

Initial Analysis of Natural and Anthropogenic Adjustments in the Lower Mississippi River since 1880

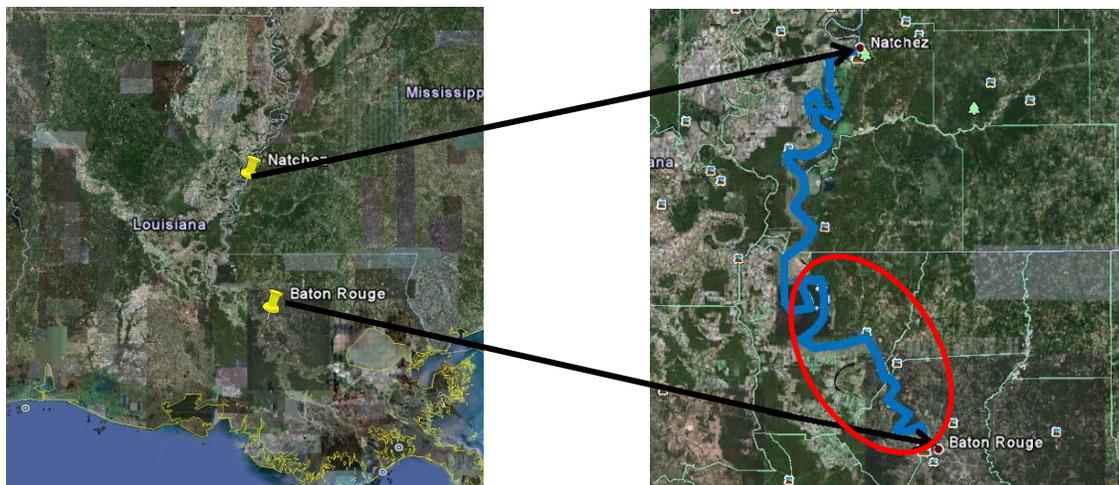
Objective: The objective of this term project is to use ArcGIS to evaluate the relationship between engineer interventions and channel adjustments in three dimensions in a section of the Lower Mississippi River, Natchez, MS to Baton Rouge, LA, between 1880 and the present. See figure 1 below.

Execution: The author will use hydrographic surveys conducted by the US Army Corps of Engineers and the Mississippi River Commission to create three dimensional representations of the river channel in ArcGIS. Channel adjustments will be observed through the progression of subsequent surveys and described qualitatively and descriptively. Using the large body of literature published on this section of the river, the author will describe and relate engineering interventions to channel adjustments.

Data: Data will be taken from the following website. It will also be provided by the New Orleans District of the US Army Corps of Engineers. (Continued on next page)

<http://www.mvn.usace.army.mil/eng2/hydsrv/MSHYD.asp>

Figure 1. The black arrows denote the proposed study area. The red circle is the actual study area.



Data (continued): My primary sources for data are USACE hydrographic surveys from 1915, 1949, 1964, and 1991. The files I used are CAD files, dgn extension, which are digitized versions of the maps found at the link above. Figure 2 below displays part of a map survey as well as a digitized section of the same area.

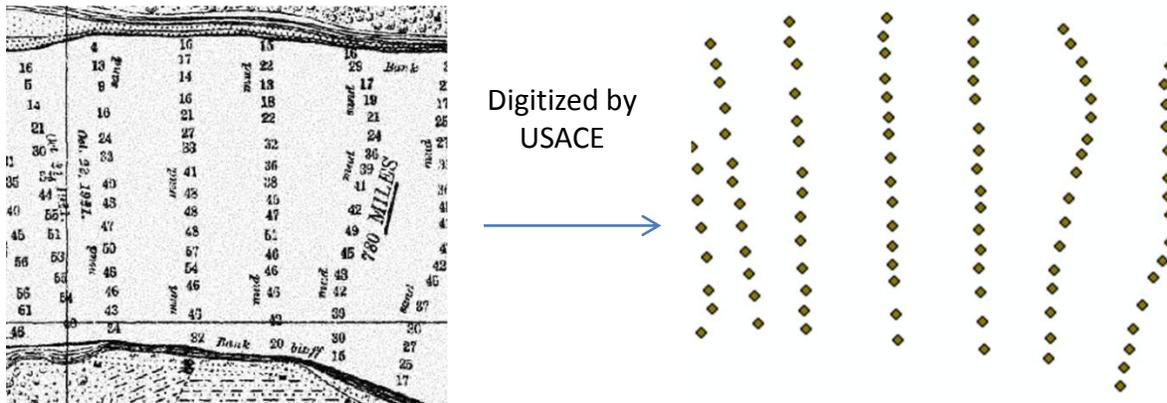
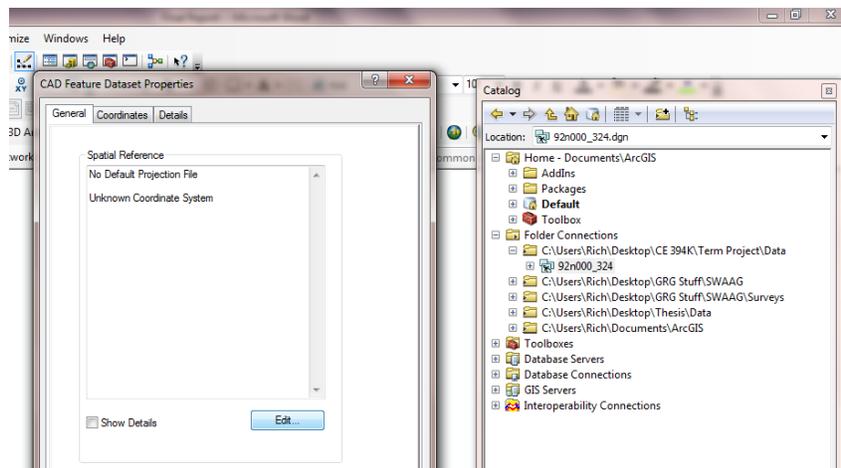


Figure 2. USACE Hydrographic Surveys in Map and CAD format.

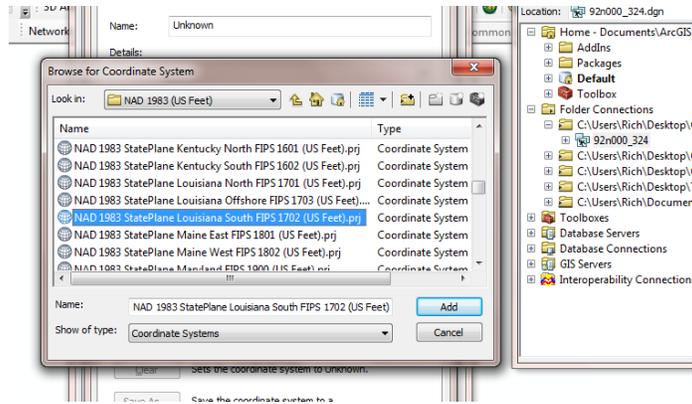
Data Preparation

The CAD files were initially unprojected and unuseable in ArcGIS. Some preparation is required.

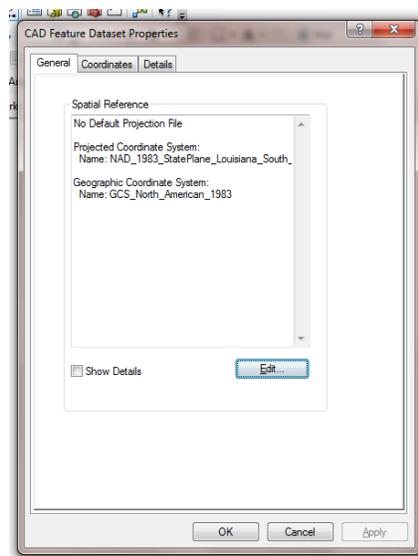
1. Projection. Create a connection to your working folder with the dgn file. Right click on the file → properties. You will see that there is no projection selected.



