Volume

3

ENGENIOUS SYSTEMS, INC.

StormShed 2nd Generation

Tutorial

STORMSHED 2ND GENERATION

Tutorial

PO Box 30188
Seattle, WA 98103
Phone 206-784-7175 • Fax 206-782-7138

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Tutorial

The StormShed2G tutorial is designed to familiarize the user with the location of program features as well as demonstrate the basic steps to accomplish standard tasks.

This volume does not deal with the many program features. Volume 2, Program Description describes the program features and organization. This Volume is designed to step the user through a sequence of steps required to accomplish certain design tasks. It starts with simple data entry for Basins, Discharge structures, and Nodes.

This Volume then integrates the data into a detention pond design.

Chapter 1

Starting a Project

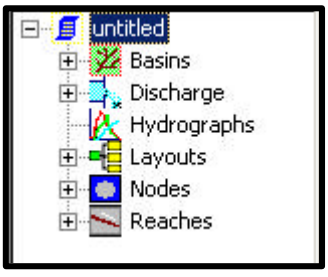
This chapter is focused on starting a new project. Each project consists of a set of data divided into the following categories.

- Basins
- Discharge Structures
- Hydrographs
- Layouts
- Nodes
- Reaches

Projects are not required to have data in all the categories. When the program is started, the first thing that needs to be done is to create a new project or work in a previously created project. StormShed2G automatically opens to the last project that was opened. If this is the first time that the program has been started, there obviously isn't a previous project that you worked on, so the program automatically defaults to an untitled project.

If the Project name on the upper left of the program window is not untitled, create a new project by selecting the menu combination **File / New**.

The Tree View will display an untitled project. The view contains the categories, with a PROTOTYPE record already defined for each category except Layouts and Hydrographs.

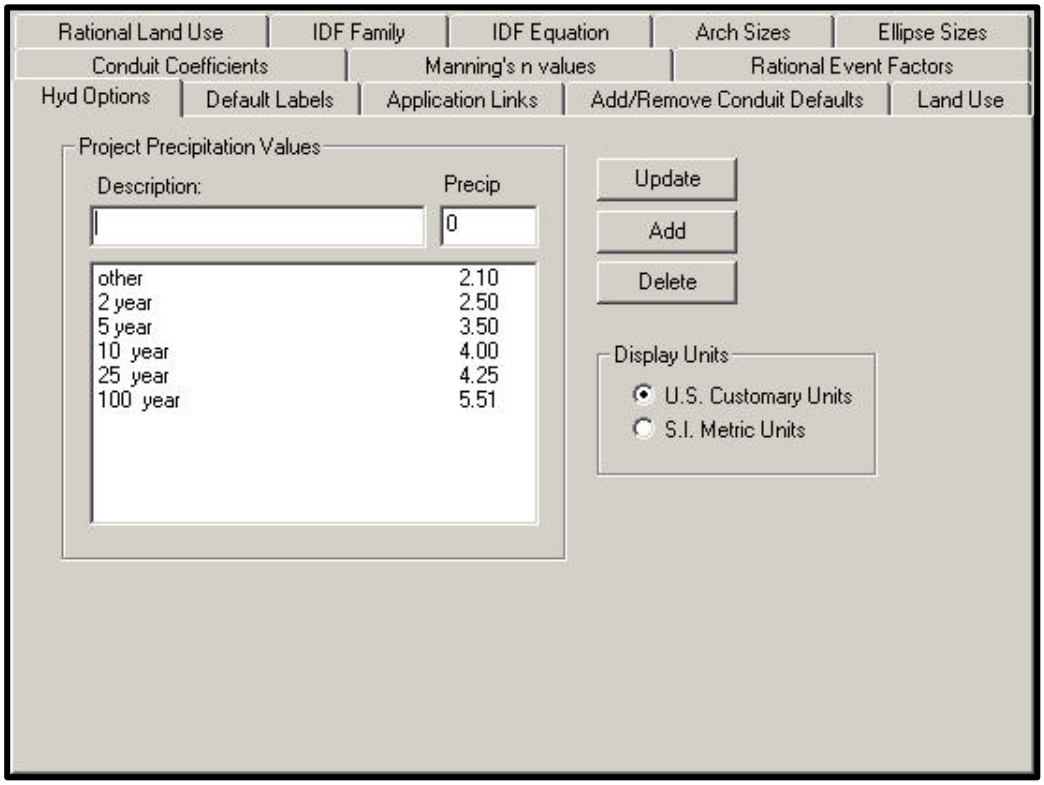


PROTOTYPE records should not be deleted from the project. They are used as the template for general records of the category type. Also, they are the placeholder records that the Layout uses when nodes and reaches are placed in the Layout.

Layouts will be discussed later, but when creating a layout, one inserts nodes and reaches. The program inserts

PROTOTYPE nodes and reaches as placeholders until the engineer can modify them to reflect the actual node or reach at that location.

Perhaps the first order of business is to define the precipitations associated with the projects design events. Select the **Data/Config** menu combination and enter adjust the default precipitations associated with each design event. Although most projects will not use all the design events, it is a good idea to enter the complete precipitation data for each event because a future condition might require it. If the data is omitted now, then the correct precipitation will have to be researched at a later time. Also, there should not be a question as to whether the entered precipitation is correct for the project or "left" over from the default project.



In general, this data entry form is similar in concept to many of the others in the program. At the top there are two fields, the description and the precipitation field. Along the side, there are three buttons, the Update, Add and Delete buttons. Below the Description and Precip edit fields is a list of design events. To modify the 2 year precipitation, simply left mouse click on the 2 year description line in the lower list box. The description and precipitation for the 2 year design event will be moved to the Description and Precip fields. Modify either fields and press the Update button.

To add a new design event, enter a description and precipitation value in the Description and Precip fields. Press the Add button.

To delete a design event, select it from the list box and press the Delete button.

The most common mistake is to forget to press the Update button after modifying the fields. Failure to press the button will result in no changes to the data.

Press the Close button when modifications to the project design events are complete.

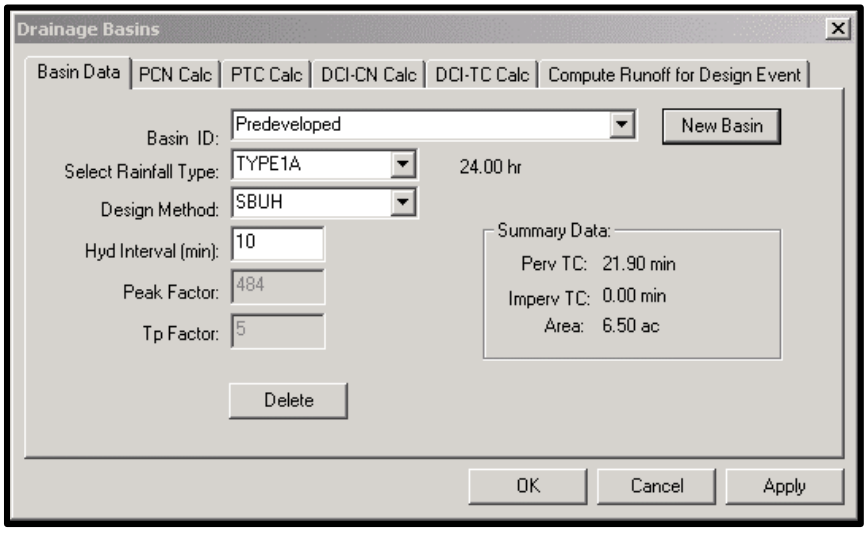
- Select the **File / Save As** , menu combination.
- Navigate to a location where project data is to be stored. Don't put your data in the programs installation directory!
- Enter Tutorial for the filename, or anything else that makes sense.
- Press the Save button.

Chapter 2

Entering Basin Data

Every project has to have at least one drainage area, so we will demonstrate data entry by defining a drainage basin. In the Tree View, click on the + symbol next to Basins then double left mouse click on PROTOTYPE. The prototype basin record will appear.

- The default Rainfall Type is TYPE2 and the Default Design Method is SCS. Using the dropdown for each, change the rainfall type to TYPE1A and the design method to SBUH.
- Click on the New Basin button.
- In the AutoLabel Dialog, change the default ID from B-001 to Predeveloped. Press the OK button in the AutoLabel Dialog.



Several things happened (not necessarily in order). First, a new record named Predeveloped was created using the PROTOTYPE record as a template. It is currently displayed, ready for modification. Second, the PROTOTYPE record itself was updated to default to the TYPE1A rainfall type and also use the SBUH design method. Third, the Basin Predeveloped was added to the Tree View.

Since the PROTOTYPE record was used as a template, there is already some data associated with this record.

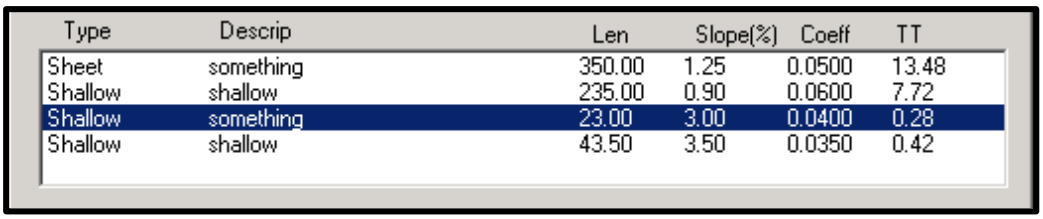
- Click on the PCN Calc tab.

- From the Description drop down, select Open spaces, lawns, parks (50-75% grass).
- Enter 3.5 in the field for Area.

- In the HSG field, select *HSGB* from the drop down. Note that it automatically fills in a Curve Number value.

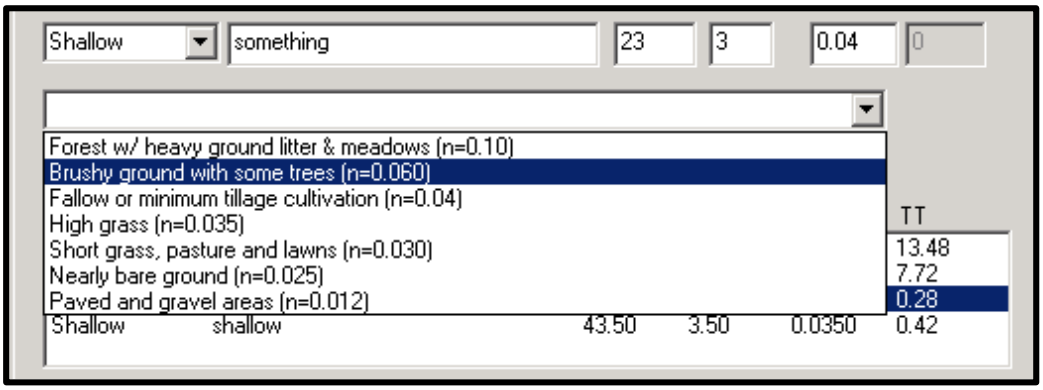
> ***The values that are available from the drop down are customizable from the Data\Config menu selection.***

- Click on the Add button. The new sub-area will appear in the list box below.
- Click on the PTC Calc tab.
- Click on the shallow flow travel time reach that is 23 feet long.



Type	Descrip	Len	Slope(%)	Coeff	TT
Sheet	something	350.00	1.25	0.0500	13.48
Shallow	shallow	235.00	0.90	0.0600	7.72
Shallow	something	23.00	3.00	0.0400	0.28
Shallow	shallow	43.50	3.50	0.0350	0.42

- Change the coefficient by selecting Brushy ground with some trees (n=0.060) from the large drop down.



