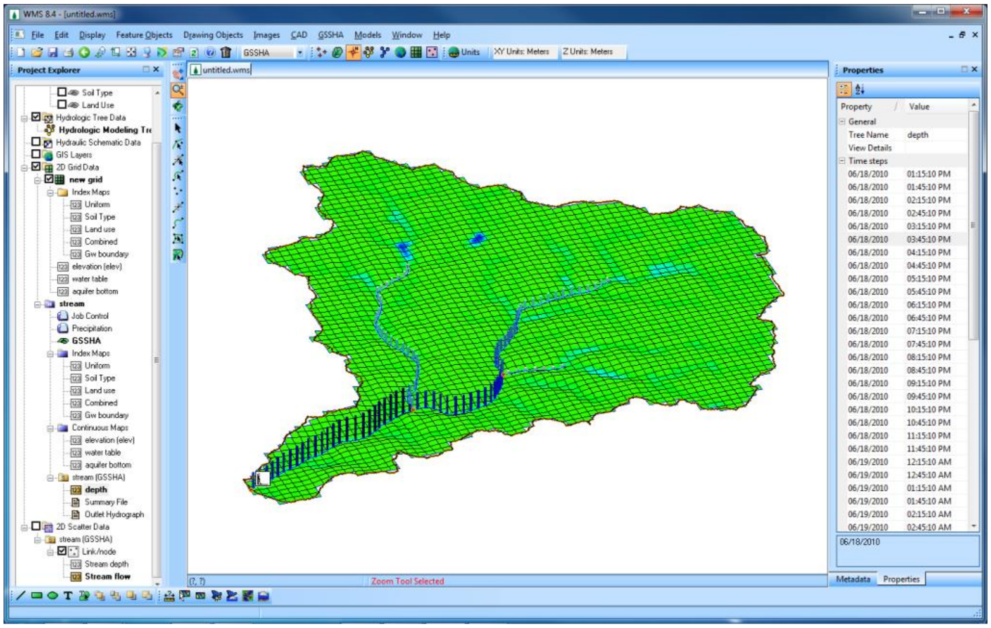
v. 10.1

WMS 10.1 Tutorial

GSSHA – Modeling Basics – Stream Flow

Integrate stream flow with a GSSHA overland flow model



Objectives

Learn how to add hydraulic channel routing to a GSSHA model and how to define channel properties. Learn how to define the interaction between overland and channel flow in a GSSHA model. Then learn how to visualize channel output in WMS.

Prerequisite Tutorials

- GSSHA – Modeling Basics – Infiltration

Required Components

- Data
- Drainage
- Map
- Hydrology
- 2D Grid
- GSSHA

Time

- 30-45 minutes

1 Contents

2 Adding Streams to a GSSHA Simulation

While there are streams in the GSSHA coverage, channel simulation has not been turned on and channel properties are undefined. Define channel properties on the stream arcs in WMS. Continue to work with the same project. Open the project, or the backup copy if needed, then save the stream project to a new file to get started.

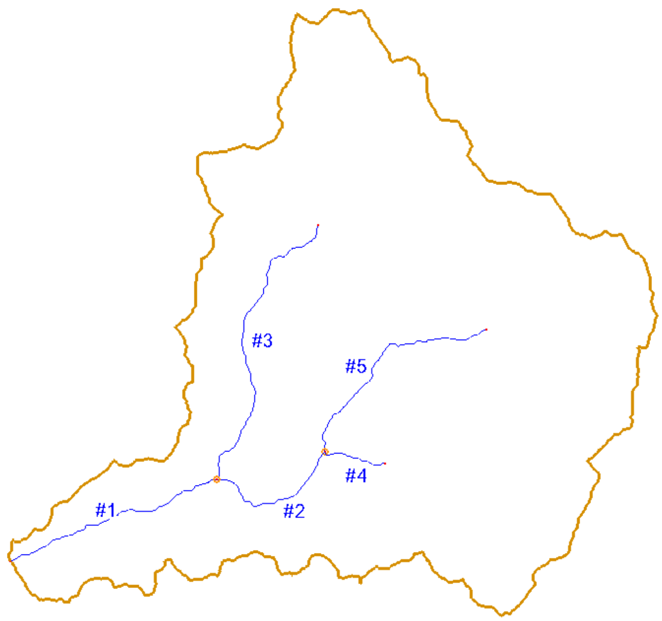
1. In the 2D Grid module select ***GSSHA | Open Project File***.
2. Locate the ***GSSHA Distributed Hydrologic modeling*** folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
3. If the project was saved in the last workshop, browse to and open the file ***\GSSHA Distributed Hydrologic modeling\Personal\Infiltration \UpdatedInfil.prj***.
4. If the project was not saved, open this file: ***\GSSHA Distributed Hydrologic modeling\Infiltration\ UpdatedInfil.prj.***
5. Save this project file with a different name so the original project remains unchanged. Select ***GSSHA | Save project File*** and save as ***\GSSHA Distributed Hydrologic modeling\Personal\Streams\stream.prj***.