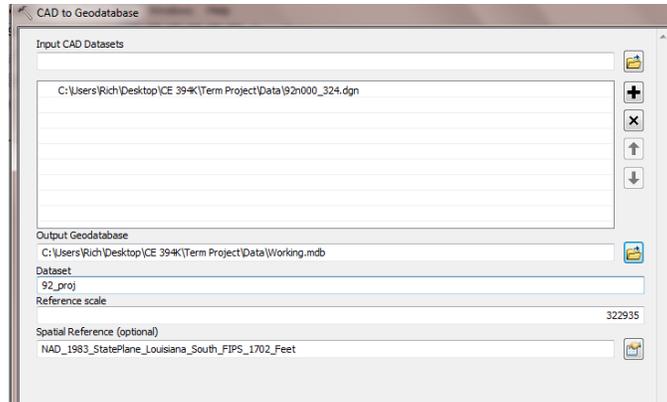
Choose edit → select → projected coordinate system. After some experimentation applying what I learned in the course about projections, I discovered that all four surveys were projected in the NAD 1983 StatePlane Louisiana FIPS 1702 (US Feet). Click add →ok.



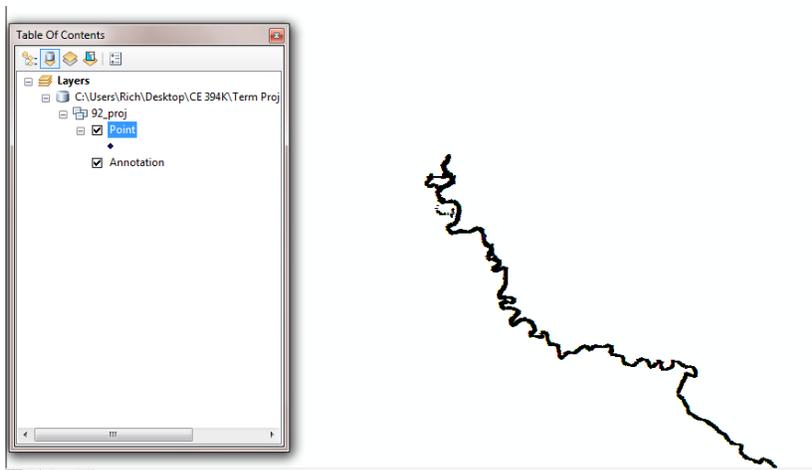
Now, you should see that the file has the correct spatial reference.



2. CAD to Geodatabase. ArcGIS has the capability to convert CAD files to a Geodatabase. Search for “CAD” in the search window and select the “CAD to Geodatabase” tool. Select the dgn file as the “Input CAD file” and the working geodatabase as the “Output Geodatabase”. Initially, when I ran this tool, the tool appeared to run correctly. However, I could not locate the output file. I discovered that the default “Dataset” name (the output file name) was too long for the tool to run correctly. After I changed the “Dataset” name to something short, the tool ran perfectly.



This returns a point file and an annotation file.

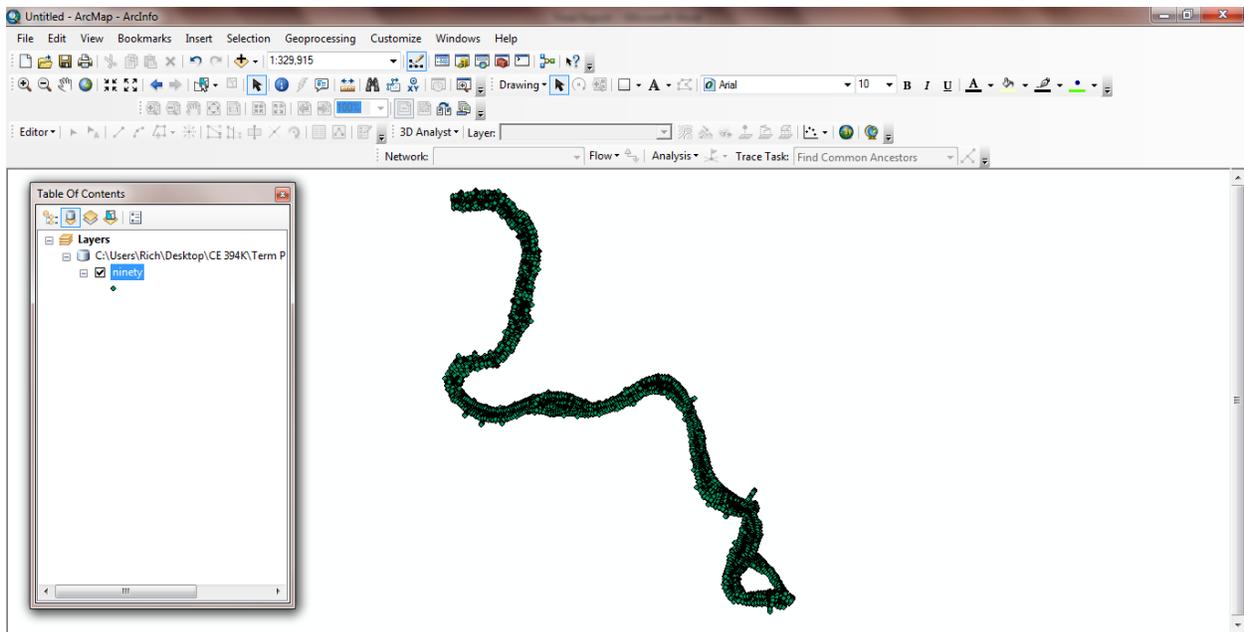
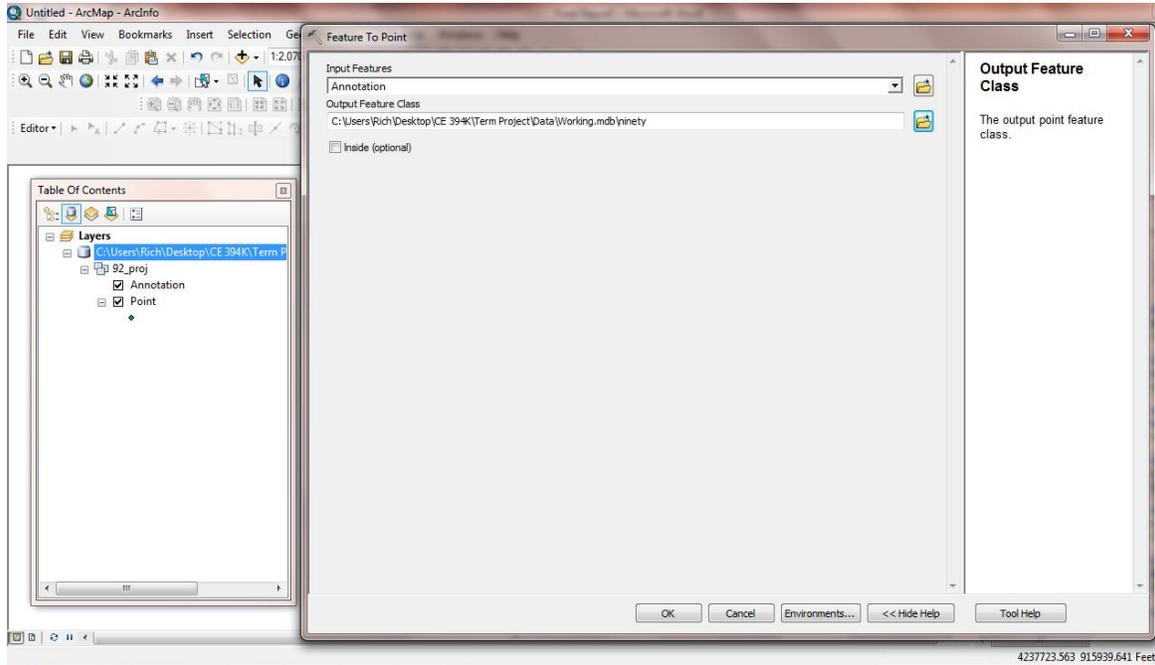


3. Edit file to study area. This particular file has nearly 90,000 points and includes data outside the study area. Next, I will edit and delete data points outside the study area. This will improve processing speed. Click on Editor → start editing. Then select “Select features by polygon” and draw a polygon around the study area.



