In this tutorial you will learn about:

- The design criteria for ditches.
- How to model a conveyance ditch.
- An introduction to reaches and nodes.
- How to include infiltration in the ditch design.
- How to use the calculator to estimate a ditch size.

Ditch Example

You have been asked to determine if the 'V' bottom ditch running parallel to the road is adequate to convey the runoff from both the road and back slopes. Figure 4-1 and 4-2 shows the plan and cross section view of the example project and details are noted below:

- The pervious area from the back slopes contributing to and including the ditch is **1.0 acre**.
- The SCS soil type is **Type C** and the ground cover is primarily **forest in fair conditions**.
- The average slope of the ground is **1%**.
- The calculated time of concentration for the forested condition will be **50 ft** of sheet flow and **1750 ft** of shallow concentrated flow to the beginning of the ditch.
- The **20' x 900'** ***(0.413ac)*** roadway, without curbing, contributes to the ditch with a cross slope of **2%.**
- The ditch is **900'** long and has a longitudinal slope of **1%,** with a ground cover as **nearly bare ground**, very little grass**.** The side slopes are **3:1**.

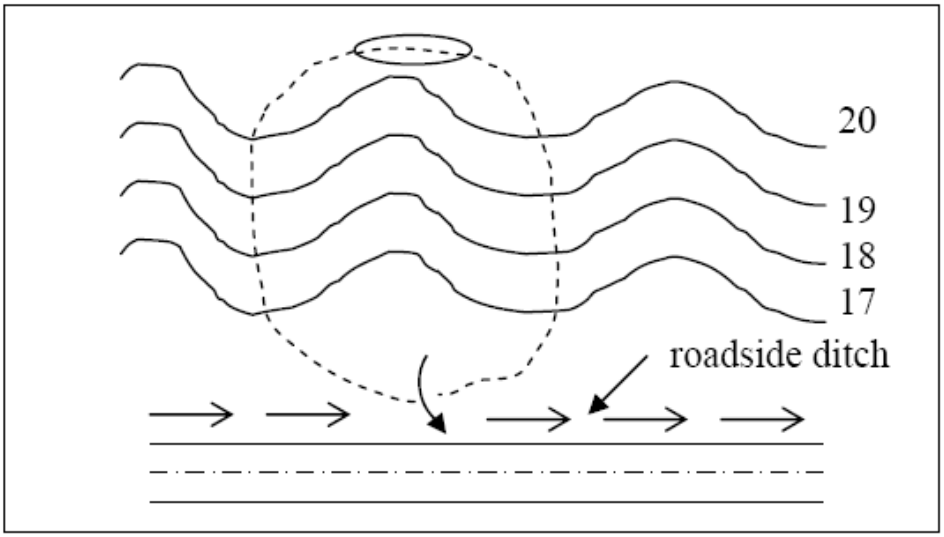


Figure 4-1. Plan View

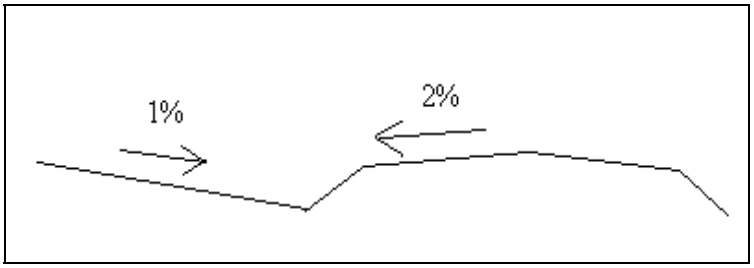


Figure 4-2 Cross Section

Design Criteria

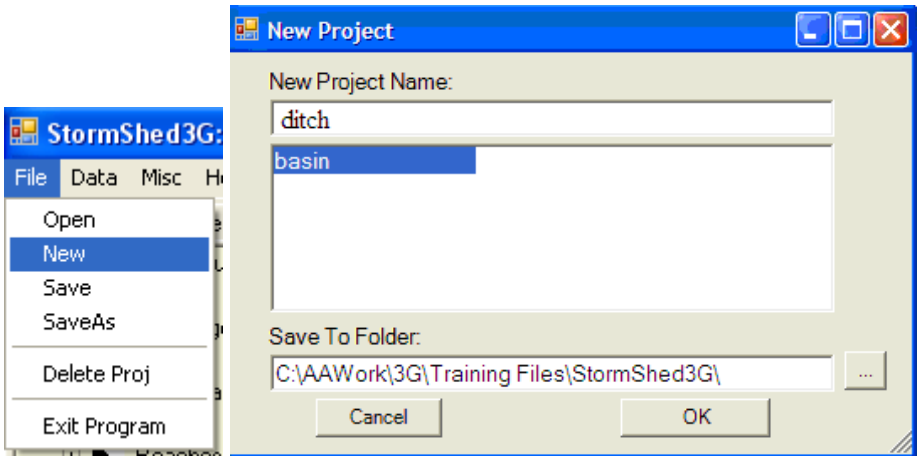
Roadside ditches are generally located alongside uncurbed roadways with the primary purpose of conveying runoff away from the roadway. This is different than a bioinfiltration or biofiltration swale (or bioswale), in that a ditch only conveys drainage runoff where as a bioswale both conveys runoff and provides runoff treatment by filtering the runoff through vegetation. Also the recommended shape of a bioswale is a trapezoid, not a 'V' ditch.

The design criteria for ditches are in located in Section 4-3 of the Hydraulics Manual. In short the following is required:

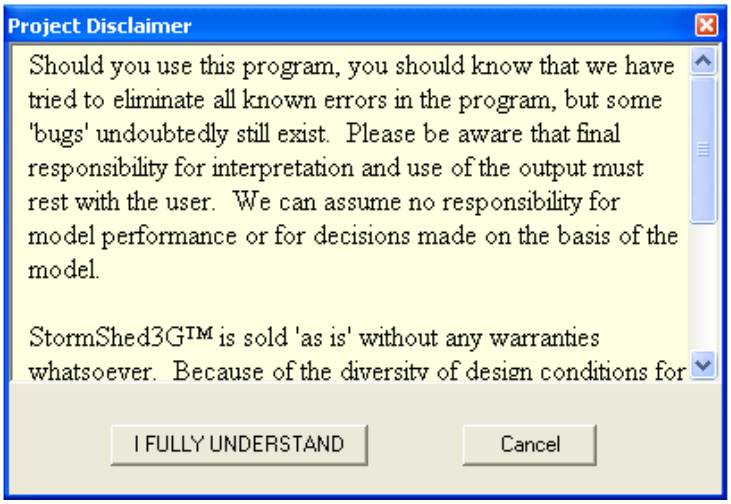
- The design storm is the 10 year 3 hour MRI short duration storm.
- The maximum depth of water in the ditch is 0.5' below the bottom of sub-grade or of sufficient depth to prevent saturating the subgrade.
- Velocities in the ditch should not exceed 5 ft/sec and the ditch slope should be less than 6%.

Creating a New File

Select **File>New** and input: **ditch**. Then click on Ok.

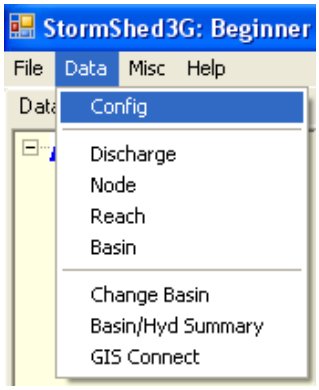


The 3G project disclaimer dialog will appear as shown below. Select **I Fully Understand** and the box will close.

