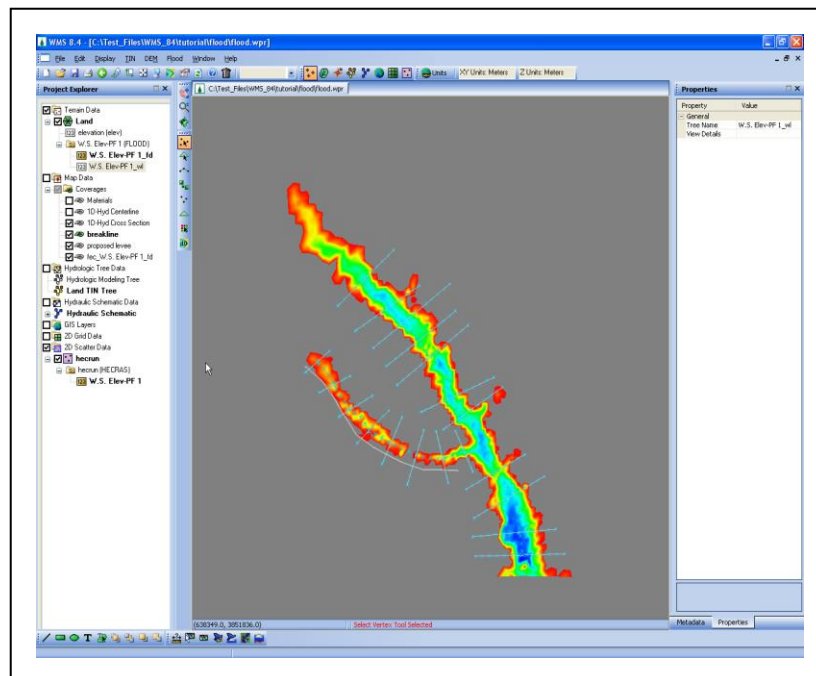


WMS 10.1 Tutorial

Hydraulics and Floodplain Modeling – Floodplain Delineation

Learn how to use the WMS floodplain delineation tools



Objectives

Experiment with the various floodplain delineation options in WMS. Delineate floodplains using water surface elevations that have been manually entered from known data, that have been estimated using the WMS channel calculator, and that have been computed using HEC-RAS. Learn how to determine floodplain boundaries and to generate flood depth and impact polygons.

Prerequisite Tutorials

- Hydraulics and Floodplain Modeling – HEC-RAS Analysis

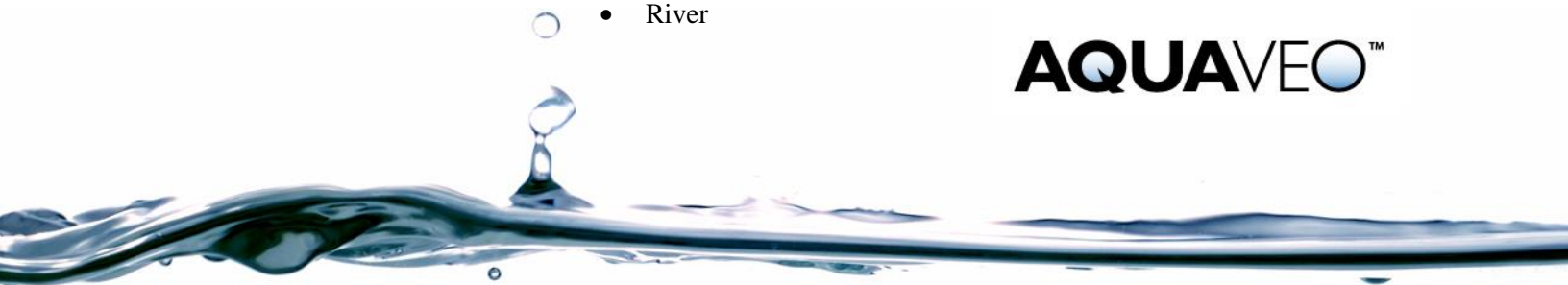
Required Components

- Data
- Drainage
- Map
- River

Time

- 30-60 minutes

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1 Introduction

This exercise demonstrates how to perform a floodplain delineation with WMS. Before WMS can delineate a floodplain, provide an elevation TIN (Triangulated Irregular Network) and a scatter point dataset with river stage values. TIN elevations might be obtained from survey data, or by converting DEM (Digital Elevation Model) points to TIN vertices. River stage files can be assembled manually, or read in from a HEC-RAS project file.

