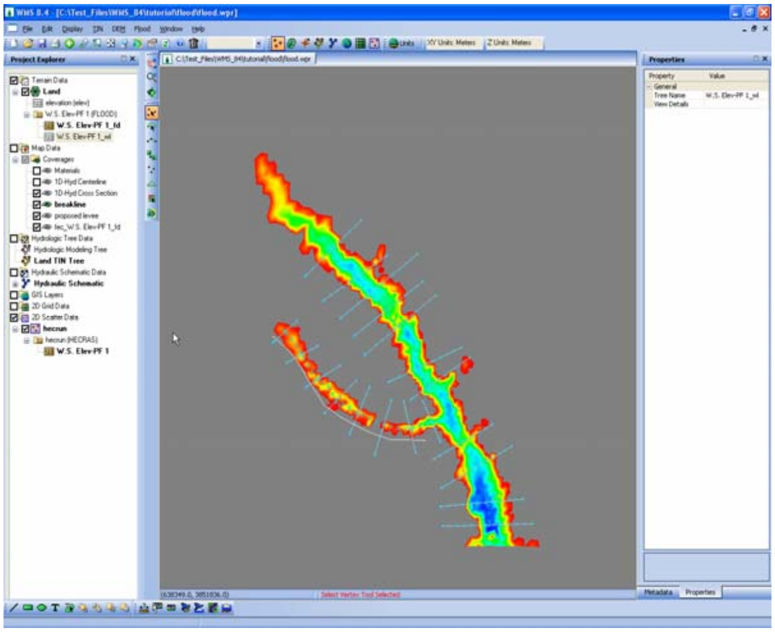
v. 8.4

WMS 8.4 Tutorial

Hydraulics and Floodplain Modeling – Floodplain Delineation

Learn how to us 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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2 Introduction

This exercise demonstrates how to perform a floodplain delineation with WMS. Before WMS can delineate a floodplain, users must provide an elevation TIN (Triangulated Irregular Network) and a scatter point data set 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.

3 Objectives

This exercise will familiarize you with 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 teach you 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

4 Floodplain Delineation Options

You can 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.

Users may want to 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, we will 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. Close all instances of WMS
2. Open WMS
3. Select ***File | Open***
4. Locate the folder ***C:\Program Files\WMS84\tutorial\flood***
5. Open *"flood.tin"*

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

6. Right-click on *Land* under *Terrain Data* on the Project Explorer and select ***Display Options***
7. On the *TIN* tab, toggle off the check box for *Unlocked Vertices* (it may already be off)
8. Toggle off the check box for *Triangles*
9. Select *OK*
10. Select ***File | Open***
11. Open *"samplescatter.wpr"*
12. Select ***Flood | Delineate***
13. Enter 100 for the Max search radius

14. Enter "sr100" for the solution name
15. Select *OK*

We will now change the Search radius and re-calculate a floodplain

16. Select ***Flood* | *Delineate***
17. Increase the Max search radius to 500
18. Change the solution name to "sr500"
19. Select *OK* to delineate a new floodplain
20. Examine the flood depth solution by selecting the sr100_fd data set.

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.

21. Delineate two additional floodplains using Max search radii of 1000 and 2000, and set the solution names to "sr1000" and "sr2000"
22. Select the corresponding flood depth data sets (sr1000_fd and sr2000_fd)

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

Now, we will experiment with using different Flow path values.

23. Select ***Flood* | *Delineate***
24. Enter 1000 for the Max search radius
25. Toggle on the *Flow path* check box
26. Enter 500 for the Max flow distance
27. Rename the solution as "fp500"
28. Select *OK*
29. Delineate two additional floodplains similarly by using Max flow distance values of 1500 and 3000 and examine their solution sets.

Once again, there is little variation in these last two delineations. Therefore, we might leave our 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 until you get a feel for how they change the floodplain delineation.

