NHDPlusV2 Workshop Hands-on Exercise

Contents

Objective of Hands-on Session

Provide students with an opportunity to apply the knowledge gained during workshop lectures. See “Workshop Presentations” on the NHDPlus Webpage under “Documentation.

It will also help the student to have access to the NHDPlusV21 User Guide to research documentation on data files and fields.

Conventions Used in Hands-on Instructions

Bold text is generally text that you will see in ArcMap or ArcCatalog. Sometimes, you will need to hover over menus and buttons to see the text provided in the instructions.

There are several places throughout the session where the user must join data to other data. If the user has a problem with a join not executing properly, close your ArcMap session, remove any existing indexes using ArcCatalog, re-open ArcMap and try the join again.

Occasionally, the instructions request that you save the ArcMap mxd. This is simply good practice and in some instances you will need the mxd later in the exercise.

Install Data

a. On your computer, create a folder called \NHDPlusV21. The illustrations throughout the exercise may use

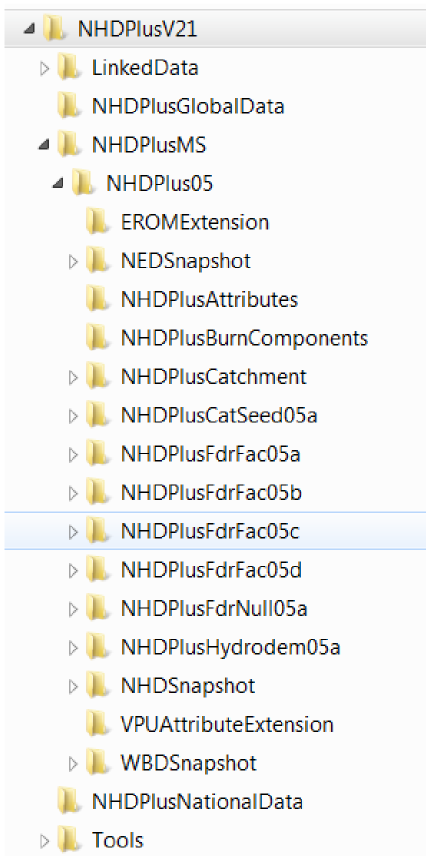
C:\Users\<user name>\Documents\NHDPlusV21 or

D:\<user name>\NHDPlusV21,

however you may put this folder in any location where you have full read/write access. Avoid any folder that contains spaces in the path name.

b. Obtain all Workshop*.zip files from the NHDPlus website under “Documentation” and place them in the \NHDPlusV21 folder.

c. Unzip each Workshop*.zip file “here” preserving the folder structure inside the .zip file. Your workshop folder should look like this:



d. Make sure that you have ArcGIS installed. Version 10.2.2 was used to build this exercise. Higher versions of ArcGIS should work, however screen displays may may vary.

e. Open ArcMap.

f. Open \NHDPlusV21\Workshop1.MXD and ensure that ArcMap has located all data in the table of contents. If not, return to step c above and confirm that your folder structure and naming is correct and that you have downloaded and uncompressed all of the Workshop materials.

g. Close ArcMap.

Set Up Data

The first step after obtaining and installing NHDPlusV21 data is to perform some data setup. The set up involves creating spatial and attribute indexes, and building raster pyramids. This step will greatly improve the experience of using the NHDPlusV2 data.

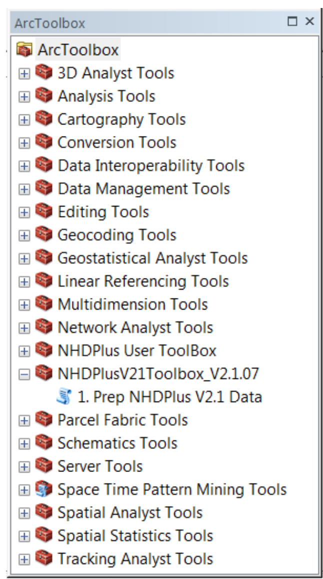
a. Make a working sub-folder called \NHDPlusV21\Working.