In WMS, the tools for working with 2D grid data are in the 2D Grid module. The tools for working with the stream data are in the Map module. In order to set up the stream model four things must be done:

- Set the stream arcs to a GSSHA stream arc type
- Define the channel cross section geometry
- Define the channel thalwegs
- Turn on the channel routing job control item
- Turn on additional output options to visualize the GSSHA stream Output

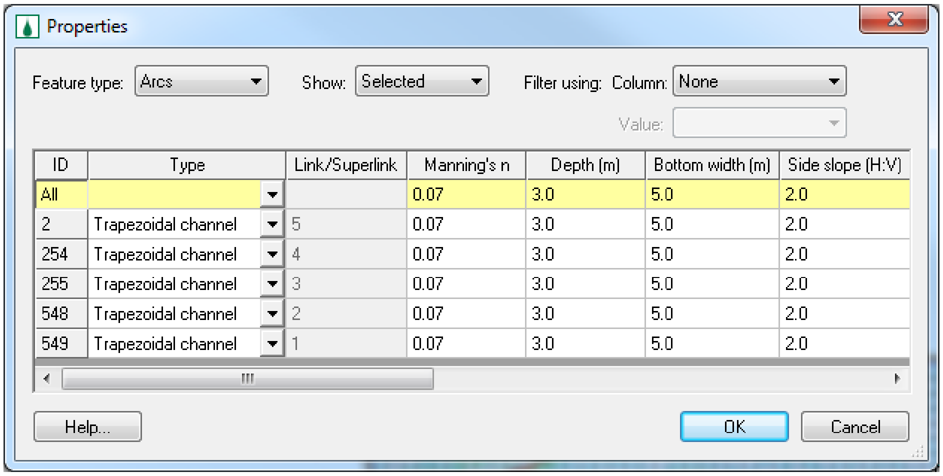
When originally delineating this watershed, stream arcs in the GSSHA coverage were created. These stream arcs, however, are currently assigned a generic stream attribute. Further, the stream density (node spacing) is defined according to the threshold limit used when originally delineating the watershed. Manually edit the streams after the watershed has been delineated, but determine the appropriate stream density when first delineating the watershed. Note the importance of defining the stream point density in the hydrologic modeling wizard tutorial.

1. Select the ***Map Module*** .
2. Select the *Select feature line branch* tool .
3. With this tool selected, click on the stream segment labeled "#1" on the following figure to select all streams.



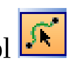
4. Select ***Feature Objects* | *Attributes***…
5. In the Properties dialog, select the "*Trapezoidal Channel*" type for the first row in the table (colored yellow) which allows defining channel geometry for all selected stream arc(s). See the following figure.
6. Enter the remaining channel properties in the same first row of the Properties dialog according to the following table.

Parameter	***Value***
Manning's N	0.07
Channel Depth	3
Bottom Width	5
Side Slope	2



7. Select *OK*

So far all the stream arcs in the basin are defined as trapezoidal channels and have identical properties. There are two types of channels that GSSHA recognizes: trapezoidal and break-point (derived from actual cross section geometry). It would be nice to add some variation to our streams to represent the streams narrowing upstream. To do this increase the dimensions of the most downstream arc.