2 Objectives

This exercise will show how to delineate a floodplain based on water surface elevations for a river and a TIN which represents the topography for the area. The exercise will instruct how to:

- Experiment with the various floodplain delineation options, including input data, search radius, flow path, and quadrants
- Perform floodplain delineations with water surface elevations acquired by the following techniques:
 - Manually entered in a scatter point file
 - Approximated with the Channel Calculator in WMS
 - Computed with HEC-RAS
- Use a Flood Barrier coverage to restrict flood waters
- Generate flood depth, impact, and extent coverages

3 Floodplain Delineation Options

Choose from several different delineation options, which in turn affect how the floodplain is computed. Options include Search Radius, Flow Path, and Quadrants.


The Search Radius option determines how many TIN vertices are taken into account when performing the delineation. The Max search radius is the maximum distance that WMS will “look” from each scatter point to determine the intersection between the water surface and the land elevations. One method for choosing a value for the maximum search radius is to increase the radius until the floodplain extents no longer change.

The Flow Path option ensures that the interpolated values for the floodplain are hydraulically connected.



The Quadrants option makes sure that water level data for interpolation is selected from all directions surrounding the point of interpolation rather than in just one direction (quadrant). In general, it is best to turn on the Quadrants option when computing a floodplain.

If desired, run several floodplain delineations with varied options in order to see how the floodplain changes. Optimal settings for the delineation options vary with model geometry. For more details on these delineation options, refer to the WMS Help.

To experiment with some of the delineation options, open a TIN and a scatter point set. The TIN contains the land surface elevations and the scatter point set contains water surface elevations.

1. Open WMS. If WMS is already open, select *File / New* then click **No** if asked to save changes.
2. Select *File / Open*  to access the *Open* dialog.
3. Locate the “flood” folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
4. Open “flood.tin”.

In order to simplify the screen, turn off the display of TIN vertices and triangles.

5. Right-click on “Land” under “Terrain Data” on the Project Explorer and select **Display Options**  to open the *Display Options* dialog.
6. On the *TIN* tab, toggle off the check box for *Unlocked Vertices* (it may already be off).
7. Toggle off the check box for *Triangles*.
8. Select **OK**.
9. Select *File / Open*  to access the *Open* dialog.
10. Open “samplescatter.wpr”.
11. Select *Flood / Delineate*. The *Floodplain Delineation* dialog will appear.
12. Enter “100” for the *Max search radius*.
13. Enter “sr100” for the *solution name*.
14. Select **OK**.

Now change the Search radius and re-calculate a floodplain

15. Select *Flood / Delineate*. The *Floodplain Delineation* dialog will appear.
16. Increase the *Max search radius* to “500”.
17. Change the *Solution name* to “sr500”.
18. Select **OK** to delineate a new floodplain.
19. Examine the flood depth solution by selecting the “sr100_fd” dataset in the Project Explorer.

Viewing the other flood depth solution reveals a significant difference between the two floodplain delineations. The floodplain extends quite a bit further for the 500 search radius than for the 100 search radius.

20. Delineate two additional floodplains following steps 11-14, using *Max search radii* of “1000” and “2000”, and set the solution names to “sr1000” and “sr2000”.
21. Select the corresponding flood depth datasets (sr1000_fd and sr2000_fd).

Notice that there is very little difference between the floodplains delineated with search radius values of 1000 and 2000. Therefore, use a value of 1000 since having found that increasing the radius does not change the delineation appreciably.

Now, experiment with using different Flow path values.

22. Select *Flood / Delineate*. The *Floodplain Delineation* dialog will appear.
23. Enter “1000” for the *Max search radius*.
24. Toggle on the *Flow path* check box.
25. Enter “500” for the *Max flow distance*.
26. Rename the solution as “fp500”.
27. Select **OK**.
28. Delineate two additional floodplains similarly by using *Max flow distance* values of “1500” and “3000” and examine the solution sets.