b. Open ArcCatalog

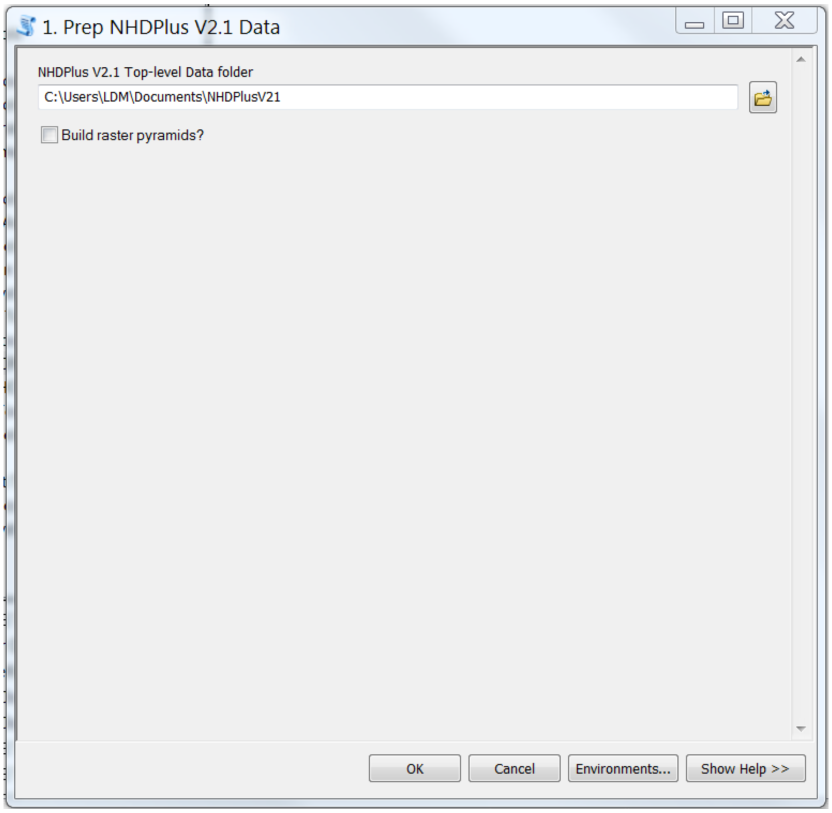
c. Open ArcToolbox

d. Add new Toolbox
    i. Right click on **ArcToolBox** at the top of the tool list,
    ii. Select **Add Toolbox**,
    iii. Navigate to \NHDPlusV21\Tools\NHDPlusToolbox_V2.1.07
    iv. Select NHDPlusUserV2.1 Toolbox.tbx.

e. Prepare your NHDPlusV21 data.
    v. Click on the newly added **NHDPlusUserV2.1 Toolbox** and open **Prep NHDPlus V2.1 Data** tool.



vi. Specify the **NHDPlus V2.1 Top-Level Data Folder** by navigating to the \NHDPlusV21 folder. You may need to use the **Connect to Folder** button to find it.



vii. If you chose to check the "Build raster pyramids" option, the preparation will take longer. However, you may want to build pyramids because they greatly improve raster display performance.

viii. The tool displays messages about which files and attributes are being indexed. If you do not see the messages, make sure you have background processing disabled. To do this, click the **Geoprocessing** menu in ArcCatalog, Select **Geoprocessing Options**, and uncheck the box next to **Enable**.

f. Create a working file geodatabase.

i. Open ArcCatalog
ii. Create a Working folder under \NHDPlusV21.
iii. Right click on \NHDPlusV21\Working and add a **New->File Geodatabase** called Workshop1.gdb.
iv. Close ArcCatalog.

Create a Working ArcMap Document.

Typically, you'll create an ArcMap document which contains the NHDPlusV21 data that you plan to use for your work. This section of the hands-on exercise walks you through adding, symbolizing, joining and relating NHDPlusV21 data.

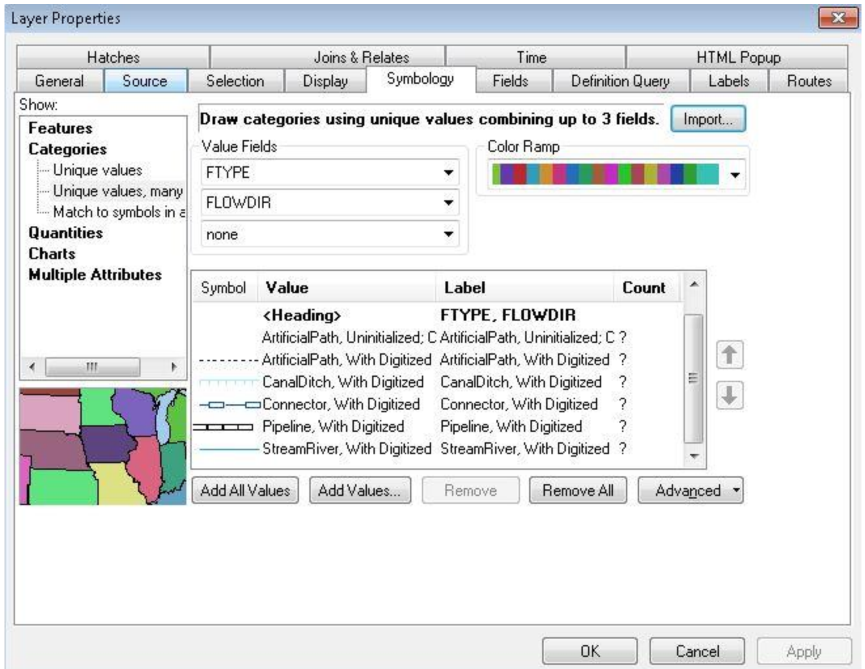
a. Open ArcMap
b. Right click on **Layers**. Select **Properties** and the **Coordinate System** tab. Set the map projection to Albers by importing the projection as follows. Click the **Add Coordinate System** button  and select **Import.** Browse to and chose \NHDPlusV21\NHDPlusMS\NHDPlus05\NEDSnapshot\Ned05a\elev_cm to set the projection.

c. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDFlowline.shp. Symbolize with \NHDPlusV21\NHDFlowline.lyr.

   \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDWaterbody.shp. Symbolize with \NHDPlusV21\NHDWaterbody.lyr.