- Click on the Update button.
- Click on the Compute Runoff for Design Event tab.
- Select any Design Event from the drop down selector and press the Compute button. The program should return an answer. If not, there has been some type of data input error.
- Press the Close button to close the dialog.

To obtain a summary report on the basin:

- Right mouse click on the Predeveloped record in the Tree View.
- From the pop up menu, select **To History**.
- Click on the  followed by the  toolbar button to toggle the current report view to update itself.

The current report view should now display a summary report for the Predeveloped Basin. If the report is not visible, click on the  button on the tool bar. If the  is already selected, click on the  once to change the view, then click on the  for refresh the view.

> ***The next section illustrates an alternate method of creating a new record based on another record.***

To create another drainage area description based on the Predeveloped basin that was just defined:

- Right mouse click on the Predeveloped record in the Tree View.
- From the pop up menu, select **New**.
- Replace B-001 with Developed in the AutoLabel Dialog box.
- Press the OK button.

A new drainage basin named Developed has been added to the Tree View. It is identical to the basin named Predeveloped.

- Right mouse click on the Developed record in the Tree View.
- From the pop up menu, select **Open**.

> ***Double left mouse clicking on the Developed record ID in the Tree View will also open the dialog.***

The goal is to modify the existing drainage area to reflect a developed condition. The following steps will modify the area defined as pervious CN values to a lesser area and insert it into the DCI-CN Calc. Adjustments will be made to the DCI-TC calculator. If DCI (Directly Connected Impervious) area is an unfamiliar concept, see Vol 2, Program Description.

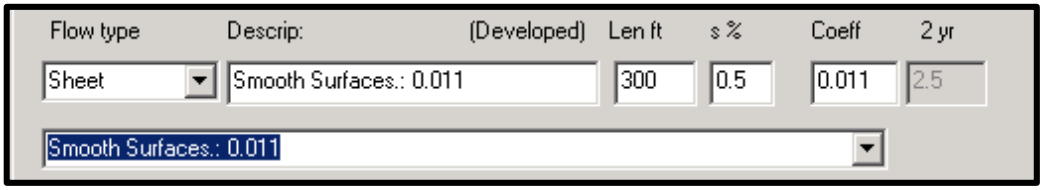
- Click on the PCN Calc tab.
- Click on the Open spaces, lawns parks subarea in the list of sub areas.
- Press the Delete button.
- Click on the Farmsteads subarea in the list of sub areas.
- Press the Delete button.
- Click on the PTC Calc tab.
- Click on the shallow travel time reach with a length of 23 feet.
- Press the Delete button.
- Click on the shallow travel time reach with a length of 43.5 ft.
- Press the Delete button.
- Click on the DCI-CN Calc tab.
- From the Description drop down selector, select Impervious surfaces (pavements, roofs, etc).

- Enter 5.5 where in the Area Field.

- Select HSGD from the HSG Drop Down selector.

- Press the Add button.

- Click on the DCI-TC Calc tab. Enter the following data.



Use the drop down selector to select the "Smooth Surfaces: 0.011" description. The program has built in land use types from which to select. The land uses can be modified for your specific locale via the* Data/Config *menu selection.

- Click on the Add button.

- Click on the Close button to close the dialog.

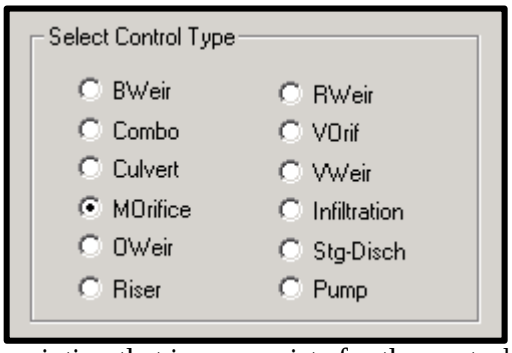
Save the project if you are not planning to move onto the next chapter.

Chapter 3

Entering Discharge Data

To define a discharge structure that will be used for detention control

- Click on the + symbol next to Discharge in the Tree View.
- Click once on the PROTOTYPE record in the Tree View to give it focus.
- Now double click on the PROTOTYPE record in the Tree View that appears below Discharge.
- Click on the New Control button and enter Orifice in place of *D-001*.
- Press the OK button.
- In the section labeled Select Control Type, select the MOrifice radio button. ***Notice that the second tab in the dialog changes depending on which control type is selected***!



- Change the Description field to a description that is appropriate for the control that is selected.
- Set the Max El to something reasonable, 108 ft.

> ***This tutorial will use the default elevations. In a real project, the outlet elevation should be adjusted to actual conditions!***

- Click on the Multiple Orifice tab. Notice that the Orif Coeff field already contains a default coefficient of 0.62. Leave the remaining fields set to zero (0). Later the program will fill in the appropriate values (as part of the detention tutorial).

- Press the  to close the dialog.

Save the project if you are not planning to move onto the next chapter.

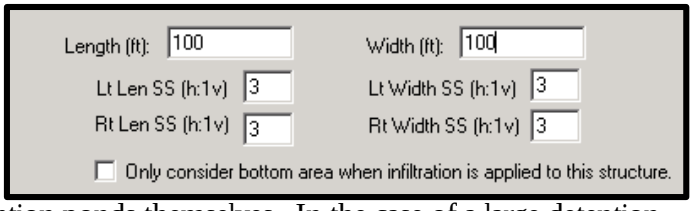
Chapter 4

Entering Node Data

Like the other data structures, creating a node is similar in sequence. In StormShed2G, a node is something that understands volume. All nodes can compute it's own volume. Nodes are used to define junctions in conveyance systems, and also as detention ponds. As far as the program is concerned, a manhole is as valid a detention pond as a trapezoidal shaped hole in the ground.

The node that is defined here will be used in the detention example.

- Click on the + symbol next to Nodes in the Tree View.
- Click once on the PROTOTYPE to give it focus.
- Now double click on the PROTOTYPE record in the Tree View that appears below Nodes.
- Click on the New Node button and replace N-001 with Trap.
- Press the OK button.
- Select the Trap Pond radio button along the right side of the dialog. This will change the third tab in the dialog to Trap Pond.
- Click on the Trap Pond tab.
- Enter the following data.



Nodes can have drainage areas associated with them. The most obvious example is an inlet. The contribution drainage area for an inlet drains into the inlet. Less obvious examples are the detention ponds themselves. In the case of a large detention pond, the contributing area is the size of the pond. StormShed2G allows multiple

contributing drainage areas to be associated with each node. The second tab allows for the selection of those drainage areas. Notice that there is no indication of design events associated with the drainage areas. The design event will be selected at the time of computation.

- Press the 

button to close the dialog.

Save the project if you are not planning to move onto the next chapter.

Chapter 5

Simple Detention

This chapter is essentially a continuation of the previous chapters. The previous chapters demonstrated data entry for basins, discharge structures and nodes. In this chapter, the entered data will be used to design a detention pond.

The key to detention routing is the definition of a Detention Pond node. The Detention Pond node is not the same as the Trap node that was defined in the previous chapter. The Trap node is the structure the program uses to create a stage storage relationship. StormShed2G needs a node that encompasses the entire detention pond as intelligent people intrinsically understand in a conversation.

When two engineers discuss a detention pond, they typically refer to a pond at some location. Implicit in their conversation is the knowledge that the pond consists of both a storage element and a discharge element. The Detention Pond node is the programs method of providing the same knowledge.

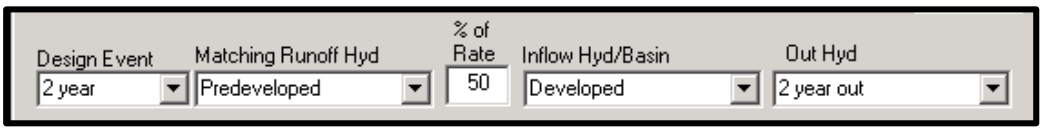
- Double left mouse click on the PROTOTYPE record for Nodes.
- Click on the New Node button.
- Replace the AutoLabel ID with Pond1.
- Click on the OK button.
- Select the Detention Pond radio button in the Node Types group.
- Click on the Level Pool Data tab.

- Select Trap from the Storage ID drop down selector.
- Select Orifice from the Discharge ID Selector.

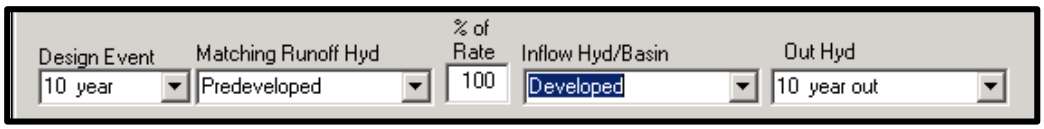
- Select the Puls radio button from the Method Group.
- Press the Close button to close the dialog.

The example detention pond will be sized to match 50% of the 2 year design event and 100% of the 10, and 100 year design events. With the detention pond node defined:

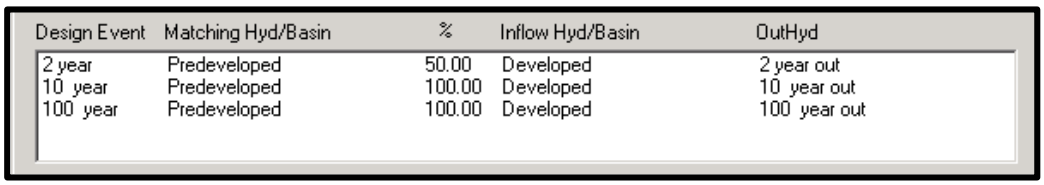
- Click on the  button on the tool bar.
- Select Pond1 from the Select Detention Pond Node drop down selector.
- Enter the 2 year design event data by using the drop down selector. For the % of Rate field, enter 50.



- Click on the Add button.
- Enter the 10 year design event data:



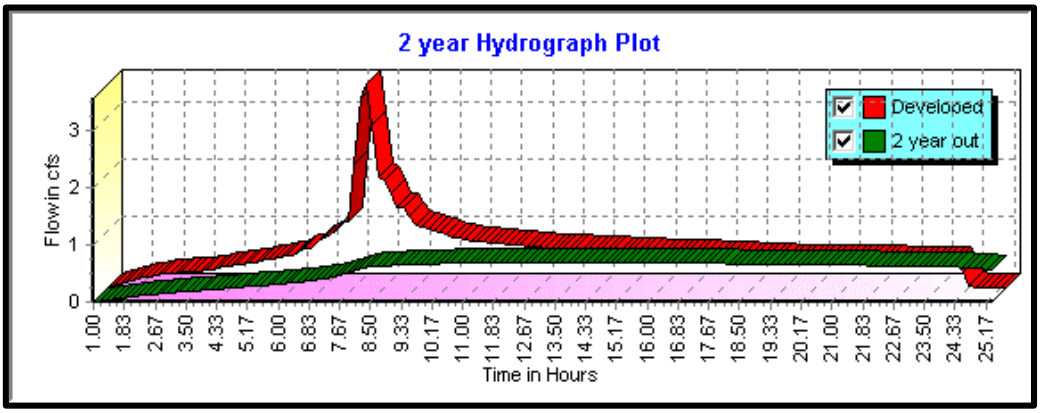
- Click on the Add button.
- Repeat for 100 year design event.



- Select the Puls Routing Method from the Routing Method Group.
- Click on the Size Outlet button.

When the computation is complete, the results are summarized in the results list box and a blank plot screen is displayed.

- Click on the 2 year design event in the summary list box.



