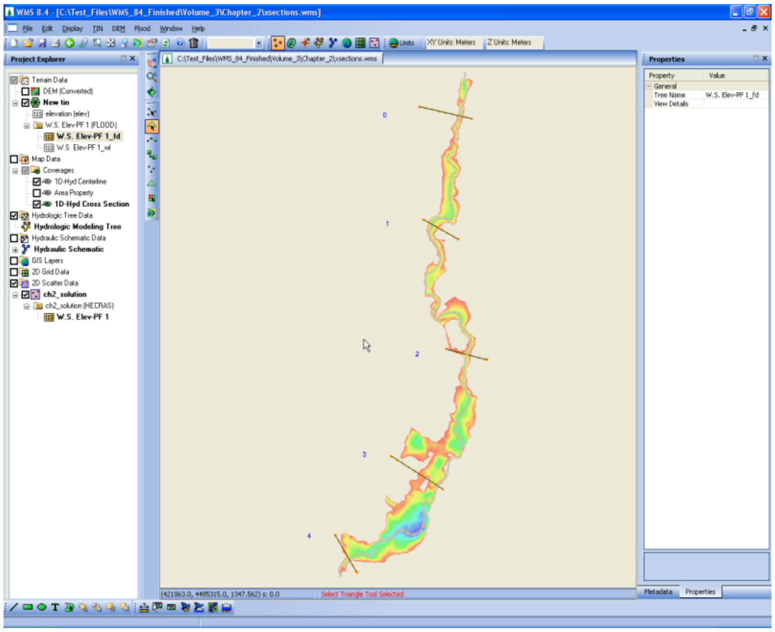
WMS

v. 9.1

WMS 9.1 Tutorial

Hydraulics and Floodplain Modeling – Managing HEC-RAS Cross Sections

Modify cross sections in an HEC-RAS model to use surveyed cross section data



Objectives

Build a basic HEC-RAS model from a conceptual schematic of cross sections, river banks, and river centerlines. Extract the cross sections from background elevation data. Then merge surveyed cross sections into extracted cross sections using the cross section database management tools in WMS. Export and run your HEC-RAS model, read the results into WMS, and delineate a floodplain using the HEC-RAS results.

Prerequisite Tutorials

- Hydraulics and Floodplain Modeling – HEC-RAS Analysis

Required Components

- Data
- Drainage
- Map
- River

Time

- 30-60 minutes

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1 Contents

2 Introduction

HEC-RAS is a 1-D river model that relies on cross section data along reaches to compute results. Cross sections can be extracted from a TIN in WMS, but the TIN does not always define the channel with enough resolution to get an accurate cross section through the channel. Tools in WMS make it possible to manage cross sections by editing their shape, defining properties, and merging multiple cross sections together. Surveyed channel cross section data can be merged with cross sections extracted from a TIN in order to develop cross sections that accurately depict both the channel and surrounding terrain.

3 Objectives

In this exercise you will learn how to merge cross sections and use the data for input into a HEC-RAS model by:

1. Creating a conceptual river model
2. Converting a DEM to a TIN for background elevation data
3. Extracting cross sections
4. Merging cross sections

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5. Running HEC-RAS
6. Delineating the floodplain using HEC-RAS results

4 Creating a Conceptual River Model

A conceptual river model can be created by using GIS data to define the centerline and bank arcs, material properties, and cross section location and geometry. Background images are also useful in creating and viewing this GIS data.

4.1 Open Centerline and Bank Arcs

1. Close all instances of WMS
2. Open WMS
3. Switch to the *Map* module
4. Select ***File | Open***
5. Locate the ***xsecs*** folder in your tutorial files. If you have used default installation settings in WMS, the tutorial files will be located in ***\My documents\WMS 9.1\Tutorials\.***
6. Open *"river.map"*
7. Select ***Edit | Current Projection...*** to set your current projection
8. Toggle on *Global projection*
9. Click *Set Projection*
10. Set Projection to *UTM* and Datum to *NAD 27*
11. Set Horizontal Units to *Meters*
12. Set Zone to *12 (114°W - 108°W - Northern Hemisphere)*
13. Select *OK*
14. Set Vertical Units to *U.S. Survey Feet*
15. Select *OK*
16. Select *OK* if a message appears telling you that your horizontal and vertical units are inconsistent.

