In this example you will:

- Learn more about Flow Control or Minimum Requirement 6 in the Highway Runoff Manual (HRM).
- Review the definition of a Detention Pond as presented in the HRM.
- Create an inflow hydrograph for the detention pond using the hydrograph subtraction command.
- Display the hydrographs.
- Create a stage storage detention pond.
- Model three different outlets including: sizing an orifice, an orifice/weir combo, and a drywell.
- Route a hydrograph through the detention pond using three different outlet structures.

## **Detention Pond Example**

A section of highway near the city of Spokane (Climatic Region 3) is to be improved with an additional lane in each direction. Design a detention pond (BMP FC.03) using the data below, as well as the flow control guidance and design criteria on the following pages.

- The existing configuration consists of <u>two 12-foot lanes</u> with a <u>6-foot shoulder</u> on one side and an <u>8-foot shoulder</u> on the other in each direction.
- The north and south bound lanes are separated by a 50-foot grassed median.



- The proposed project will add <u>one 12-foot lane in each direction</u> on the inside into the median, while maintaining the current shoulder widths.
- The pavement is <u>sloped 2%</u> towards a <u>"V" shaped median</u> acting as a conveyance system with <u>4:1 side slopes</u>.



• The roadway profile is **<u>2500'</u>** long on a <u>continuous 5%</u>.



- No off-site drainage enters the project area.
- The median area is grassed with no appreciable amount of brush and the soil in the project vicinity has a NRCS identification as <u>Spokane</u>. From the TR55 CN Tables in Appendix 4B in the HRM, Table 4B-1 rates Spokane soils as <u>Type C</u>. From Table 4B-3 for EWA, <u>Meadow cover for type C soils has a CN=71</u>.
- The <u>existing</u> roadway contributes <u>4.36 acres of impervious</u> runoff and the <u>2.87</u> <u>acres of pervious</u> runoff.
- The proposed project will contribute <u>5.74 acres of impervious</u> surface and <u>1.49</u> <u>acres of pervious</u> runoff.

# Flow Control Definition

Flow control is Minimum Requirement 6 in the HRM. Unless an exemption applies (see section 3-3.6 of the HRM), any project that adds 5,000 square feet or more of net-new impervious surfaces in a TDA 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. Whenever possible, infiltration should be used to provide flow control.

## Flow Control Design Guidance

Unless an exception applies, the flow control design criteria for detention facilities, summarized in Table 3-7, should be followed. The goal is to maintain the pre-existing runoff rates at the project location after the proposed project has been constructed. Whenever possible, infiltration should be used to provide flow control. If infiltration is not possible, runoff should be detained in a detention pond and released at the rates shown in Table 3-7.

Facility Type	Criteria	Model
Detention/combination treatment and detention	Provide storage volume required to match <sup>1</sup> / <sub>2</sub> of the 2- year predeveloped peak flow rate and match the	Single Event Model (SCS or SBUH) Climatic Regions 1–4 Regional Storm; OR
facilities	100-year peak flow for property damage.	Type 1A Storm for Climatic Regions 2 & 3 only
Infiltration facilities	Size facility to infiltrate the entire volume of the 25- year storm with an overflow, and check the 100-year peak flow for property damage, or infiltrate 100 % of the storm runoff volume.	Single Event Model (SCS or SBUH) Climatic Regions 1–4 Regional Storm; OR Type 1A Storm for Climatic Regions 2 & 3 only

Table 3-7.	Eastern	Washington	flow	control	criteria.
------------	---------	------------	------	---------	-----------

As noted in the **Model** column of **Table 3-7**, the volume from the Regional Storm for Climatic Regions 1–4; <u>OR</u> Type 1A storm for Climatic Regions 2 and 3 should be used to size the detention facility.

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 5-4.2.3 for pond and release structure design information.

## **Down Stream Analysis**

Any outfall that leaves WSDOT Right of Way is required to have a Down Stream Analysis (DA) as part of the Hydraulics Report. A DA examines the impacts an outfall will on a conveyance system downstream of the project site. Section 4-7 of the Hydraulics Manual provides details of the analysis.

## **Detention Pond Definition**

Detention ponds are open basins that provide live storage volume to enable reduction of stormwater runoff flow rates and allow 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.

## **Design Criteria**

The following is a summary of section FC.03, Detention Ponds from the HRM.

- Detention ponds are designed to drain completely within 72 after a storm event so that the live storage volume is available for the next storm.
- The pond should with 1' of freeboard above the 25 year design storm and the designer should verify the 100 year storm does not cause any damage to downstream property.
- Generally the facility is sized by subtracting the existing basin runoff from the proposed basin runoff and using that volume as a starting place to size the pond. This is done so the detention pond contains additional runoff from the proposed basin, while maintaining the runoff conditions from the existing basin.
- Ponds must be a minimum of 5' from any property line or vegetative buffer and 100' from any septic tank or drain field.
- The interior of the pond should be hydroseeded up to the 100 year elevation.
- Follow the guidelines in section 5-3.7.1 from the Highway Runoff Manual, to provide maintenance access to the ponds.
- A primary overflow (usually a riser pipe within the outlet control structure) must be provided for the detention pond system to bypass the 100 year developed peak flow. A secondary emergency overflow can be provided as additional protection against overflows should the designer feel that the primary overflow would likely become plugged.

In addition to the guidelines noted above, designers should review the process for designing flow control facilities in EWA outline in section 4-4.5 of the HRM. This tutorial was developed using the outline and sections are noted throughout in blue.

#### Start a new project

To start a new project in StormSHED, we first need to name a new project.

- Open StormShed 3G and select **File>New** from the main toolbar.
- Create a new project by selecting: File>New
- Enter the project name <u>widening</u> in the New Project Name input field and hit **OK**.

🖶 New Project	
New Project Name: widening	
detention pond 4 detention pond detention pond2 ditch infiltration pond	
Save To Folder:	
C:\AAWork\3G\StormShed3G\	
Cancel	ОК

## **Determine Rainfall Depths**

#### **Rainfall Setup**

Open the Project Configuration dialog box by selecting **Data>Config** from the program menu. Using the methods described in the **Regional Storm Tutoria**l, determine the precipitation values and input as shown below and click on the **Close** button to close the dialog box.