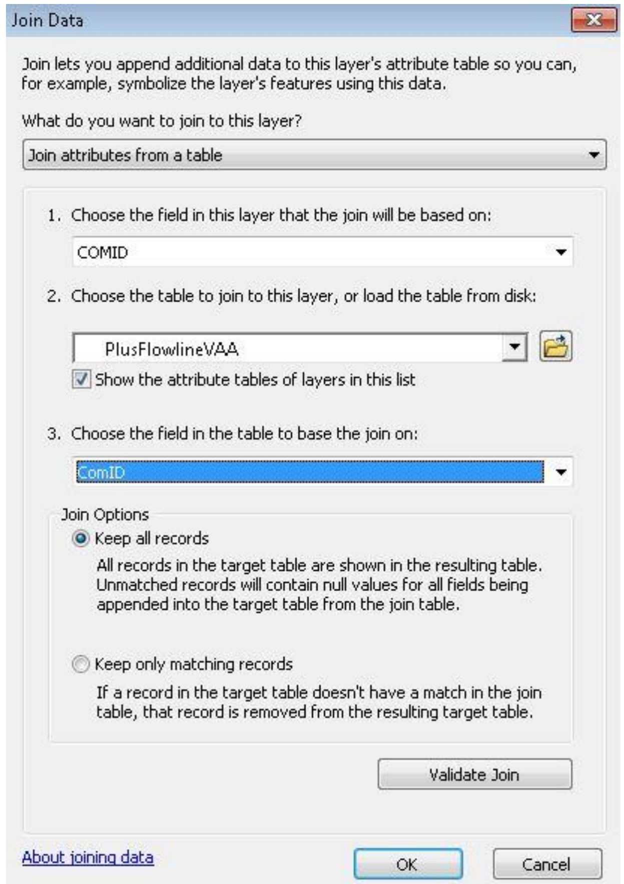
   \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDArea.shp. Symbolize with \NHDPlusV21\NHDArea.lyr

   Perform the following steps to symbolize each feature class with cooresponding layers: Right click on feature class in the **Table of Contents** and open the **Properties** dialog box. Click on the **Symbology** tab and select **Import**. Navigate to the NHDPlusV21 folder and select the appropriate layer file. Click **Add**. Choose to import **Complete Symbology Definition** and click **OK**. Accept defaults and click **OK**. Then click **Apply** and **OK** before closing the **Layer Properties** dialog box.

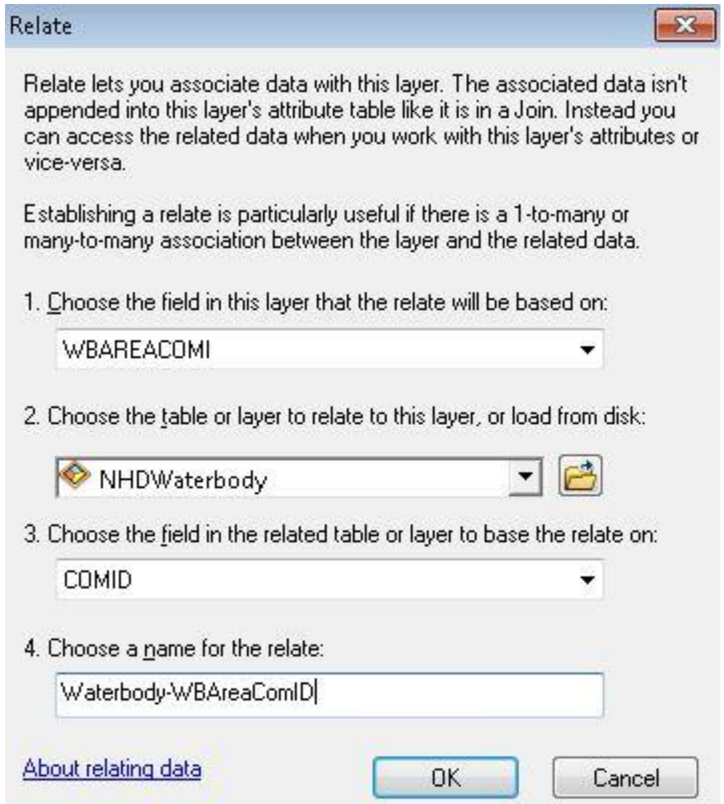


Note: NHDFlowlines with FlowDir = “Uninitialized” are made invisible.This is because these flowlines are ones where the NHD is not sure of the direction of flow. Consequently, these are not considered part of the NHDPlus network

d. **Join** NHDFlowline.ComID with \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusAttributesPlusFlowlineVAA.ComID


Join Data
Join lets you append additional data to this layer's attribute table so you can, for example, symbolize the layer's features using this data.
What do you want to join to this layer?
Join attributes from a table
1. Choose the field in this layer that the join will be based on:
COMID
2. Choose the table to join to this layer, or load the table from disk:
PlusFlowlineVAA
Show the attribute tables of layers in this list
3. Choose the field in the table to base the join on:
ComID
Join Options
Keep all records
All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.
Keep only matching records
If a record in the target table doesn't have a match in the join table, that record is removed from the resulting target table.
Validate Join
About joining data
OK
Cancel

e. **Relate** NHDFlowline.WBAREAComI to NHDWaterbody.ComID. Call the relate "Waterbody-WBAreaComID".



Note: This relates the NHDFlowline Artificial Path features to the NHDWaterbody feature through which the Artificial Path flows.

f. **Relate** NHDFlowline.WBAREAComID to NHDArea.ComID. Call the relate "Area-WBAreaComID".

Note: This relates the NHDFlowline Artificial Path features to the NHDArea feature through which the Artificial Path flows.

g. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\Catchment.shp. Symbolize with no fill and red edges.

h. **Relate** Catchment.FeatureID to NHDFlowline.ComID. Call the relate "FeatureID-ComID".