Clicking on any of the summary design events will produce a plot comparing the detention pond outflow hydrograph against the developed inflow hydrograph. To save the chart to the current report view:

- Click on the Save Chart button. Note that if the 2, 10 and 100 year charts are to be saved to the current report view, each must be selected and saved.
- Click on the Apply button to save the current pond design settings.
- Click on the button on the tool bar.

LPOOLCOMPUTE [POND1] SUMMARY USING PULS

Event	Match Q (cfs)	Peak Q (cfs)	Peak Stg (ft)	Vol (cf)	Vol (acft)	Time to Empty
2 year	0.6857	0.6855	1.4537	15843.04	0.3637	35.00
10 year	4.1343	4.1341	1.7851	19832.15	0.4553	37.50
100 year	7.3786	7.3777	2.1034	23800.86	0.5464	37.67

(Chart not reproduced because it looks exactly like the one above).

The result of the demonstration indicates the peak stage for the 100 year design event is 2.1 ft. Generally, this is too shallow for a pond. The engineer typically adjusts the Trap nodes dimensions until an acceptable pond depth is attained.

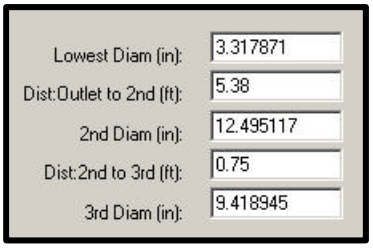
- Click in the + symbol next to Nodes in the Tree View.
- Double click on the Trap record.
- Click on the Trap Pond tab.
- Change the Length and Width dimensions to 50 ft. x 25 ft.

- Press the Close button.
- Click on the button on the toolbar.
- Press the Size Outlet button.

Design Event	Match Flow	Peak Outflow	Peak Stage	Detention Vol	Hrs to Empty	% Vol
2 year	0.6857 cfs	0.6862 cfs	105.2761 ft	14621.68 cf (0.3357 acft)	31.67 hrs	100.01%
10 year	4.1343 cfs	4.1335 cfs	106.0248 ft	18323.07 cf (0.4206 acft)	34.00 hrs	100.00%
100 year	7.3786 cfs	7.3782 cfs	106.6777 ft	21954.40 cf (0.5040 acft)	34.17 hrs	100.00%

The result indicates that the peak stage for the 100 year design event is 106.68 ft. Assume that the pond depth is satisfactory. Examine the orifice control structure.

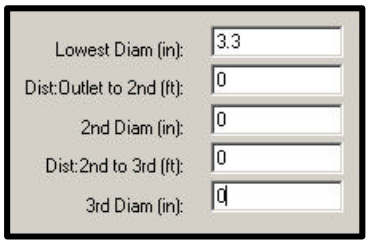
- Click on the + symbol next to the Discharge category in the Tree View.
- Double left mouse click on the Orifice record.
- Click on the Multiple Orifice tab.



Examination of the orifice diameters computed by the program indicates that second and third orifice diameters are rather large. In fact, considering the difference in stage between the 100 and 10 year design events is less than the third orifice diameter, the design just doesn't work. Numerically, it appears satisfactory, however, the orifice is simple too large.

While StormShed2G can compute numbers, it cannot exercise engineering judgment! The solution is to replace the second and third orifice with a weir. Note the peak stage for the 2 year design event. If a weir is to replace the second and third orifice, it should be placed no lower than the peak stage of the 2 year design event. Placing it at a lower elevation would result in an over designed lowest orifice.

- Zero all distances and diameter except the Lowest Diam in the dialog. (Proabably won't hurt to round it off too!)
- Click on the Discharge Data tab.
- Click on the New Control button.



- Change the AutoLabel ID to Weir, press the OK button.
- Select the RWeir radio button from the Select Control Type group.
- Set the Crest El to the peak stage of the 2 year event or higher. In this case, enter 105.3 ft.
- Make sure the Max Hgt field is higher than the Crest El by a reasonable amount.
- Click on the Rectangular weir tab.

> ***The program will not design the width of the weir. The strategy is to enter a length, check it by using the Compute button in the pond design Dialog, then make adjustments.***

- Enter a weir length of 1 ft.

Just because a weir has been designed, the program still does not know to include the weir in the pond design computations. A combination discharge structure must be created for the program to use in subsequent computations.

- Click on the Discharge Data tab.
- Click on the New Control button.
- Change the AutoLabel ID to Combo, press the OK button.
- Change the control type to Combo
- Click on the Combo discharge structure tab.
- Click on the Orifice record in the left list box to select it.
- Click on the Add button.
- Click on the Weir record in the left list box to select it.
- Click on the Add button.

- Click on the Close to close the dialog.

Now that a combination control structure has been defined, all that is necessary is to tell the program to use it instead of the Orifice structure.

- Open the Pond1 Node. (You should know how to do that by now).
- Click on the Level Pool Data tab.
- Change the Discharge ID from Orifice to Combo.
- Press the Close button.

With the combination control structure specified as the discharge id instead of an orifice, we **cannot** use the Size Outlet button. The program must operate in an analysis mode. That is, run the computation, see if the answer is acceptable, change some parameters, and try again.

- Click on the Compute button.

Design Event	Match Flow	Peak Outflow	Peak Stage	Detention Vol	Hrs to Empty	% Vol
2 year	0.6857 cfs	0.6853 cfs	105.3046 ft	14753.44 cf (0.3387 acft)	31.83 hrs	100.01%
10 year	4.1343 cfs	3.5467 cfs	106.3371 ft	20011.99 cf (0.4594 acft)	34.33 hrs	100.00%
100 year	7.3786 cfs	6.4172 cfs	107.2304 ft	25337.91 cf (0.5817 acft)	34.50 hrs	100.00%

The peak outflow for the 10 and 100 year design events are less than the Match Flow rates. The weir dimension meets the design criteria. At this point, considerations for the report are in order. Click on the results line that graphs will be required. Then click on the Report button once. Press the  to view the report.

The current report view now contains the summary information associated with the pond design computation. To generate a document that can be edited in MS Word, select the **View/History To Word** menu sequence. The **History to Word** menu selection will import the entire history to MS Word, not just what is currently displayed in the Report view. It really helps to occasionally use the other menu sequence, **View/Clear History**!

Chapter

6

Splitting Flows

There are several methods of splitting flows, there are also numerous reasons why anyone would want to. The method that should be used to split flows is dependent on the reason why it needs to be done. Generally, the reasons fall into two categories, planning and design level.

At the planning level, it is not necessary to have an exact answer, since flows are only general in nature. The intent would be to specify a level of performance during design. In this case, an acceptable method would be to use the Hydrograph Divert program feature to simply divert flow from the hydrograph.

The program supports two forms of divert. The simple case of diverting all flows greater than x cfs to another hydrograph (divert by rate) or diverting a certain percentage of each hydrograph ordinate to another hydrograph (divert by a volume). In the latter case, the result is two hydrographs, one with a "flat top" at the specified rate, and the second contains the portion of the original hydrograph that was greater than the specified rate.

When diverting based on a percentage (by volume), the result is two hydrographs whose volume is the specified percentage of the total combine hydrograph volume. The peak rate of the new hydrograph is also lowered by the same percentage.

From a planning standpoint, the two forms of divert represent a performance that the final design needs to achieve. In the case of the divert by rate option, the planner is saying that x cfs must be diverted from the main hydrograph and routed in another direction. In the case of the divert by percentage option, the planner is saying that the volume of the main runoff hydrograph needs to be decreased by a certain percentage for some purpose.

StormShed2G makes it easy to divert by rate or percent by using the Hydrograph Manipulation functions provided by pressing the  ***toolbar button and selecting the*** 

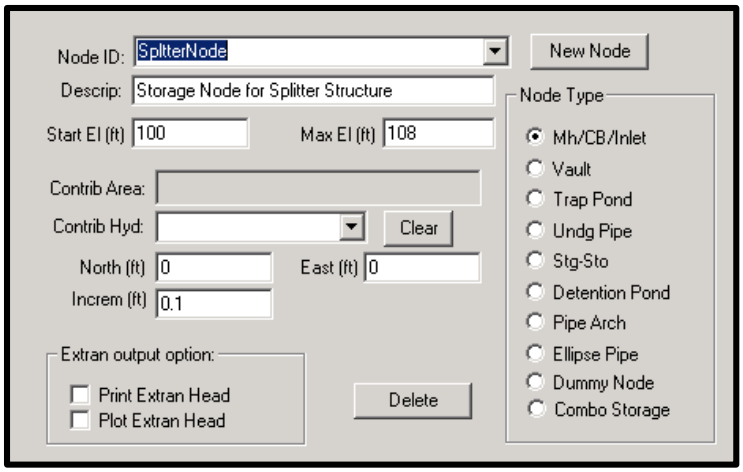
tab.

Note that these are planning level tools. It is during final design that the engineer must actually design a structure that will achieve the specified goals. This is often a difficult task.

The recommended method is to model the flow splitter structure as a detention pond consisting of two control structures. This works because the program automatically creates an outflow hydrograph through each structure based on the hydraulic characteristics of the control structures. This example will split the flows for the Developed basin defined in the previous example.

The data components that must be setup are:

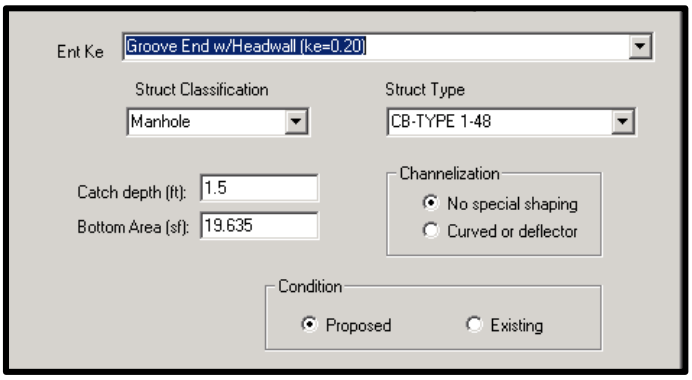
- A Manhole that acts as the storage structure (we will call it SplitterNode).
- A Detention Pond Node that points to the SplitterNode and also the control structure. (we will call it SplitterPond).
- A weir to manage the lower design flows.
- A second weir to manage flows greater than the low flow condition.



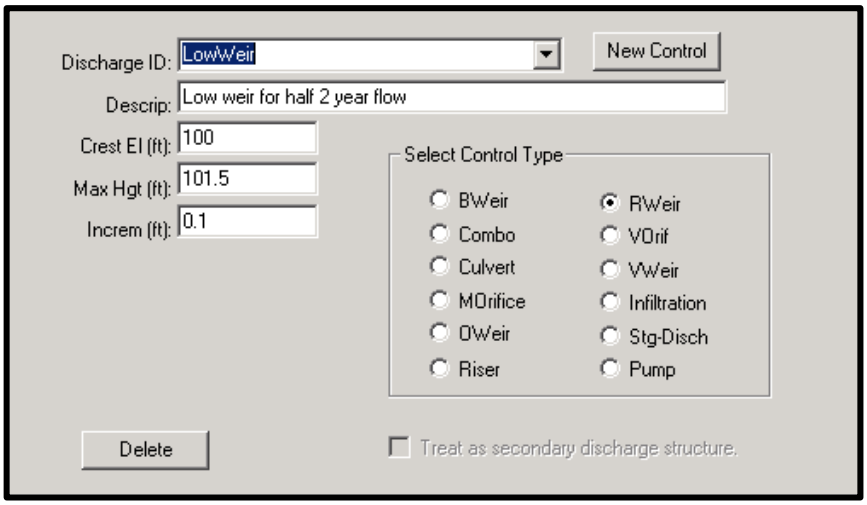
Assume that the design criteria requires that runoff from the two year design event is treated for water quality prior to detention. This means the runoff must be separated, then recombined prior to entering the detention pond. We will use the previously defined basins for the computation.