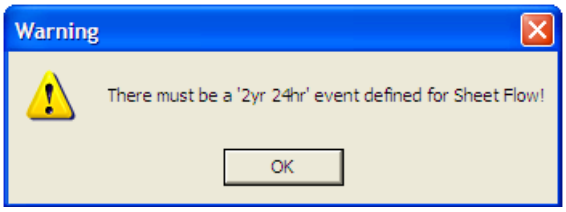


Set Project Defaults

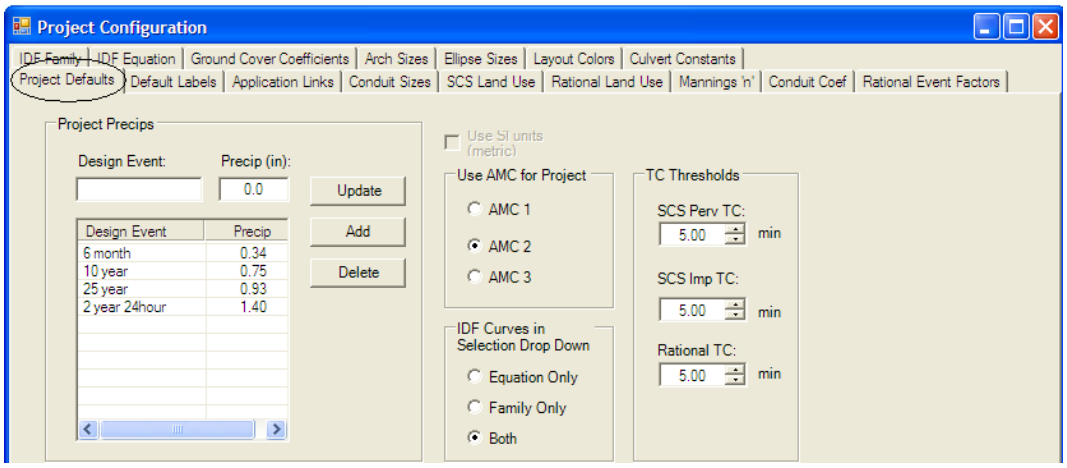
Select **Data>Config.**



Before the **Project Configuration** box opens, the following warning will appear. This is a reminder that the 2 year 24 hour precipitation is required.

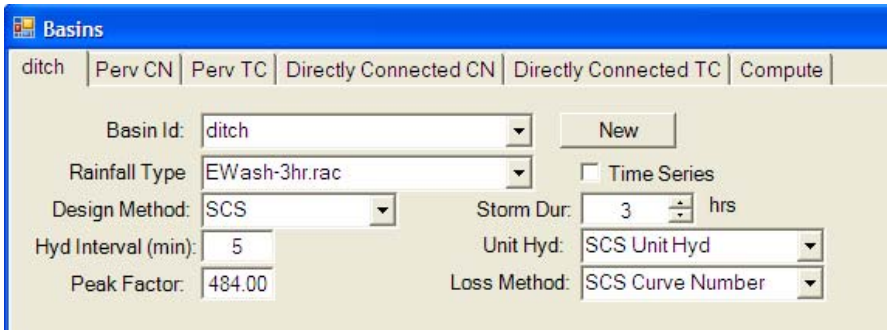


After selecting **OK**, the Project Configuration box will open as shown below.

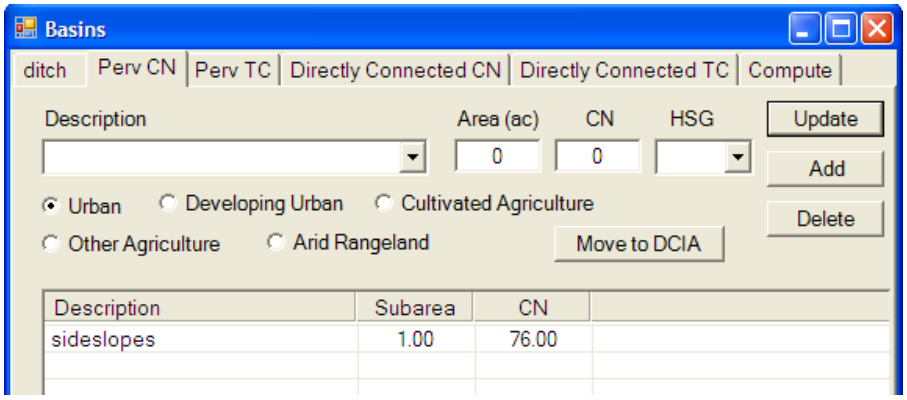


Create Basin

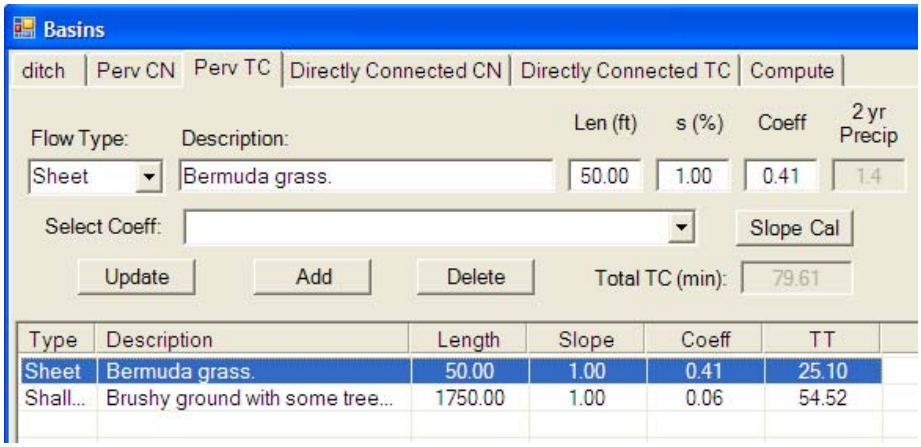
- Create a new basin named '**Ditch**'.



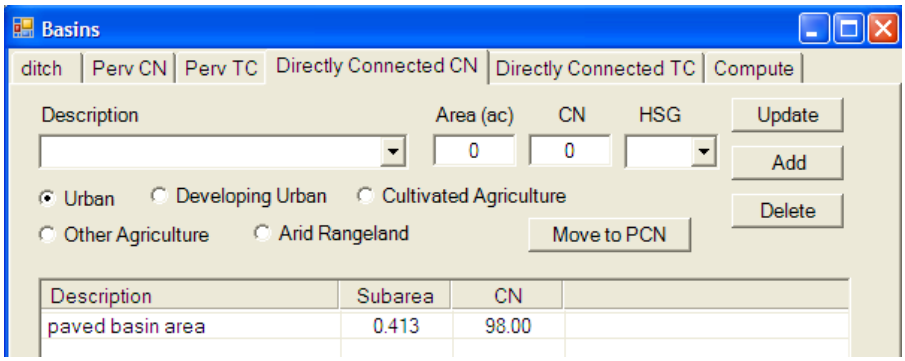
- Then define the pervious area site conditions in the ***Perv CN*** tab using the ditch example description on the previous page and input the values shown below.



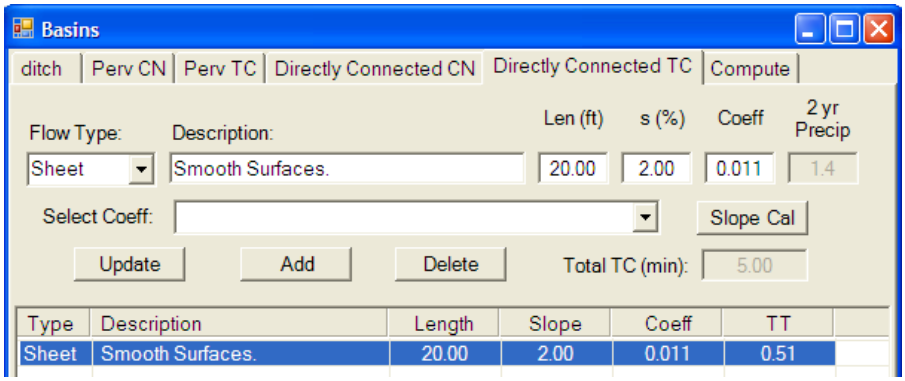
- Next, select the ***Perv TC*** tab and define the pervious surface side slope area.



- Define the impervious basin area (roadway draining toward the ditch) in the ***Directly Connected CN*** tab.