5 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 data set (in this case, the data set would be water surface elevation values for each coordinate). Each coordinate may be associated with more than one data value. Figure 5-1 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
```

Figure 5-1: File format for 2D scatter point file

1. Select ***File* | *New***
2. Select *No* when asked if you want to save changes

For this exercise, the scatter file has been created for you. We will open it with a text editor to view how it is set up:

3. Select ***File* | *Edit File***
4. Open *"wse.txt"*
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 data set might represent current water levels, and WSE2 might represent expected levels given future developments, such as a proposed levee.

6. Close Notepad

5.1 Open the Scatter Point Data

1. Select ***Flood* | *Read Stage File***
2. Open *"wse.txt"*
3. Select ***File* | *Open***
4. Open *"flood.tin"*

5.2 Delineate the Floodplain

1. Select ***Flood* | *Delineate***
2. Choose *WSE1* from the Select stage data set 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***
8. Choose *WSE2* from the Select stage data set list
9. Select *OK*

5.3 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, you will 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. Choose *WSE1_fd* in the Original data set combo box
3. Choose *WSE2_fd* in the Modified data set combo box
4. Select *OK* to accept the default classes, ranges, attributes, and names
5. Select *Yes* to create the coverage

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

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

The dialog that opens shows the amount of change from the original data set to the modified data set, 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.

6 Creating Scatter Points with the Channel Calculator

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

1. Select ***File | New***
2. Select *No* when asked if you want to save your changes

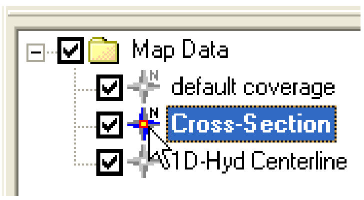
WMS has a tool that allows us to interactively create scatter points and assign a data value to each point. The values for water surface elevations might be obtained by digitizing from a background image, or from another source. You can also use a cross section coverage in conjunction with the channel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

For this example, we will use the Channel Calculator to compute water depths for various cross sections in our 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).

We will begin by opening a map file containing a Cross Section coverage. This coverage contains several cross section arcs along our stream reaches.

6.1 Open the Cross Section Arcs and River Centerlines

1. Select ***File* | *Open***
2. Open the files named *"flood.tin"* and *"cross_section.map"* and *"reaches.shp"*
3. Right-click on the Coverages folder in the Project Explorer and select ***New Coverage*** from the pop-up menu