Skip section 4.2 if you are not able to connect to the Internet using your computer.

4.2 Getting a Background Image

Using an Internet connection you can load a background image (Aerial photo or a topo map) for the project site. You can use any of the Get Data tools in WMS to load images from the internet.

1. Select the *Get Online Maps* tool located in the Add GIS Data drop-down menu in the Get Data menu bar. The *Get Online Images* dialog will appear.

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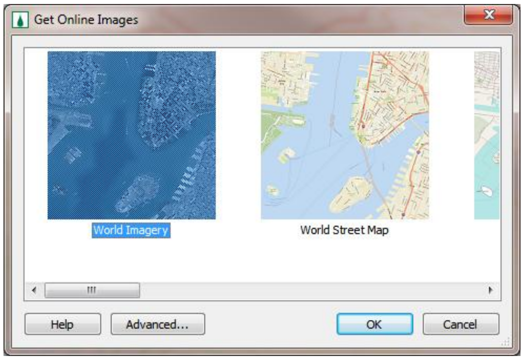
2. Select *World Imagery* and click *OK*.



3. WMS will load the background image file. It will take few moments depending upon the internet connection. Once done, you can see an aerial photo added to the background.
4. Skip to section 4.4.

4.3 Open Background Images

If you do not have reliable internet access, you should open images showing the area we are interested in modeling as follows:

1. Select ***File | Open***
2. Open *"jordannarrows.jpg"* and *"midvale.jpg"*

4.4 Define Centerline and Bank Arcs

1. Zoom in close enough around a section of the feature arcs so that you can see three distinct arcs as shown in Figure 4-1

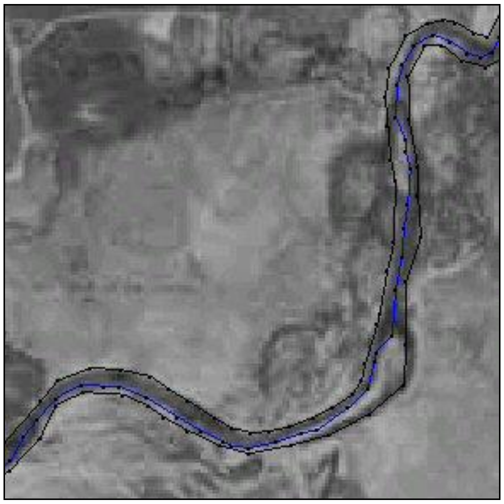


Figure 4-1: Centerline and bank arcs.

The middle arc is the centerline arc that defines the thalweg of the river reach and the outer arcs define the right and left banks.

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2. Use the *Select Feature Arc* tool to select the middle arc
3. Select ***Feature Objects | Attributes*** and choose Centerline
4. Select *OK*
5. Enter Jordan River for the River Name
6. Enter Riverton in the Reach Name
7. Select *OK*
8. Use the *Select Feature Arc* tool to select both outer arcs
9. Select ***Feature Objects | Attributes*** and choose Bank
10. Select *OK*

4.5 Create Materials

Materials are defined on an Area Property coverage by digitizing polygons representing different materials using a background image, such as an aerial photograph, or by using land use data from a shapefile or another source. Each different material that is defined will be used later to assign roughness values to the cross sections. In this exercise we will read in a map file containing material data that has already been digitized.