Note: This links the flowline to the catchment which represents the immediate drainage area for the flowline.

i. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusAttributes\PlusFlow.dbf

j. **Relate** PlusFlow.FromComID to NHDFlowline.Comid. Call the relate "FromComID".

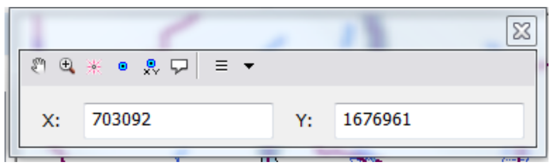
k. **Relate** PlusFlow.ToComID to NHDFlowline.Comid. Call the relate "ToComID".

l. **Relate** PlusFlow.NodeNumber to NHDFlowline.ToNode. Call the relate "ToNode".

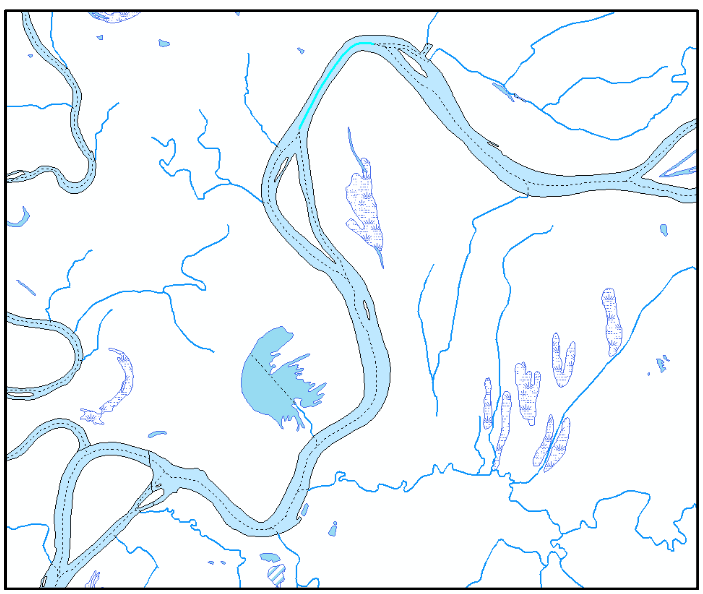
Note: The PlusFlow.NodeNumber is the node between FromComID and ToComID. The relate links the PlusFlow record to the bottom of the FromComID.

m. Save \NHDPlusV21\Working\Student1.mxd

n. Use the **Zoom to XY** tool, on the ArcMap Toolbar. Use the arrow pull down to change the units to Meters. Enter the coordinates and click the **Zoom** button to zoom to these coordinates:

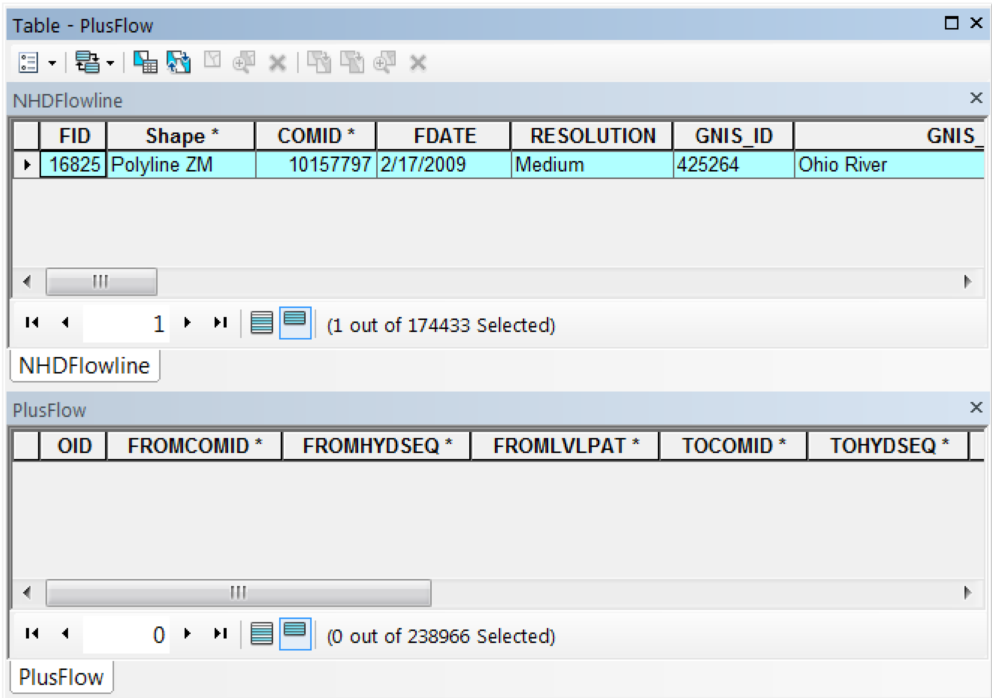


o. Set the Map Scale to 1:125,000. Select the NHDFlowline shown in the picture.