🔜 Pr	oject Configuration	1			
Ration Projec	nal Event Factors   IDF F t Defaults   Default Lab	amily   IDF Equa	ation   Ground Cov Links   Conduit Si:	ver Coefficients   Arch Sizes   Ellip zes   SCS Land Use   Rational La	se Sizes   Layout Colors   Cu nd Use   Mannings 'n'   Conc
	Project Precips			Use SI units	
	Design Event:	Precip (in):	Update	Use AMC for Project	TC Thresholds
	, Design Event	Precip	Add	C AMC 1	SCS Perv TC:
	6 month 2 year 24 hour	0.97	Delete	AMC 2     AMC 3	SCS Imp TC:
	5 year 10 year	1.70 2.00			5.00 = min
	25 year 100 year	2.20		IDF Curves in Selection Drop Down	Rational TC:
				C Equation Only	5.00 🕂 min
	<	>		Both	

- Change the precipitation for the <u>2 yr 24 hour</u> event to <u>1.4</u> 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)

🔡 S	torms	ihed3	G
File	Data	Misc	Help
0	pen		entation
N	ew		nd 4
S	ave		
S	aveAs		ing
D	elete Pr	oj	ITOTYPE Je
E	xit Prog	ram	
	_ 📥	Hydro	graphs

Determine the predeveloped and postdeveloped time of concentration. Select the storm hyetograph and analysis time interval. For each TDA input the values in to StormSHED.

#### **Defining Drainage Areas**

#### Create Existing Basin

First define the existing drainage area then work from left to right going through the tabs.

- 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**.

🖶 Basins			
existing Perv CN Pe	rv TC 🛛 Directly Connected CN 🗍 Directl	y Connected TC Compute	
Basin Id:	existing	New	
Rainfall Type	TYPE1A.RAC	▼ Time Series	
Design Method:	SCS 💌	Storm Dur: 24 🕂 hrs	
Hyd Interval (min):	10	Unit Hyd: SCS Unit Hyd 💌	
Peak Factor:	484.00 Lo	oss Method: SCS Curve Number 💌	
	Summary Data		
	Perv TC: 11.13 min.		
	Imperv TC: 5.00 min.		
	Total Area: 7.23 ac		

- Click on the "*Perv CN*" tab.
- Click on the "Prototype subarea" line.
- Modify per Figure below

💀 Basins				
existing Perv CN Perv TC Directly Conn	ected CN Dire	ectly Connected	TC Compute	
Description type b soils	Ar	ea (ac) 2.87	CN HSG	Update
• Urban C Developing Urban C	Cultivated Agr	iculture		Add
C Other Agriculture C Arid Rangelar	nd		Move to DCIA	
Description	Subarea	CN		
type b soils	2.87	58.00		

• Click on the **Update** button.

• Delete any default areas that are not used.

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 one of the default travel time reaches to modify it.
- Make it <u>Shallow flow</u>, 25 feet in length with a <u>slope of 25%</u>. For the coefficient, use <u>Short Grass</u> to depict the median.
- Click on the **Update** button.
- Modify the "*Flow Type*" drop down to <u>int. Channel</u>.
- Change the description to **<u>Grassed</u>** reflect drainage down the ditch.
- Change the length to <u>2500 feet</u> with a slope of <u>5%</u>.
- Select <u>Grassed</u> for the coefficient.
- Press the **Add** button.
- Delete any default areas that are not used.

🔡 Basin	s 💦					
existing	Perv CN $(Perv TC)$ Directly Connected CN   I	Directly Conn	ected TC	Compute		
Flow Typ	e: Description:		Len (f	t) s(%)	Coeff	
Shallow	<ul> <li>Brushy ground with some trees (n=0</li> </ul>	.060)	25.00	25.00	0.06	0
Select Coeff:     Grassed (n=0.030)     Slope Calc       Update     Add     Delete     Total TC (min):     11.13					Slope Calc	
Туре	Description	Length	Slope	Coeff	TT	
Shallow	Brushy ground with some trees (n=0.060)	25.00	25.00	0.06	0.16	1
intCha	Grassed (n=0.030)	2500.00	5.00	0.03	10.97	

- Add the roadway drainage area and CN value of the project site.
- Click on the "*Directly Connected CN*" tab.
- Modify per Figure below and press the **Add** button.

🖶 Basins						×
existing   Perv CN   Perv TC   Directly Conn	ected CN Dire	ectly Connected	TC Compute			
Description	AI	rea (ac)	CN HSG	]	Update	
roadway drainage	•	4.36	98	•	Add	
🖲 Urban C Developing Urban C	Cultivated Agr	iculture			Delete	
Other Agriculture O Arid Rangelar	nd		Move to PCN	·		
Description	Subarea	CN				
roadway drainage	4.36	98.00				

• Add the Sheet flow shown in the figure below.

🔡 Basin	S					
existing	Perv CN   Perv TC   Directly Connected (	CN Directly Cor	nnected TC	ompute		
Flow Ty Sheet	be: Description:		Len (ft)	s (%)	Coeff 2 y Prec 0 1.399	r xip 199
Select	Coeff:		•	Slop	e Calc	
	Update Add	Delete	Total T	C (min): 5.	00	
Туре	Description	Length	Slope	Coeff	TT	
Sheet	half the roadway	38.00	2.00	0.011	0.84	

- Click on the "*Directly Connected TC*" tab..
- Make it *Sheet flow*, <u>38 feet</u> in length with a slope of <u>2%</u>. For the coefficient, use <u>Smooth surface</u> to depict the roadway
- Click on the **ADD** button

#### Create Developed Basin

The "Existing" basin can now be used as a template for the developed basin. This will save time, as all the values entered will remain as defaults The designer will only need to modify the numbers that are different.

- Double click on the "Existing" basin under the "Basins" node in the Tree View.
- Press the **New Basin** button.
- Enter **<u>new basin</u>** for the Basin ID.