Once again, there is little variation in these last two delineations. Therefore, leave the Flow path value at 1500. As a note, when the TIN includes an area of unusually high elevations near the river (such as a levee), it is a good idea to use the Flow paths option.


Experiment further with the display options to get a feel for how they change the floodplain delineation.

4 Creating a Scatter Point File

A scatter file can be created with any text editor or spreadsheet application. The required input for the file are (x, y) coordinates for each data point, and a corresponding dataset (in this case, the dataset would be water surface elevation values for each coordinate). Each coordinate may be associated with more than one data value. Table 1 shows the file format for a 2D scatter point file:

ID	X	Y	"dataset 1"	"dataset 2"
1	2343	32322	34.3	45.7
2	2348	32318	33.9	45.4
3	2350	32316	33.5	45.0
etc				

Table 1 File format for 2D scatter point file

1. Select *File* / **New** .
2. Select **No** when asked to save changes.

For this exercise, the scatter file has been previously created. Open it with a text editor to view how it is set up:

3. Select *File* / **Edit File** to open the *Open* dialog.
4. Select "wse.txt" and click **Open**.
5. If asked, select **OK** to open the file with Notepad.

The datasets for the water surface elevations are named "WSE1" and "WSE2." The WSE1 dataset might represent current water levels, and WSE2 might represent expected levels given future developments, such as a proposed levee.

6. Close Notepad.

4.1 Open the Scatter Point Data

1. Select *Flood* / **Read Stage File**.
2. Form the *Open* dialog, open "wse.txt".
3. Select *File* / **Open**  to access the *Open* dialog.
4. Open "flood.tin".

4.2 Delineate the Floodplain

1. Select *Flood* / **Delineate**. The *Floodplain Delineation* dialog will appear.
2. Choose "WSE1" from the *Select stage dataset* list.
3. Change the *Max search radius* to "1500".
4. Toggle off the *Flow path* check box.
5. Change the *Number of stages in a quadrant* to "3".
6. Select **OK**.

This will begin the delineation process for the first set of water surface elevations. When WMS finishes, delineate a new floodplain based on the second set of elevations:

7. Select *Flood* / **Delineate**. The *Floodplain Delineation* dialog will appear.
8. Choose "WSE2" from the *Select stage dataset* list.

9. Select **OK**.



4.3 Creating a Flood Impact Map

WMS can use two separate floodplain delineations to generate a Flood Impact coverage.

A Flood Impact coverage shows the difference between two flood depth or water level sets. The differences are divided into ranges or classes. Using the floodplains delineated in the previous steps, create a Flood Impact coverage in order to investigate the difference in flooding with and without the proposed levee.

1. Select *Flood / Conversion / Flood* → **Impact Map**.
2. The *Flood Impact Coverage* dialog will open. Choose “WSE1_fd” in the *Original dataset* combo box.
3. Choose “WSE2_fd” in the *Modified dataset* combo box.
4. Select **OK** to accept the default classes, ranges, attributes, and names.
5. Select **Yes** to create the coverage.

This new dataset is calculated as WSE1_fd – WSE2_fd indicating that all values in the second dataset were subtracted from the corresponding values in the first dataset.

6. Switch to the **Map**  module.
7. Choose the **Select Feature Polygon**  tool.
8. Double-click on any one of the polygons to open the *Flood Extent Attributes* dialog.


The dialog that opens shows the amount of change from the original dataset to the modified dataset, as well as the impact class ID and name.

Besides creating a tabular data file as described above, scatter point sets can also be created interactively with the tools in WMS, or opened from a HEC-RAS solution file. The following sections demonstrate these two methods for constructing scatter point data to be used in a floodplain delineation.

9. Click **OK** to close the dialog.

5 Creating Scatter Points with the Channel Calculator

This section will demonstrate how to interactively create scatter points in the 2D Scatter Point module and enter a water surface elevation for each point. To begin, clear all data from WMS and begin afresh.