Choose “switch selection” from table options and then select “delete”, then Editor → Stop Editing.

4. Feature to Point. By now we have a data set that is limited to the study area but is still unuseable with the bathymetry data in annotation files. Use the "Feature to Point" tool to create a point feature file from the annotation file



It is necessary to prepare each survey in this manner.

Conversion to the same vertical datum

Before comparisons between different surveys can be made. Each data set needs to be referenced to the same, or similar, vertical datums. This is a two step process. The main source for comparing each survey is the notes section on each survey. This section states what exactly the values on each map indicate. The second step is ensuring that the data points in each point file match the map survey points. The survey points on the maps do match those in the data files which allows us to use the notes section for reference.

After some study of each notes section, it is apparent that the 1949, 1964 and 1991 surveys are all vertically referenced to “channel bottom in feet” from the Mean Sea Level of 1929 or the NGVD 29. On the other hand, the 1915 survey was recorded as a “sounding below” an average water surface. See figure 3 below for a graphical interpretation of the 1915 survey.

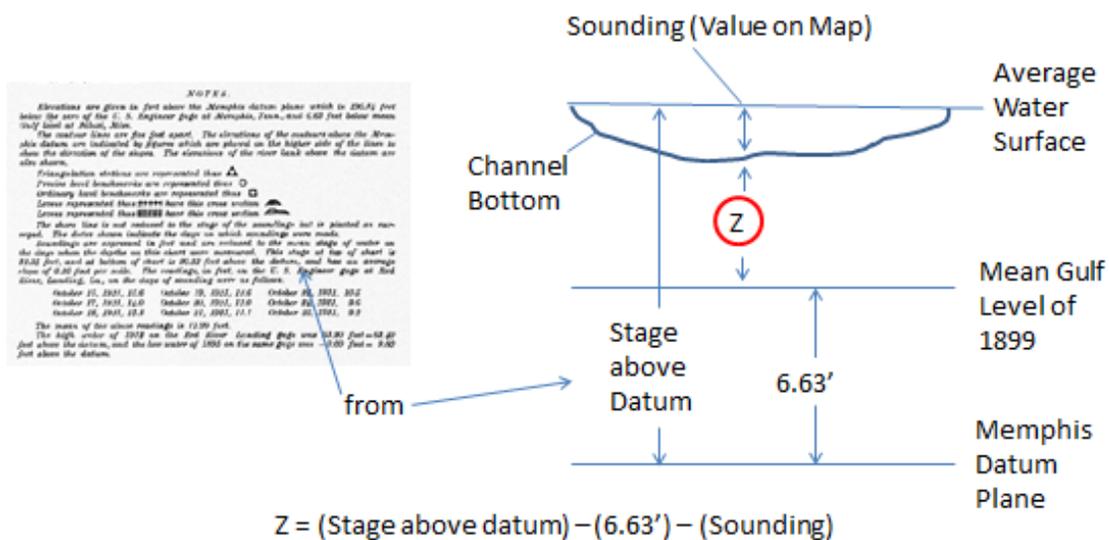


Figure 3: 1915 Hydrographic Survey Data Representation

The value “z”, above in figure 3, is the value we will gain through using the field calculator. This will be referenced to the “Mean Gulf Level of 1899”. It may be nearly impossible to characterize the difference, at each point, between the “Mean Gulf Level of 1899” and the “Mean Sea Level of 1929” and the NGVD 29. So, we will leave our surveys at one of these datums with the understanding that there may be several feet of error.

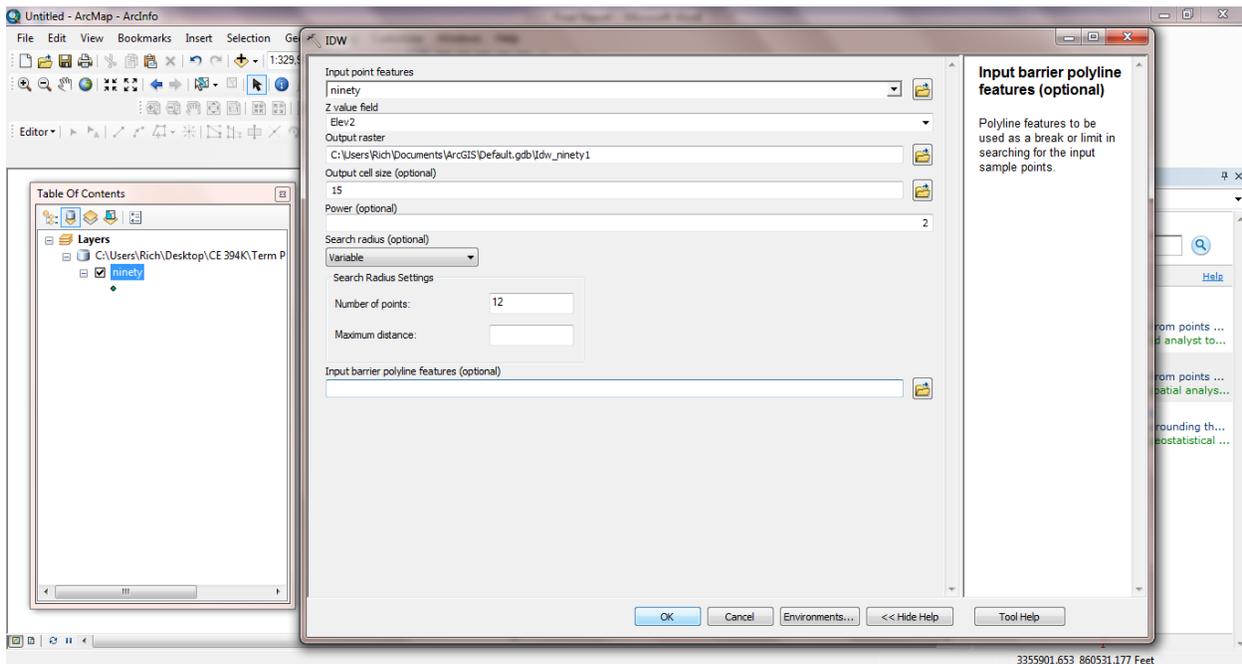
1. Add a field to the point feature file. Open the table for the feature file, select Table options → Add field. Choose float field type.

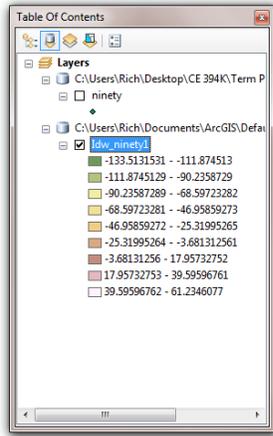
2. Conduct field calculation. Here I conducted a field calculation for each section of the data by map section. I did this to account for the “stage above datum” which was different for each section. Since the “stage above datum” was given as two values, one each at the upstream and downstream section of the map, and the value differences were less than 3 feet, I used the average for each section.