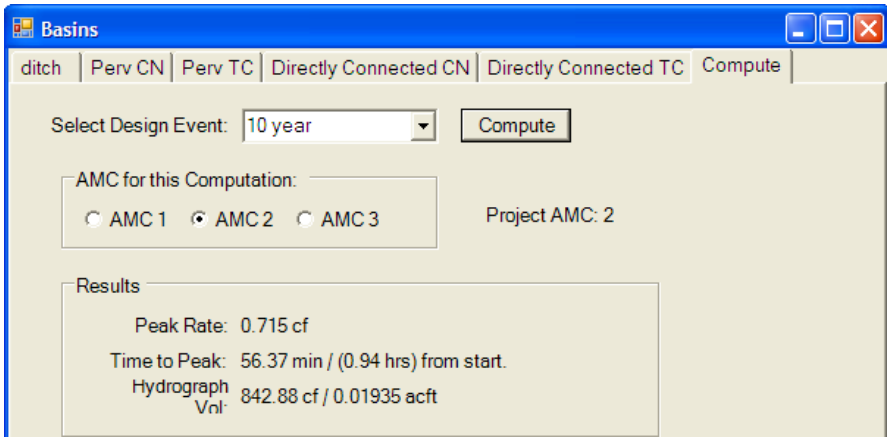


- Finally, define the flow path from the roadway, into the ditch in the ***Directly Connected TC***.



Finally, estimate the flow rate of the runoff by using Compute button.

- Select **10 year** from the pull down menu.
- LMB click on the **Compute** button and the results should match as shown below.
- To save and close the basin dialog box, select the **Close** button.

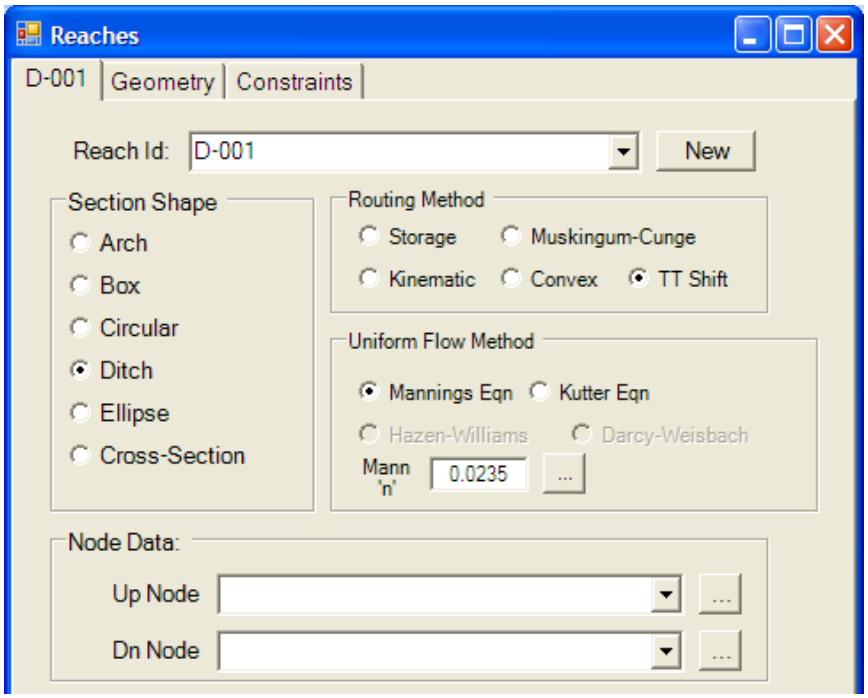


Create a Reach

Next, we need to create a Reach that will represent the ditch.

- In the ***Data Tree View***, click on the "+" symbol next to the Reaches node.
- Double click on "**PROTOTYPE**" under the Reaches node.
- Click on the **New** button in the Reach Definition dialog.

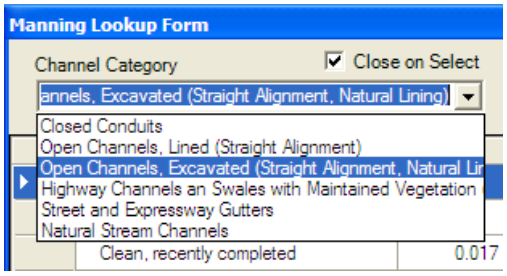
- Override the default label with **D-001** and Click **OK.**

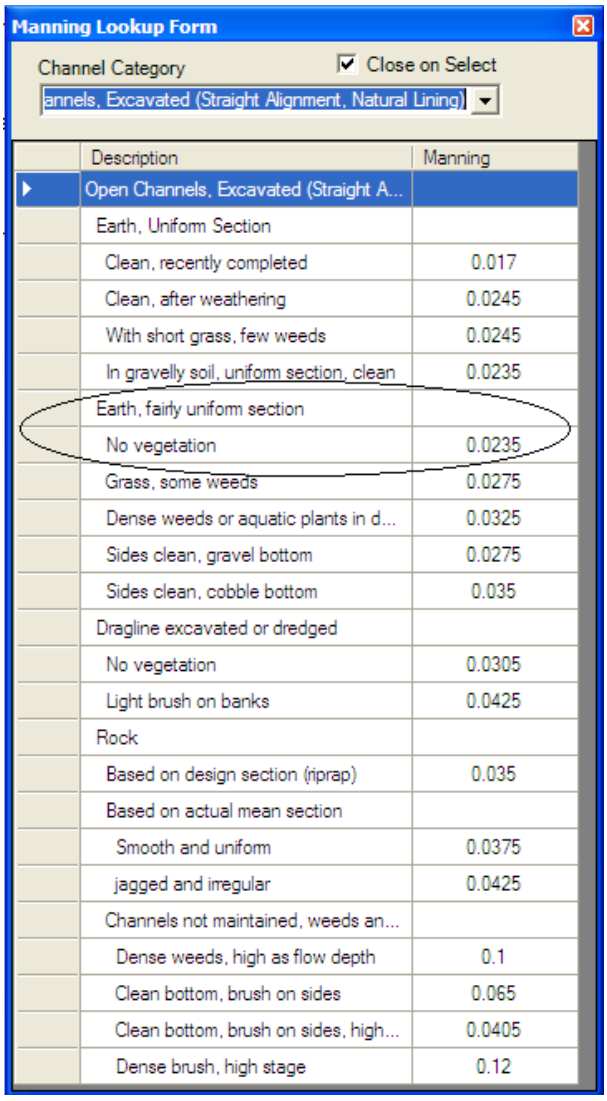


- After the reach has been named, the next step is to define the "*Section Shape*" or the type of reach. For this application, select **Ditch**.
- Change the "*Routing Method*" to **TT Shift**.

  The '*Routing Method*' box contains 4 hydrologic routing methods and the Travel Time Shift. The hydrologic methods actually route the hydrograph through the reach taking advantage of the storage that is available in the reach. While the TT shift uses the Manning's equation to compute the hydraulic parameters based on the peak flow rate and assumes a constant depth. Of the 5 options presented, the Muskingum-Cunge and TT shift are used the most. For most applications the **TT shift** should be used; however there are applications where this method is conservative. For long reaches with a flat slope the Muskingum-Cunge provides a more representative analysis because this method allows the flow to spread out producing a lower peak.