1. Select *File / New* .
2. Select **No** when asked to save changes.

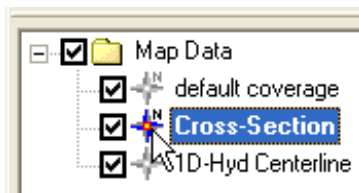
WMS has a tool that allows interactively creating scatter points and assign a data value to each point. The values for water surface elevations might be obtained by digitizing from a background image, or from another source. It's also possible to use a cross section coverage in conjunction with the channel calculator to create scatter points with calculated depths along a river centerline.

For this example, use the Channel Calculator to compute water depths for various cross sections in the channels and create a scatter point at each cross section arc. The water surface elevation will be equal to the water depth computed by the Channel Calculator plus the ground elevation (given by the TIN).

Begin by opening a map file containing a Cross Section coverage. This coverage contains several cross section arcs along the stream reaches.

5.1 Open the Cross Section Arcs and River Centerlines

1. Select *File / Open*  to access the *Open* dialog.
2. Open the files named “flood.tin” and “cross_section.map” and “reaches.shp”. Do this one file at a time or multi-select using the *CTRL* key.
3. Right-click on the “Coverages” folder in the Project Explorer and select **New Coverage** from the pop-up menu.
4. In the *Properties* dialog, change the *Coverage type* to “1D-Hyd Centerline”.
5. Select **OK**.
6. Switch to the **GIS**  module.
7. Select *Mapping / Shapes* → **Feature Objects**.
8. Select **Yes** to use all shapes.
9. In the *GIS to Feature Objects Wizard*, select **Next** twice and then **Finish**.
10. Hide “reaches.shp” by deselecting it in the Project Explorer.
11. Switch to the **Map**  module.
12. Select the **Select Feature Arc**  tool.
13. Select *Edit / Select All*.
14. Select *Feature Objects / Attributes* to open the *Arc Type* dialog.
15. Change the *Arc type* to “Centerline”.
16. Select **OK**, and the *River Reach Attributes* dialog will appear.
17. Select **Cancel** on the *River Reach Attributes* dialog three times to return to the WMS screen.
18. Select the **Frame**  macro.
19. Select the “Cross-Section” coverage from the Project Explorer so that it will be the active coverage.



5.2 Using the Channel Calculator to Compute Depths

The Channel Calculator is a good tool for approximating channel flows or flow depths. Given a flow rate, the Calculator can compute a flow depth, and vice versa. As calculating flow depths, jot down the depth values to recall them later when creating the 2D scatter points.

1. Switch to the **Hydrologic Modeling**  module.

2. Select *Calculators / Channels*. The *Channel Calculations* dialog will open.
3. Toggle on the *Use Cross-Section Database* option.
4. Click the **Select Cross Section** button.
5. Select “Cross section 1” and select **OK**.

The cross section displays in the small graphics window. Adjust the Z scale using the drop-down selector to better visualize the cross section. To see this:

6. Choose a *Z scale* of “25:1” and notice the change in the display.

With the cross section selected, set necessary parameters to perform calculations for depths.

7. Click the **Launch Channel Calculator** button to launch the Hydraulic Toolbox Channel Calculator in the *Channel Analysis* dialog.
8. Enter a value of “0.002” for *Longitudinal slope*. This is an estimate for the ground slope in the vicinity of Cross section 1.
9. Enter a value of “450” for the *flow*.
10. Select the **Calculate** button.
11. Select **OK**.
12. Select the **Create Stage Point** button in the *Channel Calculations* dialog.
13. Repeat the previous steps 4-12 to compute depths and create a stage points for all remaining cross sections. The following table provides Flow and Longitudinal slope values for use with each cross section.

Cross Section	Flow (cms)	Slope
Cross section 1	450	0.0020
Cross section 2	450	0.0015
Cross section 3	300	0.0019
Cross section 4	300	0.0006
Cross section 5	150	0.0087
Cross section 6	150	0.0037

The Channel Calculator can also be used to generate a rating curve

14. Click on the **Launch Channel Calculator** button.
15. Select the **Compute Curves** button in the *Channel Analysis* dialog.

The default is to create a rating curve for the entered flow vs. depth for the selected cross section, but it’s possible to also create curves for all of the other options listed.

Furthermore, enter a depth in the *Channel Analysis* dialog and compute Depth on the Y Axis vs. any of the listed options (Flow would replace the Depth option for the X Axis)

16. Select **OK** in the *Curve Selection* dialog.

Double-click in the rating curve plot window and then click on the *export* button to export the data to a spreadsheet if desired.