8. Click on the *Select feature Arc* tool  (be sure not to select the *Create Feature Arc* tool which looks similar but does not have the arrow).
9. Select the most downstream arc (#1 in the figure above) and select ***Feature Objects | Attributes***
10. Enter the following attributes:

Manning's n	Depth	Bottom width	Side slope
0.075	3.5	7	2

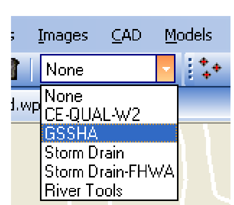
11. Click *OK* to close the Properties window.

The stream arcs now have defined geometries and are ready to be smoothed.

3 Smoothing the Channel Thalweg Elevations

Now that the channel geometry for each stream arc has been defined, it is important to ensure that each arc is flowing downhill. Due to the coarse resolution of the DEM data, stream arcs will often have segments that flow uphill, which causes digital dams in the stream network. To avoid this problem, look at the stream profile and modify the stream node elevations until each arc segment goes downhill in the upstream-downstream direction. First, however, redistribute the vertices on the arcs to a more manageable spacing since by default stream nodes were created at the resolution of the original DEM, which is approximately 10 meters.

1. Select the ***Map Module*** .
2. If the Model combo box on the X,Y,Z edit bar is not set to GSSHA, change it to GSSHA now.

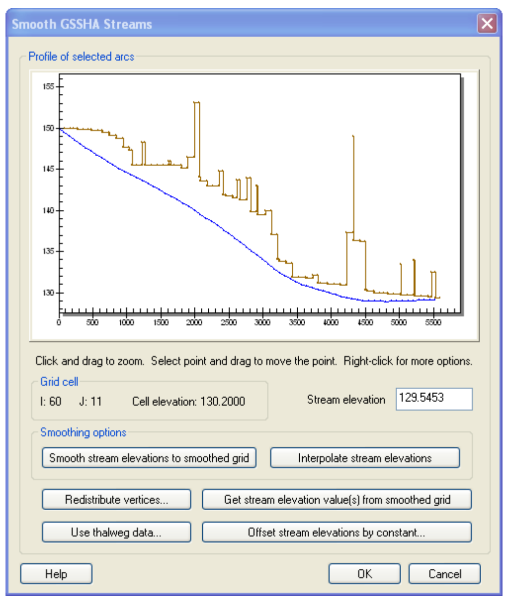


3. Click on the *Select Feature Arc Branch* tool .
4. Click on the stream segment labeled "#1" from the previous figure.
5. Select ***Feature Objects* | *Redistribute.***
6. Type 90 in the box next to *Spacing*, check the option to *Use Cubic Spline* and click *OK.*

The node spacing on the arcs is now about similar to the grid size. Now smooth the thalweg elevations by selecting continuous channel segments until all channel segments have been smoothed.

7. Select the ***Select Arc*** tool .
8. Select arc # 1 as shown on the figure above, and while holding down the shift key, select stream arc "#3" so this continuous channel segment is selected with no branches.
9. With these streams selected select ***GSSHA* | *Smooth Stream Arcs***…

In the Smooth GSSHA Streams dialog, see a profile of the selected arcs. Notice that while the segment has a general downward trend, in some places the streambed is significantly adverse. While GSSHA is able to handle adverse slopes, it is not desirable that adverse slopes should be in the model where they do not exist naturally. Mitigate this problem by making slight changes to the node elevations along the segment.



10. Select the "*Interpolate stream elevations*" buttons as many times as needed (probably 10-15 times) to generate a smooth stream segment with no uphill flow, then click *OK.*
11. If uphill flow cannot be eliminated in this manner, edit individual points by dragging the point to a new position or editing the value in the box next to "*Stream elevation*." Be especially careful to make sure the nodes next to the outlet do not create adverse slopes. Moving nodes manually and selecting the *Interpolate stream elevations* button is an effective way of eliminating any adverse slopes in the stream segments.