First define a storage node from which the runoffs will be split.

- From the Tree View, create a new node and Label it SplitterNode.



- Click on the Manhole/CB/Dummy tab and change the values as shown.
- From the Tree View, create a new discharge structure. Label it LowWeir.

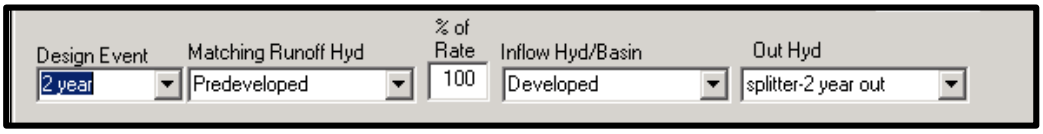


- Select the Rectangular Weir tab and enter 0.5 ft for the weir length. The length is arbitrary.
- Define a detention pond node. Call it SplitterPond. Make sure the node type is Detention Pond.
- Select the Level Pool Data tab and select SplitterNode and LowWeir for the Storage and Discharge ID.
- Press the Close button to close the dialog.

> ***Since a new detention pond node has been created, we might need to toggle out of the Pond Design View, then back into it to update the Detention Pond Node choices.***

- If the Pond Design View is active, click on the button once then click on the button to refresh the choices. If the Pond Design View is not the current view, select the button.
- From the drop down selection, select SplitterPond.

- Add the following data:



- Don't forget to press the Add button.

- Press the Compute button.

Design Event	Match Flow	Peak Outflow	Peak Stage	Detention Vol	Hrs to Empty	% Vol
2 year	1.3715 cfs	3.2886 cfs	101.5849 ft	31.12 cf (0.0007 acft)	24.83 hrs	100.00%

In this example the correct button to press is the Compute and not the Size Outlet button. The reason is that the LowWeir structure already has it's dimensions defined and what we want to do is see how well the LowWeir structure performs.

Several comments are in order. First we see the peak out is 3.29 cfs and the peak stage is 101.58 ft. We will use this stage to when defining the second weir that will handle larger design events. Note that the match flow is 1.3715 cfs, the 2 year Predeveloped runoff rate. The Peak Outflow does not match the Match Flow rate. In this scenario, it really doesn't make any difference what was entered in the Match Hyd/Basin and Match % columns. Since the Compute button was pressed, the program simply took the Developed runoff hydrograph and routed it through the control structure and pond to see how the control structure performed. In this case the result was a peak stage of 101.58 ft based on the weir dimensions.

Now that we know the peak stage over the weir is 101.58 ft, we can set the second weir elevation.

- From the Tree View, create a new discharge structure. Label it HiWeir.

- Set the crest elevation to 101.60 ft and the Max Hgl to elevation 105 ft.

- Select the Rectangular weir tab and enter 3 feet for the weir length.

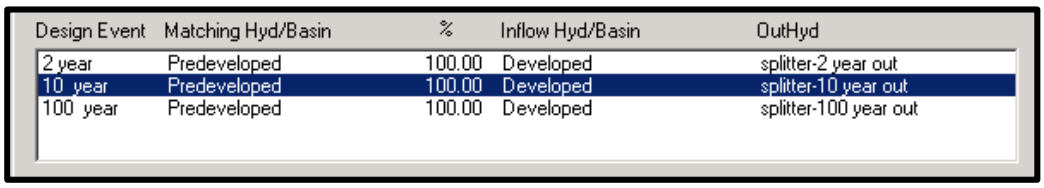
- Press the Close button.

- Create a new combination control structure. Call it SplitterCombo.
- On the second tab for the combination structure, include LowWeir and HiWeir in the Structure to Include list.
- Make sure the 

checkbox is selected.
- Select the 

button.
- Open the SplitterPond node dialog and change the DischargeID to "SplitterCombo".
- Select the 

button to close the dialog.



Design Event	Matching Hyd/Basin	%	Inflow Hyd/Basin	OutHyd
2 year	Predeveloped	100.00	Developed	splitter-2 year out
10 year	Predeveloped	100.00	Developed	splitter-10 year out
100 year	Predeveloped	100.00	Developed	splitter-100 year out

- In the Pond Design View, add the 10 and 100 year design events. Note that you will need to type in the OutHyd ids to make it look like the example above.
- Press the 

button.

When the computation is completed, there are nine (9) additional hydrographs that are created. Three (3) hydrographs represent the total outflow from the pond. They are as labeled in the OutHyd column on the Pond Design input form. There are two (2) that are created for each design event, one for the LowWeir and one for the HiWeir controls. With this information, the flows through the LowWeir control for the 2, 10 and 100 year design events can be routed through a water quality swale. The HiWeir hydrographs can then be routed in another direction.

If both the HiWeir and LowWeir hydrographs are suppose to be joined back together again downstream before entering a detention pond, it is probably easier to just use the "splitter-x year out" hydrographs as input into the detention pond. Although they are not technically as accurate as joining the two separated hydrographs again after water quality treatment, it probably will not make any difference. Since the combined flows enter a detention pond, the effect due to staggering of peak flows due to water quality treatment is lost in the pond attenuation process.

The procedure for splitting flows is identical to detention pond design. The only real difference is that the emphasis is on to releasing the flows through the controls structures with as little attenuation as possible whereas in a detention or retention type of design, the goal is to actually provide some sort of attenuation.

It might be noted that in the above example, the LowWeir was sized to accommodate the 2 year event. When a 10 or 100 year design event is routed through the structure, the LowWeir outflow hydrograph will have a larger volume and peak flow rate than the 2 year event. There is really no way of getting around this.

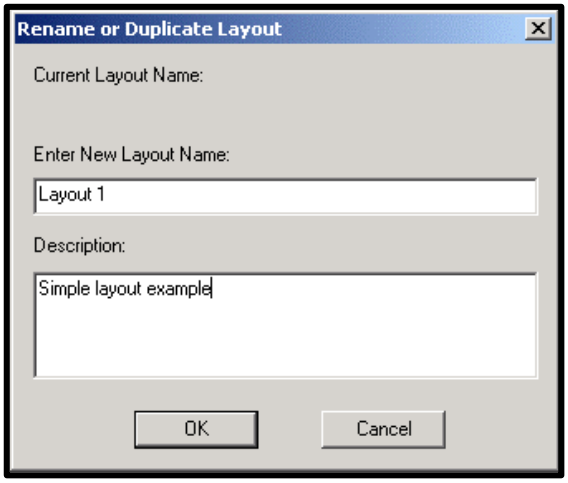
Chapter 7

Layouts

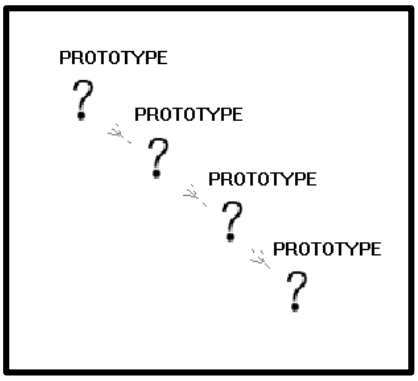
StormShed2G supports schematic type layouts. It is designed to quickly develop a schematic view of a project without worrying about absolute locations. The schematic layout uses the relative angles between nodes to determine losses due to changes in direction when computing hydraulic grade line elevations for each node. Generally, the losses are small and the variation between the schematic angle and the actual angle between nodes is small, resulting in discrepancies between actual and schematic losses within the accuracy of the design assumptions inherent in storm water computations.

This tutorial will eventually use some of the same data that was created in the previous chapters of this tutorial. We will use the same project file.

- If the project file was closed, re-open it.
- Click on the  to expose the Layout view.
- From the program menu, select **Layout/LayoutMenu/ New Layout.** Enter the data shown and press the OK button. (If the menu item is inactive, click in the Tree View once to give it focus.)



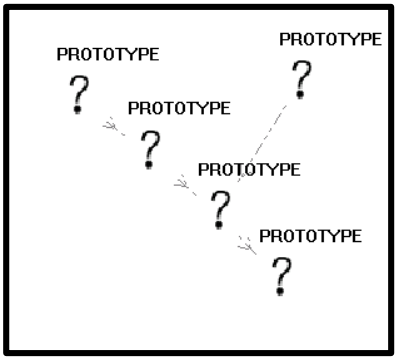
- Click on the  button on the toolbar. Notice that the button remains depressed. (If the button is not active, left mouse click once anywhere in the layout view window to give it focus.)



- Left mouse click four (4) times from the upper left to the lower right as shown.

> ***The program will insert both PROTOTYPE Nodes and Reaches into the layout as placeholders. They can then be defined. If the layout does not have the PROTOTYPE node labels, press the button until it appears. Likewise, if there are labels shown with the reaches, press the button until reach labels are not shown. Clicking on the or will automatically re-depress the button. If this occurs, reselect the button and skip the next step.***

- Click on the button on the tool bar once to tell the program to create a branch line that will connect to the layout.
- Click on the upper right of the layout view, then click on the third node that was previously entered.
- Click on the button again to unselect it.



> ***The program requires that nodes are inserted into the layout starting with the most upstream node and proceeding downstream. Examine the schematic layout and note the flow direction of the reaches.***

With the layout created, use the left mouse button to move the nodes around. (Left mouse click on a node, while holding the mouse button down, more the move around the screen.) Note that the reaches appear elastic, meaning they are redrawn to stay connected to the nodes. The length associated with each reach is unaffected by the visual distance between nodes! This is **not** a CAD program.

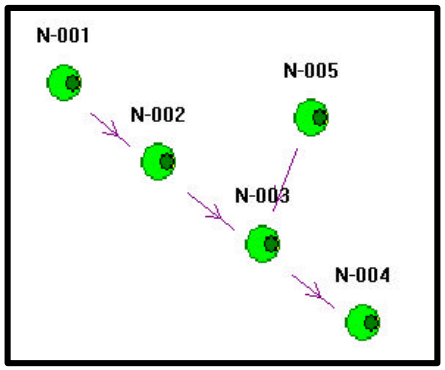
The next step in the process is to define node and reaches that will replace the PROTOTYPE's inserted into the layout. The process is simple, open the dialog associated with the node, create a new Node record, press the Apply button.

The Apply button informs the layout that it needs to be updated because the node or reach associated with the graphic object has been revised.

- Double click on the first node that was inserted into the layout.
- When the nodes dialog appears, press the New Node button.
- We will accept the Auto Label name, press the OK Button.

> ***If the Auto Label Id is not N-001, then it has probably already been created. Use the ID drop down selector and select N-001. Continue.***

- From the radio buttons along the right side of the dialog, change the Node Type to Mh/CB/Inlet.
- Set the Max El value to 105.
- Press the Apply button.
- Double click on the next node that was inserted. Note that the ID of the Node dialog reverts to the PROTOTYPE id again. Repeat the above steps until all the nodes have been identified as shown.



- When all nodes have been identified. Press the Close button to close the dialog.

Looking at the diagram, we want to change N-004 to reflect the outlet end of a pipe, not a manhole or catch basin type structure.

- Double click on the N-004 node and change the Node Type to a Dummy Node.
- Press the Apply button. This informs the layout that something associated with the symbol has changed.
- Press the Close button to close the dialog.

> ***Dummy Nodes are used to identify the upper and lower ends of reaches where a physical structure does not exist. They are simply placeholders.***

Before proceeding, the reach labeling needs to be changed to show the reach ID.