1. Select ***File | Open***
2. Open *"materials.map"*
3. Zoom in around the materials polygons on the Area Property coverage
4. Right-click on the *Area Property* coverage and select ***Display Options***
5. Select *Map Data* and toggle *Color Fill Polygons* on
6. Select *OK*
7. Select ***Edit | Materials*** to view the material types associated with each color
8. Select *Cancel*

5 Converting a DEM to a TIN

Cross section geometry can be extracted from a TIN in WMS. We will create a TIN by opening a DEM and converting it to a TIN. It is also possible to filter redundant DEM points out of the TIN that we create.

5.1 Open a DEM

1. Switch to the *Terrain Data* module
2. Select ***File | Open***
3. Open *"91606647.hdr"* in the "*91696647*" folder
4. Select *OK*

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5. Select *Yes* to change projection
6. In the *Object Projection* section toggle on *Global Projection* and click *Set Projection* button
7. Ensure *Geographic (Latitude/Longitude)*, and *NAD 83* are selected in the *Projection* and *Datum* drop down boxes
8. Select *OK*
9. Set vertical units to *Meters*
10. In the *Project Projection* section toggle *Set* on
11. Click *Set Projection*
12. Set *Projection* to *UTM*, *Datum* to *NAD 27*, *Planar Units* to *METERS*, and *Zone* to *12 (114°W - 108°W – Northern Hemisphere)*.
13. Select *OK*
14. Set the vertical units to *Meters*
15. Select *OK*

5.2 Convert to a TIN

1. Select ***DEM | Conversion | DEM->TIN | Filtered***
2. Select *OK*
3. Right-click on *New Tin* under *Terrain Data* in the Project Explorer and select ***Display Options***
4. On the *TIN* tab, toggle *Triangles* off and *Boundaries* on
5. Select *OK*
6. Hide the DEM by toggling its check box off

6 Extracting Cross Sections

It is very easy to extract cross section geometry from a TIN in WMS. This is done by creating arcs that represent the plan view of the cross sections on a 1D-Hyd Cross Section coverage.

1. Switch to the *Map* module
2. Select ***File | Open***
3. Open *"xsections.map"*

4. Hide the materials polygons by toggling Area Property coverage in the Project Explorer off
5. Hide the background image by toggling it off
6. Zoom in around the cross section arcs labeled 0 - 4
7. Select the ***Contour Options*** icon

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8. For the Contour Interval, select the *Specified Interval* and enter a value of 10.0
9. Select *OK*

You can see that the cross section arcs are approximately as wide as the floodplain might be. They end where there is a sharp break in slope and the terrain gets relatively steep. Wider cross section arcs are generally not necessary for a HEC-RAS analysis.

10. Make sure the 1D-Hyd Cross Section coverage is active in the Project Explorer
11. In the Model drop-down list at the top of the screen select *River Tools*

12. Select ***River Tools | Extract Cross Section***
13. Select *OK*
14. Enter "xsec" for the name of the new cross section database where all of the cross sections will be stored

7 Merging Cross Sections

Any two cross sections can easily be merged in WMS. We will create a new cross section database that stores surveyed channel cross section data and merge it with the cross sections that we just extracted from the TIN. Merging cross sections will create more accurate cross section geometry data. Cross sections are merged by aligning both cross sections using reference points such as the thalweg or bank locations and then inserting points from one cross section into the other.

7.1 Open Channel Cross Section Data

1. Select ***File | Edit File***
2. Open *"channel.txt"*
3. Select *OK* to open with Notepad or choose any other text editor or spreadsheet
4. Leave *channel.txt* open for later use

7.2 Create a New Cross Section Database

1. In WMS, Select ***River Tools | Manage Cross Sections***
2. Choose the *New Cross Section Database* button
3. Enter channelxsec.idx for the File name
4. Select *Save*

7.3 Define Channel Cross Sections in the Database

The current cross section database should be *channelxsec.idx* (the one that you just created).