- In the "*Uniform Flow Method*" box, there are only two available options available for ditches (or cross sections). Select the Manning's equation, this is the one most commonly used in the United States. The Manning's value can either be input manually, or selected from a table by clicking on the '**…**' box to the right as shown below. *All the values provided in the table are the average values from the Hydraulics Manual Appendix 4-1, Manning's Roughness Coefficients.*



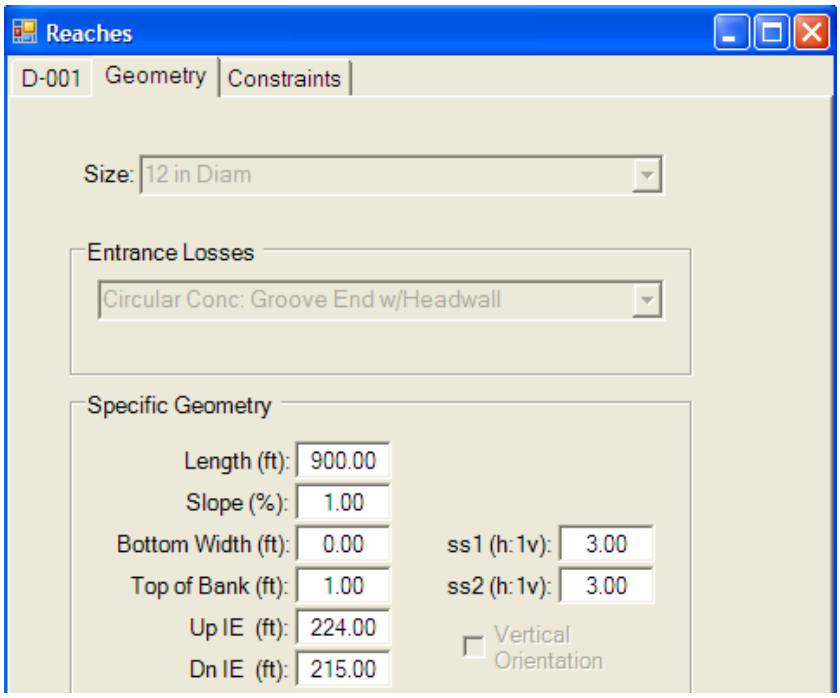


Using the pull-down menu, select '**Open channels, Excavated (Straight Alignment, Natural Lining)**'. From that table, the closest match is **No vegetation** under the category '**Earth, fairly uniform section'**. LMB click on **No vegetation** and the ***Manning Lookup Form*** will close and the Mannings value of 0.0235 will automatically be input into the Mannings 'n' input box.

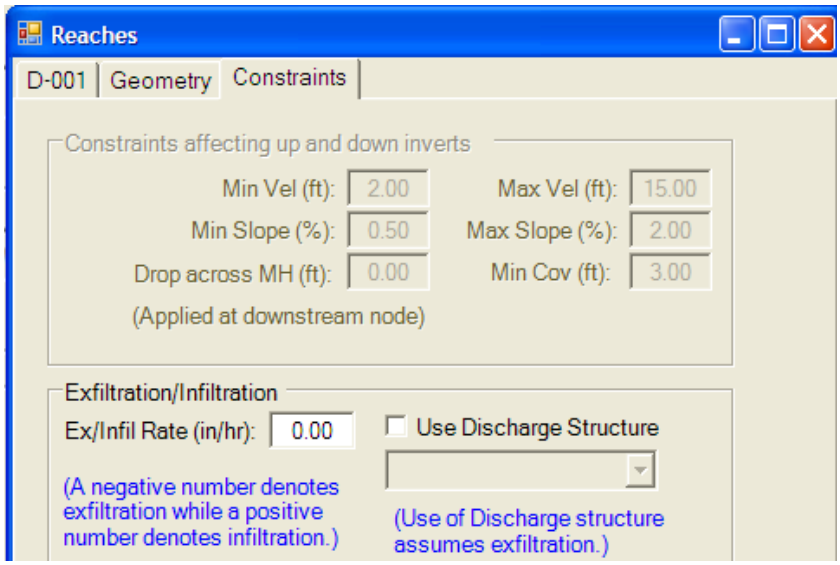
The following bullets apply to the lower options on the **reach dialog** box.

- Notice the "*Node Data*" boxes are blank. They remain blank until the up and down reaches are either defined in the layout view or manually attached.
- The "*Contrib Discharge*" option only applies when the reach is immediately down stream of a detention system. Using the pull down menu, the discharge structure that is coming through the reach can be identified.
- Only check the "*Save Route Hyd*" box, if you would like to see a hydrograph created from runoff going through this reach.

Next, select the ***Geometry*** tab. Notice the "*Size*" and "*Entrance Losses*" option are not available; these options only apply to pipes.



- Input the Ditch "*Specific Geometry*" values as shown above.

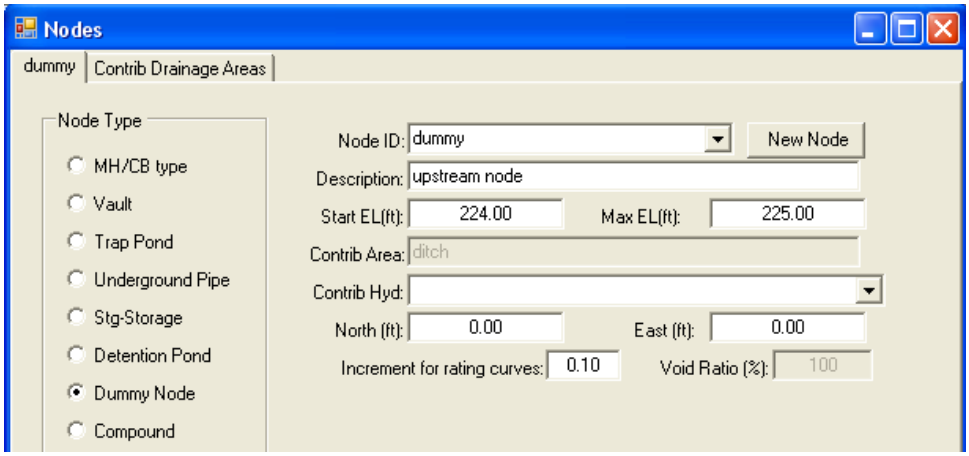


- The ***Constraints*** tab applies mostly to pipes and will be discussed further in the Network Tutorial. The only option that applies to ditches is *infiltration/exfiltration*, which represents flow into and out of the reach. In this case, infiltration is when water is entering a reach (high water table and a perforated pipe) and it is represented by a positive value. Exfiltration is water exiting or leaving a reach (due to a ditch that infiltrates runoff into the soil or a reach with joints not properly sealed) and is represented by a negative value. Right now leave this value at **0,** we will repeat the example using this option.
- Click on the **Close** button to close the dialog box.

Create Nodes

A node is required for every transition in a reach, even if there is no structure present. In this tutorial, a **Dummy Node** must be defined to represent the ends of the reach so StormSHED 3G can perform the calculations.

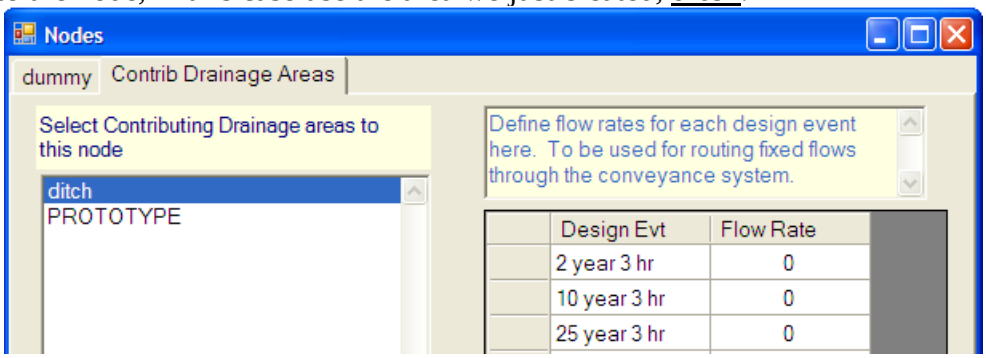
- Open the "PROTOTYPE" node in the Nodes section of the ***Data Tree View***.
- Click on the **New Node** button.
- Rename the default node ID to **dummy1**.



- For the "*Description*" type '**upstream point of ditch**'. For larger projects it maybe beneficial to provide more information in the description so when the report is read it is easy to determine the use of the node.
- The "*Node Type*" box is where the application of the node is defined. For the "*Node Type*", select **Dummy Node**. Once the Dummy Node radio button is selected, notice the third tab disappears as there is no structure to define.
- The "*Start EL'* refers to the outlet elevation or in this case the bottom of the ditch elevation or **224**. The "*Max EL*" is the top of the bank for a ditch or the rim elevation of the catch basin or manhole. In the case of trap pond or vault this would be the ground elevation. For this example input the "*Max EL*" **225**.
- The "*Contributing Area*" is the name of the basin that is attached to this node. Once it is selected from the ***Contributing Drainage Areas*** tab, it will be shown in gray on this tab.
- The "*Contrib Hyd"* pull down menu allows the designer to create a Hydrograph and apply that Hydrograph to the node. For this example, leave it blank.
- Generally the "*North*" and "*East*" boxes are left at zero, inputting a value here only affects the location of the node in the layout view. If no value is entered, StormShed 3G will use the approximate location in the layout view when computing.
- The "*Increment for rating curve*" option, only applies to the number of points plotted on the rating curve. For computing, the program will use as many points as needed to run the analysis.

