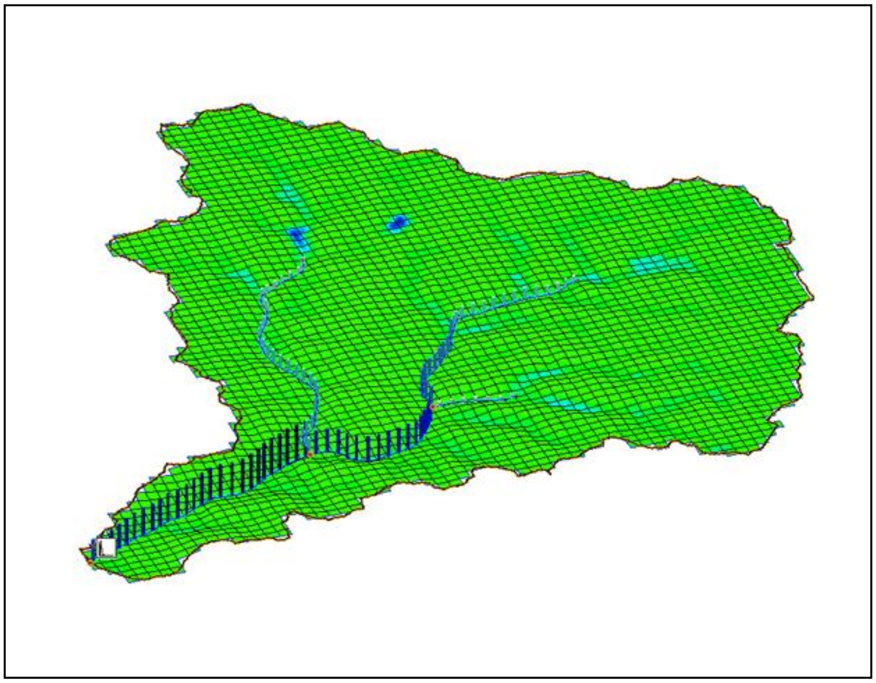
v. 11.0

WMS 11.0 Tutorial

GSSHA – 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.

Prerequisite Tutorials

- GSSHA – Infiltration

Required Components

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

Time

- 20–35 minutes

1 Introduction

In order to increase the accuracy of a simulation and to add more detail to a hydrologic model, 1-D hydraulic channels can be added to a previously constructed GHHSA model. This will enable the user to model and track the interaction between channel and overland flow and how it affects the final hydrograph and subsequent results.

2 Getting Started

Starting WMS new at the beginning of each tutorial is recommended. This resets the data, display options, and other WMS settings to their defaults. To do this:

1. If necessary, launch WMS.
2. If WMS is already running, press *Ctrl-N* or select *File* | **New…** to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click **No** to clear all data.

The graphics window of WMS should refresh to show an empty space.

4. Click **Open** to bring up the *Open* dialog.
5. Change the *Files of type* to "WMS XMDF Project File (*.wms)".
6. Navigate to *Streamflow* and **Open** "Streams.wms" to close the *Open* dialog and import the project file.
7. Click **OK** to overwrite the existing land use table.
8. Click **OK** to overwrite the existing soil type table.
9. Switch to the **Map Module** .

3 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. The first step is to define channel properties on the stream arcs in WMS.

In WMS, the tools for working with 2D grid data are in the 2-D Grid Module. The tools for working with stream data are in the Map Module. In order to set up the stream model five 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 **Select feature line branch**  tool.
2. With this tool selected, click on the stream segment labeled "#1" in Figure 1to select all streams.

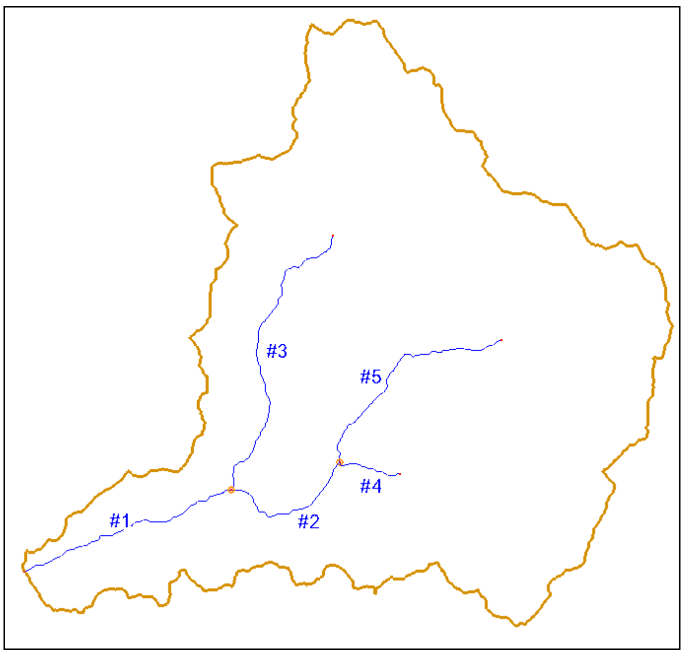


Figure 1 Labeled stream segment arcs.

3. Select *Feature Objects* | **Attributes…** to bring up the *Properties* dialog.
4. Under the *Type* column, in the *All* row, select "Trapezoidal Channel".
5. In the *All* row, enter the following values according to the table below:

Parameter	Value
Manning's n	0.07
Depth (m)	3
Bottom width (m)	5
Side slope (H:V)	2

6. Select **OK** to close the *Properties* dialog.

7. Select **Yes** to renumber links.
8. Select **All** to number all the arcs in the "GSSHA" coverage.

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.