🔜 Basins			
new basin Perv CN F	Perv TC   Directly Connected CN   D	Pirectly Connected TC Compute	
Basin Id: Bainfall Tupe	new basin	New Time Series	
Desian Method:	SBUH	Storm Dur: 24 + hrs	
Hyd Interval (min):	10	Unit Hyd: SCS Unit Hyd 🔍	
Peak Factor:	484.00	Loss Method: SCS Curve Number 💌	
	Summary Data		
	Perv TC: 11.05 min.		
	Imperv TC: 5.00 min.		
	Total Area: 7.23 ac		

- Press OK to close the "AutoLabel" dialog box.
- Click on the "*Perv CN*" tab.
- Modify the **<u>Type B soils</u>** area to **<u>1.49</u>** acres.
- Click the **Update** button

🔡 Basins					
new basin Perv CN Perv TC Directly Co	nnected CN 🗍 🛛	Directly Con	nected TC	Compute	
Description	A	rea (ac)	CN	HSG	Update
type b soils	•	1.49	58.00	▼	Add
Ithan C Developing Urban C	Cultivated Agr	iculture			
		io un un o			Delete
Other Agriculture C Arid Rangelar	nd		Movelt	o DCIA	
Description	Subarea	CN			
type b soils	1.49	58.00			

- Click on the "<u>**Perv TC**</u>" tab
- Modify half the roadway Shallow flow to <u>13ft</u>
- Click the **Update** button

💀 Basins					
new basin   Perv CN   Perv TC   Dijectly Connecte	d CN Directly (	Connected TC	Compute		
Flow Type: Description:		Len (ft)	s (%)	Coeff	_
Shallow 💽 Brushy ground with some trees	(n=0.060)	13.00	25.00	0.06 0	
Select Coeff:		•	Slope	e Calc	
Update Add	Delete	Total T	'C (min): 11.	.05	
		-			
Type Description	Length	Slope	Coeff	TT	
Shallow Brushy ground with some trees (n=0.0	13.00	25.00	0.06	0.08	
intCha Grassed (n=0.030)	2500.00	5.00	0.03	10.97	

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

- Click on the "*Directly Connected CN*" tab.
- Modify the Roadway drainage area to <u>5.74</u> acres.
- Click the **Update** button

🖶 Basins					
new basin   Perv CN   Perv TC (Directly Co	nnected CN	Directly Conne	ected TC	Compute	
Description	A	rea (ac)	CN	HSG	Update
roadway drainage	<u> </u>	5.74	98.00		Add
O Urban C Developing Urban C	Cultivated Agr	riculture			Delete
🔿 Other Agriculture 🛛 🔿 Arid Rangelar	nd	_	Move t	to PCN	
		1			
Description	Subarea	CN			
roadway drainage	5.74	98.00			

- Click on the "*Directly Connected TC*" tab
- Modify half the roadway Sheet flow to 50ft
- Click the **Update** button

🖶 Basins					X
new basin   Perv CN   Perv TC   Directly Connect	ed CN Directly I	Connected TC	Compute		
Flow Type: Description:		Len (ft)	s (%)	Coeff 2 yr Precip 0 1.39999	1
Select Coeff:		•	Slop	e Calc	
Update Add	Delete	Total 1	°C (min): 5.	00	
Type Description	Length	Slope	Coeff	TT	
Sheet half the roadway	50.00	2.00	0.011	1.05	

## **Estimate the Pond Size**

We are going to estimate the pond size by subtracting the existing and new basin hydrographs.

- From the Layout View menu, select the tab marked >*Hydrograph* Click on the "Subtract" tab.
- Input the values shown below for the 25 year Design Event and hit Subtract. Repeat using the 100 year Design Event.

	× ×			1
sign	Summary Add Flow Add H	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Rec	distribute Subtr	act
dDe	Subtract Hyd:	existing 🗸		
Pon	From Hyd:	new basin 💌		
iew	Use Design Event:	25 year 🔹		
ν	Save Subtracted hyd in:	design pond		
Histo	Save remainder hyd in:	other 🗸		
we		Result Hydro Peak Q: 0.679616 cfs Vol: 0.2192 acft		
ut 🤇		Remainder Hydro Peak Q: 2.14719 cfs Vol: 0.7351 acft		
ayo		[		
ls		<u>Subtract</u>		
grapl				
ydro				
I				
s				
Plots				
Plots				
sign Plots	Summary Add Flow Add H		distribute Subtr	act
d Design   Plots	Summary   Add Flow   Add H Subtract Hyd:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing	distribute Subtr	act
Pond Design Plots	Summary   Add Flow   Add H Subtract Hyd: From Hyd:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin	distribute Subtr	act
iew   Pond Design   Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin 100 year	distribute Subtr	act
ory View   Pond Design   Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in:	-lyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing	distribute Subtr	act
History View Pond Design Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Tyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin 100 year design pond other	distribute Subtr	act
ew   History View   Pond Design   Plots	Summary Add Flow Add F Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft	distribute Subtr	act
ut View   History View   Pond Design   Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft Remainder Hydro Peak Q: 2.5617 cfs Vol: 0.9007 acft	distribute Subtr	act
Layout View History View Pond Design Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft Remainder Hydro Peak Q: 2.5617 cfs Vol: 0.9007 acft	distribute Subtr	act
hs Layout View History View Pond Design Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft Remainder Hydro Peak Q: 2.5617 cfs Vol: 0.9007 acft Subtract	distribute Subtr	act
graphs Layout View History View Pond Design Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd Combine Delete Detail Divert Import Export Move Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft Remainder Hydro Peak Q: 2.5617 cfs Vol: 0.9007 acft Subtract	distribute Subtr	act
Vdrographs Layout View   History View   Pond Design   Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft Remainder Hydro Peak Q: 2.5617 cfs Vol: 0.9007 acft Subtract	distribute Subtr	act
s Hydrographs Layout View History View Pond Design Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd Combine Delete Detail Divert Import Export Move Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft Remainder Hydro Peak Q: 2.5617 cfs Vol: 0.9007 acft Subtract	distribute Subtr	act
drographs Layout View History View Pond Design Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd   Combine   Delete   Detail   Divert   Import   Export   Move   Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft Remainder Hydro Peak Q: 2.5617 cfs Vol: 0.9007 acft Subtract	distribute Subtr	ract
s Hydrographs Layout View History View Pond Design Plots	Summary Add Flow Add H Subtract Hyd: From Hyd: Use Design Event: Save Subtracted hyd in: Save remainder hyd in:	Hyd Combine Delete Detail Divert Import Export Move Shift/Red existing new basin 100 year design pond other Result Hydro Peak Q: 0.810812 cfs Vol: 0.255 acft Remainder Hydro Peak Q: 2.5617 cfs Vol: 0.9007 acft Subtract		listribute Subtr

The results are shown in the lower box. We are interested only in the '<u>Result Hydro</u> <u>Peak Vol</u>'. <u>0.22 acft</u>, which will be used as a starting place to design the pond. The 'Remainder Hydro Peak' is the same as the existing basin or the volume that will be released from the pond (as opposed to the <u>result hydro peak vol</u> being contained in the detention pond). A more detailed description of the difference between 'Result' and 'Remainder' is described in the '**Hydrographs in 3G Description**' Section later in this tutorial.

