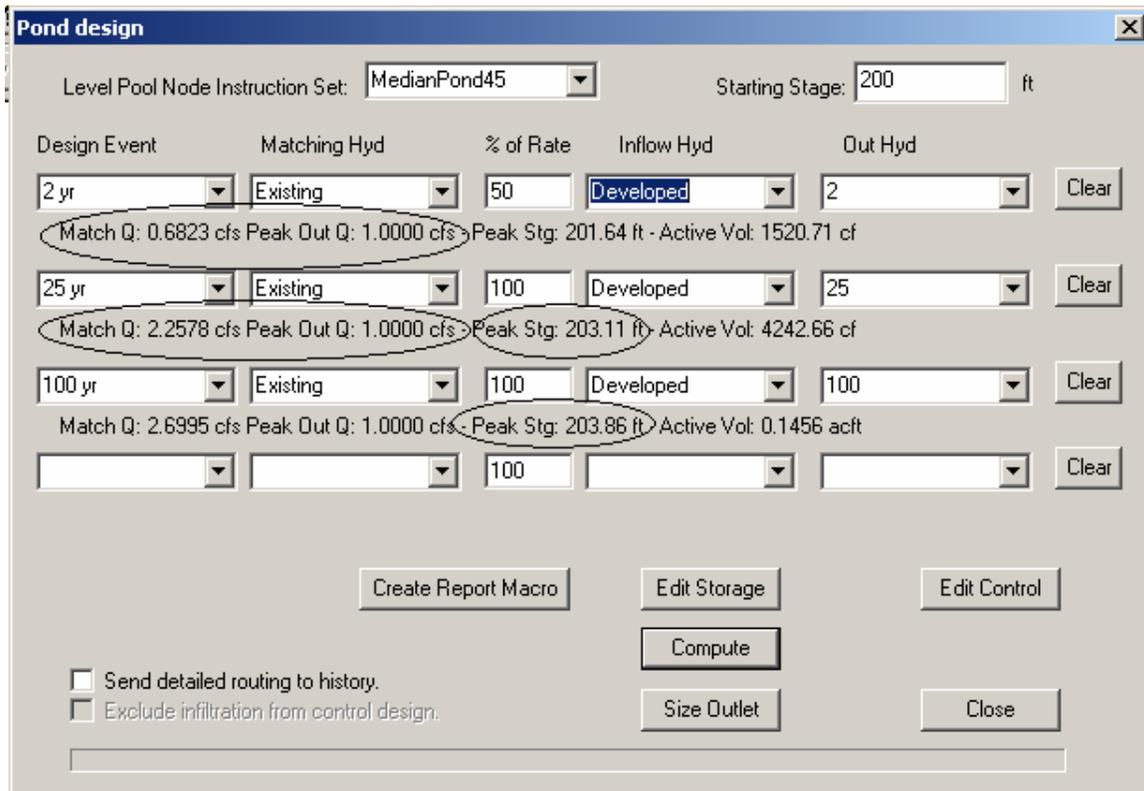
Change the “Discharge ID” to “drywell”.

- Press the **OK** button.



Open the pond design dialog box by clicking the right mouse button in the white space of the tree view.

- Press the **Compute** button.



| Design Event | Matching Hyd | % of Rate | Inflow Hyd | Out Hyd | |
|--|--------------|-----------|------------|---------|-------|
| 2 yr | Existing | 50 | Developed | 2 | Clear |
| Match Q: 0.6823 cfs Peak Out Q: 1.0000 cfs Peak Stg: 201.64 ft - Active Vol: 1520.71 cf | | | | | |
| 25 yr | Existing | 100 | Developed | 25 | Clear |
| Match Q: 2.2578 cfs Peak Out Q: 1.0000 cfs Peak Stg: 203.11 ft - Active Vol: 4242.66 cf | | | | | |
| 100 yr | Existing | 100 | Developed | 100 | Clear |
| Match Q: 2.6995 cfs Peak Out Q: 1.0000 cfs Peak Stg: 203.86 ft - Active Vol: 0.1456 acft | | | | | |
| | | 100 | | | Clear |

Buttons: Create Report Macro, Edit Storage, Edit Control, Compute, Size Outlet, Close

Options:
 Send detailed routing to history.
 Exclude infiltration from control design.

Results

Notice the Peak Out Q for the 2 year storm exceeds the Match Q. This is acceptable because a drywell provides subsurface discharge and in this case the flow control requirement is gone. The only parameter we are concerned with is the Peak Storage and for both the 25 and 100 year storms the Elevation is below the Peak Elevation. In both cases, we exceed the design requirements infact the designer could reduce the pond size.