Interpolation, Mask Creation and Clipping

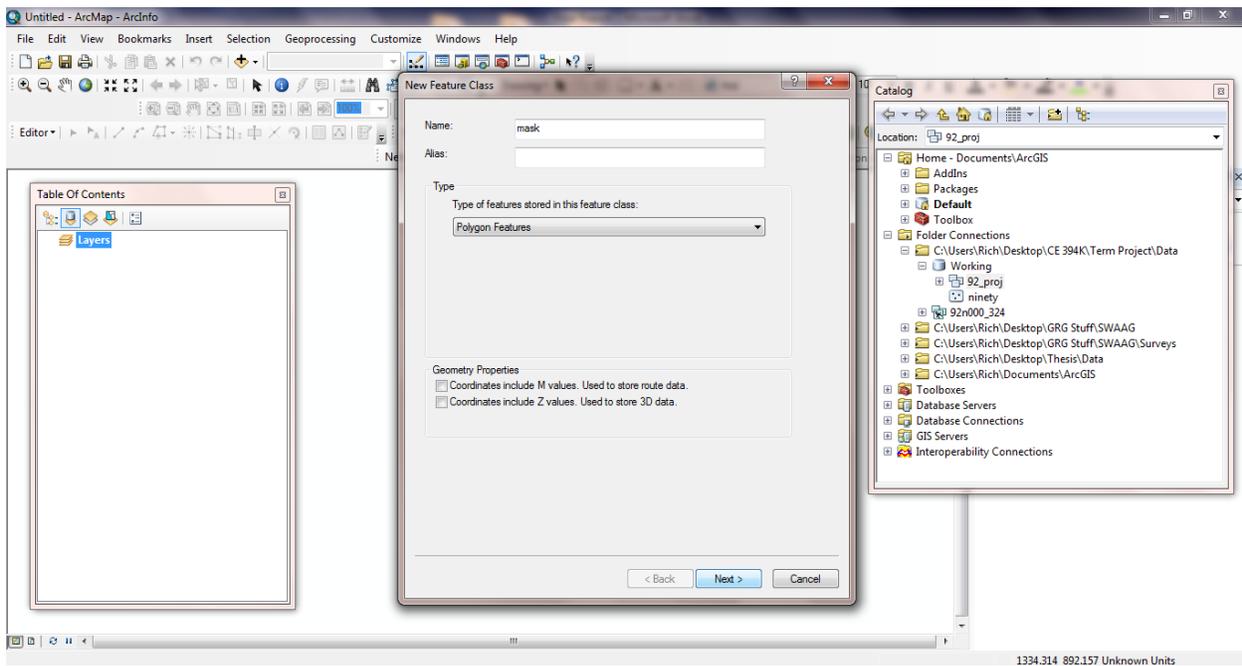
Next I will interpolate each point file using the IDW tool, create a mask for clipping, and then clip the interpolated surface with the point mask. The 1949 and 1964 CAD files included polygons which will serve as a mask.

1. Open the IDW tool and use the point feature class as the input.

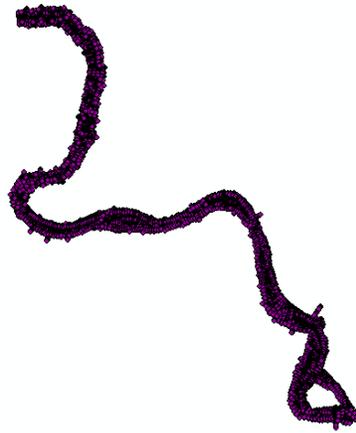
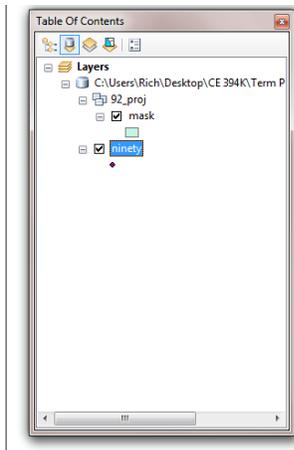




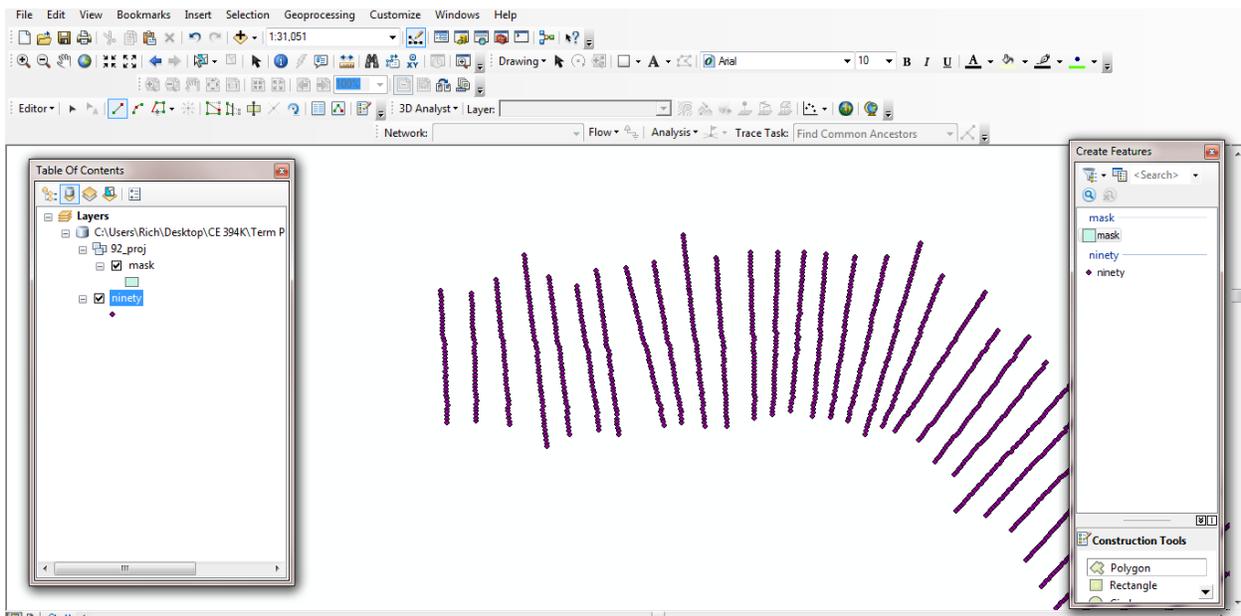
2. Mask creation. Create a new polygon feature class in your geodatabase. Add the polygon to your workspace.



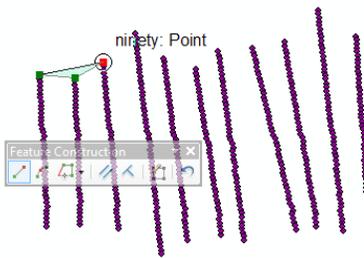
Add the point feature file to your workspace.



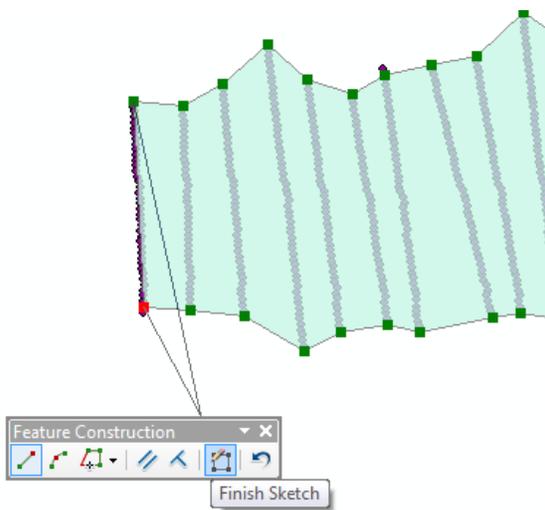
Start editing. On the “Create Features” toolbar, select the mask polygon file and choose the polygon construction tool.



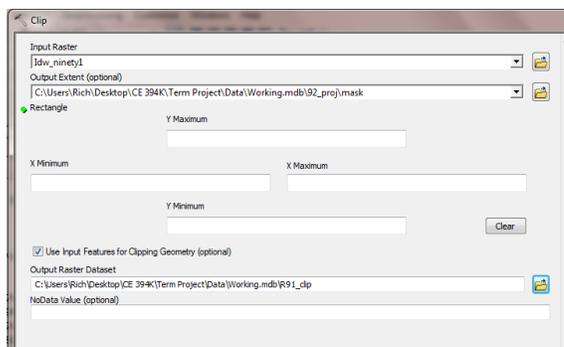
Choose the “straight segment” tool from the “feature construction” toolbar and start clicking on the extent of each survey line.