## Have StormSHED compute a hydrograph

## Create a hydrograph

Next we will create a hydrograph given the data we have input into StormSHED so far. Using the subtract function does not create a hydrograph, it only computes the peak Q and volume. To view the hydrograph, follow the directions outlined in the bullet items below:

- To see the hydrograph select the '*Plots*' tab, located right below the '*Hydrograph*' tab in the Layout View.
- Select the '<u>design pond</u>', '<u>existing</u>', and '<u>developed</u>' (to select all three, hold the control key down and use a single LMB click on each name).
- The *Type of Plot* we want is a **hydrograph**.
- The *Hydrograph/Basin List*, allows the design to only display hydrographs or basins or both in the column on the left side. We want both so, select the <u>List</u> <u>Both</u> radio button.
- From the *Design Event* pull down menu, select 25 year.
- Next select the '*Plot*' tab to see the Hydrograph for the options we selected.

fiew   History View   Pond Design	Ito Control Plot B-001 developed existing other PROTOTYPE	Type of Plot • Hydrographs C Node Rating Curves C Discharge Rating Curves C Rainfall Types	Hydrograph/Basin List C List Hydrographs C List Basins C List Both Design Event 25 year T
Plots Hydrographs   Layout V		Elevation Range       From El:     100       To El:     105       At Every:     1	PROTOTYPE

A Hydrograph looking similar to the one below should appear. When the developed hydrograph (green) and the existing hydrograph (yellow) are subtracted, the new hydrograph created is 'design pond' in red (or the area that needs to be stored in the detention pond.



# Hydrographs in 3G Description

In the Hydrograph Subtract Tab, there were two names required to save the hydrographs '*Result Hydro Peak*' and '*Remainder Hydro Peak*', this section provides a more detailed explanation of these terms. In the example we were only concerned with the '*Result Hydro Peak*' or the black area shown below, which is the difference between the runoff generated from the existing basin and the runoff generated from the proposed basin. The white area represents the existing basin or the '*Remainder Hydro Peak*'.



**Overlap Hydrograph** 

If the hydrographs were actually offset, they might look like what is shown below. Where the black hydrograph is the developed basin and the combination of the aqua and white is the existing. When the existing is subtracted from the developed, the area shaded in black is the area that is required for storage and the area in aqua is the remainder runoff, from a detention perspective; it is the volume that will theoretically be released from the pond. In this case the sum of the subtracted and remainder hydrographs would have the same volume as the developed hydrograph.



**Offset Hydrograph** 

For the offset hydrograph, the Subtract feature doesn't concern itself with the area in white, it only reports the subtracted area and the remainder area.

## Assume the size of the detention facility

#### **Define a Storage Element**

For this project we will be designing a Stage Storage Pond with different outlets. The first-step is to design a Stage Storage pond.

- In the Tree View, double click on the node "*PROTOTYPE*" record.
- Click on the **New Node** button and change the "AutoLabel" ID to <u>Pond45</u>.

Press the **OK** button to close the "AutoLabel" dialog box. The *Start El* is the bottom pond elevation, for now leave it at **<u>108ft</u>**., StormSHED 3G will

🖶 Nodes					
pond45 Contrib Drainage Areas	Stage-Storage 1	able			
Node Type	Node ID:	pond45		<ul> <li>New Node</li> </ul>	1
MH/CB type	Description:	detention pond			
C Vault	Start EL(ft):	200.00	Max EL(ft):	108	-
C Trap Pond	Contrib Area:				
O Underground Pipe	Contrib Hyd:				-
Stg-Storage	North (ft):	0.00	East (ft):	0.00	"
C Detention Pond	Incremen	t for rating curves:	0.10 Void F	Ratio (%): 100	-
C Dummy Node					
C Compound					

automatically change these values once the stage-storage table has been created.

On the next page is the detention pond plan and cross sectional views, including staged elevation and volume information.

# Plan View of Odd Shape





The dimensions are selected using the area available for a pond and the volume from the 100 year storm (the subtracted volume from the existing and developed hydrograph) of about **11090 cubic**-feet with a depth of five (5) feet. <u>*The volume per stage can be*</u> <u>*calculated using Inroads for odd shape ponds*</u>. On a real project, the designer might use this process when right of way is limited and to try to fit a pond in the space available. Then the odd shape could be input into 3G using a volume per stage as noted above and illustrated on the next page. If space was not limited, the trap pond command could be used till the desired volume was achieved (see the Infiltration example).

- Input the values from InRoads into the *Stag-Storage Table* tab as shown below.
- Verify the <u>Stage-Volume</u> radio is selected.
- Select the 'pond 45' tab and note the bottom elevation has automatically changed to 205 feet.
- Hit '<u>Ok</u>' to close the box.

	🔜 Nod	es			
ſ	pond45	Contrib Drainage A	Areas Stage-Storag	e Table	
l		Stage (ft):	Storage (cf):		
l		200	0	Type of Data:	
l		201	702	C Stage - Area 💿 Stage - Volume	
l		202	1972		
ł		203	3938	Program ovporte activo storago	
		204	6728	volumes, therefore the lowest stage	
		205	11090	should have zero active volume. All subsequent stages should have total	
I	*			cummulative volumes. Stages in ft	
				(m), Area in sf (sm), Volumes in cf (cm).	

# Assume the size of the orifice and input into StormSHED (a good estimate is 1 inch diameter orifice per 0.05cfs outflow).

#### **Define a Control Structure - Orifice**

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 <u>New Control</u> button.
- Replace the "AutoLabel" Control ID with <u>Orifice</u>.
- Press <u>**OK**</u> to close the "AutoLabel" dialog box.
- Change the *Control Type* to "<u>Multiple Orifice</u>".
- Change the "Outlet Elev" to <u>200</u>.
- Change the "Max Elev" to <u>205</u>.

🖶 Control Structures		
orifice Multiple Orifice		
Select Control Type	Control ID:	
Multiple Orifice 🗨	orifice	New Control
	Description:	
	orifice outlet	
	Start El:	Max WS EI over Ctrl
	200.00	205.00
	Increment:	
	0.10	

- Click on the "*Multiple Orifice*" tab.
- Change the "Lowest Orif Elev" to 198.5 feet and then select CLOSE.



It is assumed that the pond bottom elevation is 200 ft and the maximum depth is five (5) feet above that. The program will size the orifice dimensions, so leave all control dimensions at zero. The lowest orifice elevation is set at 1.5 feet below the outlet elevation; see the Multiple Orifice Structure above. 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.