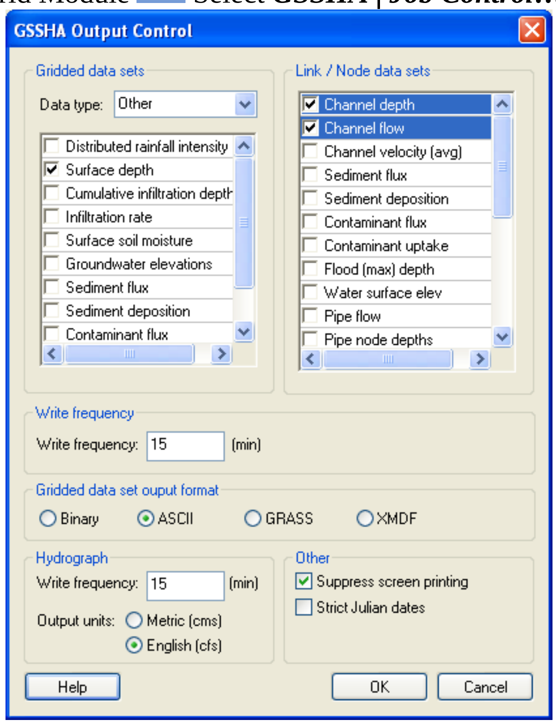
12. Drag a box to zoom into any area where more detail is wanted. Other options for modifying the stream plot display can be accessed by a right-click menu in the stream plot window.
13. After finishing smoothing the streams and removing any adverse slopes, click *OK* to close the *Smooth GSSHA Streams* dialog.

Once the stream segment is smooth, select a new stream segment or combination of segments to smooth. Repeat the smoothing process outlined in steps 8 through 13 until adverse slopes have been removed from all stream segments in the basin. After removing adverse slopes, the streams are now ready for use in the GSSHA model.

Before saving the model, the stream routing option must be turned on in the Job Control dialog for GSSHA to run with the 1D stream flow option.

4 Changing Output Control Options

1. In the 2D Grid Module  Select ***GSSHA* | *Job Control…***

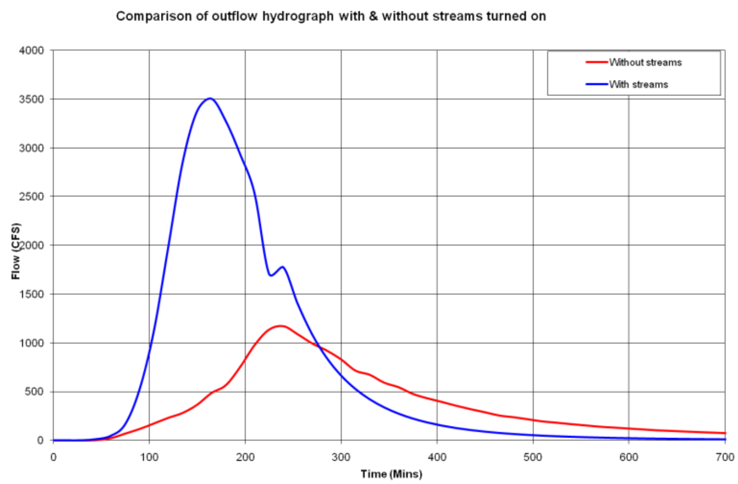


2. Under *Channel routing computation scheme* select *Diffusive Wave*.
3. Click on *Output Control* and toggle on *Channel Depth* and *Channel Flow* and select *OK.*
4. Click *OK.*
5. Save the model as ***\GSSHA Distributed Hydrologic modeling\Personal\Streams\stream.prj***

5 Running the model and viewing the outflow hydrograph

1. Select ***GSSHA* | *Run GSSHA***. Select *OK* to run the model.

2. After the simulation has finished running, open the *Summary* file. View and compare the total amount of discharge, Final volume on surface, final volume in channels, infiltration, and other parameters. If the channel profile is not smoothed correctly, a large amount of water will be trapped in the channel. Close the summary file and return to WMS.
3. Open the outlet hydrograph.
4. Right-click on the hydrograph plot and select View Values. Then select and copy the flow values.
5. Open the spreadsheet ***\GSSHA Distributed Hydrologic modeling\tables\InitialGSSHAComparison.xls*** and paste the hydrograph ordinates under the column *With Streams* (under the *Data* tab). Paste the data in the white areas only.
6. Visualize the difference in outflow hydrographs between the two models in the *W_WO_Streams* tab.
7. Close the *View Values* window and the *Hydrograph* plot window in WMS when done.