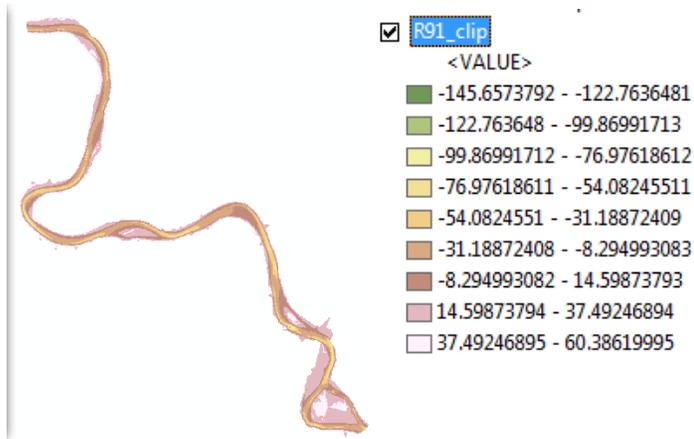
Once you are complete, click on finish sketch, and stop editing. Your mask is ready for use!



3. Clipping. Use the Clip tool from the data management toolbox. This tool is used for clipping rasters versus feature files and is not found underneath the “Geoprocessing” header. Make sure you check the “Use input features for clipping geometry”.



Here is the clipped raster!



Now, conduct this operation for each of the four surveys.

Thalweg Identification

Here I will characterize the thalweg along the channel of each survey. The thalweg is not dependent on bank characterization or water stage on the day the survey was completed and is thus a good way to measure morphologic changes in the river and a good item to compare among survey years.

My start for identifying the thalweg is based on the paper by Dr. Maidment and others at www.cwrw.utexas.edu/gis/gishydro03/Channel/RiverChannels.doc. See figure 4 below for the method outlined in this paper:

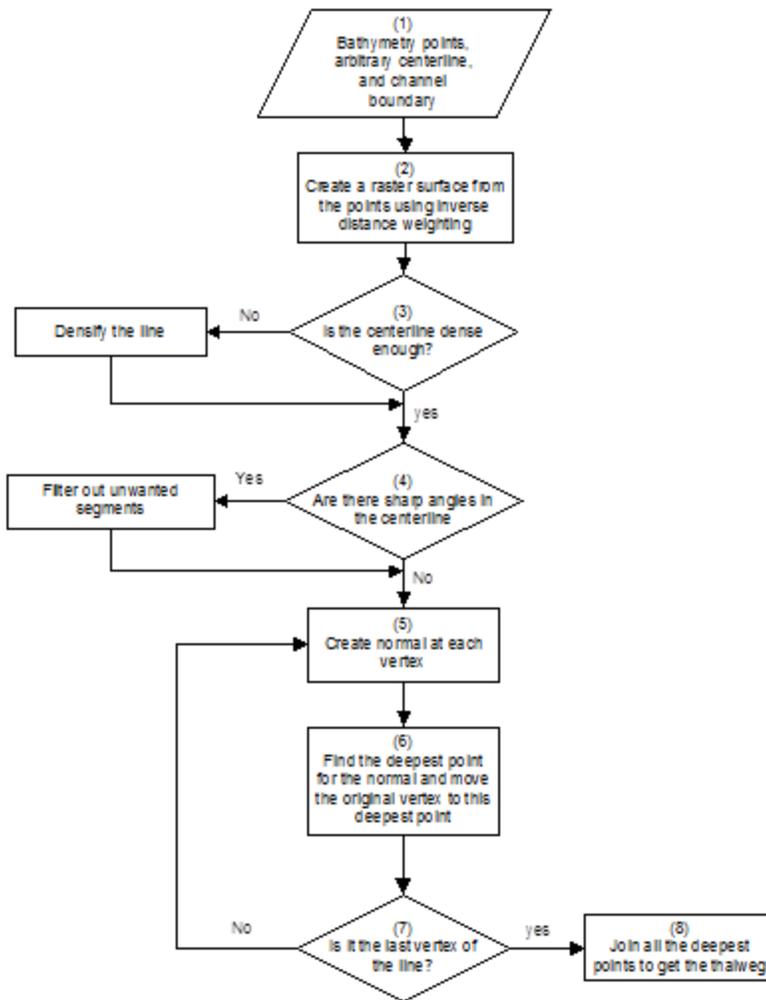


Figure 4: Method to identify the thalweg (Maidment et al, 2005)

After using this method on a small portion of the river channel, I decided I wanted to use a tailored approach to thalweg identification that would suit my needs here. See following text and figure 5 for this tailored approach. The steps are denoted below and on figure 5.

Description of Steps

Step 1. An interpolated raster surface of the channel bottom is required, raster A.

This method of thalweg identification makes use of the fact that the river channel in the study area is mostly north-south trending or east-west trending.

Steps 2 and 3. Next, I create two rasters from the focal statistics tool in order to identify the value of the deepest part of the channel in vertical and horizontal cross sections and assign that value to each cell in the cross section.

Steps 4 and 5. Then, I subtract the original raster surface from the new raster surface to identify the location of the deepest part of the channel. In the output raster here, the deepest part of the channel has the value of zero, while all other areas are a negative value.

Step 6. Then, I load a mask for easy identification of the “zero” (deepest) values. I chose zero as the color red, and all negative values as the color black.

Steps 7 and 8. Here, I create a line feature class with a z component, start editing, and draw the line along the thalweg using the raster built from east-west cross sections to draw the thalweg in north-south trending reaches of the river and the raster built from north-south cross sections to draw the thalweg in the east-west trending reaches of the river. We end here with a two dimensional thalweg, or, a thalweg in planform only.

Step 9. Then I use “interpolate to shape” to give the thalweg the elevation of the values from the original interpolated channel bottom surface, creating a three dimensional thalweg.

Weaknesses of this approach stem from the thalweg rarely orienting absolutely north-south or east-west so that the cross sections I use are not normal to the thalweg. Through it must be noted that the method outlined in figure 4 does not use normal sections either. These sections are “normal” to the arbitrary centerline, not to the thalweg. The method denoted in figure 5 is much quicker than the method from figure 4. In fairness to the authors of the method described in figure 4, their method serves a different purpose than the one pursued here and was very instructional in designing an approach for thalweg identification.