- All nodes support a "*void ratio*" for the inside of the node. Generally this is left as 100% voids. This could be helpful if the structure is filled with rock for example, the program will compute the correct volume of available in the structure based on the void ratio.

Select the ***Contributing Drainage Area*** tab and choose the basin that is contributing runoff to the node, in this case use the area we just created, **ditch**.

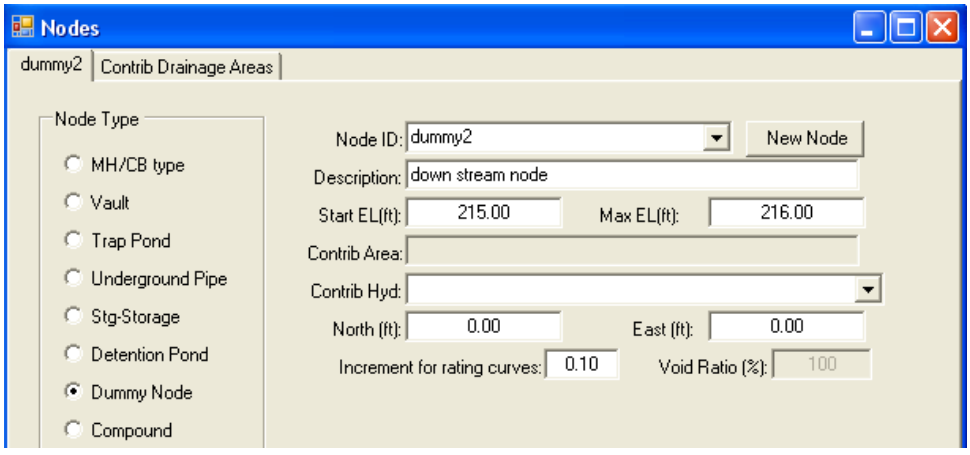


It is also possible to manually input a fixed design flow rates instead of specifying a contributing drainage area. For this example we will leave the flow rates set at zero.

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

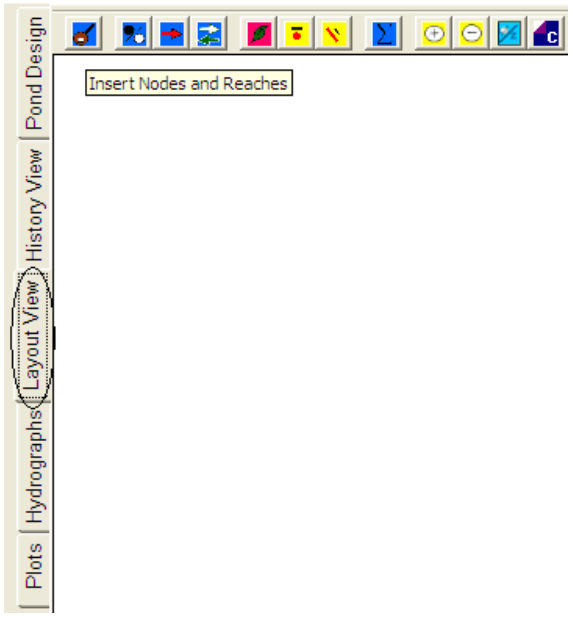
Next create the downstream node.

- Re-open the node named dummy <u>instead of the PROTOYPE node</u> and select the New Node button. Name the node **<u>dummy2</u>** and hit OK. By doing this all the values entered in the original node (except the name) are carried over into the new node (including the contributing drainage area).
- Change the "*Start*" and "*Max El*" as shown below.
- The select the ***Contributing Drainage Area*** tab and unselect the basin.
- Finally close the dialog box.

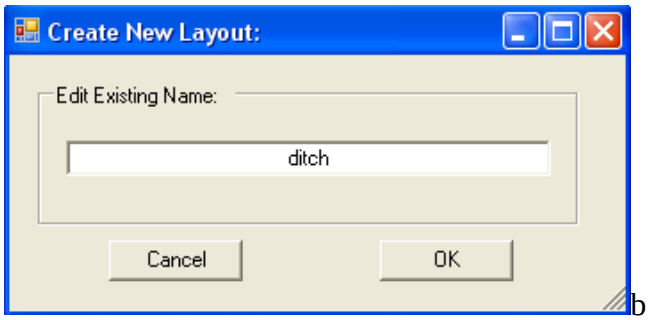


Create a New Layout.
Next create a layout to represent the ditch.

- In the Layout View, click on the ***Layout View*** Tab and select the '*Insert Nodes and Reaches*' button in the upper left corner.



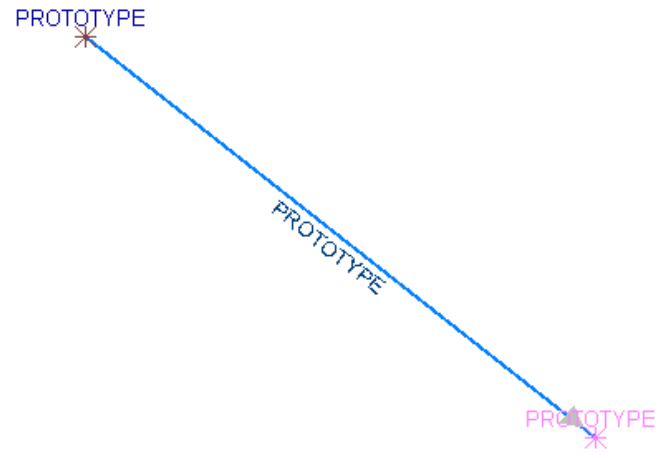
- Before any nodes or reaches can be placed, the program will prompt you to name the layout. Since some projects can have multiple layouts, it is recommended that the name of the layout be meaningful to the area being designed. For this example use '**ditch**'.



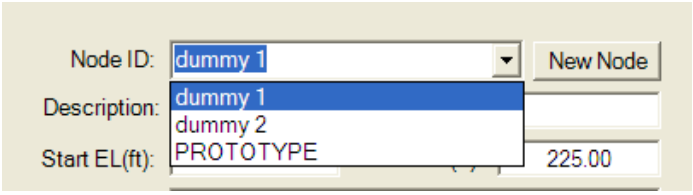
b

- Select **OK** after inputting the layout name.

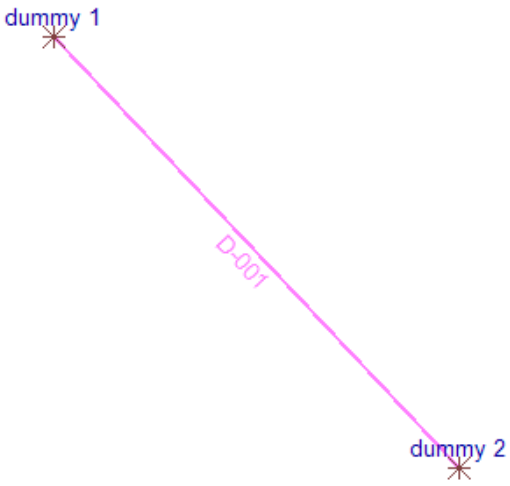
- Next select the approximate locations of the up and down nodes as shown below. Since the nodes and reaches have not been defined, the names default to the *PROTOTYPE* record.



- Next we will define the nodes and reaches. Double LMB click on the upper node. Use the pull down menu to select **dummy 1** for the Node ID.