## **Define the Detention Pond Node**

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

Notice that again, the "*Start El*" and "*Max El*" are not changed, they will change automatically based on the data input into the **Detention** tab.

_			
	Nodes		
m	edianpond45 Contrib Drai	nage Areas Detention	
	Node Type	Node ID: medianpond45   New No	ode
	C MH/CB type C Vault	Description: pond and orifice	—
	C Trap Pond	Start EL(ft): 200.00 Max EL(ft): 205.00	
	O Underground Pipe	Contrib Area:	
	C Stg-Storage	Contrib Hyd:	•
	Evel Pool	North (ft): 0.00 East (ft): 0.00	
	C Dummy Node	Increment for rating curves: 0.10 Void Patio (%)	10
	C Compound		0

- Select the *Detention* tab.
- From the "Storage ID" drop down, select **Pond45**.
- From the "Discharge ID" drop down select Orifice.
- Click back on the "medianpond45" tab

🔜 Nodes				
medianpond45	Contrib Drainage Areas	Detention		
The i stage node pon Sel der	metphor of a detentic e-storage and a stag from which the stora 145 ect the control structu ved:	n pond is e discharg ge rating c re from wh	used to denote a single entity from which a ge rating curve can be derived. Select the curve should be derived: ] ich the discharge rating cuve can be	

Notice that the program automatically updated the *Start* and *Max* elevations.

🔜 Nodes		
medianpond45 Contrib Drainag	e Areas   Detention	
Node Type	Node ID: medianpond45	▼ New Node
C MH/CB type	Description: pond and orifice	
C Vault	Start EL(ft): 200 Max EL(ft):	205
C Trap Pond	Contrib Area	

• Click on the **OK** button to close the "*Node*" dialog box.

#### Sizing the Control Structure

The program will automatically design multiple orifice structures to meet the design requirements.

- Select the *Pond Design* tab in the Layout View.
- Using the pull down menus, input the values shown below for the 2, 25, and 100 year design event, selecting the Add button after each input.

- Note the <u>**2 year**</u> storm should only have <u>**50%**</u> of the rate.
- 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 and is automatically named by StormSHED.

Design Event	M	atching Runo	ff Hyd			°∕ of l	Rate			Add
100 year	▼ ex	disting	ii ii ju			▼ 100.0				
		flau Uud/Dag				0.44	in and			Delete
		IIIOW HYU/Das	sin.				iyu.			Stm Dur (hrs):
	ne	ew basin				▼ 100 y	ear out			24 🛨
a seguration	The off			Contract of the	The second se		0000	-		
Computatio	onalIn	structions:								
2 year 24 hour	existing	g	50.00	new ba	sin		2 yea	ar 24 hour out		- Routing Tabl
2 year 24 hour 25 year 100 year	existing existing existing	g g a	50.00 100.00 100.00	new ba new ba	sin sin sin		2 yea 25 ye 100 y	ar 24 hour out ear out vear out		Routing Tabl
2 year 24 hour 25 year 100 year	existin existin existin	g g g	50.00 100.00 100.00	new ba new ba new ba	sin sin sin		2 yea 25 ye 100 y	ar 24 hour out ear out year out		Routing Tabl
2 year 24 hour 25 year 100 year	existin existin existin	g g g	50.00 100.00 100.00	new ba new ba new ba	sin sin sin		2 yea 25 ye 100 y	ar 24 hour out ear out year out		Routing Tabl
2 year 24 hour 25 year 100 year Kesults:	existing existing existing	g g g	50.00 100.00 100.00	new ba new ba new ba	sin sin sin		2 yea 25 ye 100 y	ar 24 hour out ear out year out	g	Routing Tabl     Size Outlet     Save Chart
2 year 24 hour 25 year 100 year <b>Results:</b> Design Ev	existing existing existing Match	g g h Flow (cfs)	50.00 100.00 100.00 Peak O	new ba new ba new ba ut (cfs)	sin sin sin Max Depth (ft)	Detention Vo	2 yea 25 ye 100 y	ar 24 hour out ear out year out Hrs to Empty (hr)	% Vol	Routing Tabl
2 year 24 hour 25 year 100 year <b>Results:</b> Design Ev 2 year 24 hour	existing existing existing Matcl	g g h Flow (cfs) 309716	50.00 100.00 100.00 Peak O 0.655	new ba new ba new ba ut (cfs)	sin sin sin Max Depth (ft) 2.720113	Detention Vo 3387.7411	2 yea 25 ye 100 y	ar 24 hour out ear out year out Hrs to Empty (hr) 0.00	% Vol 99.85	Routing Tabl
2 year 24 hour 25 year 100 year Results: Design Ev 2 year 24 hour 25 year	existing existing existing Matcl 1. 2.	g g g h Flow (cfs) 309716 147194	50.00 100.00 100.00 Peak O 0.655 2.147	new ba new ba new ba ut (cfs) 198 7158	sin sin sin Max Depth (ft) 2.720113 3.340659	Detention Vo 3387.7411 4888.4379	2 yea 25 ye 100 y 0 (cf) 76 178	ar 24 hour out ear out year out Hrs to Empty (hr) 0.00 0.00	% Vol 99:85 99:91	Routing Table Size Outlet Save Chart Report Display Peak

• Press the **Size Outlet** button.

Next we will review the multiple orifice sizes StormSHED selected and see if they are practical and/or constructible.

- Open the Orifice dialog box and select the *Multiple Orifice* tab to view the orifice sizes.
- Next, designers need to look at the dimensions StormSHED selected for the orifice and apply engineering judgment. Examine the orifice discharge structure. Note that the lowest orifice is **3.8 inches in diameter** and is located at our input elevation of **198.5 feet**. The second orifice is **8.44 inches** in diameter and is located a distance of **0.6 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.

🔜 Control Structures	
orifice Multiple Orifice	
Orifice Coefficient: 0.62	Overflow Riser
5th Diam (in): 0.00	Dist from 4th to 5th (ft): 0.00
4th Diam (in): 0.00	Dist from 3rd to 4th (ft):
3rd Diam (in): 1.03125	Dist from 2nd to 3rd (ft): 0.50
2nd Diam (in): 8.794922	Dist from Outlet to 2nd (ft):
Lowest Diam (in): 3.802734	Outlet El.

Designers should change the orifice sizes to something nominal.

• Modify the Multiple Orifice diameters and distances to match as shown below..