- Click on the  button until the Reach not yet defined! label appears on the sketch. Look at the lower right hand corner of the program window. It will say REACH ID.

- Double click on the reach between N-001 and N-002.

> ***Getting the reach dialog to appear can sometimes be a challenge. It is easiest when the reach is drawn at a 45-degree angle. It is most difficult when the reach is drawn perfectly vertical or horizontal. Windows uses the rectangle created by each end of the reach as the "hit" test. In the case of perfectly vertical or horizontal, the "hit" has to be dead on.***

- Ensure that the settings are:

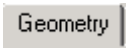
  - Manning's = 0.013
  - Section Shape = Circular
  - Material = Conc-Spun
  - Size = 12" Diam
  - Entrance Losses = Circular Conc
  - Entrance Losses = Groove End w/ Headwall
  - Length = 250 ft
  - Slope = 0.5%

- The procedure is similar to creating nodes. Click on the 

button.

- Press the 

button accepting the default reach label, P-001. If it is not P-001, use the drop down selector to select P-001.

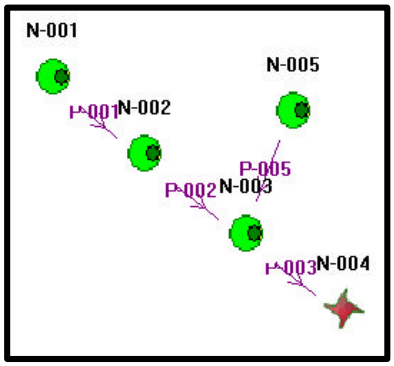
- Select the 

tab and press the 

button. The button will synchronize the reach up and down inverts based on the inverts of the reaches entering the upstream node and the node constraints. Note that the 

button for reach P-003 should be used after P-005 has been synchronized!

(This means you will need to create reaches P-003 and P-005, then go back and Sync, then P-003.)



- Press the Apply button.
- Double click on the next reach and repeat the above until the layout appears as shown. Notice that the diagram does NOT have a P-004. The trick is to press the New Rch button twice. This creates a P-004 reach in the database, but doesn't assign it to a layout element.

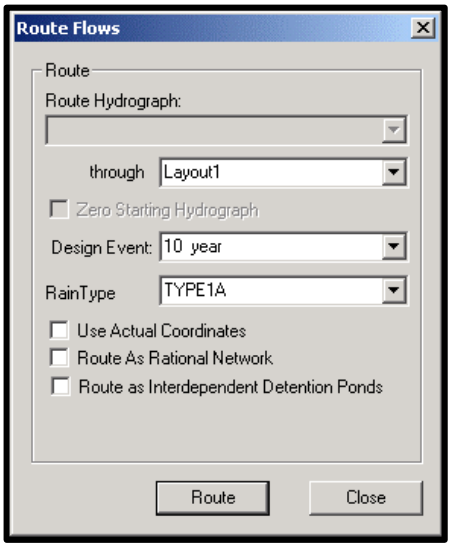
> ***The program only supports one (1) outgoing reach from each node. From a labeling standpoint, this offers an ideal method of maintaining distinct labels that can be associated with nodes. If the outgoing reach from each node always has the same number as the node, then labeling is simplified, since all that is necessary is to label the node and the outgoing reach is then known! In the case of P-004, it is created as part of the database, but need not ever be used in the layout.***

Since this is only a demonstration example, we can take a short cut. Normally, drainage areas would be defined for each of the catch basins associated with the layout. Assuming that only N-001 and N-005 are catch basins, each would require a contributing area from which runoff can be computed. In this example, we will just use the basins that were defined in the detention example. Granted, these are rather large areas to be contributing to a catch basin, but this is only an example.

- Double click on the N-001 node.
- Click on the Contributing Drainage Areas tab.
- Select Predeveloped from the list of drainage areas.
- Press the Apply button.
- Double click on the N-005 node.
- Click on the Contributing Drainage Areas tab.

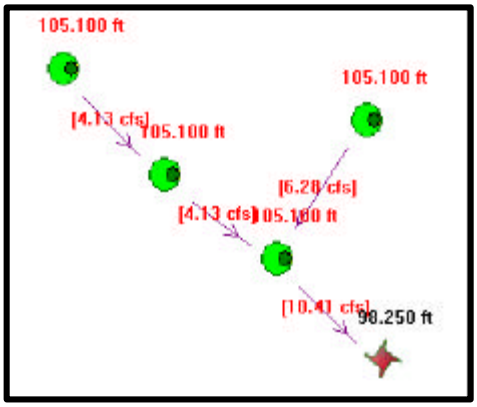
- Select Developed from the list of drainage areas.
- Press the Apply button.
- Press the Close button to close the dialog.
- Assuming that the Node ID labels are currently displayed in the layout view, press the button once. The Basin Id's will be displayed in square [brackets]. Where there is no contributing basin, the Node ID will remain displayed. Otherwise toggle through the labels until they appear.

The layout is now fully defined. The nodes are all linked with reaches and all nodes and reaches have a unique ID. The uppermost nodes, N-001 and N-005, has contributing basins associated with them (meaning there is flow entering those reaches).



- Click on the Σ button on the toolbar.
- Make sure all the checkboxes are UNCHECKED!
- Select a Design Event and RainType and press the Route button.

The program allows the specification of design event and rainfall type at runtime. Meaning that regardless of the design event and raintype that is specified in the drainage basin record, it is over-ridden by the selection in this dialog. If there are errors in the data, the program will simply report that errors were found. An actual list of the errors can be reviewed in the current report view. Press the button on the toolbar. Most likely, there is data missing in one or all of the reaches. Possibly a missing entrance loss coefficient. This would occur if the PROTOTYPE record is incomplete. Correct the errors and repeat the computation.



When the layout is successfully computed the layout should appear as shown. Don't worry if the numbers are not identical, there are plenty of reasons why they may not be at this point. The program automatically changes the node labeling to show hydraulic grade line (HGL) Elevations and

reach labeling to show peak flow rates. The HGL Elevations are shown in red, indicating that there is a problem at those nodes. Furthermore, if examined closely, you will see that in every case, they are 0.1 ft higher than the Max elevation specified for the node.

When the HGL elevation is higher than the maximum elevation of the node, the program defaults to 0.1 ft above the max elevation.

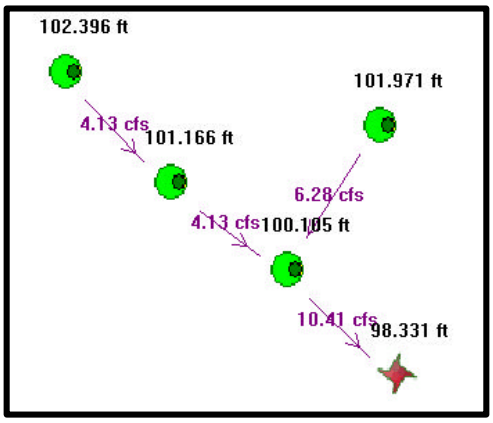
The reach flow rates are also in red and in square brackets. This indicates that the reach is under capacity. The reason is because when the reaches were created, the PROTOTYPE record was used as a template. All the reaches in the layout have the same dimensions as the PROTOTYPE.

Assuming all the reaches are suppose to be at a 0.5% slope and 250 ft in length, the program can size the pipes to make the flow work. The process is to zero the pipe diameters, followed by re-computing the layout. When re-computing the layout, if a pipe diameter is zero, the program will size the pipe diameter based on the other known hydraulic parameters.

- Click anywhere on the layout view to give that view the program focus.
- Select the menu sequence **Layout\Zero Diameters**.
- Using the mouse pointer select the reaches P-001 through P-005 by left mouse clicking on P-001, and while holding the button down, moving the mouse to P-005. All nodes will be selected.

> ***Mouse selection is standard windows feature. Use the key combinations ctrl-click to select specific items in the reach. Use the key combination shift-click or click and drag to select ranges.***

- Click on the OK button.
- Select the Σ button.
- Select the Route button.
- Select the Close button.



The layout now displays HGL elevations that are not surcharging the maximum

elevation of the node and peak flow rates through the reaches that are not in square brackets.

- Click on the  button several times until the reach sizes are displayed. They now range in size from 15 to 21 inches in diameter.

Warning

The program also adjusted the starting invert for P-001 when asked to size the pipe diameter! The starting invert is the minimum cover below the maximum node elevation (rim elevation of the manhole) minus the pipe diameter.

The next step is to see what happens when the program is asked to size both the pipe diameter and the slopes.

- Click anywhere on the layout view to give that view the program focus.
- Select the menu sequence **Layout\Zero Diameters**.
- Using the mouse pointer select the reaches P-001 through P-005 by left mouse clicking on P-001, and while holding the button down, moving the mouse to P-005. All nodes will be selected.
- Select the Slopes check box. (Both Diameters and Slopes are checked).
- Select the  button.
- Re-compute the layout.

Both the diameters and slopes have been selected based on the constraints that are specified for each pipe. Pipe inverts have also been adjusted. Results of each computation can be viewed by pressing the  button. Note that the  button only show the most current computation. A complete history is available by selecting the menu combination **View\History View**.

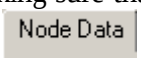
At this point, it should be emphasized that the program will only size circular pipes. Arch, elliptical and box shaped reaches will not be sized, nor will ditches. The program expects those other shaped to be fully dimensioned.

In-Line Detention

Layouts can include in-line detention. In this example, we will substitute node N-003 with the Pond1 created earlier in this tutorial.

- Open the reach dialog for P-003. Note the upstream invert elevation (94 ft.).
- Close the reach dialog.
- From the Tree View, open the Trap node. Change the Start El to the elevation noted above. Close the Trap node.
- From the Tree View, open the Orifice discharge structure. Change the Outlet Inv to the elevation noted above. Close the Orifice discharge structure.
- Lets arbitrarily set the Weir elevation to 100 ft. Open the Weir discharge structure and change its Crest Elevation to 100 ft.
- Open the Combo discharge structure, on the second tab, check the Split total outflow . . . checkbox.
- Press the 

button.
- Since the elevations of the controls and Trap node has changed, we need to toggle the Pond1 structure so that it knows the elevations has changed. Open the Pond1 node, view the 

data page making sure that Combo is selected for the discharge structure, then return to the 

tab. Press the 

button to close the dialog.
- Double click on Node N-003 in the layout view.
- From the drop down ID selection field, change the node to Pond1.
- Click on the 

button.
- Close the Dialog.
- Click on the 

button and re-computed the layout.

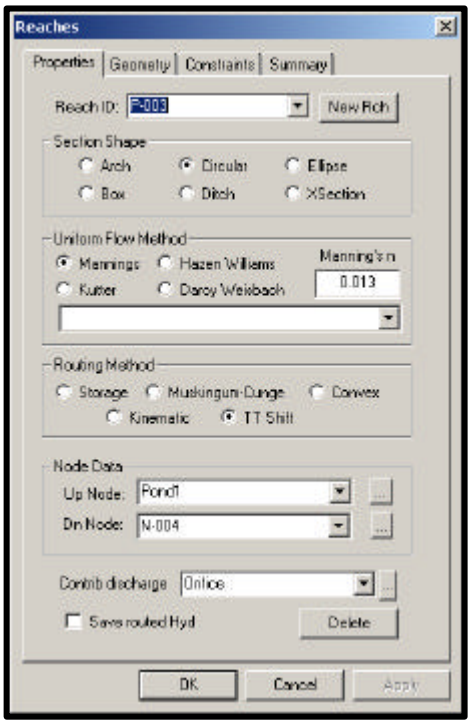
That's it! The detention pond is computed as part of the network. The program will NOT size a detention pond that is part of a layout! The general procedure is to size the pond separately, then insert it into the layout for final analysis. Don't worry about the red numbers. Remember, Pond1 was originally sized for only the Developed

runoff, in this case the layout is routing flows from both the Developed and Predeveloped basins through the layout.