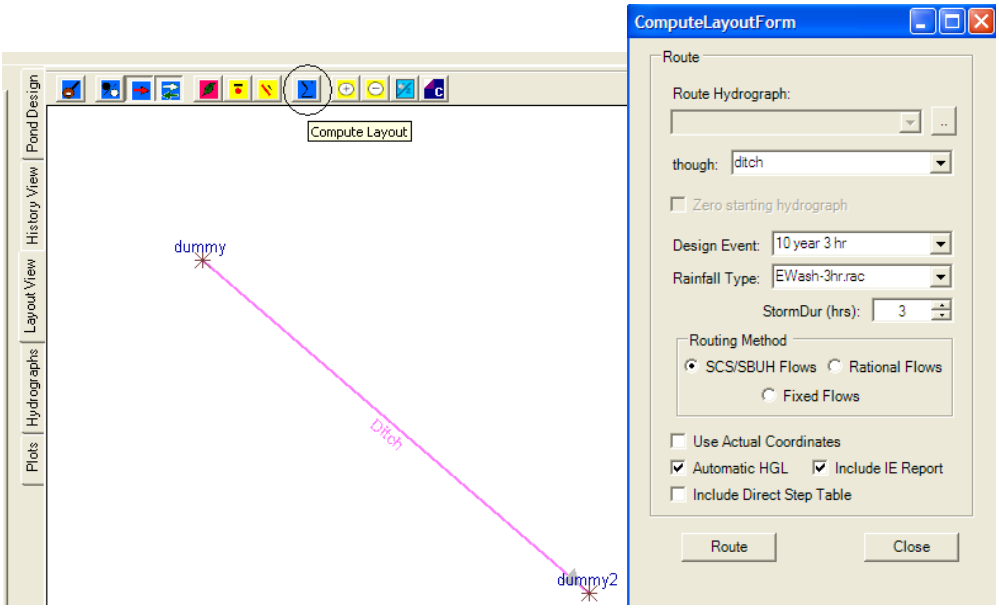


- Repeat this process to define the reach and down stream node. When finished the layout should appear as shown in the next view.



- If the names are not shown, use the '*Toggle Node Label*' and '*Toggle Reach Label*' buttons until the node and reach name are shown.

- To route the design storm through layout, select the compute layout button.



- In the "*through*" box, use the pull down menu to select the name of the layout to run the design storm through. In this case select **ditch**.
- Use the pull down menu to define the Design Event as the **10 year** and Rainfall Type as the **EWash-3hr.rac** for EWA and **Type IA** for WWA. For the Storm Duration; input **3 hrs** for EWA and **24 hrs** for WWA. Note that while these options were set when defining the basin, the values entered in the compute command override those settings.
- "*Routing Method*" – select the desired routing method for the layout. This option would override whatever design event and rainfall type was input into each basin, for just the compute command (the actual values input in the basin do not change). *Notice depending on what is selected, the pull-down options above change for the Design Event and the Rainfall Type.*
- "*Use Actual Coordinates*' – this would only apply if the "*North*" and "*East*" values were input when the nodes were created. For WSDOT projects this option is generally not used.
- *"Automatic HGL"* – if this option is selected the HGL analysis will be sent to the History View along with the Conduit Notes. If this box is not marked, only the Gravity Analysis will be sent to the History View. **For this example check this box**.
- "*Include IE Report*" – when this box is selected, a report will be included in the history view of the invert elevations for the reaches and nodes. This option

allows the designer to verify the location of the inverts. **For this example check this box.**

- "*Include Direct Step Table*" – when this box is selected, a report will be included in the history view of the invert elevations for the reaches and nodes. This option
- Finally, select the **Route** button to route the design storm through the layout and then select the close button to **Close** the dialog box.

Select the ***History View*** tab to see the routed information, as shown below.

Appended on: Friday, January 18, 2008 1:07:18 PM
ROUTEHYD [] THRU [ditch] USING [10 year] AND [EWash-3hr.rac] NOTZERO RELATIVE SCS/SBUH

Gravity Analysis using 3 hr duration storm

Reach ID	Area (ac)	Flow (cfs)	Full Q (cfs)	Full ratio	nDepth (ft)	Depth ratio	Size	nVel (ft/s)	fVel (ft/s)	Infil Vol (cf)	CBasin / Hyd
D-001	1.413	0.715	----	0.00	0.3521	----	Ditch	1.923	-----	0.00	ditch

HGL Analysis

From Node	To Node	HG El (ft)	App (ft)	Bend (ft)	Junct Loss (ft)	Adjusted HG El (ft)	Max El (ft)
							215.3521
dummy 1	dummy 2	224.3242	--na--	--na--	--na--	224.3242	225.0000

Conduit Notes

Reach	HW Depth (ft)	HW/D ratio	Q (cfs)	TW Depth (ft)	Dc (ft)	Dn (ft)	Comment
D-001	0.3242	na	0.715	0.3521	0.3242	0.3521	Direct Step Backwater Calc

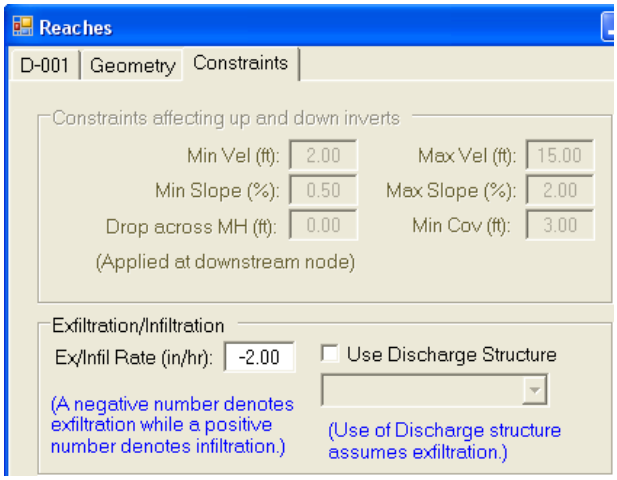
Node and Reach invert report

Node and Reach invert report				
Node	dummy 1		Out ie	224.00 ft
	Reach	D-001	I.E. Out	224.00 ft

Exfiltration

Now we will apply Exfiltration to the reach to see how it affects flow in the ditch.

- In the ***Layout View***, double LMB on the reach and select the ***Constraints*** tab.
- Type '**-2**' into the Exfiltration/Infiltration box. This represents water leaving the reach at a rate of 2 in/hr.



- **Close** the Reach dialog box.
- Select the **Compute** button and route the **10 year storm** through the layout.
- **Close** the Compute Layout Form dialog box and select the ***History View*** tab.

Note the Flow has decreased in the reach from **0.715 to 0.622 cfs**. Using the Exfiltration/Infiltration option will decrease the flow rate Q and Volume, which would decrease the size of a detention facility down stream.

Appended on: Friday, January 18, 2008 1:14:15 PM
ROUTEHYD [] THRU [ditch] USING [10 year] AND [EWash-3hr.rac] NOTZERO RELATIVE SCS/SBUH

Gravity Analysis using 3 hr duration storm

Reach ID	Area (ac)	Flow (cfs)	Full Q (cfs)	Full ratio	nDepth (ft)	Depth ratio	Size	nVel (ft/s)	fVel (ft/s)	Infil Vol (cf)	CBasin / Hyd
D-001	1.413	0.6222	----	0.00	0.3345	----	Ditch	1.854	-----	297.95	ditch

HGL Analysis

From Node	To Node	HG El (ft)	App (ft)	Bend (ft)	Junct Loss (ft)	Adjusted HG El (ft)	Max El (ft)
							215.3345
dummy 1	dummy 2	224.3047	--na--	--na--	--na--	224.3047	225.0000

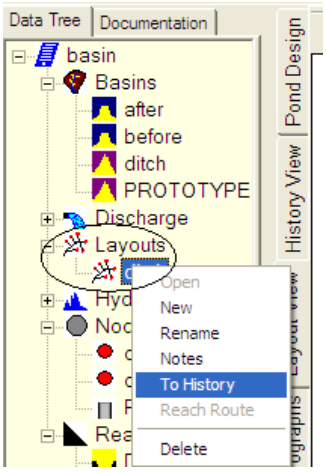
Conduit Notes

Reach	HW Depth (ft)	HW/D ratio	Q (cfs)	TW Depth (ft)	Dc (ft)	Dn (ft)	Comment
D-001	0.3047	na	0.6222	0.3345	0.3047	0.3345	Direct Step Backwater Calc

Node and Reach invert report

Node and Reach invert report				
Node	dummy 1		Out ie	224.00 ft
	Reach	D-001	I.E. Out	224.00 ft

Creating a Report



There is no report command in StormSHED 3G, instead data must be copied from the History View and pasted into a word document. The information in the history view is not cumulative, so it is important to copy the data before sending anything else to the history view.