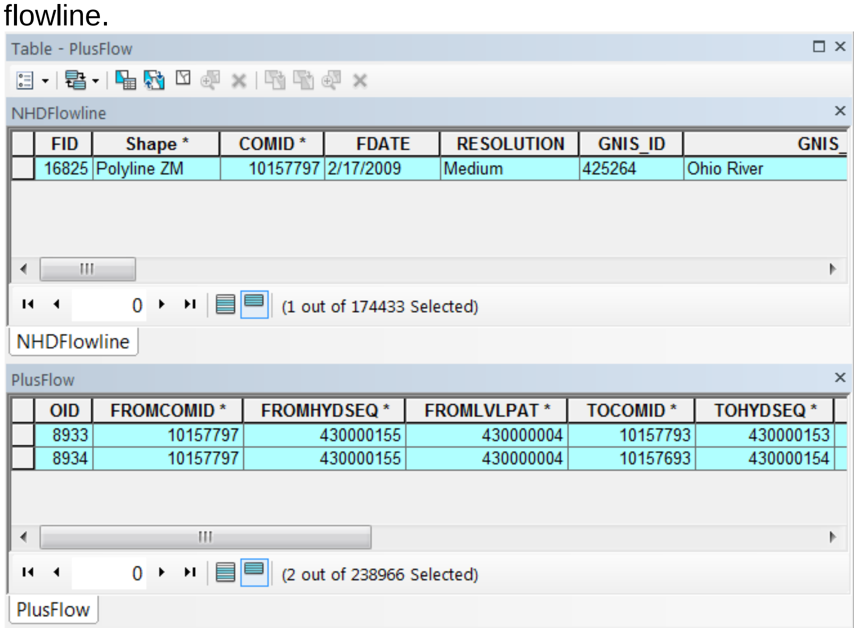
p. Open the NHDFlowline table. Open the PlusFlow table.

q. Use **Table Options->Arrange Tables->New Horizontal Tab Group** and display just selected records.



r. Using the relates between NHDFlowline and PlusFlow, we're going to walk down the network. Each time the following two steps are performed, the navigation in the PlusFlow table will move down one flowline. Perform these steps 4 times and watch what happens. Note that when the navigation gets to the flow split, it continues down both paths progressing one flowline at a time along each path.

i. From the NHDFlowline table, execute the FromComID relate. This selects the PlusFlow records where the selected flowline is the upstream/from flowline.



ii. From the PlusFlow table, execute the ToComID relate. This selects the flowlines that are next downstream.

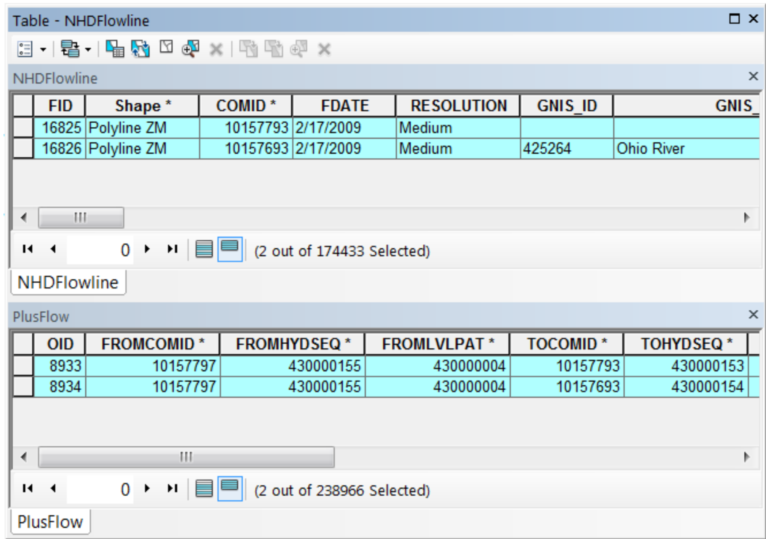


Table - NHDFlowline

NHDFlowline

FID	Shape *	COMID *	FDATE	RESOLUTION	GNIS_ID	GNIS_
16825	Polyline ZM	10157793	2/17/2009	Medium		
16826	Polyline ZM	10157693	2/17/2009	Medium	425264	Ohio River

0 (2 out of 174433 Selected)