1. Click on the *Edit Cross Section Database* button

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2. Click the *New* button to add a cross section to the database
3. Select the *Edit* button to edit the cross section
4. Click the *Add* button and enter 7 to add seven points to the cross section
5. Select *OK*
6. Toggle *XY* off
7. Copy and paste the cross section data for Channel Section 1 from *channel.txt* (opened in Notepad) into the Cross-Section Attributes Geom Edit tab as shown in Figure 7-1. Make sure to paste the data into the first row.

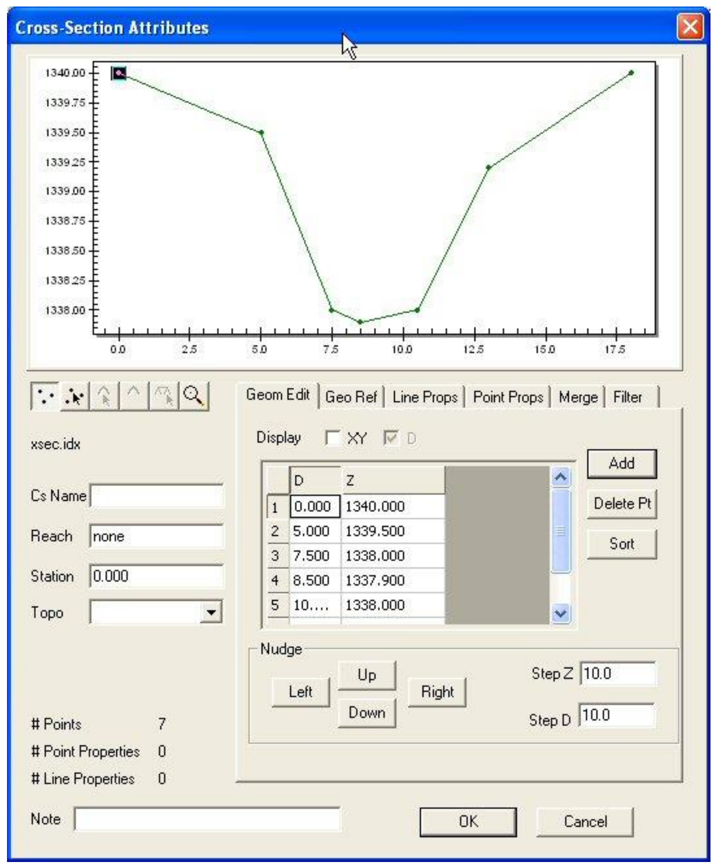

Figure 7-1: Adding cross section geometry data to the database.

8. Select the Point Props tab
9. Click the *Auto Mark* button to automatically define thalweg and right/left bank points. These reference points will be used to align cross sections for merging.
10. Select *OK*
11. Repeat steps 2-10 to add the 4 remaining channel cross sections in *channel.txt* to the cross section database
12. Click the *Save* button
13. Select *OK*

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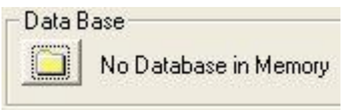
14. Select *OK*
15. Close the text file: *channel.txt*
16. Select *No* if asked to save changes

7.4 Align Channel Cross Sections with Extracted Cross Sections

1. Use the *Select Feature Arc* tool  to select the cross section arc at the top of the screen labeled 0
2. Select ***Feature Objects | Attributes***
3. Select *Assign Cross Section*

This will allow you to view all of the extracted cross sections and assign the highlighted geometry to this cross section arc.

4. Click the *Edit* button
5. Select the Line Props tab to view the material properties (roughness values) that will be applied to each cross section. These can be edited if necessary.
6. Select the Merge tab
7. Select the *Load Insert Cs* button



8. Click on the Data Base *Browse* button
9. Open *"channelxsec.idx"*
10. Make sure that the csid number that is highlighted for the channel cross section matches the csid number of the extracted cross section that you are editing (these numbers also match the number labels displayed next to each cross section arc on the screen)
11. Select *OK*

You will see a profile of the surveyed cross section geometry appear in the upper left corner of the profile view of the extracted cross section geometry as shown in Figure 7-2.