9. 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).
10. Select the most downstream arc (#1 in Figure 1 above) and select *Feature Objects* | **Attributes…** to open the *Properties* dialog.
11. Enter the following attributes in the second row:

Manning's n	Depth (m)	Bottom width (m)	Side slope (H:V)
0.075	3.5	7	2

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

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

4 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. Click on the **Select feature line branch** tool.
2. Click on the stream segment labeled "#1" from Figure 1.
3. Select *Feature Objects* | **Redistribute…** to bring up the *Redistribute Vertices* dialog.
4. For *Average spacing*, enter "90".
5. Turn on *Use Cubic Spline*.
6. Click **OK** to close the *Redistribute Vertices* dialog.

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

7. Select the **Select feature Arc** tool.
8. Select arc # 1 as shown in Figure 1, 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/Pipe Arcs…** to open the *Smooth GSSHA Streams* dialog.

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.

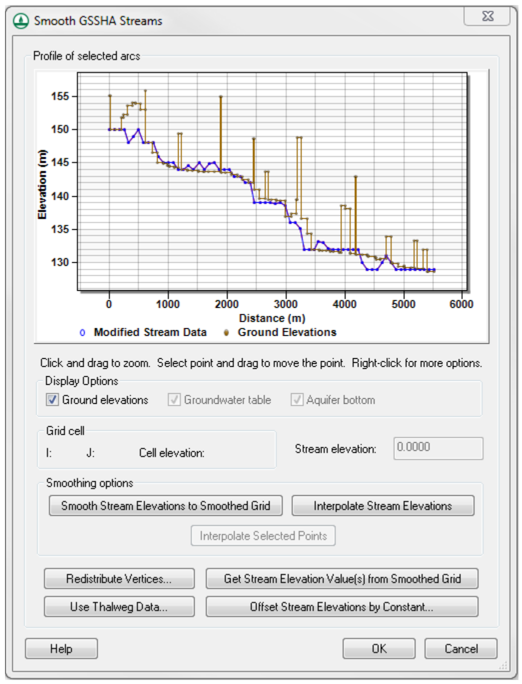


Figure 2 Smooth GSSHA Streams dialog

10. Click the **Interpolate Stream Elevations** button as many times as needed (probably 10-15 times) to generate a smooth stream segment with no uphill flow.

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.

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.

11. After finishing smoothing the streams and removing any adverse slopes, click **OK** to close the *Smooth GSSHA Streams* dialog.

12. 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 10 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.

5 Changing Output Control Options

1. Switch to the **2-D Grid Module**, and select *GSSHA* **| Job Control…** to open the *GSSHA Job Control Parameters* dialog.
2. Under *Channel routing computation scheme* select *Diffusive Wave*.
3. Click on **Output Control…** along the bottom of the dialog to open the *GSSHA Output Control* dialog.
4. Under *Link/Node data sets*, turn on both "Channel depth" and "Channel flow".
5. Select **OK** to close the *GSSHA Output Control* dialog.
6. Click **OK** to close the *GSSHA Job Control Parameters* dialog.
7. Select *GSSHA* | **Save Project File…** to bring up the *Save GSSHA Project File* dialog.
8. Navigate to *Streamflow\Personal\Streams*
9. Enter "stream.prj" as the *File name* and click **Save** to save the project and exit the *Save GSSHA Project File* dialog.

6 Running the model and viewing the outflow hydrograph

1. Select *GSSHA* **| Run GSSHA…** to open the *GSSHA Run Options* dialog.
2. Select **OK** to exit the *GSSHA Run Options* dialog and open the *Model Wrapper* dialog.
3. Once the simulation has finished running, click **Close** to exit the *Model Wrapper* dialog.
4. Select the **Select hydrographs** tool, and double-click on the hydrograph near the outlet of the watershed to open the *Hydrograph* dialog.
5. In an external spreadsheet program, open "InitialGSSHAComparison.xls" which can be found under *Streamflow\tables*.
6. The "W_WO_Streams" tab should be automatically selected in the spreadsheet. This shows a comparison of the hydrographs with and without streams accounted for in the model. The hydrograph should appear similar to Figure 3 below.

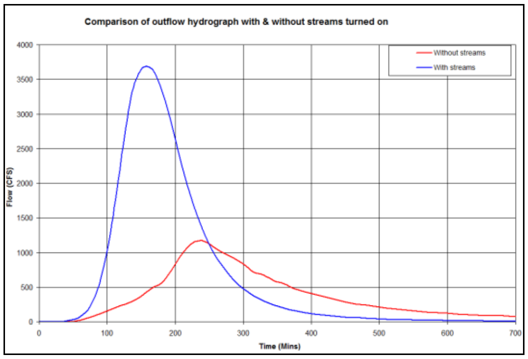


Figure 3 Hydrographs of the model which display the differences between modeling with and without streams.

7. When finished observing the differences, close the spreadsheet and return to WMS.

7 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.

8 Conclusion

This concludes the "GSSHA – Stream Flow" tutorial. This tutorial covered how to add hydraulic channel routing to a GSSHA model and how to define channel properties in order to track the interaction between overland and channel flow.