17. Close the plot window by selecting the X in the upper right corner of the window when done viewing the curve rating plot.
18. Select **OK** to close the *Channel Analysis* dialog.

19. Select **OK** to close the *Channel Calculations* dialog.

5.3 Interpolating Stages Along the Centerline

A scatter point is now created with a computed water surface elevation at each cross section where it intersects the centerline as shown in Figure 1. In order for the flood delineation to work better, interpolate values along the centerline.

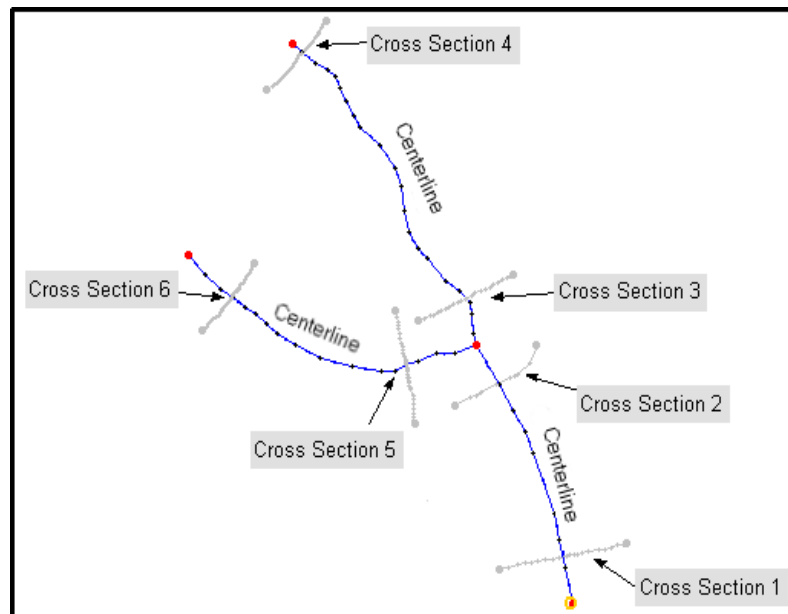
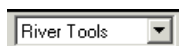


Figure 1 Labels for each cross-section



1. Make sure the “1D-Hyd Centerline” coverage is active in the Project Explorer (this should also activate the “River Tools” menu in the *Model* drop-down list).
2. Select *River Tools / Interpolate Water Surface Elevations*.
3. In the *Interpolate Stages* dialog, set the *Create a data point* field to “At a specified spacing”.
4. Enter “30” for the *Data point spacing*.
5. Select **OK**.

Notice the many scatter points added along the centerline arcs, resulting in a view similar to that in Figure 2 (the symbol for scatter points may be different).

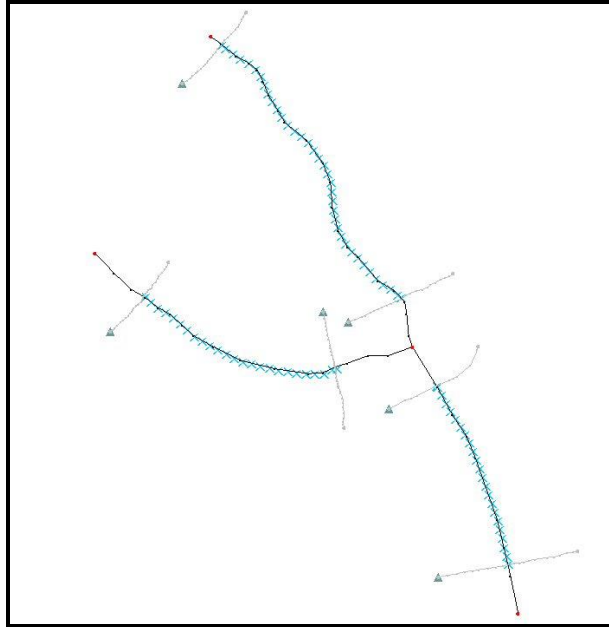



Figure 2 View of Interpolated scatter points

If the scatter points did not interpolate as shown above, the most probable reason is that the original scatter points were not placed close enough to the Centerline arc. In order to continue, delete the scatter point set and either try creating the points again, or open the sample scatter point set contained in *samplescatter.wms*.