🔡 Control Struct	ures 🔲 🗖 🔀
orifice Multiple Orific	xe
Orifice Coefficier	It: 0.62
5th Diam (i	n): 0.00 Dist from 4th to 5th
4th Diam (i	n): 0.00 Dist from 3rd to 4th (ft): 0.00
3rd Diam (i	n): 0.00 Dist from 2nd to 3rd (ft): 0.00
2nd Diam (i	n): 9.00 Dist from Outlet to 2nd (ft): 3.00
Lowes	t Diam (in): 4.00 Outlet El.
Lowes	t Orif El (it): 198.50

Use the computer model to route the hydrographs through the detention facility and orifice structure.

Adjust the volume and discharge structures and keep running the computer model until the released flows and detention pond design requirements are met.

• Then select **OK** and return to the *Pond Design* tab. This time select the **Compute** button. Then we will verify the following:

- The Peak Out Q does not exceed the Match Q for both the 25 and 2 year storm. Note the Match Flow for the 2 year is the full flow and should be multiplied by 50% to verify the Peak Out is not greater.
- There is 1' of free board above the 25 year pond elevation.
- The 100 year elevation does not exceed the top of pond elevation at 205'.

l Design	Select Detenti Pond Not	on de: medianpond45	medianpond45						Start Stg (ft)	0.00		Update
w Pond	Design Event:	Matching Rund	Matching Runoff Hyd:					% of Rate				Add
	ļ	-										Delete
Vier		Inflow Hyd/Ba	Hyd/Basin:				Out Hyd:				Stm Dur (hrs):	
Ciol						-					-	24 📫
Hist	Computatio	nal Instructions:										
×.	Design Ev	Matching Hyd/B	%	Inflow H	Inflow Hyd/Basin			Outhyd			_	Compute
nt 🤇	2 year 24 hour 25 year	existing existing	50.00 100.00	00 new basin			2 year 24 hour out 25 year out					Routing Table
Layo	100 year	existing	100.00	00 new basin				100 ye	ear out			Size Outlet
	<										>	0.20 00000
Iraph	Results: Save Chart										Save Chart	
lo <sup>2</sup>	Design Ev	Match Flow (cfs)	Peak O	ut (cfs)	Max Depth (ft)	Deten	tion Vol	(cf)	Hrs to Empty (hr)	% Vol	_	Report
ž	2 year 24 hour	1.309716	0.698	3074	2.584998	312	2.10688	3	0.225	100.07		
	25 year	2.147194	2.13	5045	3.371852	497	5.46691	7	0.148	99.98		Display Peak Elev
di si	100 year	2.561696	2.619	1245	3.662/83	5/8	/.16456	5	0.272	99.99		Large Volume
ā											- 1	Maximum Plot Time:
												1491 ÷

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 or equal to the Match Q.

All the other requirements are met, so this pond size meets the design criteria for flow control and detention ponds.

# Adjust the basin to include the surface area of the pond

This is a brand new requirement for the next revision (after the 2006 HRM) the upcoming revision to the HRM. The idea is since precipitation falling on the pond will also contribute to the pond volume, it must be included in the analysis as impervious surface. This will take atleast two iterations to properly size the pond: once to estimate the pond size without the pond contributing and a second time to see if the pond size can handle the additional volume for the pond itself.

## **Modify Developed Basin**

Next we will modify the Developed Basin to include the surface area of the pond.

- Open the basin called <u>New Basin</u>.
- Select the *Directly Connected CN* tab.

🖶 Basins					
developed   Perv CN   Perv TC	Directly Conne	cted CN	Directly	Connected T	C Compute
Description	A •	rea (ac) 0	CN 0	HSG	Update Add
C Urban C Developing Url	lture Mo∨e t	• PCN	Delete		
Description	Subarea	CN			
roadside drainage pond (11090cft/5ft)	5.74 0.05	98.00 98.00			

- For the *Description* input **pond** (11090cft/5ft) (converted to acres), 0.05 acres for the *Subarea*, and 98 for the CN.
- Select the **Add** button and close the dialog box.
- Return to the *Pond Design* tab and select the **Compute** button.

The results that include the surface area of the pond are shown below.