4. 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*
9. 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***
15. Change the Arc type to *Centerline*
16. Select *OK*
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.

6.2 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 we calculate flow depths, we need to jot down the depth values so we can recall them later when we create the 2D scatter points.

1. Switch to the *Hydrologic Modeling* module
2. Select ***Calculators* | *Channels***
3. Change the Type to *Cross Section*
4. Click the *Select Cross Section* button
5. Select *Cross section 1* and select *OK*

The cross section displays in the small graphics window. You can 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 we are ready to set necessary parameters to perform calculations for depths.

7. Change the Units to *Metric*
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 the *Create Stage Point* button
12. Repeat the previous steps 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

13. Select the *Compute Curves* button

The default is to create a rating curve for the entered flow vs. depth for the selected cross section, but you can also create curves for all of the other options listed. Furthermore, you can enter a depth in the Channel Calculator and compute Depth on the Y Axis vs. any of the listed options (Flow would replace the Depth option for the X Axis)

14. Select *OK*

You can right-click in the rating curve plot window to export the data to a spreadsheet if you want.

15. When you are done viewing the rating curve plot, close the plot window by selecting the X in the upper right corner of the window
16. Select *OK* to close the Channel Calculator

6.3 Interpolating Stages Along the Centerline

You should now have a scatter point created with a computed water surface elevation at each cross section where it intersects the centerline as shown in Figure 6-1. In order for the flood delineation to work better we want to interpolate values along the centerline.

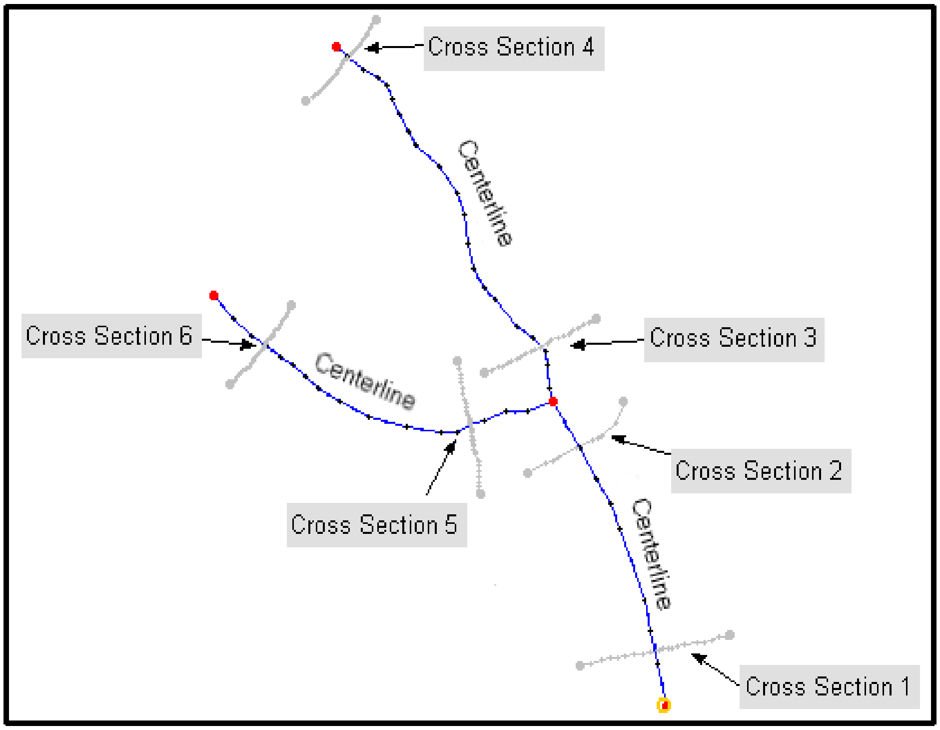


Figure 6-1: Labels for each cross section.

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. Set the Create a data point field to *At a specified spacing*
4. Enter 30 for the spacing
5. Select *OK*

You should see many scatter points added along the centerline arcs, resulting in a view similar to that in Figure 6-2 (the symbol for scatter points may be different).

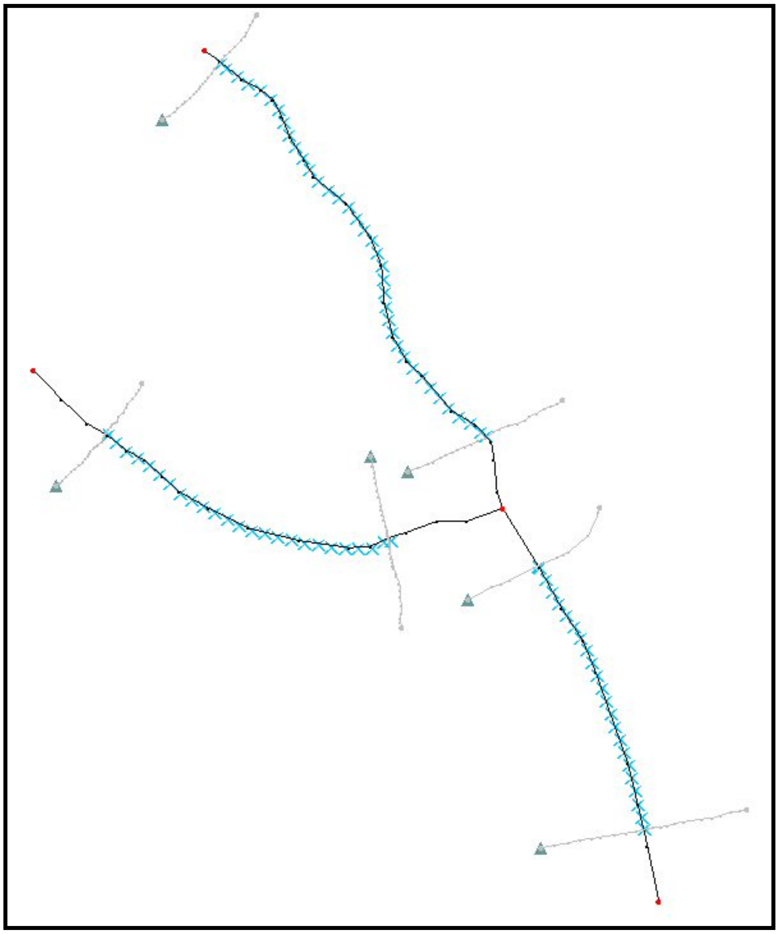


Figure 6-2: View of interpolated scatter points.

If your 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.wpr*.

6.4 Delineate the Floodplain

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

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

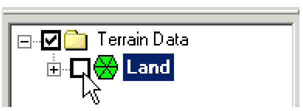
7 Delineation from HEC-RAS Data

7.1 Reading the HEC-RAS Solution

In this section, we will use water surface elevations computed as a result of a separate exercise that builds a HEC-RAS project. First, we will 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 if you want to save changes