5.4 Delineate the Floodplain



1. Switch to the **Terrain Data**  module.
2. Select *Flood / Delineate*. The *Floodplain Delineation* dialog will appear.
3. Change the *Max search radius* to “1000”.
4. Toggle on the *Flow path option* and enter a *Max flow path* value of “1000”.
5. Select **OK**.
6. Turn on the display of the flood depth contours, “elevation (elev)_fd” in the “Terrain Data” folder of the Project Explorer, to view the results

The floodplain has finished delineating based on the water elevations that were calculated independently. The next section will describe how to open a set of scatter points that were entered into a text file.

6 Delineation from HEC-RAS Data



6.1 Reading the HEC-RAS Solution

In this section, use water surface elevations computed as a result of a separate exercise that builds a HEC-RAS project. First, read a WMS project file that contains a TIN and then import a HEC-RAS solution from a model developed from the TIN:

1. Select *File / New* .
2. Select **No** when asked to save changes.
3. Select *File / Open* .
4. Open “flood.wpr” in the *Open* dialog.

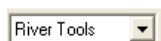
To simplify the display, hide some elements of the model



5. From the Project Explorer, hide “Land” (TIN) in the “Terrain Data” folder by toggling off its check box.
6. Switch to the **River**  module.
7. Select *Display / Display Options*  to open the *Display Options* dialog.
8. On the *River Data* tab, toggle off the *River Hydraulic Schematic* check box.
9. Select **OK**.
10. Select *HEC-RAS / Read Solution*. The *Open* dialog will appear.
11. Open “hecrun.prj”.

The HEC-RAS solution is read in as a set of scatter points, with one water surface elevation for each cross section. The floodplain delineation interpolation will work much better if there are more points than the sparsely spaced points that are part of the solution. To increase the density of the scatter points, interpolate between existing points to create additional points along the centerline and cross section arcs. Since the water surface is assumed constant along a cross section and varies linearly between this does not violate any of the modeling assumptions.


12. Toggle off the check box for the “Materials” coverage.
13. Activate the “1D-Hyd Centerline” coverage in the Project Explorer.
14. If needed, choose “River Tools” from the *Model* drop-down list.
15. Select *River Tools / Interpolate Water Surface Elevations*.
16. In the *Interpolate Stages* dialog, choose “At a specified spacing” for the *Create a data point* option.
17. Enter “60” for the *Data point spacing*.
18. Select **OK**.
19. Select the “1D-Hyd Cross Section” coverage from the Project Explorer.
20. Select *River Tools / Interpolate Water Surface Elevations*.
21. Select **OK** in the *Interpolate Stages* dialog to interpolate with the options set as before.




Notice that the screen is more densely populated with scatter points. Note that along the centerline arcs, the scatter points have been interpolated in a linear fashion, while along cross section arcs, the points that were added have the same data value as the original point.

6.2 Using a Flood Barrier Coverage

WMS allows confining a delineation from the given elevation data by creating a flood barrier coverage. Arcs representing ridges or levees (existing or proposed) may be created in the model, and these in turn alter the floodplain delineation by restricting interpolation of the floodplain so that values on the dry side of the levee are not interpolated. In this exercise, a map file of arcs representing a proposed levee will be used to demonstrate the effects of incorporating a flood barrier coverage.

1. Select *File / Open*  to access the *Open* dialog.
2. Open the file named “levee.map”.

Two new coverages are now added to the “Map Data” folder in the Project Explorer. The coverage entitled “proposed levee” is a Flood Barrier coverage and “breakline” is a General coverage.

3. Verify that proposed levee is the active coverage in the Project Explorer.
4. Select the **Zoom**  tool.
5. Zoom in around the proposed levee as shown in Figure 3. The proposed levee is located along the west bank of the tributary stream.