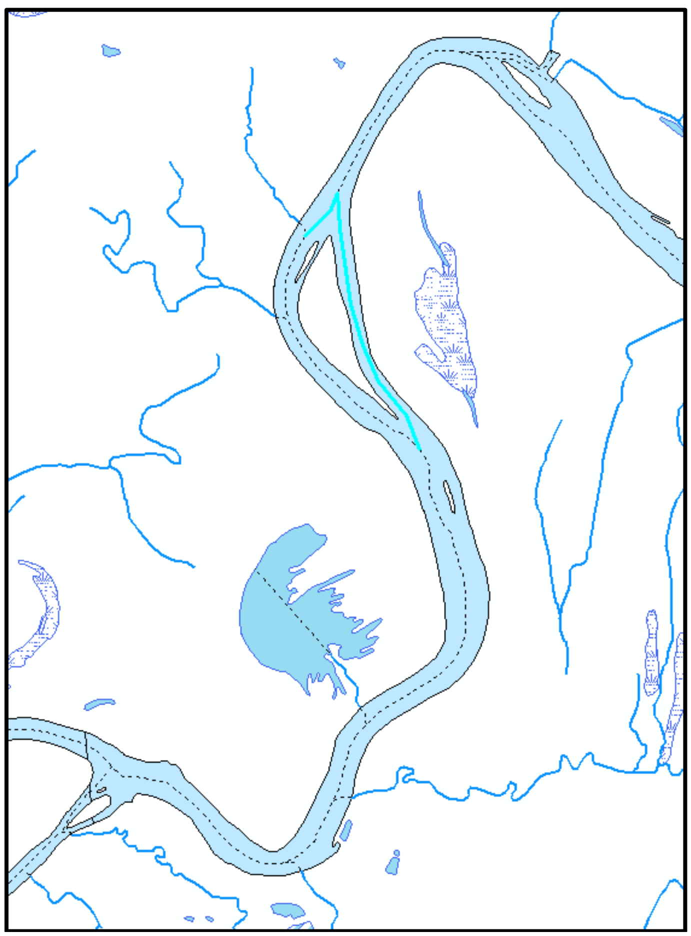
NHDFlowline

PlusFlow

OID	FROMCOMID *	FROMHYDSEQ *	FROMLVLPAT *	TOCOMID *	TOHYDSEQ *
8933	10157797	430000155	430000004	10157793	430000153
8934	10157797	430000155	430000004	10157693	430000154

0 (2 out of 238966 Selected)

PlusFlow



Note: There is a desktop tool, available from the NHDPlusV2 tools web page, which scripts the navigation using the PlusFlow table. The tool is called NHDPlusV2 Flow Table Navigator.

Save the Student1.mxd and close ArcMap.

Add Raster Layers to ArcMap Document

There are 9 raster layers in each NHDPlus Raster Processing Unit (RPU):

The ***elev_cm*** grid is the original elevation data used to build NHDPlus. It contains integer values of elevation, with centimeters as the vertical unit. The original floating-point NED data were multiplied by 100 and converted to integer in order to allow automatic compression of the grids. This saves a large amount of disk space.

The **shdrelief** grid is an integer grid. As its name implies, shdrelief contains the shaded relief generated from the elevation grid elev_cm.

In each cell of the ***fac*** grid (a.k.a. flow accumulation) is the number of upslope cells that drain to that cell. The grid contains a skewed distribution of values. The vast majority of cells contain small numbers (less than 100), however the cells along major flow paths can have values into the hundreds of millions.

The ***fdr*** (a.k.a. flow direction) grid contains only nine unique values, one for each possible flow direction out of a cell. The values indicate the direction of flow to an adjacent cell. Each cell contains a coded numeric value that stands for east, southeast, south, southwest, west, northwest, north, or northeast. A value of zero means that the cell is a sink and there is no flow to any adjacent cell. Although it is easy to display this grid, it is not particularly easy to interpret. This grid may sometimes be inspected closely in order to understand the flow in a very small area, but generally this grid is not displayed. The fdr grid is used by automated procedures to derive flow paths or delineate basins/watersheds.

The **fdrnull** grid is a variant of the flow direction grid in which the cells of BurnLineEvent features are set to NoData. FdrNull can be used to compute flow path length grids. Flow path length grids are useful for a variety of purposes including determining the mean flow path length within a catchment or deriving stream riparian buffer areas. This grid is primarily for analysis rather than display.

The ***cat*** grid contains an unusually large number of unique grid values. In most cases you don't really need to see the records in the ***cat*** attribute table or to display the grid. All the same information is in the ***catchment.shp*** attribute table, and can be used much more readily in that form. The ***cat*** grid is primarily useful for gridded overlay analysis such as the Spatial Analyst's Zonal Statistics tool. We'll use the cat grid in the **Linking Data to the Network** section later in the exercise.

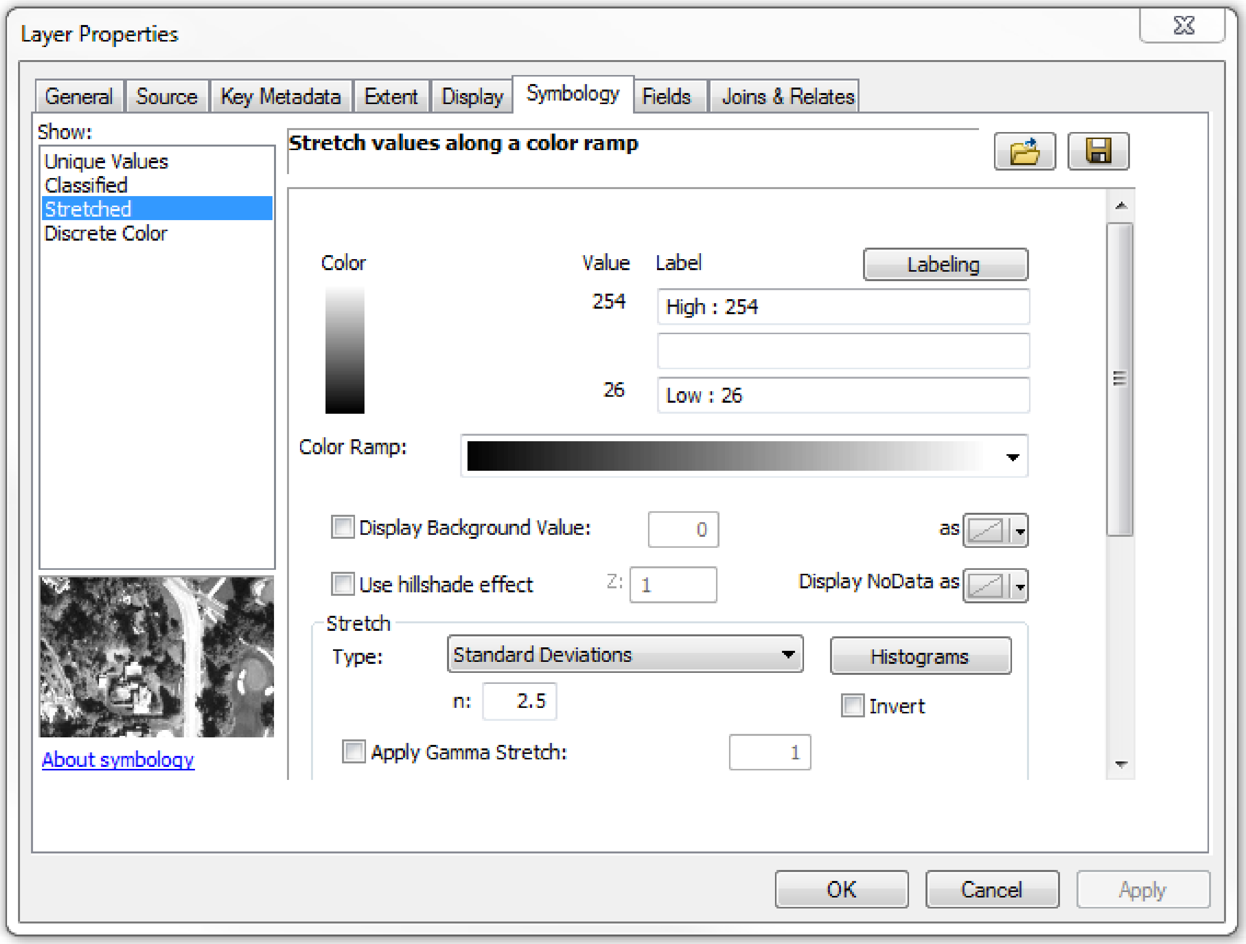
The **catseed** grid is an integer grid which contains the seed cell for each catchment. The catchment gridcodes are stored in the seed cells. This grid is distributed as documentation of the raster processes used to build NHDPlus.