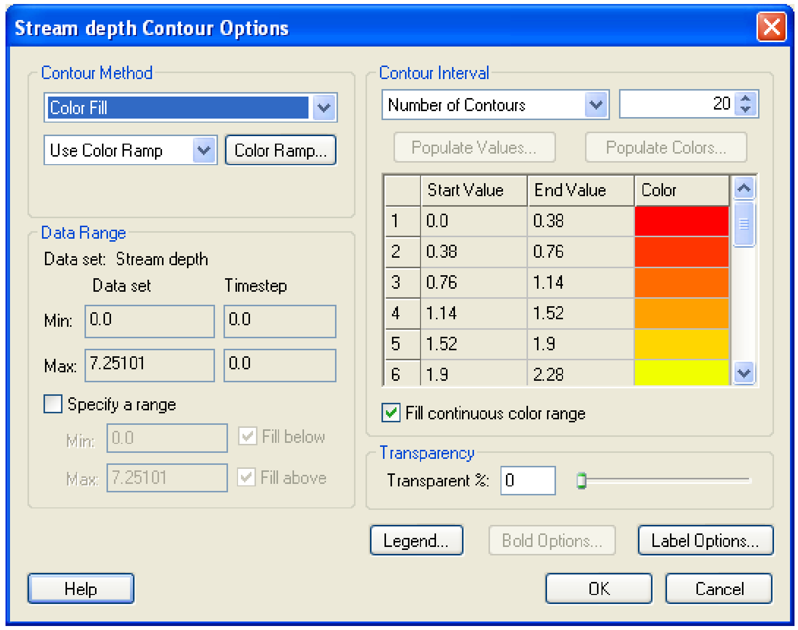
6 Visualizing Stream Flow Data

While the streams are connected to the overland flow plane, they represent a separate but coupled model. The depth and flow outputs from this stream hydraulic model are in a format called the link/node dataset format. These files hold a data value for every node (arc segment) of every link at the same time step as that for the gridded output data. Two of the most common files in this format are the channel depth file (*.cdp) and the channel discharge file (*.cdq.).

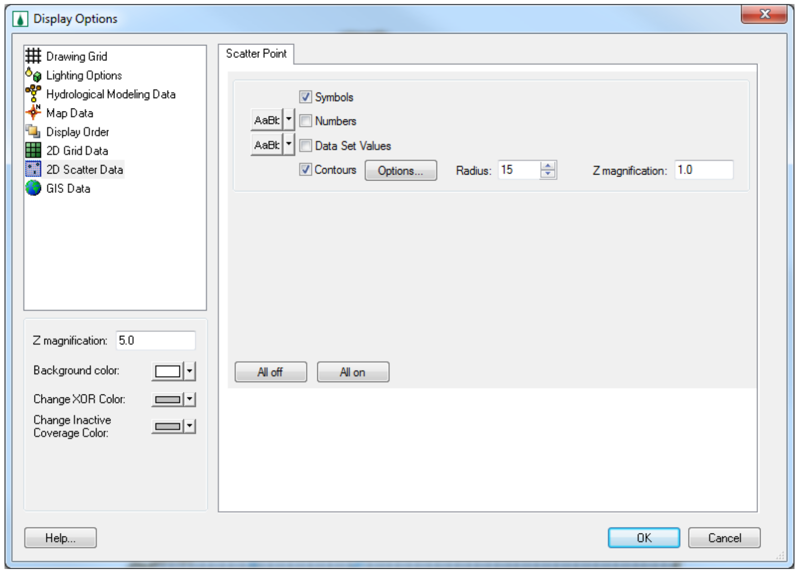
These stream datasets can be visualized in WMS. Create depth contours, flood histograms, or a movie of how these values vary with time. This tutorial will show some of these WMS visualization tools.