To copy the basin/node/reach information into a report go to the ***Data Tree View*** and **RMB click** on the **layout name**, then **LMB click** and select **To History**. Select the ***History View*** tab, highlight the data, and copy the data by selecting **Ctrl C**. Use **Ctrl V** to paste into a word document.

The data shown below was copied from the ***History View***.

Appended on: Friday, January 18, 2008 1:19:45 PM

Layout Report: ditch

Event	Precip (in)
6 month	0.34
10 year	0.75
25 year	0.93
2 year 24hour	1.40

Reach Records

Record Id: D-001

Section Shape:	Ditch		
Uniform Flow Method:	Manning's	**Coefficient:**	0.0235
Routing Method:	Travel Time Shift	**Contributing Hyd**	
DnNode	dummy 2	**UpNode**	dummy 1
Length	900.00 ft	**Slope**	1.00%
Bottom Width	0.00 ft	**Top of Bank**	1.00 ft
SS1	3.00v:1h	**SS2**	3.00v:1h
Up Invert	224.00 ft	**Dn Invert**	215.00 ft

Node Records

Record Id: dummy 1

Descrip:	upstream node	Increment	0.10 ft
Start El.	224.00 ft	Max El.	225.00 ft
Void Ratio	100.00		
Dummy Type Node			

Contributing Drainage Areas

Record Id: ditch

Design Method	SCS	**Rainfall type**	EWash-3hr.rac
Hyd Intv	5.00 min	**Peaking Factor**	484.00
Storm Duration	3.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	1.00 ac	**DCIA**	0.413 ac
Pervious CN	76.00	**DC CN**	98.00
Pervious TC	53.1315 min	**DC TC**	5.00 min

Pervious CN Calc

Description	SubArea	Sub cn
sideslopes	1.00 ac	76.00
Pervious Composited CN (AMC 2)		76.00

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet	Bermuda grass.	50.00 ft	1.0%	0.41	1.40 in	25.0951 min
Shallow	Brushy ground with some trees (n=0.060)	900.00 ft	1.0%	0.06		28.0364 min
Pervious TC						53.1315 min

DCI - CN Calc

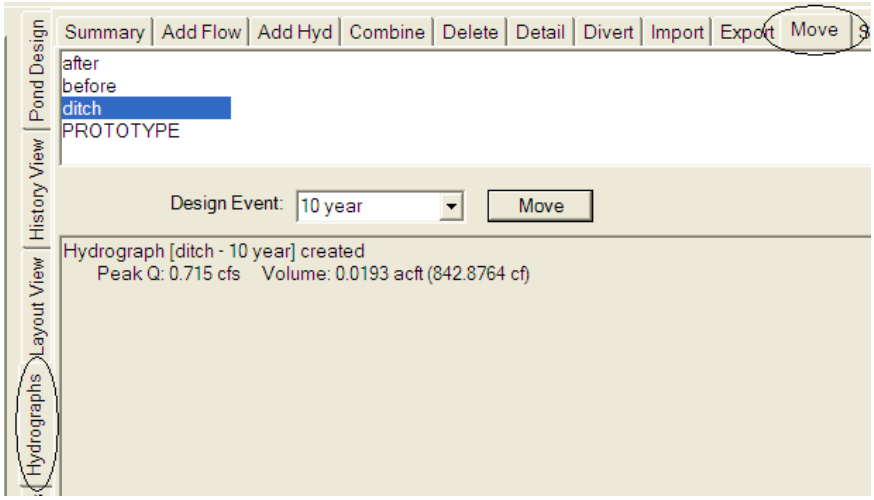
Description	SubArea	Sub cn
paved basin area	0.413 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet	Smooth Surfaces.	20.00 ft	2.0%	0.011	0.00 in	0.5055 min
Pervious TC						0.5055 min

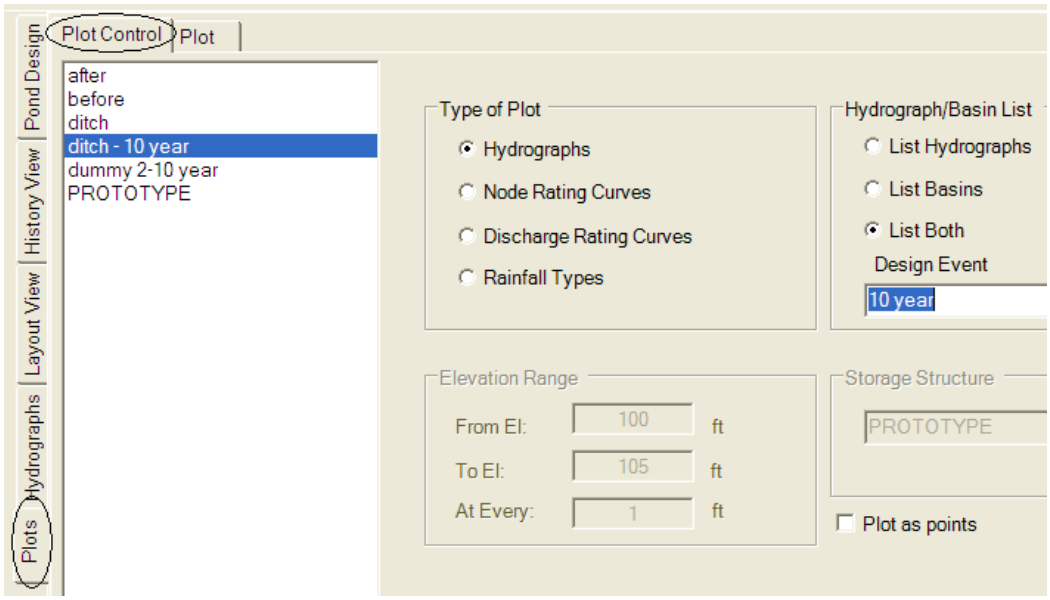
Move Hydrograph Option

The **Compute** option also allows a hydrograph to be routed through a reach. We are going to use the ***Move Hydrograph*** option to generate a hydrograph from the basin we created. The ***Move Hydrograph*** option allows as many basins as desired to be moved into one hydrograph based on a specified design event. The benefit of this option is it allows the designer to manipulate the final hydrograph before routing it through the layout.