The **filledareas** grid is an integer grid which identifies cells raised by the Fill process that occurs after the hydro-enforcement process. This grid is distributed as documentation of the raster processes used to build NHDPlus.

The **hydrodem** grid is an integer grid of the hydro-conditioned version of elev_cm, with all aspects of the NHDPlus burn components integrated and filled. This grid is used to generate the flow direction grid from which the flow accumulation and catchment grids are generated. The elevations are in centimeters. This grid is distributed to document the hydro-enforcement processes used to build NHDPlus.

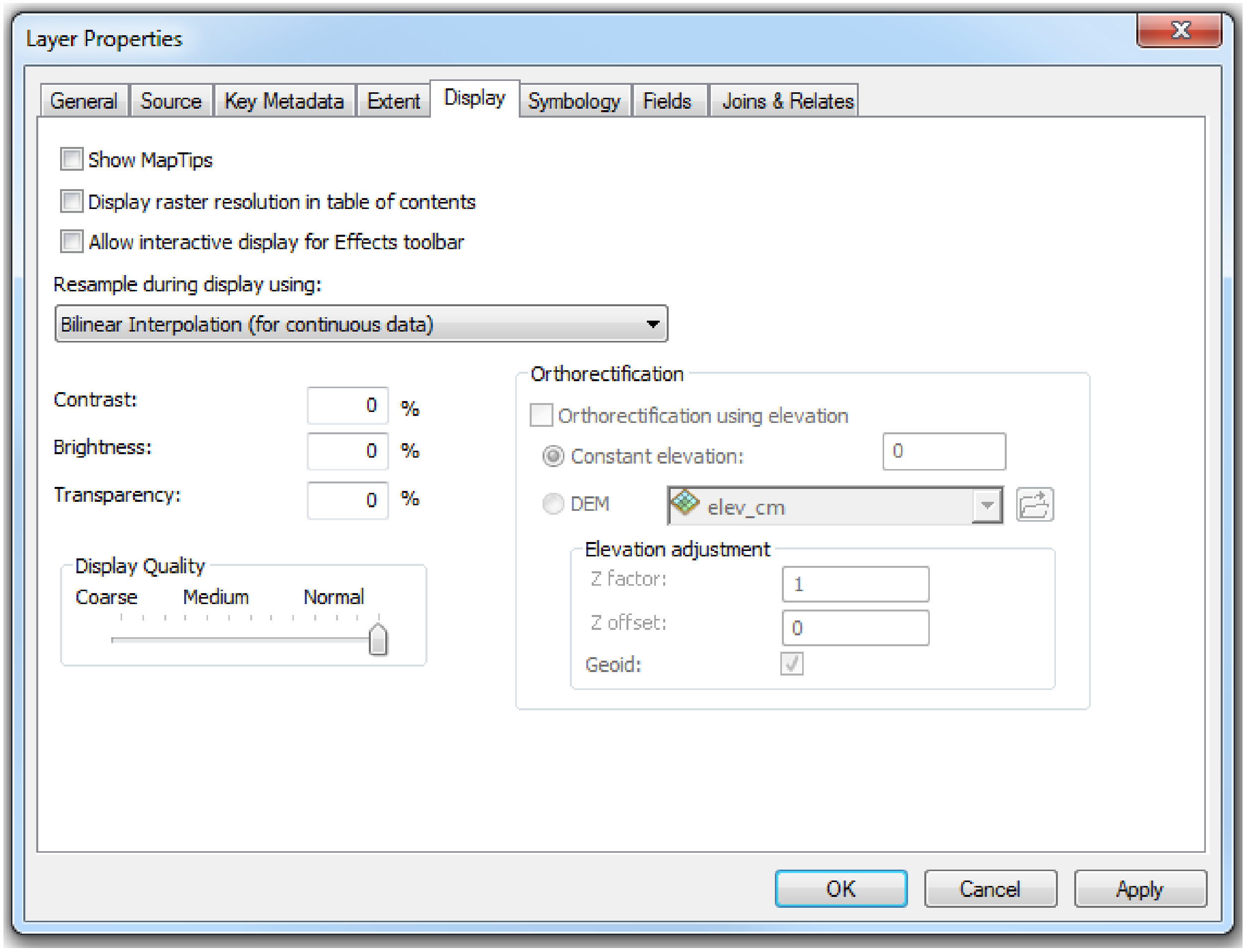
a. Starting with Student1.mxd from section above, **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NEDSnapshot\Ned05a\shdrelief. Say Yes" to building pyramids.