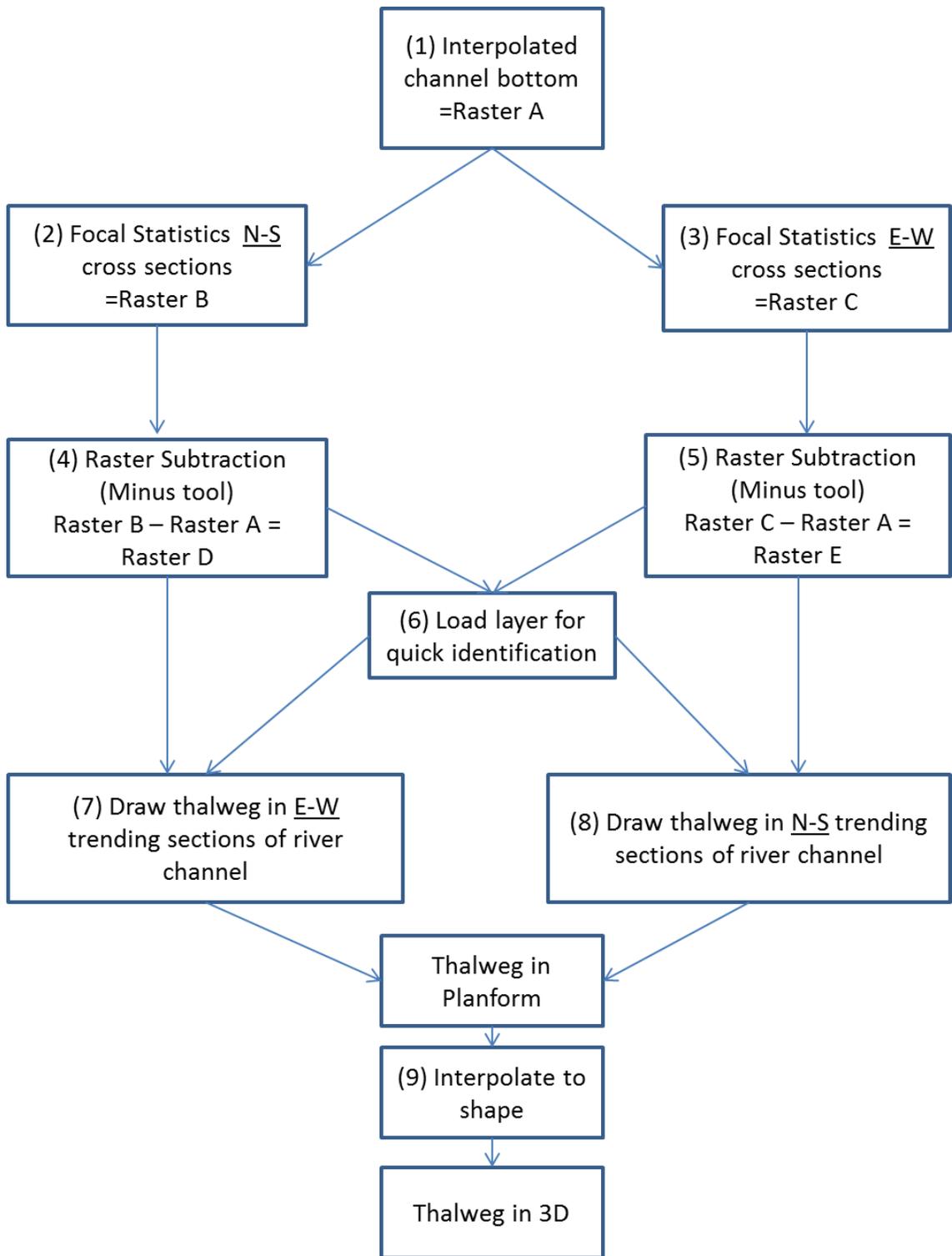
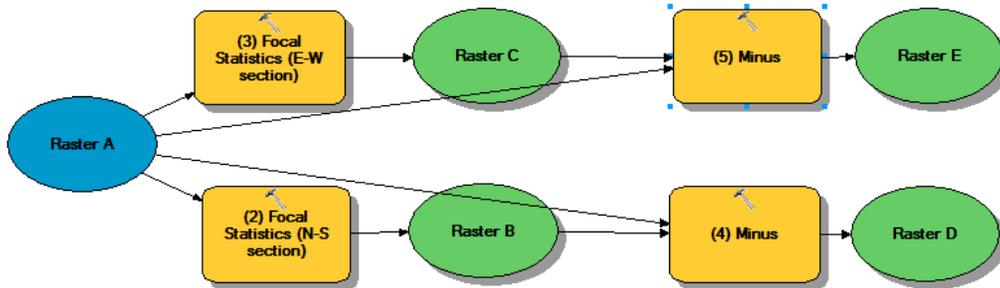


Figure 5. Method used in this study to identify the thalweg.

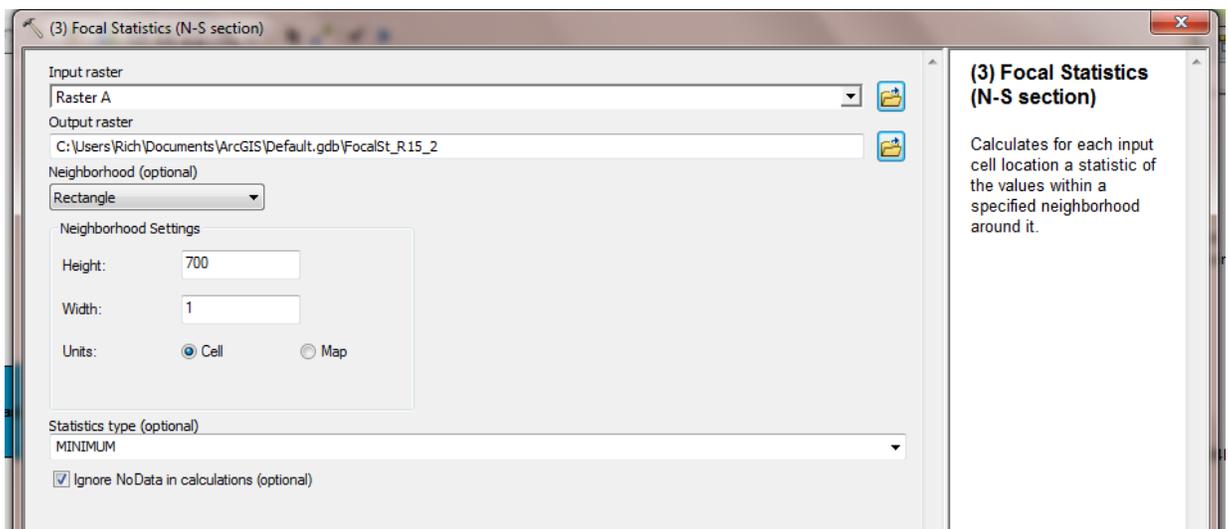
Steps in detail

Step 1. Here I am using the 1915 survey. The clipped, interpolated surface has already been created.

Steps 2, 3,4, and 5 are completed here using model builder. However, each step is explained.

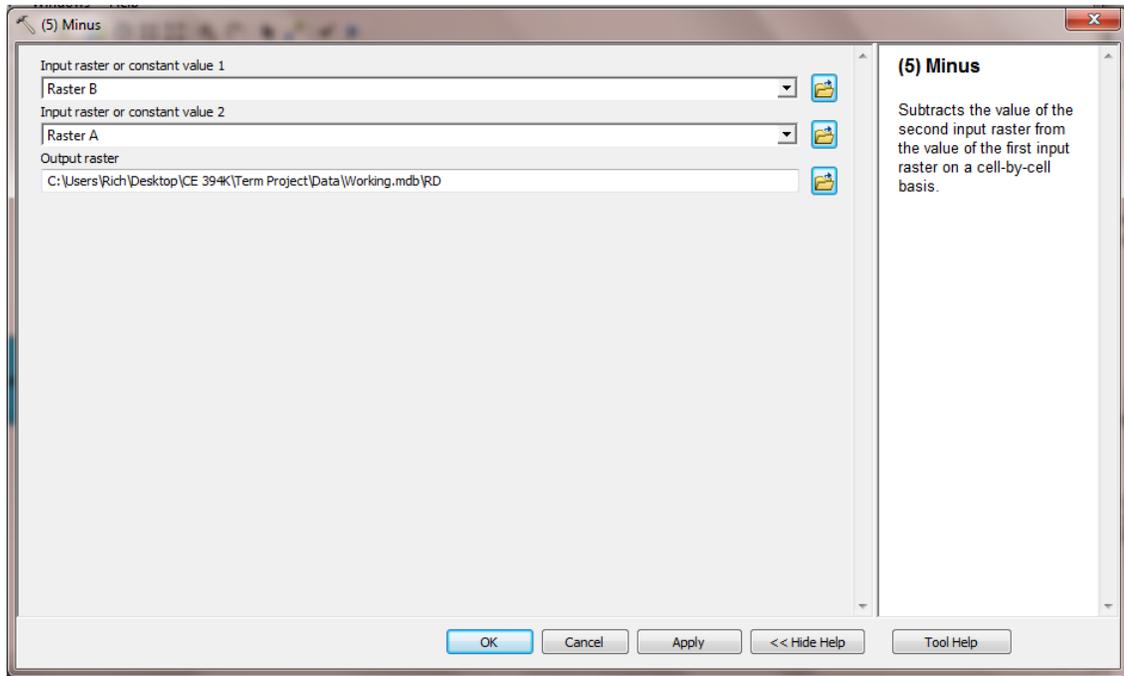


Step 2: Here Focal statistics will calculate the minimum (deepest) value for a rectangle 700 cells high by 1 cell wide. The value of 700 was chosen to capture the entire width of the channel (in east-west trending reaches) but to isolate one meander from another. Because our raster A has a cell size of 15 feet, a value of 700 is equal to 10,500 feet. The channel widths in the study area are generally less than 5,000 feet. Since the specified rectangle is centered on the cell in question, this value of 700 allows cells on the channel margin to return the same values as those in the channel center. Channel meanders are distant enough (e.g. 17,000 feet), that using 700 cells here will isolate each meander and return only the deepest value in that meander's cross section.