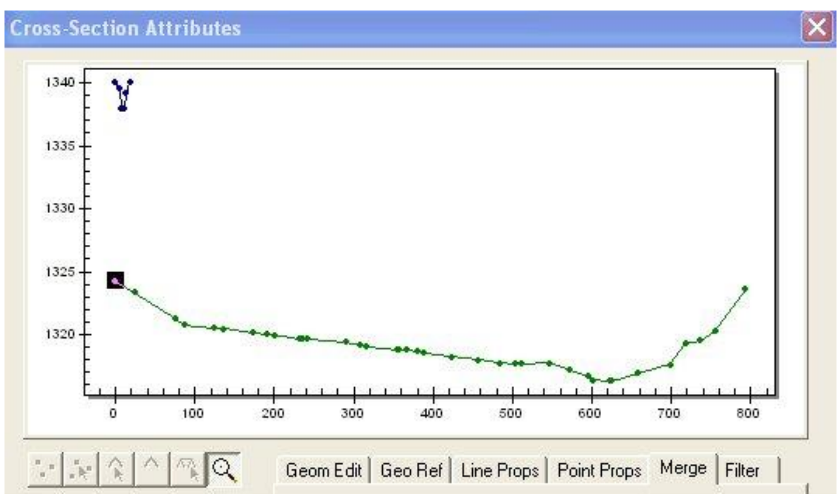


Figure 7-2: Merging cross sections.

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Merge cross sections using the Alignment tools shown in Figure 7-3. You can align cross sections using reference points (point properties) that are defined on both cross sections such as left end, left bank, thalweg, right bank, and right end. Enter a value for the Offset and the cross section will be offset that distance from the alignment point. Specify a distance for Step Z and use the Up and Down buttons to move the inserted cross section vertically. Do the same for Step D using the Left and Right buttons to move the cross section horizontally. The horizontal and vertical scales on the plots are useful for determining the distances to enter. (Remember that the scales are not equal and so the vertical distances are magnified)

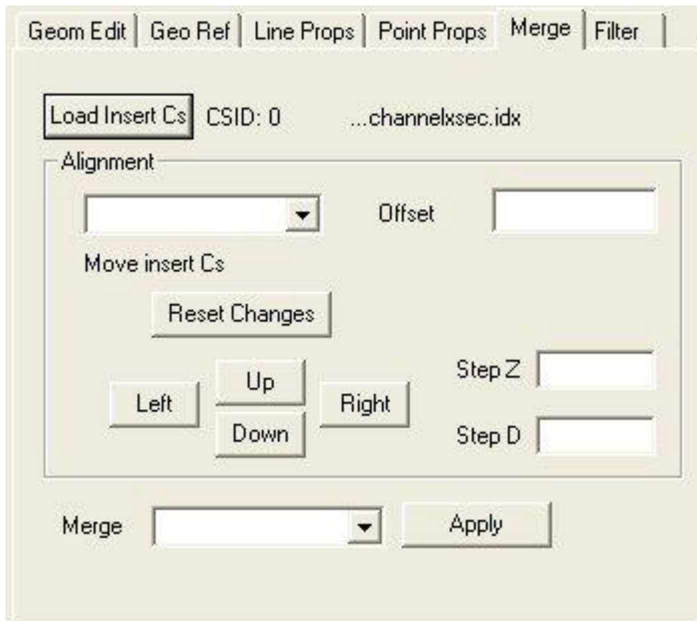
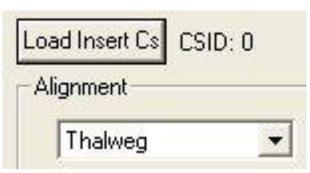


Figure 7-3: Alignment tools.