Inflow Hyd/Basin:     Out Hyd:     Dele       Inflow Hyd/Basin:     Out Hyd:     Stm Dur       Computational Instructions:     Inflow Hyd/Basin     Outhyd     Z       Design Ev     Matching Hyd/B     %     Inflow Hyd/Basin     Outhyd     Comp       2 year 24 hour     existing     50.00     new basin     2 year 24 hour out     Z       2 year 24 hour     existing     100.00     new basin     2 year 24 hour out     If Routi       100 year     existing     100.00     new basin     100 year out     If Routi       100 year     existing     100.00     new basin     100 year out     Size O       Results:       Design Ev     Match Flow (cfs)     Peak Out (cfs)     Max Depth (ft)     Detention Vol (cf)     Hrs to Empty (hr)     % Vol       2 year 24 hour     1.309716     0.701125     2.60758     3166.501931     0.225     100.01	Design Event	Matching Rund	off Hyd:			% of F	Rate			Add			
Inflow Hyd/Basin:     Out Hyd:       Stm Dur       Computational Instructions:       Design Ev       Design Ev       Matching Hyd/B       ½       Inflow Hyd/Basin       Outhyd       Computational Instructions:       Design Ev       Matching Hyd/B       ½       Inflow Hyd/Basin       Outhyd       Comp       2 year 24 hour existing       100.00       new basin       2 year out       100 year       existing       100.00       new basin       25 year out       100 year       Size O       Save O       Results:       Design Ev       Design Ev       Match Flow (cfs)       Peak Out (cfs)       Max Depth (ft)       Detention Vol (cf)       Hris to Empty (hr)       ½ Vol       Report       2 year 24 hour       1.309716       0.701125       2 60758       3166.501931       0.225       100.01		- -				▼ 100.00 ÷				Delete			
		Inflow Hyd/Ba			Out Hyd:				Stm Dur (hrs):				
Computational Instructions:         Design Ev Matching Hyd/B % Inflow Hyd/Basin       Outhyd       Comp         2 year 24 hour existing       50.00 new basin       2 year 24 hour out       Comp         25 year       existing       100.00 new basin       25 year out       Routi         100 year       existing       100.00 new basin       100 year out       Size O         Results:						•			2	• 24 ÷			
Design Ev         Matching Hyd/B         %         Inflow Hyd/Basin         Outhyd         Comp           2 year 24 hour         existing         50.00         new basin         2 year 24 hour out         If Routi           25 year         existing         100.00         new basin         25 year out         If Routi           100 year         existing         100.00         new basin         100 year out         Size 0           Results:         Design Ev         Match Flow (cfs)         Peak Out (cfs)         Max Depth (ft)         Detention Vol (cf)         Hirs to Empty (hr)         % Vol         Report           2 year 24 hour         1.309716         0.701125         2.60758         3166.501331         0.225         100.01	Computatio	nal Instructions:											
2 year 24 hour existing         50.00         new basin         2 year 24 hour out           25 year         existing         100.00         new basin         25 year out           100 year         existing         100.00         new basin         100 year out         Size 0           Results:           Design Ev         Match Flow (cfs)         Peak Out (cfs)         Max Depth (ft)         Detention Vol (cf)         Hirs to Empty (hr)         % Vol         Report           2 year 24 hour         1.309716         0.701125         2.60758         3166.501931         0.225         100.01	Design Ev	Matching Hyd/B	%	Inflow H	nflow Hyd/Basin		Outhyd			Compute			
Zb year         existing         100.00         new basin         2b year out         1 Routi           100 year         existing         100.00         new basin         100 year out         Size O           Results:         Design Ev         Match Flow (cfs)         Peak Out (cfs)         Max Depth (ft)         Detention Vol (cf)         His to Empty (hr)         % Vol         Report           2 year 24 hour         1.309716         0.701125         2.60758         3166.501931         0.225         100.01	2 year 24 hour	existing	50.00	new ba	sin		2 year 24 hour out						
Results:         Size O           Design Ev         Match Flow (cfs)         Peak Out (cfs)         Max Depth (ft)         Detention Vol (cf)         Hirs to Empty (hr)         % Vol         Reput           2 year 24 hour         1.309716         0.701125         2.60758         3166.501931         0.225         100.01	25 year	existing	100.00	new ba	sin	25 year out			I Routing Tab				
Results:         Save 0           Design Ev         Match Flow (cfs)         Peak Out (cfs)         Max Depth (ft)         Detention Vol (cf)         Hrs to Empty (hr)         % Vol         Report           2 year 24 hour         1.309716         0.701125         2.60758         3166.501931         0.225         100.01	TOO YOU	Colourig	100.00	new pa	ant		100 )	your out		Size Outlet			
Design Ev         Match Flow (cfs)         Peak Out (cfs)         Max Depth (ft)         Detention Vol (cf)         His to Empty (hr)         % Vol         Report           2 year 24 hour         1.309716         0.701125         2.60758         3166.501931         0.225         100.01				S									
Design Ev         Match Flow (cfs)         Peak Out (cfs)         Max Depth (ft)         Detention Vol (cf)         Hrs to Empty (hr)         % Vol         Report           2 year 24 hour         1.309716         0.701125         2.60758         3166.501931         0.225         100.01	<									>			
2 year 24 hour 1.309716 0.701125 2.60758 3166.501931 0.225 100.01	< Results:									Save Chart			
	<     Results:     Design Ev	Match Flow (cfs)	Peak O	Out (cfs)	Max Depth (ft)	Detention Vo	ol (cf)	Hrs to Empty (hr)	% Vol	Save Chart Report			
25 year 2.147194 2.158989 3.383938 5009.186766 0.148 99.98 I Disp	Results: Design Ev 2 year 24 hour	Match Flow (cfs) 1.309716	Peak O	Dut (cfs) 1125	Max Depth (ft) 2.60758	Detention Vo 3166.5019	ol (cf) 131	Hrs to Empty (hr) 0.225	% Vol	Save Chart Report			
100 year 2.551695 2.642911 3.678/97 5831.843534 0.278 99.99 J Large	Results: Design Ev 2 year 24 hour 25 year	Match Flow (cfs) 1.309716 2.147194	Peak 0 0.70 2.151	Out (cfs) 1125 8989	Max Depth (ft) 2.60758 3.383938	Detention Vo 3166.5019 5009.1867	ol (cf) 131 766	Hrs to Empty (hr) 0.225 0.148	% Vol 100.01 99.98	Save Chart Report Display Pea			
	Match Flo 1.309 2.147 2.561	ow (cfs) 716 194 696	Peak 0 0.70 2.151 2.642	Dut (cfs) 1125 8989 2911	Max Depth (ft) 2.60758 3.383938 3.678797	Detention Vo 3166.5019 5009.1867 5831.8435	ol (cf) 131 166 134	Hrs to Empty (hr) 0.225 0.148 0.278	% Vol 100.01 99.98 99.99	Save Chart Report Display Pea Large Volum Maximum Plot Ti			

# Check the 100-year release rate, compare to predeveloped conditions, and check for potential property damage.

The pond still meets the flow control requirements and the design criteria for detention ponds, there fore the design is acceptable. The peak discharge rate for the 2 year storm slightly exceeds the 50% requirement. Designers should consider changing the orifice size or spacing to bring this value to 50%.

# **Define a Control Structure – Orifice and Weir Combo**

Next we will repeat the process with a weir set at the 25-year elevation from the pond design using the orifices, 203.38 and create a combination discharge structure to recognize both the weir and the orifice.

• Double click on the *PROTOTYPE* under the "*Discharge*" node in the Tree View.

- Click on the **New Control** button and enter <u>Weir</u> in the "AutoLabel" dialog box.
- Press the **OK** button to close the "*AutoLabel*" dialog box.
- Fill in the remaining data for the weir as shown in below.
- Select the *Rect Weir* tab and change the length to <u>5 feet</u>.

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

weir       Rect Weir         Select Control Type       Control ID:         Rectangular Weir       New Control         Description:       weir to handle the 25 year event         Start Et       Max WS El over Ctrl         203.33       205.00         Increment:       0.10
Select Control Type       Control ID:         Weir       New Control         Description:       Weir to handle the 25 year event         Start El:       Max WS El over Ctrl         203.33       205.00         Increment:       0.10
B
H p1 p2 P2 Rectangular thin plate weir
🔜 Control Structures
weir Rect Weir
Weir Length (ft):       3.06         3.00       Use Notch Eqn:         Wright/Baldwin Eqn       Image: Constant cd:         Height above bottom (automatically provided       Length Adjust (KI):

• 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 on the *PROTOTYPE* node under the "*Discharge*" records again.
- Press the **New Control** button and input <u>Combo</u>.
- Press the **OK** button
- Change the *Description* to "combination discharge structure"
- Change the "*Control Type*" to <u>combination</u>.

Notice that the starting and max elevation input fields have been disabled and the elevations are not correct; this will change once we input the discharge structures.