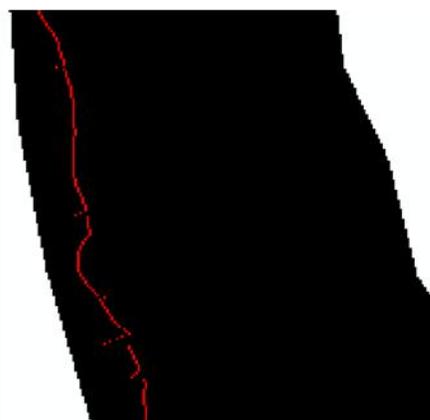
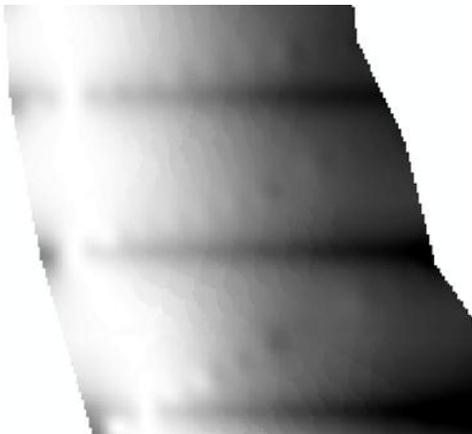


Step 3 is similar to step 2 with a height of 1 and a width of 700 cells.

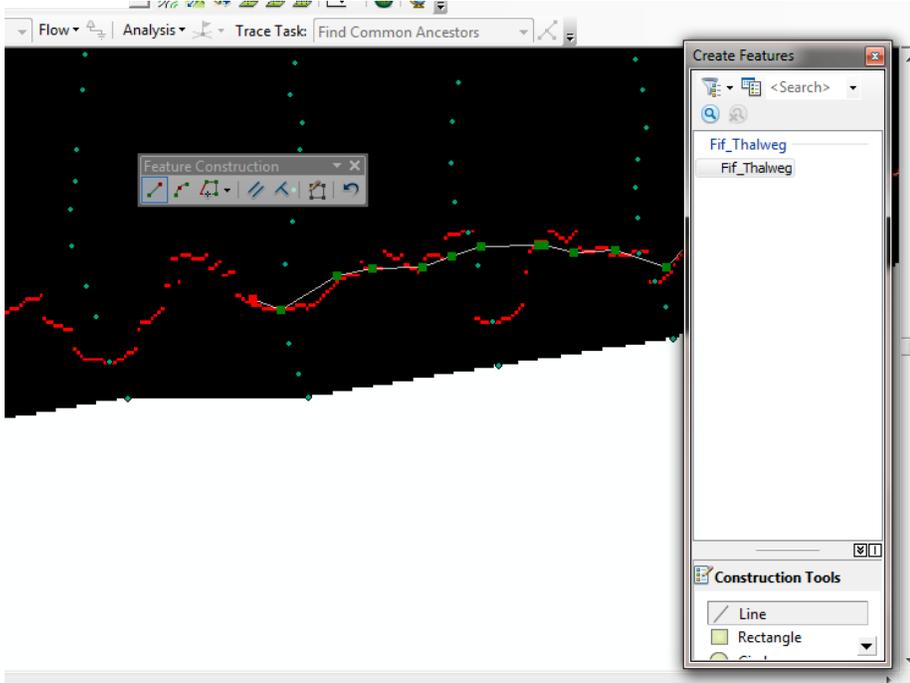
Steps 4/5: This makes use of the “Minus” tool and is a simple function.



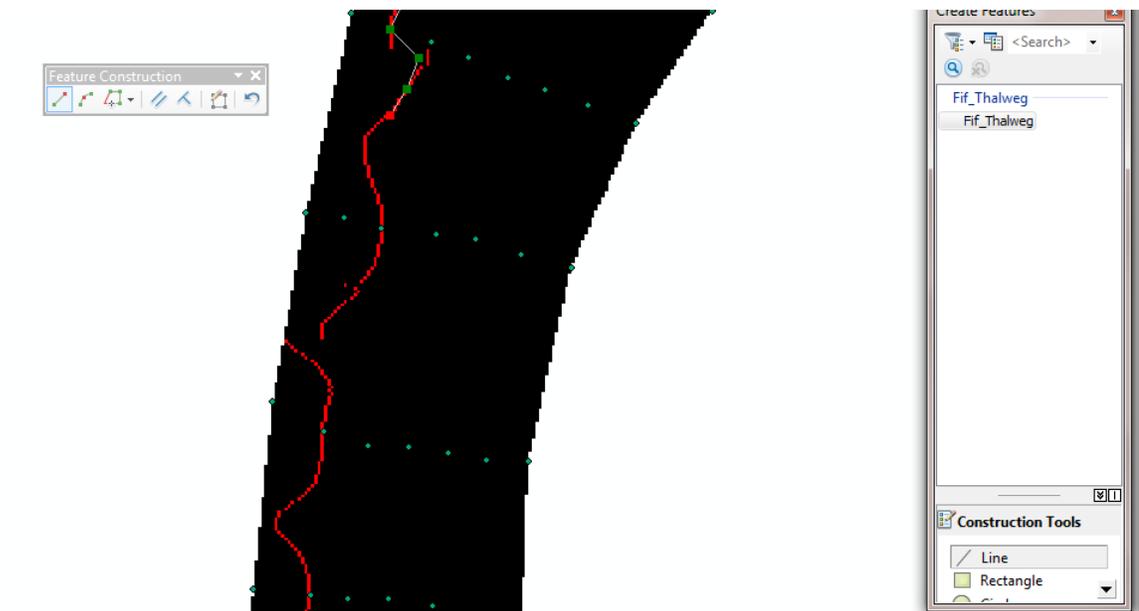
Step 6: Here I load a particular layer to make thalweg identification possible. Below, left, is what the rasters from step 4 and 5 look like when added to the workspace, making use of a stretched grayscale symbology. This isn't very useful. So, I created and saved a classified layer where red is equal to values between 0 and -0.0000001. Then, all other negative values are black. The red line is clearly the thalweg location.



Step 7. Here I am drawing the thalweg along an east-west trending reach of the river using the raster from step 4. I also like to add the original point feature file for bathymetry values for a sense of scale. Here I am making use of the edit, create features, feature construction and construction tools/tool bars.

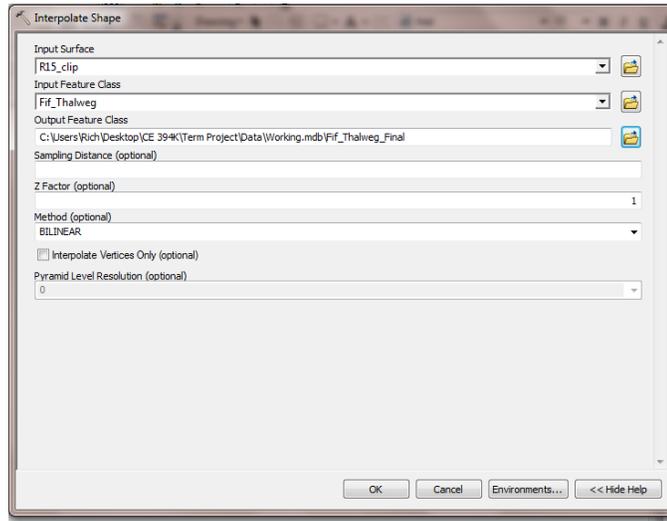


Step 8. Here I am drawing the thalweg along a north-south trending reach of the river using the raster from step 5.