What if we want flows to go in separate directions?

We can use the Pond1 to demonstrate the condition where flow needs to be split in multiple directions. Assume that the flow going through the Orifice discharge structure is to continue through the layout and the flow from the Weir discharge structure is to go somewhere else.

Because the program only allows one outlet reach per node the Weir flow must be picked up by another layout. First, lets deal with the Orifice discharge structure.

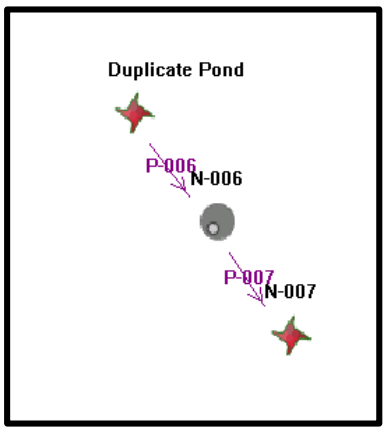


- Open Reach P-003.
- Using the Contrib Discharge selection field, select Orifice.
- Select the Apply button.
- Close the Dialog.
- Route the design storm event through the layout. Note that the flow thru reach P-003 is less than the sum of the two reached entering the Pond1 node.
- Click on the button. Assuming you have been routing the 10 year design event. Examine the runoff rates for the Pond1 – 10 year (both InHyd and OutHyd). They should be very close in peak rate and volume. Look at the 10 year Orifice rate and compare it with the N-004 – 10 year runoff rate. They should be the same, indicating that the Orifice runoff was routed through reach P-003. Look at the 10 year -Weir –Outflow rate. It should roughly equal the difference between the Pond1 – 10 year OutHyd and the 10 year Orifice runoff rate.

Generally, the program creates hydrographs for the in and out hydrographs to all Detention ponds. It also automatically creates the runoff hydrograph at the last node in the layout. When there is a combination discharge structure associated with a Detention pond, and instructed to split the outflow hydrograph among the combined structures, the program will create runoff hydrographs for each control in the combination. In order to keep track of all automatically created hydrographs, the

program associates the design event with each structure that hydrographs were based on.

What about the runoff from the Weir control structure? Presumably that goes through another conveyance system. Because the program does not support multiple "out" reaches from any node, a new layout must be created that identifies the Weir as the contributing discharge for the first reach.



- In the Tree View, right mouse click on Layout1.
- From the popup menu select **New**.
- Enter Layout2 for the new layout name.
- Enter Picks up flow from Weir structure for the description.
- Press the OK button.
- Create the layout shown.

Duplicate Pond and N-007 are dummy nodes. N-006 is just a MH node, although it doesn't make any difference in this example. P-006 and P-007 are pipe reaches, however, they can be anything in this example, it will not change the point of this demonstration, which is how to "pick-up" the runoff from the Weir discharge structure.

- Open the P-006 reach dialog.
- Specify Weir as the Contrib Discharge structure.
- Route the design event (same as you previously used) through this reach.

Note that there is no contributing basin associated with the Duplicate Pond node. The program gets its flow from the Contrib Discharge structure. An error will occur if a design event is routed through this layout that has not been routed through Layout1. The reason is because there would be no runoff hydrograph associated with the Weir control for that design event.

The program is pretty dumb. It really doesn't know that Duplicate Pond corresponds to Pond1 in Layout1. If you wanted to, a contributing basin could be added to the Duplicate Pond node and the program will process it even though that contributing basin is not reflected in Layout1!

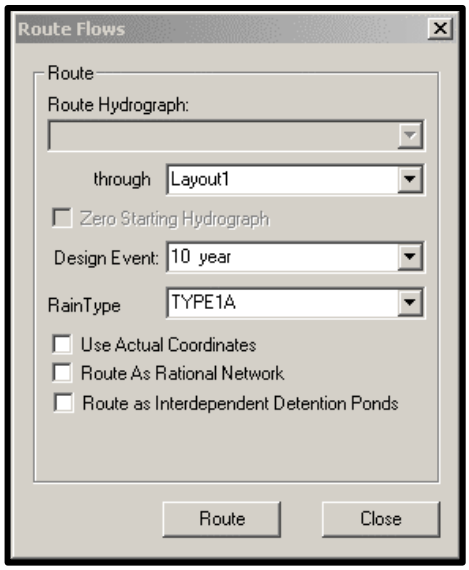
Chapter 8

Interdependent Pond Routing

Interdependent pond routing (IDPR) is an interesting subject. StormShed provides an option for the analysis of inline detention ponds. While any pond that is upstream of a lower pond can be considered inline, StormShed normally treats all ponds as independent of one another. That is, the detention pond's outlet structure is not affected over time by any downstream influences.

The previous layout example demonstrates the computation sequence. A complete runoff hydrograph is computed for the entire storm duration at each node before proceeding to the next node. In the case of the inline detention pond, the inflow hydrograph is routed through the pond based on the assumption that the lower node does not affect the ponds discharge structure. The downstream computation is complete when the program encounters a terminal node. In order to check that the assumption is valid, the program then computes a Hydraulic Grade Line (HGL) proceeding from the downstream terminal node upstream. When the program encounters a detention pond node, the program compares the maximum stage in the pond against the HGL proceeding upstream. The program reports back the higher of the two elevations.

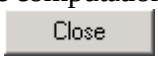
While the static computational method just described provides a mechanism to determine if backwater effects have a major impact on the detention pond performance, at times, there is a need for a more detailed evaluation.

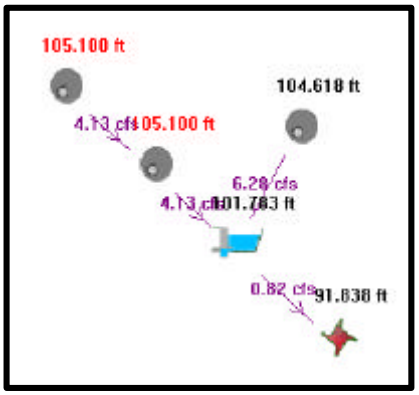


The interdependent pond analysis feature is not intended for entire layouts but for isolated sections of the project where there are two detention ponds that are inline and dependent on each other. Typically cascading pond type designs.

This chapter will demonstrate its use and attempt to point out differences in the methods, weaknesses in the analysis

methodology. To back track a little.

- Start the program. The program should open the Tutorial data file that you have been working.
- If the Layout View is not the current view, select the Layout View by pressing the  toolbar button.
- If Layout 1 is not the current layout, click on Layout 1 in the Tree View.
- Select the  toolbar button, adjust the settings as shown above and press the  button to start the computation.
- When the computation is complete, press the  button. The results should appear similar to:



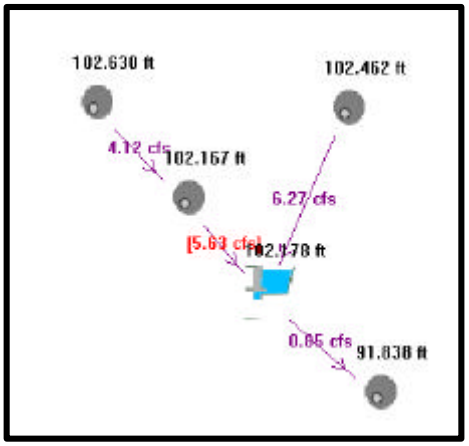
The point here isn't to have exactly the same numbers as shown. If you have modified the project a little and perhaps changed some elevations, your numbers will be different, but for the purposes of this tutorial, it does not change the discussion. The figure will be used as a starting point for comparison with an IDPR result.

The IDPR analysis for a layout is simply checking the Route as Interdependent Detention Ponds check box. When the computation is initiated, the program will route each inflow hydrograph time step through the entire layout network before proceeding to the next time step. (In the traditional approach, the entire inflow hydrograph is routed through each node before proceeding to the next node in the layout.)

The IDPR routing computation time is several orders of magnitude longer than the traditional routing because at each time step, the program checks to see what the downstream water surface elevation is, then it modifies the storage routing curve for the node. In the IDPR routing, every node is examined, if it is a detention node, the program already knows what the storage and control structures are. If the node is anything else, the program then converts it to a detention node using the geometry of the node for the storage element and the outgoing reach as the discharge structure. The program EXPECTS that the reach is a pipe reach and not something else (like a ditch reach)! Every node is treated as a detention pond and the hydrograph volumes are tracked as inflow and outflows from the ponds.

The storage available in reaches connecting the nodes are ignored! In most cases this is of little consequence, however if the connecting reaches relative volume is huge compared to the detention pond, the program will not account for the additional storage. Your answer will be conservative from the standpoint of peak stage in at each node. The program supports reverse flow based on water surface elevations at each pond.

Ok, lets look at the computation.



- Click on the Σ button again.
- Check the Route as Interdependent Detention Ponds check box.
- Press the Route button.
- When the analysis is complete, press the Close button.

The results are of the IDPR is different enough for the purposes of this tutorial. First note the differences between the HGL elevations. from the conventional layout analysis. In the case of the IDPR, since the program converted N-001 to a detention pond, it is reporting the peak stage in the pond based on a level pool routing. In the conventional analysis, the backwater computation resulted in an HGL based on the peak discharge rate flowing through the pipe.

In this example, the IDPR elevations at the nodes are lower than the elevations provided by conventional analysis. We don't know if this will always be the case, it is probably dependent on the circumstances, however, it is not surprising because in the IDPR analysis, the program accounts for available volume at each time step whereas the conventional analysis simple takes the peak hydrograph flow rate and assumes it is a constant flow for the hgl computation.

- Click on the button on the toolbar.