12. Choose *Thalweg* for Alignment to align the thalweg (specified as a point property) of the channel cross section with the thalweg of the extracted cross section
13. Enter a value for Step Z (try 5) and use the *Down* button to move the channel cross section vertically
14. Reduce the Step Z value to 1 and use the *Up* button to position the cross section
15. Keep reducing the Step Z value and using the *Up* and *Down* buttons until the cross sections are aligned correctly
16. Enter a value for Step D and use the *Left* and *Right* buttons if you need to move the channel cross section horizontally

The *Zoom* tool is useful for viewing the alignment of the cross sections close-up once you have the channel cross section located in the general area where it will be inserted.

The aligned should look similar to Figure 7-4:

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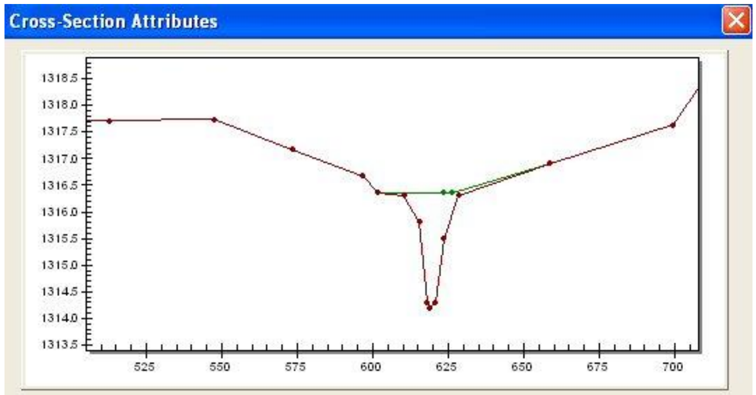

Figure 7-4: Aligned cross sections.

17. Select *Insert All* from the Merge drop-down list
18. Click *Apply* to insert the channel cross section and permanently change the extracted cross section data
19. Select *OK* and notice the updated extracted cross section geometry
20. Select *OK*
21. Select *OK*
22. Repeat this process (steps 1-21) for all of the cross section arcs

8 Running HEC-RAS

A schematic will be created using the GIS data defined in WMS and exported to HEC-RAS. Post-processing options are also available in WMS after running an HEC-RAS simulation.

8.1 Creating a Schematic and Defining Roughness Values

1. Make the 1D-Hyd Centerline the active coverage in the Project Explorer
2. Select ***River Tools | Map -> 1D Schematic***
3. Switch to the *River* module 
4. Select ***HEC-RAS | Material Properties***
5. Enter roughness values for Agriculture, Brushland, Bare, River, and Urban as shown in Figure 8-1

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Figure 8-1: Materials roughness values.

6. Select *OK*
7. Select ***HEC-RAS | Model Control***

8. Select *Materials* for use in generating roughness values
9. Select *OK*

8.2 Running HEC-RAS

1. Select ***HEC-RAS | Export GIS File***
2. Enter “hecras.prj” and Save
3. Select *Yes* if asked to replace existing file

This will start HEC-RAS with the geometry file exported from WMS already loaded.

4. Select ***Options | Unit system (US Customary/SI)*** in the HEC-RAS window
5. Select *System International (Metric System)*
6. Select *OK*
7. Select *Yes* to set the project units to SI (metric)
8. Select ***Edit | Geometric Data***
9. The display should look similar to that shown in Figure 8-2 (If you do not have the most recent version of HEC-RAS you may receive a plot extents error message. This can be corrected by selecting ***View | Set Schematic Plot Extents*** and selecting the *Set to Computed Extents* button).