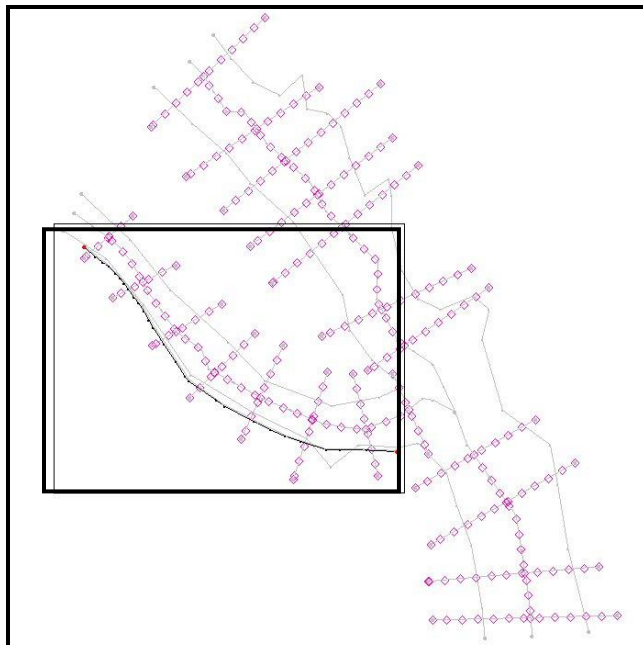


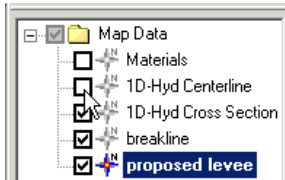
Figure 3 Zoom in on the arc representing the levee


Contouring of floodplain datasets in WMS is based on TIN vertices. Therefore, it is important to make any necessary changes to the TIN before performing floodplain delineation, especially if comparisons are to be made between different scenarios.

The flood extent is contoured to midpoints on triangle edges between flooded and dry areas. It is therefore recommended that a breakline be created on the “river side” of the flood barrier coverage in order to improve the visualization of the delineated floodplain. This breakline and the flood barrier are then forced into the TIN, effectively confining the flood contours between the two.

Now force the flood barrier and breakline arcs into the TIN. The breakline is located immediately to the east of the flood barrier (It probably cannot be seen unless zooming in closely around the flood barrier arc).


To better distinguish the proposed levee and breakline arcs, hide the 1D-Hyd Centerline coverage.




6. Toggle off the check box for “1D-Hyd Centerline” coverage in the Project Explorer.
7. Choose the **Select Feature Arc**  tool.
8. Select the flood barrier arc.
9. Select *Feature Objects / Arcs* → **Breaklines**.
10. When prompted in the *Select Arc type* dialog, choose *Use all arcs as breaklines*.
11. Select **OK**.
12. At the next prompt in the *Select Interpolation Option* dialog, choose *Interpolate Z values from existing TIN*.
13. Select **OK**.
14. Activate the “breakline” coverage by selecting it from the Project Explorer.
15. Select the breakline arc.
16. Select *Feature Objects / Arcs* → **Breaklines**.
17. When prompted, choose *Use all arcs as breaklines*.
18. Select **OK**.
19. At the next prompt, choose *Interpolate Z values from existing TIN*.
20. Select **OK**.

6.3 Delineating the Floodplain

Now that the breaklines have been added to the TIN, delineate the flood plain:

1. Switch to the **Terrain Data**  module.
2. Select *Flood / Delineate*. The *Floodplain Delineation* dialog will appear.
3. Choose the *User defined flood barrier coverage* option.
4. Make sure the *Search radius* option box is toggled on and enter “1000” for the *Max search radius*.
5. Enter “500” for the *Max flow distance*.
6. Make sure the *Quadrants* check box is toggled on.
7. Enter “4” for the *Number of stages in a quadrant*.
8. Accept the default solution and dataset names.
9. Select **OK**.

It may take some time for WMS to compute the floodplain delineation

10. From the Project Explorer, toggle-on the “Land” (TIN) check box in the “Terrain Data” folder to show it again.
11. Select the **Frame**  macro.
12. Select the dataset named “W.S. Elev-PF 1_fd” in the “W.S. Elev-PF 1 (FLOOD)” folder. The screen should appear similar to Figure 4.