Appended on: 13:13:27 Friday, August 30, 2002

ROUTEHYD [] THRU [UNTITLED] USING TYPE1A AND [10 YEAR] NOTZERO RELATIVE SCS/SBUH IDPR

N-004 - 10 year Computation

Time Step	N-005 WS Elev (ft)/Q (cfs)	N-001 WS Elev (ft)/Q (cfs)	N-002 WS Elev (ft)/Q (cfs)	Pond1 WS Elev (ft)/Q (cfs)
0.67 hrs (0.03 days)	100.75 / 0.0000	101.00 / 0.0000	97.50 / 0.0000	94.00 / 0.0000
0.83 hrs (0.03 days)	100.81 / 0.0777	101.00 / 0.0000	97.50 / 0.0000	94.02 / 0.0140
1.00 hrs (0.04 days)	100.83 / 0.1113	101.00 / 0.0000	97.50 / 0.0000	94.05 / 0.0431

1.17 hrs (0.05 days)	100.90 / 0.2032	101.00 / 0.0000	97.50 / 0.0000	94.09 / 0.0843
1.33 hrs (0.06 days)	100.93 / 0.2476	101.00 / 0.0000	97.50 / 0.0000	94.15 / 0.1122
1.50 hrs (0.06 days)	100.98 / 0.3144	101.00 / 0.0000	97.50 / 0.0000	94.22 / 0.1377
1.67 hrs (0.07 days)	101.00 / 0.3457	101.00 / 0.0000	97.50 / 0.0000	94.30 / 0.1613
1.83 hrs (0.08 days)	101.05 / 0.4088	101.00 / 0.0000	97.50 / 0.0000	94.39 / 0.1832
2.00 hrs (0.08 days)	101.06 / 0.4255	101.00 / 0.0000	97.50 / 0.0000	94.48 / 0.2040
2.17 hrs (0.09 days)	101.09 / 0.4778	101.00 / 0.0000	97.50 / 0.0000	94.57 / 0.2235
2.33 hrs (0.10 days)	101.10 / 0.5044	101.00 / 0.0000	97.50 / 0.0000	94.67 / 0.2423
2.50 hrs (0.10 days)	101.12 / 0.5370	101.00 / 0.0000	97.50 / 0.0000	94.77 / 0.2600
2.67 hrs (0.11 days)	101.12 / 0.5439	101.00 / 0.0000	97.50 / 0.0000	94.87 / 0.2762
2.83 hrs (0.12 days)	101.13 / 0.5686	101.00 / 0.0000	97.50 / 0.0000	94.97 / 0.2910
3.00 hrs (0.13 days)	101.14 / 0.5724	101.00 / 0.0000	97.50 / 0.0000	95.06 / 0.3048
3.17 hrs (0.13 days)	101.15 / 0.5922	101.00 / 0.0000	97.50 / 0.0000	95.15 / 0.3175
3.33 hrs (0.14 days)	101.15 / 0.5941	101.00 / 0.0000	97.50 / 0.0000	95.24 / 0.3294
3.50 hrs (0.15 days)	101.15 / 0.6105	101.00 / 0.0000	97.50 / 0.0000	95.33 / 0.3405
3.67 hrs (0.15 days)	101.16 / 0.6287	101.00 / 0.0000	97.50 / 0.0000	95.41 / 0.3512
3.83 hrs (0.16 days)	101.17 / 0.6626	101.00 / 0.0000	97.50 / 0.0000	95.50 / 0.3620
4.00 hrs (0.17 days)	101.17 / 0.6643	101.00 / 0.0000	97.50 / 0.0000	95.59 / 0.3724
4.17 hrs (0.17 days)	101.19 / 0.7133	101.00 / 0.0000	97.50 / 0.0000	95.68 / 0.3827
4.33 hrs (0.18 days)	101.20 / 0.7539	101.00 / 0.0000	97.50 / 0.0000	95.77 / 0.3936
4.50 hrs (0.19 days)	101.21 / 0.7686	101.00 / 0.0000	97.50 / 0.0000	95.87 / 0.4045
4.67 hrs (0.19 days)	101.22 / 0.8059	101.01 / 0.0077	97.51 / 0.0073	95.98 / 0.4153
4.83 hrs (0.20 days)	101.24 / 0.8580	101.02 / 0.0301	97.52 / 0.0293	96.09 / 0.4269
5.00 hrs (0.21 days)	101.24 / 0.8612	101.05 / 0.0608	97.55 / 0.0600	96.21 / 0.4389
6.83 hrs (0.28 days)	101.45 / 1.6254	101.47 / 0.7016	98.02 / 0.8432(r)	98.21 / 0.6062
7.00 hrs (0.29 days)	101.46 / 1.6628	101.50 / 0.7761	98.29 / 1.5670(r)	98.55 / 0.6304
7.17 hrs (0.30 days)	101.51 / 1.8509	101.55 / 0.9046	98.58 / 2.0292(r)	98.97 / 0.6585
7.33 hrs (0.31 days)	101.56 / 2.0540	101.60 / 1.0579	98.96 / 2.4309(r)	99.43 / 0.6884
7.50 hrs (0.31 days)	101.57 / 2.1081	101.63 / 1.1540	99.46 / 2.6645(r)	99.90 / 0.7180
7.67 hrs (0.32 days)	101.96 / 3.8610	101.93 / 2.1040	99.98 / 3.5670(r)	100.45 / 0.7504
7.83 hrs (0.33 days)	102.35 / 5.9041	102.30 / 3.4566	100.59 / 4.9702(r)	101.10 / 0.7873
8.00 hrs (0.33 days)	102.46 / 6.2686	102.63 / 4.1185	102.17 / 5.6267(r)	101.70 / 0.8201
8.17 hrs (0.34 days)	102.17 / 4.9611	102.37 / 3.6605	101.77 / 3.7707	102.05 / 0.8384
8.33 hrs (0.35 days)	102.03 / 3.3299	102.10 / 2.6759	102.07 / 3.7255(r)	102.14 / 0.8429
8.50 hrs (0.35 days)	102.14 / 4.5628(r)	102.09 / 2.5160	102.16 / 3.2268(r)	102.17 / 0.8448
8.67 hrs (0.36 days)	102.21 / 3.4935(r)	102.19 / 2.7865(r)	102.15 / 2.9323(r)	102.18 / 0.8451
8.83 hrs (0.37 days)	102.19 / 2.4474	102.16 / 1.9830	102.14 / 2.4669(r)	102.08 / 0.8398
9.00 hrs (0.38 days)	102.10 / 2.3938	102.16 / 1.8876	102.03 / 1.7709	101.90 / 0.8308
9.17 hrs (0.38 days)	101.91 / 2.1673	102.07 / 1.7712	101.93 / 1.8943	101.73 / 0.8217
9.33 hrs (0.39 days)	101.71 / 1.8482	101.96 / 1.5136	101.73 / 1.4042	101.56 / 0.8126
9.50 hrs (0.40 days)	101.63 / 1.8521	101.79 / 1.5293	101.53 / 1.6515	101.41 / 0.8042
9.67 hrs (0.40 days)	101.48 / 1.7519	101.72 / 1.4123	101.42 / 1.2971	101.28 / 0.7974
9.83 hrs (0.41 days)	101.47 / 1.6828	101.72 / 1.4118	101.23 / 1.5398	101.18 / 0.7917
10.00 hrs (0.42 days)	101.46 / 1.6648	101.70 / 1.3492	101.12 / 1.2281	101.10 / 0.7872

10.17 hrs (0.42 days)	101.45 / 1.6031	101.70 / 1.3555	101.03 / 1.4828	101.03 / 0.7835
10.33 hrs (0.43 days)	101.42 / 1.5019	101.66 / 1.2405	101.02 / 1.1954(r)	100.97 / 0.7805
10.50 hrs (0.44 days)	101.42 / 1.5104	101.68 / 1.2812	100.93 / 1.4143	100.93 / 0.7779
10.67 hrs (0.44 days)	101.40 / 1.4462	101.65 / 1.1996	100.92 / 1.1286(r)	100.89 / 0.7757
10.83 hrs (0.45 days)	101.39 / 1.4004	101.65 / 1.2032	100.83 / 1.3422	100.85 / 0.7737
11.00 hrs (0.46 days)	101.39 / 1.3855	101.63 / 1.1538	100.83 / 1.3896(r)	100.84 / 0.7728
11.17 hrs (0.47 days)	101.38 / 1.3727	101.64 / 1.1806	100.83 / 1.5509(r)	100.83 / 0.7725
11.33 hrs (0.47 days)	101.37 / 1.3335	101.62 / 1.1211	100.82 / 1.1153(r)	100.82 / 0.7716
69.00 hrs (2.88 days)	100.75 / 0.0000	101.00 / 0.0000	97.50 / 0.0000	94.12 / 0.1007
69.17 hrs (2.88 days)	100.75 / 0.0000	101.00 / 0.0000	97.50 / 0.0000	94.08 / 0.0733
69.33 hrs (2.89 days)	100.75 / 0.0000	101.00 / 0.0000	97.50 / 0.0000	94.05 / 0.0468
69.50 hrs (2.90 days)	100.75 / 0.0000	101.00 / 0.0000	97.50 / 0.0000	94.03 / 0.0299
69.67 hrs (2.90 days)	100.75 / 0.0000	101.00 / 0.0000	97.50 / 0.0000	94.02 / 0.0191
69.83 hrs (2.91 days)	100.75 / 0.0000	101.00 / 0.0000	97.50 / 0.0000	94.01 / 0.0122
70.00 hrs (2.92 days)	100.75 / 0.0000	101.00 / 0.0000	97.50 / 0.0000	94.01 / 0.0078

Node Summary:

N-005	
Peak In (cf/s)	6.2774
Peak Out. (cf/s)	6.2686
Peak Stage (ft)	1.7118
HGL El (ft)	102.4618
Contrib Vol (cf)	99746.69
In Vol. (cf)	100934.04
Out Vol. (cf)	100940.03
Reverse Q (cf)	-1192.2308

Pond1	
Peak In (cf/s)	11.8953
Peak Out. (cf/s)	0.8451
Peak Stage (ft)	8.1780
HGL El (ft)	102.1780
Contrib Vol (cf)	0.00
In Vol. (cf)	296366.57
Out Vol. (cf)	162842.28

N-001	
Peak In (cf/s)	4.1343
Peak Out. (cf/s)	4.1185
Peak Stage (ft)	1.6295
HGL El (ft)	102.6295
Contrib Vol (cf)	70851.46
In Vol. (cf)	71191.06
Out Vol. (cf)	71191.53
Reverse Q (cf)	-337.1741

N-002	
Peak In (cf/s)	5.7109
Peak Out. (cf/s)	5.6267
Peak Stage (ft)	4.6673
HGL El (ft)	102.1673
Contrib Vol (cf)	0.00
In Vol. (cf)	195424.23
Out Vol. (cf)	195426.55
Reverse Q (cf)	-124232.7013

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The program displays a column for each node in the layout. (This is another reason why you are encouraged to use the feature frugally). The first column is a time step. The remaining columns are the nodes. Within each node column are two numbers, the first is the water surface elevation at that time step, and the second is the outflow rate from the node at that time step. The program identifies reverse flow with a red (r). At the bottom of the main report is a node summary. From this summary one can "follow" the runoff volumes.

For Example, the inflow into N-001 from basin Predeveloped was roughly 70860 cf, and has 340 cf of reverse flow from N-002. Approximately 71190 cf leaves the node and enters N-002. N-002 receives approximately 195400 cf of runoff via reverse flow

Roughly 99750 cf entered as contributing basin runoff and 1200 cf as reverse flow from N-003. Total out from N-005 is 101000 cf. The sum of 195400 cf and 101000 cf accounts for 296400 cf entering the Pond 1 node. The total out volume for the Pond 1 is about 163000 cf. The reason is because reach P-003 identified the Orifice discharge structure as the contributing discharge structure. Only 163000 cf of runoff was diverted out the Orifice discharge structure. The remainder left the Pond 1 node via the Weir control. Verify this by looking at the hydrographs for the weirs. Since we routed the 10 year design event we should look at the summary information for that event for each control.

- Click on the  button on the toolbar.

10 year-Orifice-OutHyd	0.8451	520.00	162838.18
10 year-Weir-OutHyd	6.1940	520.00	133515.47
N-004 - 10 year	0.8451	520.00	162842.39
Pond1 - 10 year InHyd	10.4117	480.00	170600.60
Pond1 - 10 year OutHyd	6.0157	500.00	170590.23

The 10 year-Orifice-OutHyd and the 10 year-Weir-Outhyd hydrographs represent the runoff attributed to each control structure. The N-004 – 10 year hydrograph was created because it is the terminal node in the layout. The remaining two Pond1-10 year xxHyd hydrographs were created by the conventional routing and not the IDPR routing. In conventional routing the Pond1 node is a detention node and the program automatically creates a record of the inflow and outflow runoff hydrographs for each detention pond. Note that the sum of the control structures (Orifice and Weir) should equal the total outflow hydrograph from the Pond1.

One final point. Looking at reach P-003, it is the pipe below the Pond1 node. The flow is 0.85 cfs and is not in square brackets and red, meaning that the pipe is capable of conveying the flow under gravity conditions. If the pipe were not able to convey the flow rate, it would also be in square brackets and red. This is a particularly important point for this reach because the combination discharge structure does not include the reach as a possible secondary control.