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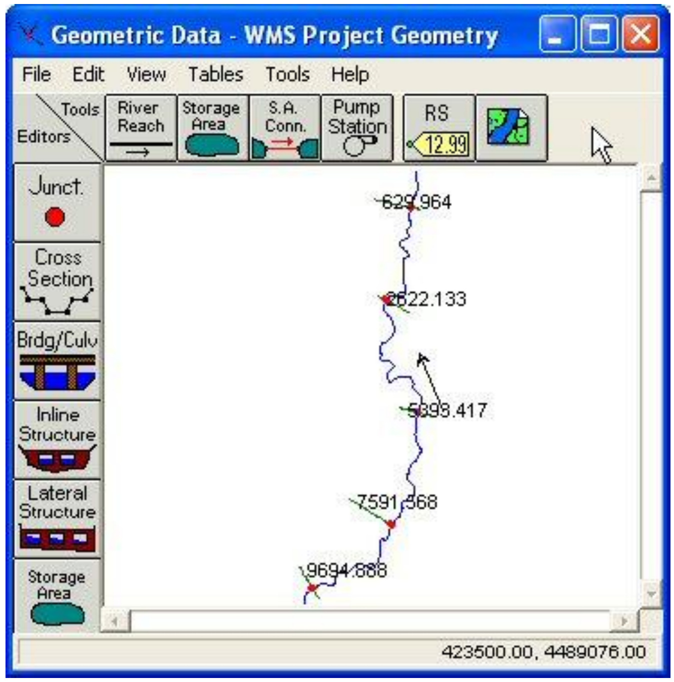
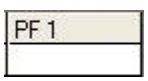


Figure 8-2: Geometric data imported from WMS.

10. Select ***File | Exit Geometry Data Editor*** on the Geometric Data window
11. Select ***Edit | Steady Flow Data***
12. Enter 80 m^3/s for PF 1 (profile flow rate)



13. Click the *Reach Boundary Conditions* button
14. Click the *Normal Depth* button to enter the Downstream boundary condition
15. Enter 0.003 for the downstream slope
16. Select *OK*
17. Highlight the Upstream boundary condition and click on the *Normal Depth* button
18. Enter 0.0015 for the upstream slope
19. Select *OK*
20. Select *OK*
21. Click the *Apply Data* button
22. Select ***File | Exit Flow Data Editor*** on the Steady Flow Data window
23. Select ***Run | Steady Flow Analysis***
24. Change the Flow Regime to *Mixed*
25. Click on the *Compute* button
26. Select *Close*
27. Select ***File | Exit*** on the Steady Flow Analysis window

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28. Select ***File | Save Project*** on the main HEC-RAS window
29. Close HEC-RAS

8.3 Post-processing

1. In WMS select ***HEC-RAS | Read Solution***
2. Use the *Select River Reach* tool to select the river reach icon displayed on the schematic
3. Select ***HEC-RAS | Plot Solution*** to view the profile plot generated by HEC-RAS for the river reach
4. Use the *Select Cross Section* tool to select one of the cross section icons displayed on the schematic
5. Select ***HEC-RAS | Plot Solution*** to view the cross section profile plot generated by HEC-RAS

9 Floodplain Delineation

HEC-RAS computes a water surface elevation at each cross section. We will interpolate the HEC-RAS results along the cross section and centerline feature arcs in order to improve the floodplain delineation. WMS intersects the water surface elevation data with the background elevation TIN in order to delineate the floodplain.

9.1 Interpolating HEC-RAS Results

1. Select ***Display | Display Options*** 
2. On the River Data tab, toggle *River Hydraulic Schematic* off
3. Select *OK*
4. Make the 1D-Hyd Cross Section coverage active in the Project Explorer
5. Make sure that none of the cross section arcs are selected
6. Select ***River Tools | Interpolate Water Surface Elevations***
7. Choose Create a data point *At a specified spacing*
8. Enter 100 for the Data point spacing
9. Select *OK*
10. Make the 1D-Hyd Centerline coverage active in the Project Explorer
11. Select ***River Tools | Interpolate Water Surface Elevations***
12. Select *OK*

9.2 Delineating the Floodplain

1. Switch to the *Terrain Data* module 
2. Select ***Flood | Delineate***

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3. Enter 500 for Max search radius
4. Enter 2 for Number of stages in a quadrant
5. Select *OK*
6. Select the flood depth dataset, W.S. Elev-PF 1_fd, from the Terrain Data folder of the Project Explorer
7. Select ***Display* | *Contour Options***
8. For Contour Interval select the *Number of Contours* option and enter 25
9. For Contour Method select *Color fill* and adjust the Transparency
10. Under Data Range, select *Specify a range*

Notice that the values of the default range are much smaller than the actual elevation of the TIN. This is because these values are the flood depth.