3. Select ***File | Open***
4. Open *"flood.wpr"*

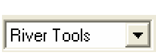
To simplify the display, we will hide some elements of the model



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***
8. On the *River Data* tab, toggle off the *River Hydraulic Schematic* check box
9. Select *OK*
10. Select ***HEC-RAS | Read Solution***
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, we will 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. 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* to interpolate with the options set as before

You should now see that your 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.

7.2 Using a Flood Barrier Coverage

WMS allows users to "confine" 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***
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 7-1. The proposed levee is located along the west bank of the tributary stream.

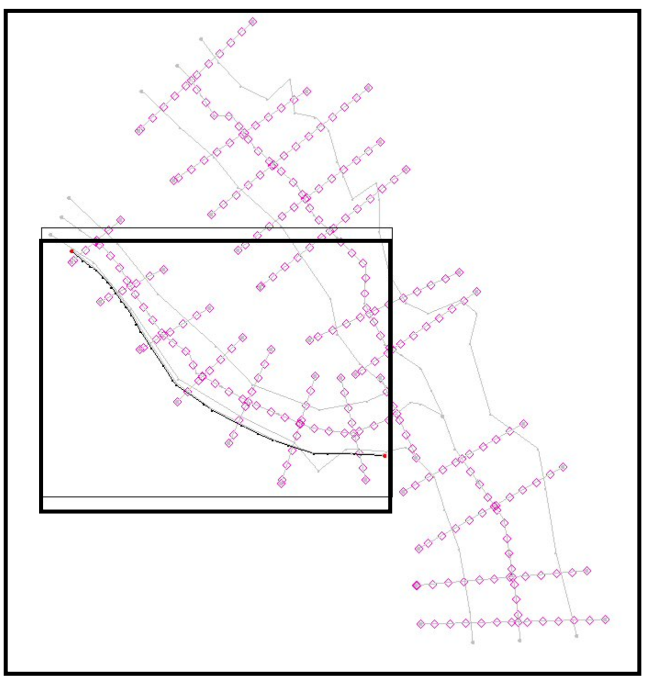


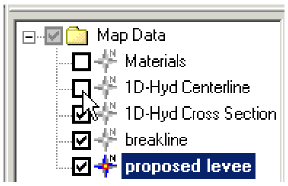
Figure 7-1: Zoom in on the arc representing the levee

Contouring of floodplain data sets 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.

You will now force the flood barrier and breakline arcs into the TIN. The breakline is located immediately to the east of the flood barrier (you probably cannot see it unless you zoom 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, choose *Use all arcs as breaklines*
11. Select *OK*
12. At the next prompt, 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*

7.3 Delineating the Floodplain

Now that we have added the breaklines to our TIN, we are ready to delineate the flood plain:

1. Switch to the *Terrain Data* module
2. Select ***Flood* | *Delineate***
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. We will accept the default solution and data set 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 data set named W.S. Elev-PF 1_fd in the W.S. Elev-PF 1 (FLOOD) folder
13. Your screen should appear similar to Figure 7-2

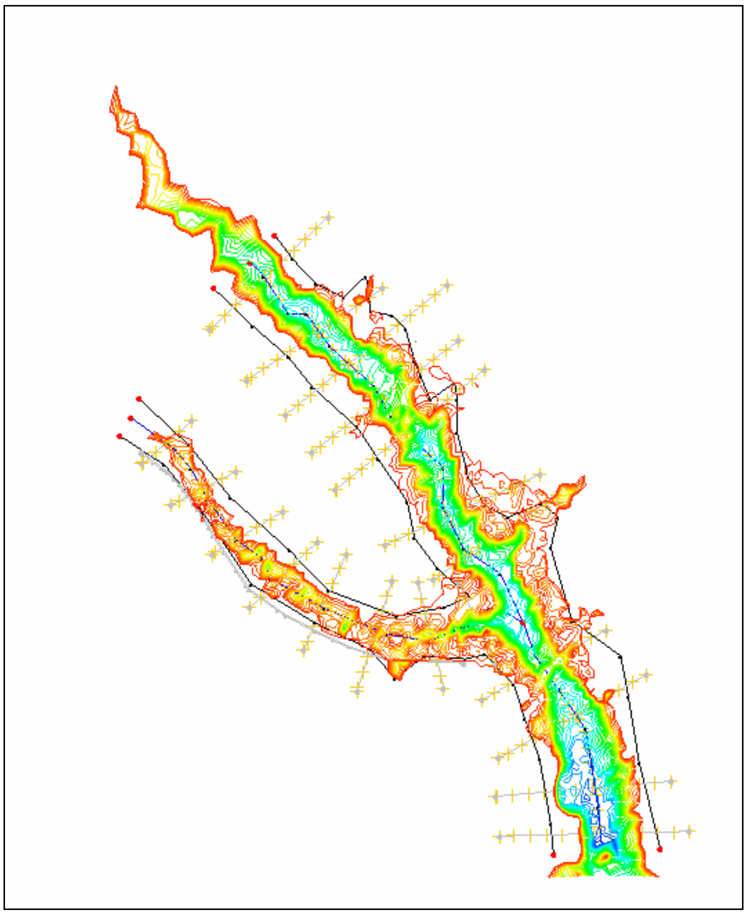


Figure 7-2: Plot of floodplain depths

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

14. Select the data set named W.S. Elev-PF 1_wl from the Project Explorer

8 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. Select *W.S. Elev-PF 1_fd* from the Select Flood Depth Data Set list
3. Select *OK* (we will 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. You could close the polygon manually be creating an arc to along the TIN boundary and then choosing to Build Polygons.

9 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. Select *W.S. Elev-PF 1_fd* from the Select Flood Depth Data Set 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, which include the average flood depth for the zone.

10 Conclusion

After completing this exercise, you should be familiar with 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