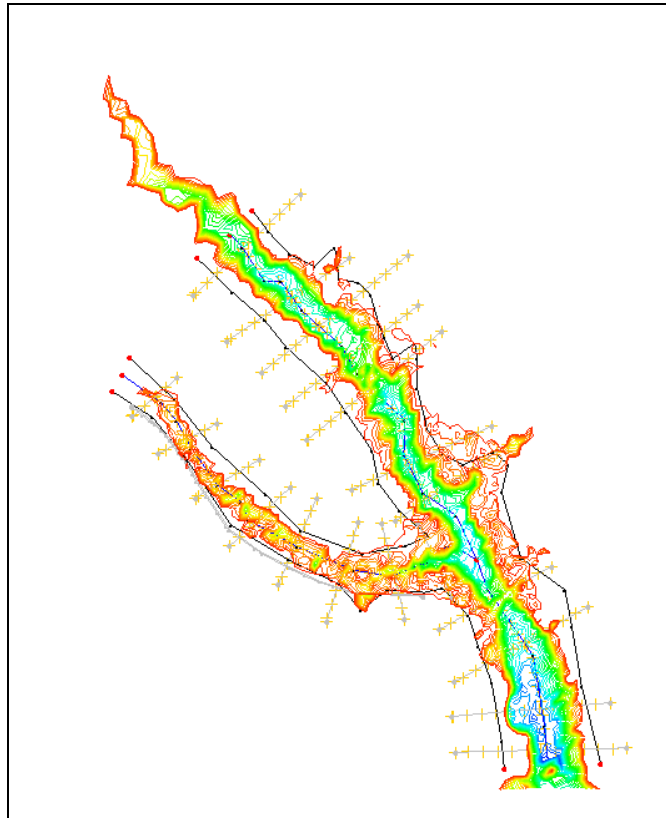


Figure 4 Plot of floodplain depths

These contours correspond to the water depths in the floodplain area. To view the water surface elevation dataset:

13. Select the dataset named “W.S. Elev-PF 1_wl” from the Project Explorer.

7 Creating a Flood Extent Coverage

Flood depth and water level information are stored with the TIN, but WMS allows for the creation of feature objects from this data. In floodplain delineation, it may be useful to create a flood extent coverage. This coverage defines the boundary of the flood and may be exported for use in GIS applications. To create the flood extent coverage:




1. Select *Flood / Conversion / Flood* → **Extent Coverage**.
2. In the *Flood Extent Coverage* dialog, select “W.S. Elev-PF 1_fd” from the *Select Flood Depth Dataset* list.
3. Select **OK** (accept the default inundation limit and coverage name).
4. If prompted, select **OK** to use all arcs.

The flood extent boundary is converted to feature lines and WMS will try to build a polygon enclosing the flooded area. However in this case it reaches the boundary of the TIN and so a complete polygon is not available. Close the polygon manually to create an arc to along the TIN boundary and then choosing to Build Polygons.

8 Creating a Flood Depth Coverage

The flood extent coverage essentially divides the watershed area into two parts: flooded and not flooded. However, it is often necessary to know not only if an area is flooded but also how much flooding has occurred.

It is common to divide the flooded area into zones, each with a depth range. In WMS, these zones are created by making a flood depth coverage. To create a flood depth coverage:

1. Select *Flood / Conversion / Flood* → **Depth Map**.
2. In the *Flood Depth Coverage* dialog, select “W.S. Elev-PF 1_fd” from the *Select Flood Depth Dataset* combo box.
3. Note the ranges and attributes of the five “zones” or “flood classes”.
4. Select **OK**.
5. Select the **Zoom**  tool.
6. Zoom in to view the bottom portion of the main channel.
7. Switch to the **Map**  module.
8. Click on the **Select Feature Polygon**  tool.
9. Double-click inside a few of the polygons that have been created. This will bring up the *Flood Extent Attributes* dialog, which include the average flood depth for the zone.
10. Click **OK** to close the dialog.

9 Conclusion

This exercise demonstrated using WMS to perform floodplain delineations in conjunction with:

- A flood barrier coverage
- Water surface elevations computed with HEC-RAS
- User-defined water surface elevations, created either interactively, or opened with a 2D scatter point file
- Post-processing in the form of creating Flood Extent, Flood Depth, and Flood Impact maps