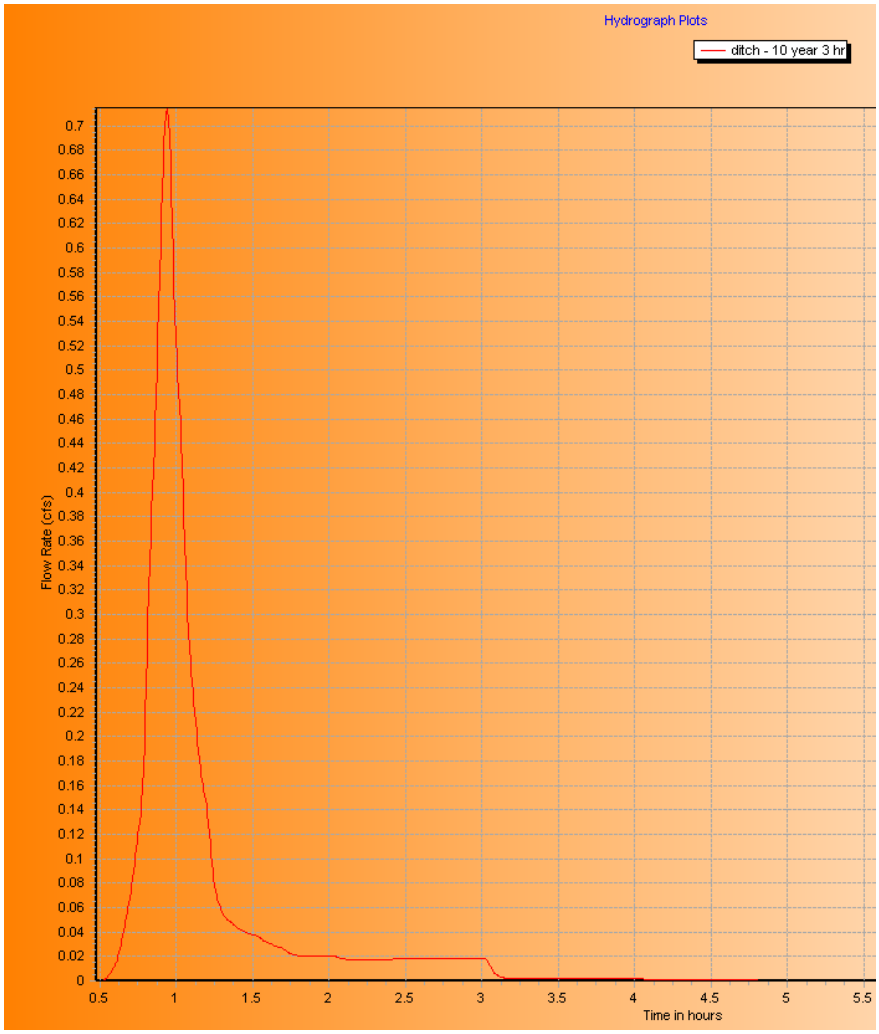


- Select the ***Hydrograph*** tab and then select the ***Move*** tab.
- The previously defined basins are shown in the top box, select the basin(s) to be moved. For this example select **ditch**.
- Next select a Design Event of **10 year** and then hit the **Move** button.
- After the **Move** button has been pressed, a new hydrograph will be created. The summary data is visible in the lower portion of the ***Hydrograph*** tab as shown above.

- To view the Hydrograph, select the ***Plots*** tab.
- Select the **ditch 10 year** hydrograph as shown below.
- For the "*Type of Plot*", select the **Hydrograph** radio button.
- The "*Hydrograph/Basin List*" instructs the program to list just the hydrographs, just the basins, or both in the box to the left. For this example, select the List Both radio button.
- The "*Design Event*" pull-down menu allows the designer to select which design event is run through a basin to generate a hydrograph. This option only applies to basins. Since we have already assigned a design event to our hydrograph, changing the event will not change our plot.
- If the "*Plot as points*" button were selected, the plot would appear as a series of points instead of line. For this example, **leave the box blank**.



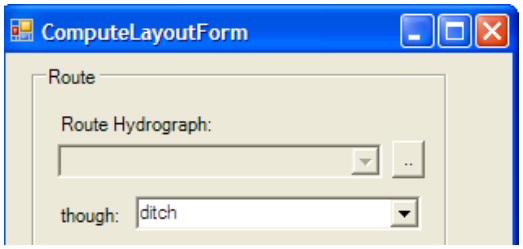
- Next select the ***Plot*** tab.



The Hydrograph above should appear.

Route Hydrograph Using Compute Command

In the ***ComputeLayoutForm*** dialog box, notice the "*Route Hydrograph*" option is not accessible.

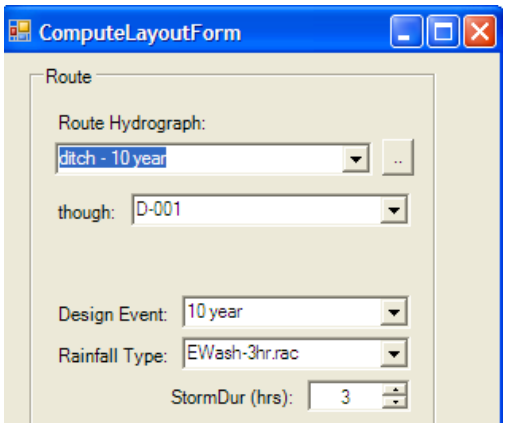


Close the Compute dialog box and got to the main tabs. Select:

Data>Reach Route

- The compute dialog box will automatically open and "*Route Hydrograph*" box will be accessible. Select **Ditch – 10 year** from the pull-down menu.

- In the "through" pull-down menu, notice only the reaches are available. Select the reach created in this example "**D-001**".



- Before selecting the Compute button, go back to the upstream and unselect the basin. *Otherwise the hydrograph and the basin will both be routed through the reach.*
- Click on the **Route** button and then **Close** the dialog box.

Go to the ***History View*** tab and data should appear as shown below.

Appended on: Friday, January 18, 2008 1:41:16 PM
ROUTEHYD [] THRU [rchRoute] USING [10 year] AND [EWash-3hr.rac] NOTZERO RELATIVE SCS/SBUH

Gravity Analysis using 3 hr duration storm

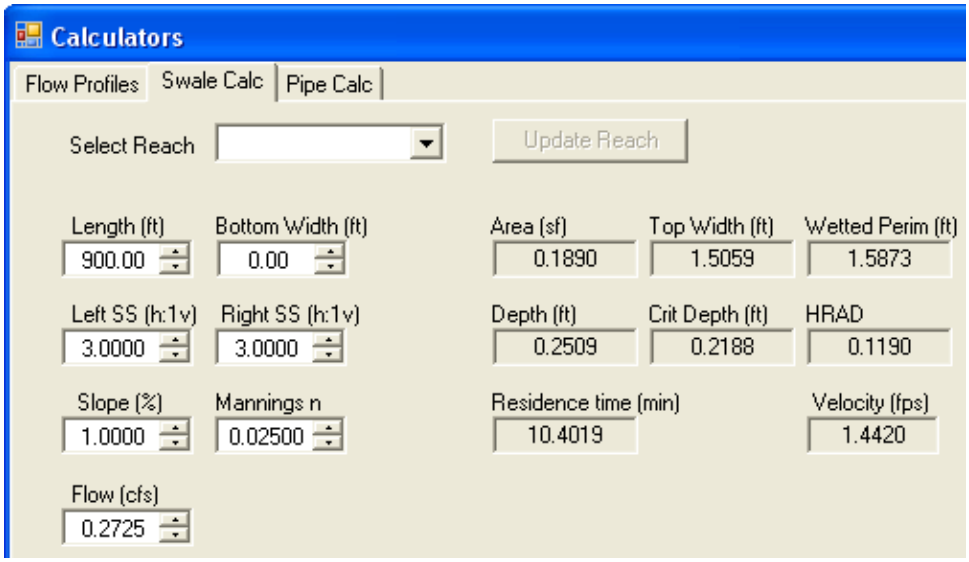
Reach ID	Area (ac)	Flow (cfs)	Full Q (cfs)	Full ratio	nDepth (ft)	Depth ratio	Size	nVel (ft/s)	fVel (ft/s)	Infil Vol (cf)	CBasin / Hyd
Starting Hyd		ditch - 10 year		**Peak Rate (cfs)**	0.715	**Hyd Vol (acft)**	0.0193	**Time of Peak (min)**	56.3655		
D-001	1.413	0.6222	----	0.00	0.3345	----	Ditch	1.854	-----	297.95	

Calculators

Another tool available in StormSHED 3G is the calculator, which can be used to estimate the size of the ditch. From the main menu select:

Misc>Calculators.

- From the "*Select Reach*" pull-down menu, select the reach that was created in this example **D-001**. Notice all the values input into the reach dialog box are carried over to the white boxes in the calculator. The values in the white boxes can be modified and the gray boxes are calculated.
- Modify the "*Flow*" to match the flow rate in the history file and the gray values on the right should match the history file output.
- Try modifying other parameters to see how the key design criteria limits are affected (velocity, depth, and grade).



This could be the starting place for a ditch design before a reach is created or it could be used to determine how to modify a reach if the history output exceeds the design criteria (ie the ditch is too large or too small).