7 Changing Contour Properties

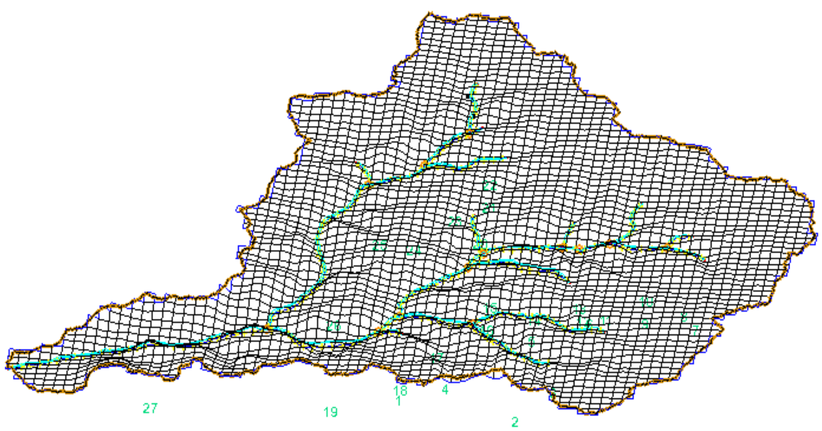
1. In the project explorer (near the bottom, under *2D Scatter Data*) click on the *Stream depth* dataset to select it.
2. Select ***Display | Display Options***. In the 2D Scatter Data window, toggle off the display of symbols and toggle on the display of *Contours* and click on *Options*.
3. Change the Contour Method to *Color fill* and click *OK*.



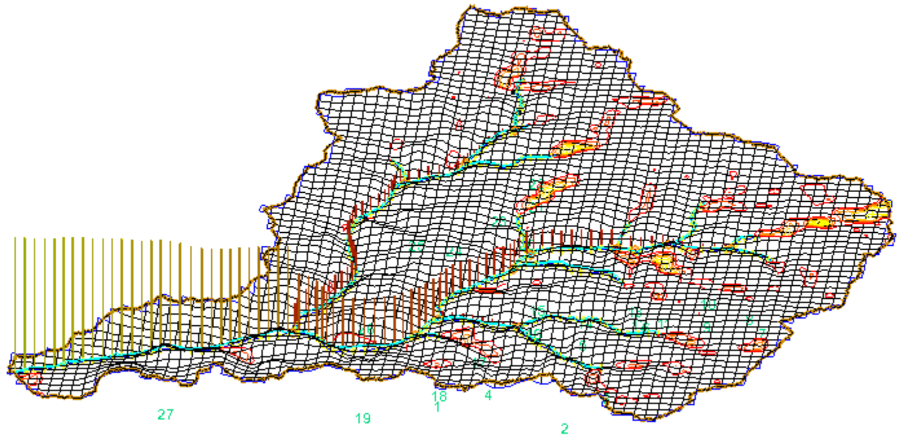
4. Change the *Radius* field to 15 and *Z-magnification* for the contours to 1.
5. On the left side of the dialog, set the Z-magnification to 5 (This sets the Z-magnification for all the data while the Z magnification under the scatter point options only sets the Z-magnification for scatter point contours).
6. Select *2D Grid Data* option in the list. Make sure that *Cells* option is set to *Smoothed.*
7. Click *OK.*



8. Click and select the "*Rotate*" tool . Then rotate the watershed by using the left mouse click so that the display is as shown in the following figure (Use the middle button on the mouse if needed to pan the display while the rotate tool is selected).



9. Now click on *Stream Flow* in the project explorer to select and toggle through different time steps in the *Properties* window at the right side of the WMS main window. When cycling through the time steps, can see cylinder diagrams representing the discharge flood wave along the streams. Also see the depth contours along the 2D overland flow plane and view the effects of overland depth on stream flow as water enters the streams. Viewing the 2D overland flow and the 1D stream flow in this way should give a clearer idea of the coupling of overland and stream flow in GSSHA.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