When using IDPR routing, the program **ignores** all controls that are designated as "secondary control" structures. (A secondary control structure is one that may be the limiting control structure at higher stages. In this example, the Orifice and Weir are considered the primary controls structures, but as the head builds, their combine capacity exceeds the ability of the receiving reach, hence the receiving reach becomes the controlling discharge structure at higher stages). As far as the program computation is concerned reach P-003 really does not exist. The combination control structure is "seen" as connecting the Pond1 to node N-004. Reach P-003 is also excluded from any reverse flow considerations.

Chapter 9

Rational Method

StormShed2G supports Rational Method with three (3) variations on how the program arrives at the intensity. The first is the traditional form where the flow rate is computed based an intensity-duration-frequency curve for the region. The intensity-duration frequency curve for a region is based on an IDF Family. An IDF Family is a text file with that contains time vs intensity for each design event. The text file ends with an .idf extension. The second, a modified version for King County, Washington is based on the same precipitation rates used in the SCS method. The last method of intensity is based on the generalized intensity equation and two (2) coefficients. (See the Program Description and Methods and References Volumes for additional info.)

Using the Modified King County Method is as easy as choosing the KingCountyIr idf Family in the Route Flows dialog box. When this idf Family is selected, the program will use the precipitation values assigned to each design event as identified by the SCS methodology.

The demonstration of the Rational Method will use the same layout that we just completed in the previous chapter. If the Tutorial Project is closed, please reopen the tutorial project.

- Display Layout 1 by clicking on Layout 1 under Layouts in the Tree View.

We will first create two rational method type drainage areas.

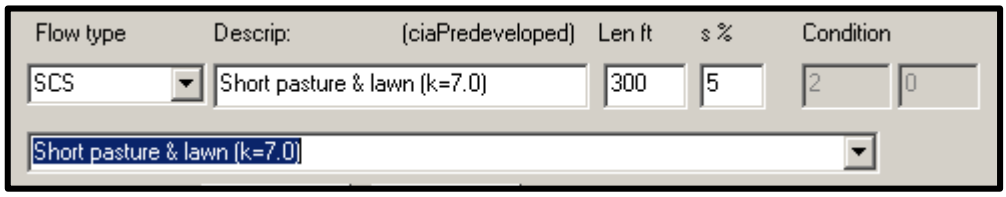
- From the Tree View open the Predeveloped basin.
- Click on the 

button and create a record named ciaPredeveloped.
- From the Design Method drop down, select RATIONAL.
- From the IDF Family drop down, select KingCountyIr.
- Click on the 

tab.

- From the Description drop down, select Pasture (n=20). The "C" value associated with Pasture is automatically entered.

- Enter 3 in the Acres field.
- Click on the Add button.
- Click on the DCI-TC Calc tab.
- Select SCS from the first drop down.
- Select Short pasture & lawn (k=7.0) from the drop down selector on the second line.



- Enter 300 for the length and 5 for the slope.
- Press Close to close the dialog.

Generally, all the drop down selections are customizable from the Data/Config dialog on the program menu bar. The customization dialog has tabs for Rational Land Use, IDF Family, ***and*** Rational Event Factors.

- From the Tree View open the Developed basin
- Click on the New Basin and create a ciaDeveloped basin.
- Change the Design Method to RATIONAL
- Change the IDF Family to KingCountyIr.

- Click on the Composite C Calc tab and entering the following data:

- Don't forget to click on the Add button.
- Click on the DCI-TC Calc tab.
- Delete the Sheet TC line left over from the Developed basin.
- Enter the following:

- Click on the Close button to close the input dialog.
- Click once in the Layout View to give it focus. If it is not shown, click on the  button.
- From the Layout menu on the program menu bar, select **Layout / NodeLabels / Basin Id**.

The layout view should now be showing the contributing basins for nodes N-001 and N-005.

- Double click on node N-001 in the Layout View to open the dialog.
- Click on the Contributing Drainage Areas tab.
- Click on the ciaPredeveloped basin. Note that we want both the SCS basin Predeveloped and the rational basin record ciaPredeveloped selected!
- Click on the Apply button.
- Without closing the dialog, double click on node N-005 in the layout.

- Click on the Contributing Drainage Areas tab.
- Click on the ciaDeveloped basin. Note that we want both the SCS basin Predeveloped and the rational basin record ciaDeveloped selected!
- Click on the Apply button.
- Click on the Close button to close the dialog.

The layout allows both SCS and Rational type contributing areas to contribute to each node. When computing using the SCS or SBUH method, the program will only accumulate the SCS type basins that are selected. When using the Rational method routing selection, the program will **only use the first** rational type basin that is selected in the list of basins.

- Click on the Σ button on the toolbar.
- Check the Rational selection: Route As Rational Network, uncheck the other check boxes.
- Select a Design Event and **KingCountyIr** for the idf Family.
- Press the Route button.
- Press the Close button.

The layout is corrected. The report view contains the computational table. The layout contains a detention pond node. In the Rational Method, the node type is ignored and not detention routing is performed. The Rational Method does not support a credible detention algorithm. While there are equations to estimate detention volumes from the Rational Method, they have fallen out of favor and are not supported here.

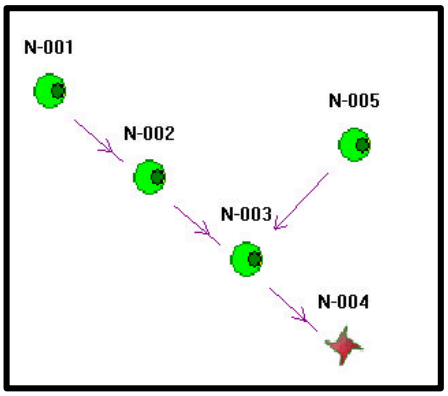
Oh, one final warning. When defining nodes, there is a field named Contrib Hyd. When using the Rational Method, it is ignored.

Chapter 10

IDPR Revisited

This section revisits the Interdependent Pond Routing feature to illustrate the use of the feature for the design of parking lot storage. Much of the material here repeats what was previously illustrated. Use of the storage combination node will be illustrated in this section.

In order to proceed, we will need to restore Layout 1 to its original condition. It will be good practice.



- First revise all nodes to be the MH/CB/Inlet type except for node N-004. Ensure that all Max El are set at elevation 105 ft.

- Next convert all the reaches to their original state. That is, they should be :

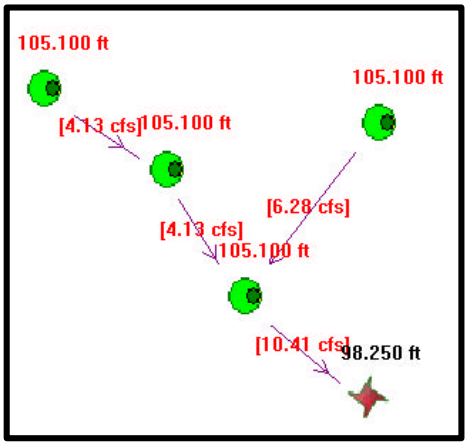
  Material: Conc-Spun
  Size: 12" Diam
  Entrance Losses: Circular Conc and Groove End w/Headwall
  Length: 250
  Slope: 0.5%

- When the reaches have all been restored to the above dimensions, systematically double click on each reach, move to the Geometry tab, and press the Sync button. Remember, this should be done in P-001, P-002, P-005 and P-003 order. P-003 has to be synchronized after the two incoming reaches to node N-003. If you did this correctly, the Dn IE for P-003 should be 97.25 ft.

- For reach P-003, remove Orifice from the Contrib discharge field.

Now that the system has been restored to the original condition, we can demonstrate the IDPR feature as it relates to surcharged manholes in a parking lot. To be certain

you are starting at a similar condition, lets recomputed the layout for the 10 year, TYPE1A design event.



- Click on the Σ toolbar button.
- Select 10 year for the Design Event
- Select TYPE1A for the RainType
- Uncheck all the checkboxes.
- Press the Route button.

The answers do not have to be exact.
What we want to see here is that all the nodes except for the dummy node is surcharged. In this case, that means the HGL elevation is in red and set at 105.1 feet. StormShed2G automatically sets the HGL to 0.1 ft above the rim elevations when the HGL is higher than the rim elevation. Note that all the reaches are in red and square brackets too. This means they are undersized.

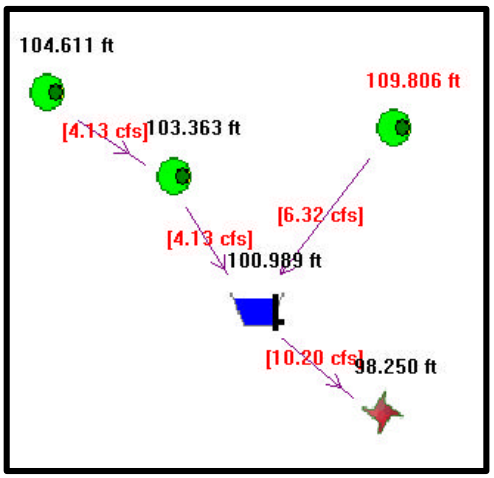
The next step is to replace N-003 with the Pond1 node.

- Open P-003 and look at the Up IE. It should be 98.5 ft. Press the Close button.
- Open the Orifice discharge structure. Change the Outlet El to 98.5 ft. Close the dialog.
- Open Weir discharge structure should already be set at 100 ft, so we will leave it alone. Change the Weir length to 3 ft. Close the dialog when done.
- Open the Combo discharge structure and refresh the elevations by pressing on the Combo discharge structure then back to the first tab. The starting elevation show now reflect 98.5. Press the Close button.
- Open the Trap Node. Change the Start El to 98.5 ft.. Press the Close button.
- Refresh Pond1 elevations by opening the record and toggling between the property pages. Close it when you are finished.

- Now that the data has been updated, lets replace N-003 with Pond1 in the layout view. You should know how to do this.

- Now redo the computation using IDPR. Click on the Σ button, check the ☑ Route as Interdependent Detention Ponds check box and press the Route button.

The results from to computation should be encouraging. We see that nodes N-001 and N-002 are no longer surcharged. That is, they aren't in red at 0.1 ft above their rim elevations.



However, there is still a problem with node N-005. Also, note that the reaches are all still undersized, but if the nodes are not surcharged, we could probably live with it. What can we do about node N-005?

Defining a Combination Storage Structure

Lets assume that node N-005 is in a parking lot. Lets also assume that the parking lot is graded to allow for ponding over N-005. We can estimate the available ponding by imagining a trapezoidal shaped are with flat side slopes centered over node N-005. Since N-005 has a bottom area of about 20 sf. We can estimate the trap dimensions as a 4.5 by 4.5 square. If the parking area is graded with a 2% slope into the node, we can easily define a trap node to these specification.

- Define a new node named ParkingOverflow.

- Make it of type Trap Pond.

- Set its starting elevation at 105 ft

- Set the other dimensions as shown.

- Create another node named N-005Combo. Make it of type Combo Storage. Select Developed as it's Contributing Drainage Areas

- Select the Combination Storage tab and Add the nodes N-005 and ParkingOverflow to it.

- Replace node N-005 with node N-005Combo in the layout view. It the graphic in the layout view didn't change, you forgot to press the Apply button.

- Re Compute the layout using the IDPR option.

The results should indicate that node N-005Combo is not surcharged. Its HGL elevation is 105.776 ft, about 9 inches of ponding depth over the N-005 rim elevation. That's about all there is to using IDPR to analyze parking area ponding!