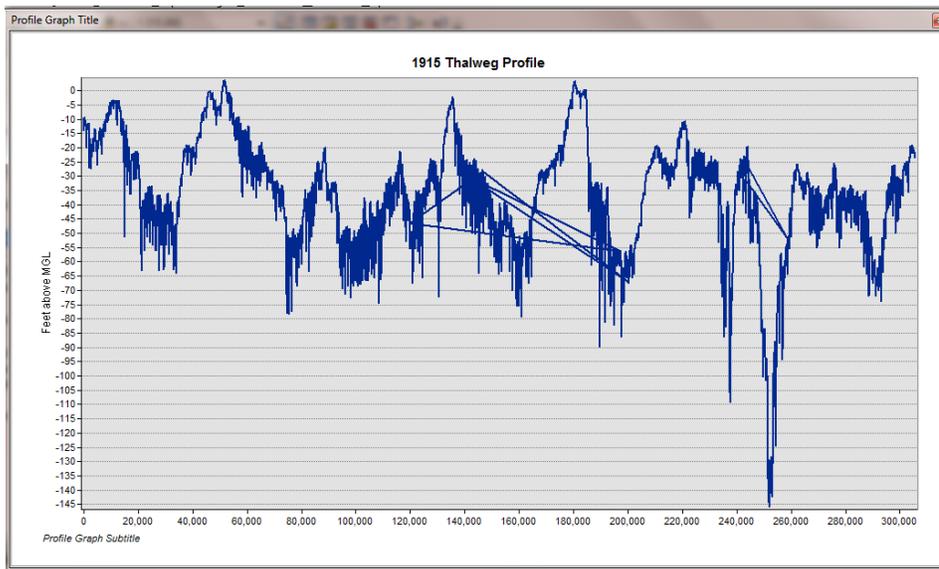


By the time I am done with steps 7 and 8 we have a two dimensional thalweg.

Step 9. Here, we interpolate the thalweg line feature with the clipped, interpolated raster surface, giving the thalweg a z component.

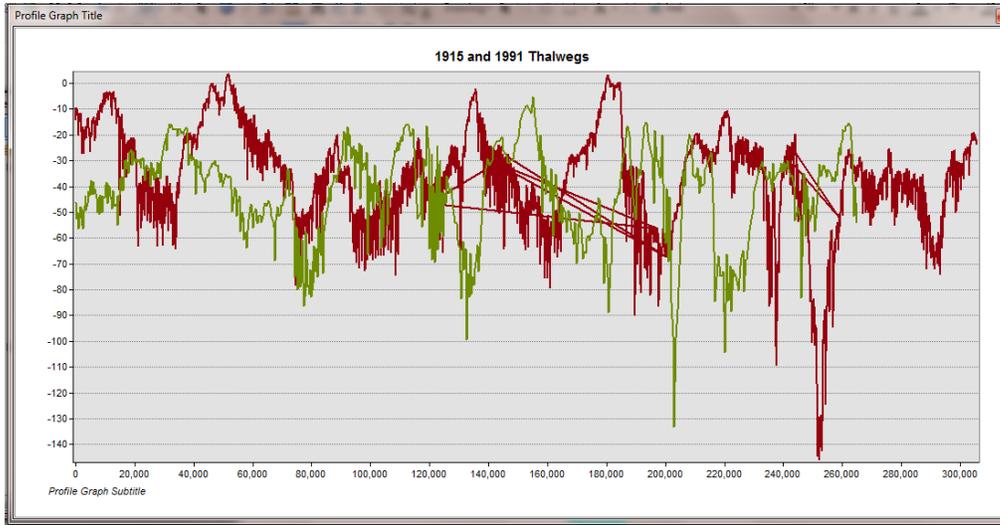


Here is a profile graph of the thalweg from the 3D analyst toolbar. The straight lines represent discontinuities in the thalweg line resulting from null values in the raster surface.

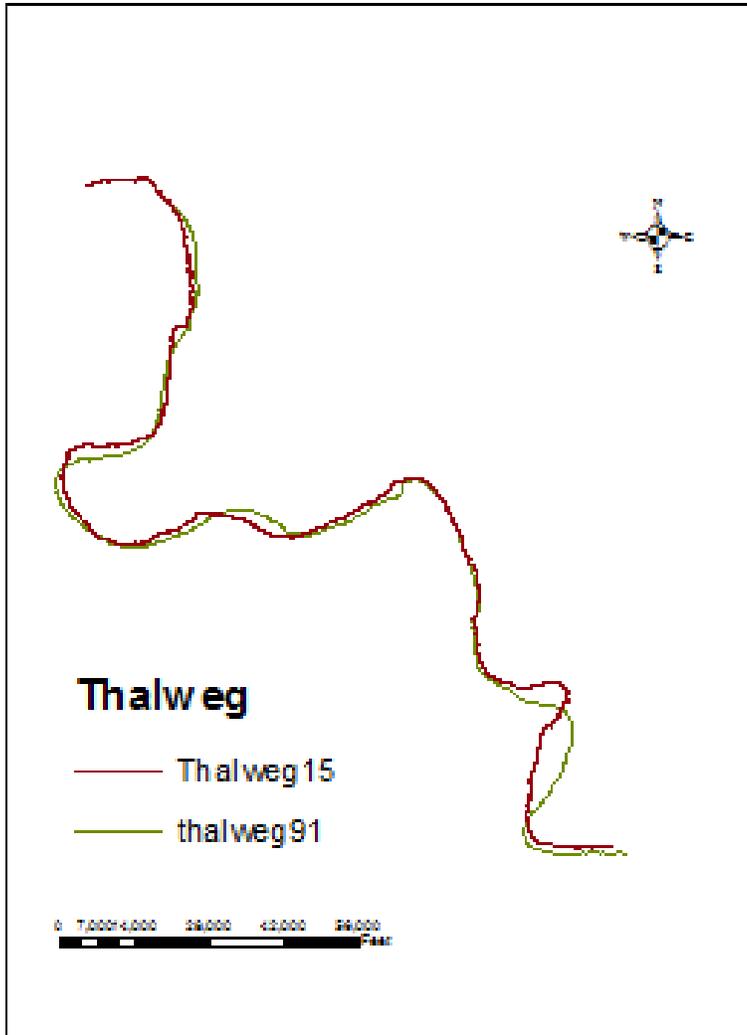


Comparisons of Thalwegs

Below are the 1915 (red) and 1991 (gold) thalwegs. Some work remains to make each thalweg continuous. Also, there is apparently quite a bit of variability in thalweg length, as drawn, in even the same river reach. The 1915 thalweg here is quite a bit longer than the 1991 survey. Because of this, in their present form, these thalwegs are more useful for local comparisons, such as pool spacing, pool depth, and slope on pool boundaries.



Below is a comparison of the two thalwegs in profile. Since the thalwegs are better indicators of geomorphologic change, this comparison is more instructive for discovering where and how the river channel has changed than using the entire channel and channel width.



Conclusions

The four surveys and thalwegs here are projected in the same xy coordinate system (NAD 83 Louisiana State Plane) and referenced to similar vertical datums (the MGL of 1899, the MSL of 1929 or the NGVD 29). Interpolated surfaces of each survey have been completed and the thalweg of each channel has been identified. More work is required for uniform bank width identification and cleaning up of the thalweg lines. This work is the starting point for further research by the author which will include morphologic classification of the channel reach through time, changes related to specific engineering interventions and geologic formations, and an estimate of the effective discharge through time.

Reference

Merwade, V.M., D.R. Maidment, and B.R. Hodges, Geospatial representation of river channels, *ASCE Journal of Hydrologic Engineering*, Volume 10, Issue 3, pp. 243-251, 2005