11. Deselect the *Fill below* and *Fill above* checkboxes
12. Select *OK*

Two data sets were created by delineating the floodplain. W.S. Elev-PF 1_fd contains flood depth values and W.S. Elev-PF 1_wl contains water surface elevations.

13. Select W.S. Elev-PF 1_wl from the Project Explorer and experiment with viewing the results, similar to the flood depth. You may also want to experiment with adjusting the transparency and turn the background image on as shown in Figure 9-1. When specifying the range, notice that the default values are actual TIN elevations.

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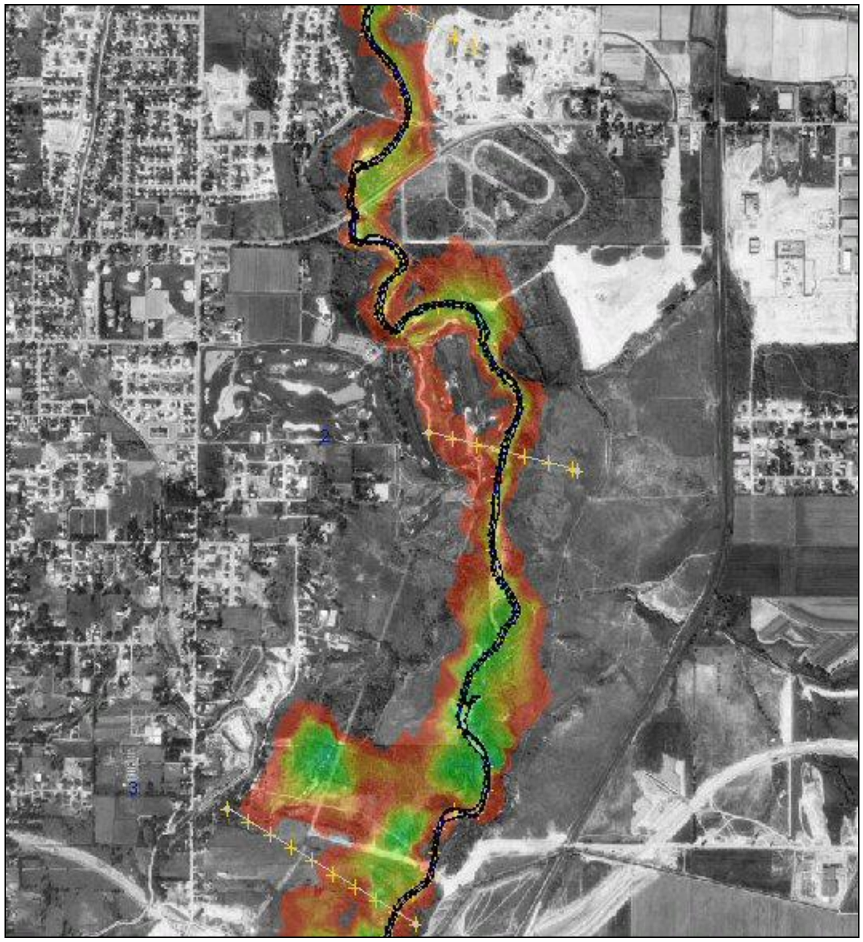

Figure 9-1: Flood depth map.

It is important to remember that the HEC-RAS results came from merged cross sections, but the floodplain is delineated on the original TIN that does not include the surveyed channel cross section data. The water surface elevations of the flood are the same, but the flood depths in the channels, where cross sections were merged, may be deeper than shown.

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