- Click on the "*Combination*" tab
- Select **Orifice** and then the **Add** button.
- Select <u>Weir</u> and then the Add button.

🔜 Control Structures			
combo Combination			
All Control Structures: orifice PROTOTYPE weir	Add Remove Refresh	Structure to Include: orifice weir	

• Click on the "*Combo*" tab.

Notice that StormShed has updated the disabled fields for elevations.

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

There is more to change. The orifice structures  $2^{nd}$  diameter needs to be deleted, the weir has replaced it.

- Open the "Orifice" discharge structure and select the "Multiple Orifice" tab.
- Zero everything except the "Lowest Orifice Diameter" as shown below.
- Press **OK** to close the dialog box.

🔜 Control Structures	
orifice Multiple Orifice	
Orifice Coefficient: 0.62	Overflow Riser
5th Diam (in): 0.00	Dist from 4th to 5th
4th Diam (in): 0.00	Dist from 3rd to 4th (ft): 0.00
3rd Diam (in): 0.00	Dist from 2nd to 3rd (ft): 0.00
2nd Diam (in): 0.00	Dist from Dutlet to 2nd (tt):
Lowest Diam (in): 4.00 Lowest Orif El (ft): 198.5	Outlet El.

The last step before re-computing the peak pond elevations is to modify the Detention Pond node with the new combination discharge structure.

- Open the "MedianPond45" node record and select the "Detention Pond" tab.
- Change the "*Discharge rating curve*" from to <u>Combo</u>.
- Press the **OK** button.

💀 No des					
medianpond45 Contrib Drainage Areas Detention					
The metphor of a detention pond is used to denote a single entity from which a stage-storage and a stage discharge rating curve can be derived. Select the node from which the storage rating curve should be derived:					
Select the control structure from which the discharge rating cuve can be derived:					

- 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 just an orifice.

d Design	Select Detenti Pond Not	ion de: medianpond45					•	Start Stg (	ft) 200.00	Update
w Pon	Design Event:	Matching Runof	f Hyd:			•	% of Rate	, 1		Add
History Vie	, .	Inflow Hyd/Bas	in:			-	Out Hyd:		•	Delete Stm Dur (hrs): 24
'iew	Computatio	nal Instructions:								
E^	Design Ev	Matching Hyd/B	%	Inflow H	Hyd/Basin		0	)uthyd		Compute
Layo	2 year 25 year	existing existing	50.00 100.00	develoj develoj	ped ped		2	? year out 25 year out		Routing Table
shqe	100 year	existing	100.00	develoj	ped		100 year out			Size Outlet
Ď	<								>	
Hydr	Results:									Save Chart
	Design Event	Match Flow (cfs)	Peak O	ut (cfs)	Max Depth (ft)	Deter	ntion Vol (cf	f) Hrs to Empty (hr)	% Vol	Report
j	2 year	1.296166	0.695	5495	2.566027	308	4.808594	0.50	100.00	
	25 year	2.133795	1.920	)458	3.550372	54	73.53767	0.167	100.00	Display Peak Elev
	100 year	2.548239	2.913	3352	3.67889	583	2.104225	0.167	100.00	Large Volume
										Maximum Plot Time:
	<								>	1510 🛨

# **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 maximum 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.

#### **Define a Control Structure – Drywell**

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 <u>Drywell</u>.
- Press **OK** to close the "AutoLabel" dialog box.
- Change the Control Type to "stg-disch" or staged discharge.
- Change the "Outlet Elev" to <u>200</u>.
- Click on the "Stage-Discharge rating table" tab.

🔜 Control Structures			
drywell Stage-Discharge Table			
Select Control Type	Control ID: drywell Description: drywell	▼ New Con	trol
	Start EI: 200.00 Increment: 0.10	Max WS El over Ctrl 205.00	

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

🖶 Con	trol Structures	5	
drywell	Stage-Discharge	Table	
	Stage	YVal	
	200	0	Stage/Discharge Bating Curve
	200.5	0	
	200.51	1	Note: Program expects active discharges
	205	1	rates, therefore, the lowest stage should have zero discharge. All subsequent
*			stages should have increasing rates.

One final step is needed before re-computing peak pond elevations. Modify the *Detention Pond* node with the drywell for the discharge structure.

• Open the "MedianPond45" node record and select the "Detention" tab

💀 Nodes 📃 🗖											
medianpond45 Contrib Drainage Areas Detention											
Node Type	N + 10 modiment//E										
	Node ID: medianpond45										
<ul> <li>мн/св (уре</li> </ul>	Description: pond and orifice										
C Vault	Start EL(ft): 200 Max EL(ft): 205										
C Trap Pond	Contrib Area:										
O Underground Pipe	Contrib Hyd:										
C Stg-Storage	North (ft): 0.00 East (ft): 0.00										
Detention Pond	Increment for rating curves: 0.10 Void Ratio (%): 100										
C. Dummu Modo											

- Change the "Discharge rating curve" to "drywell".
- Press the **OK** button.



• Open the Pond Design tab and press the **Compute** button.

d Design	Select Detenti Pond Noo	ion medianpond45   Start Stg (ft) 200.0								Upda	ite			
Pon	Design Event:	Matching Runof	Matching Runoff Hyd:					•		Add	1			
iew		•					100.00	÷		Dele	te			
∪ V		Inflow Hyd/Bas	Inflow Hyd/Basin:				Out Hyd:			Stm Dur (hrs):				
Hist						-			-	24	÷			
ma	Computational Instructions:													
nt 🤇	Design Ev	Matching Hyd/B	%	Inflow H	Hyd/Basin		Outhyd				ute			
ofe	2 year	existing	50.00	) developed			2 year out							
_	25 year	existing	100.00	develop	ped		2	5 year out		Routing Table				
ş	TUU year	existing	100.00	UU developed				uu year out		Size Or	utlet			
gra	<													
łydr	Results:	Save C	Chart											
-	Design Event	Match Flow (cfs)	Peak O	ut (cfs)	Max Depth (ft)	Deter	ntion Vol (cf	i) Hrs to Empty (hr)	% Vol	Repo	ort			
ë	2 year	1.296166	1.00		1.562316	1.562316 141		0.167	98.58					
_	25 year	2.133795	13795 1.00 3.1288 18239 1.00 3.8784		3.128895	429	7.617804	0.167	99.16	Displa	ay Peak Elev			
	100 year	2.548239			3.878425	638	8.804396	0.167	99.30	Large	Volume			
								Maximum	Plot Time:					
	<								>	1510				

#### 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 in-fact the designer could reduce the pond size.