b. Right-click on the ***ShdRelief*** grid, and choose **Properties->Symbology**. If the renderer is not set to **Stretched**, change it to **Stretched** as shown below, then click **Apply**.



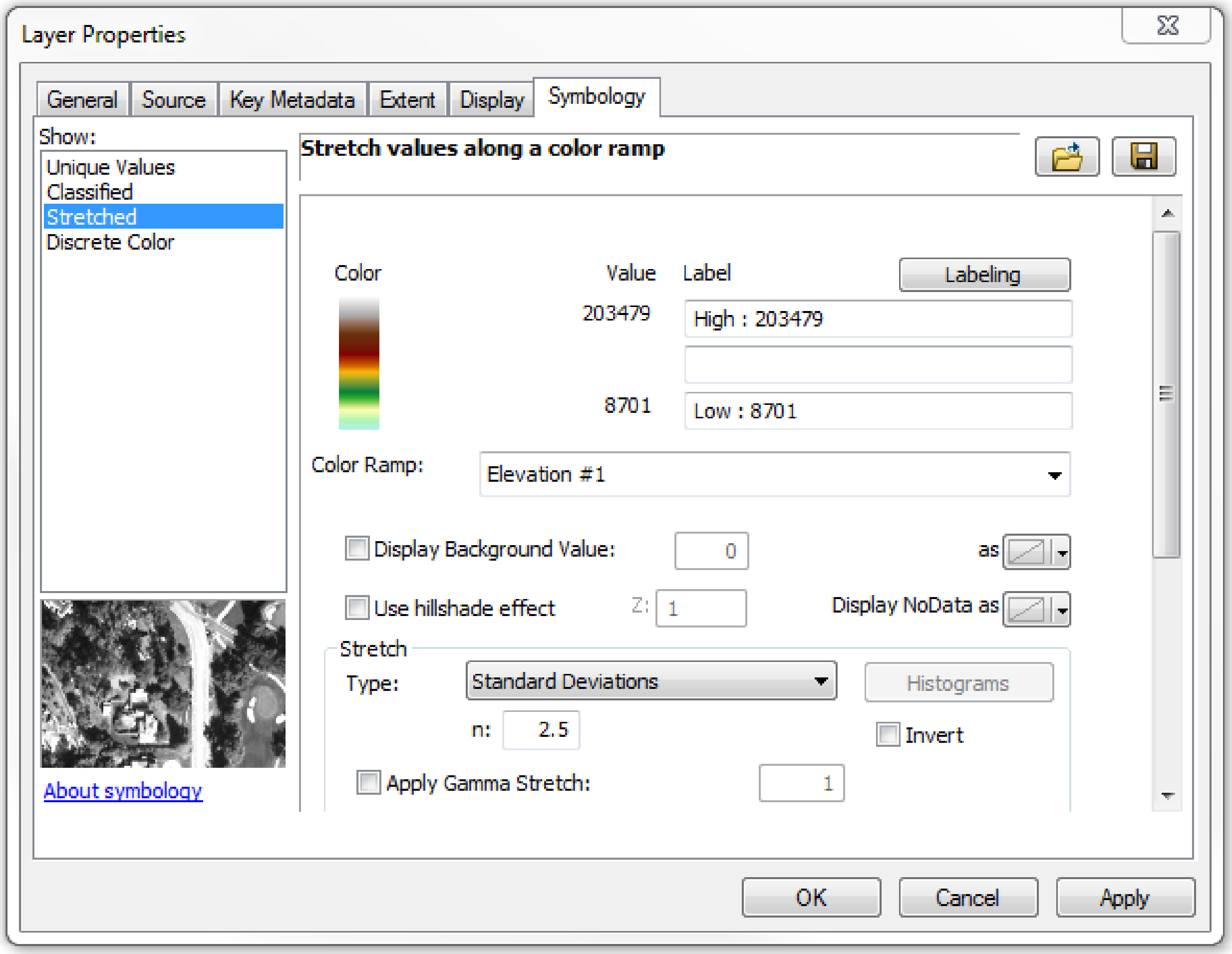
c. Turn off all layers except shdrelief. Right click shdrelief and **Zoom to Layer**. Set **Map Scale** to **1:24000**. Note the blocky grid cells.

d. Right-click on the ***shdrelief*** grid, and choose **Properties->Display**. Set **Resample During Display** pulldown to **Bilinear Interpolation** and click **Apply**. Note how the display becomes smoother.



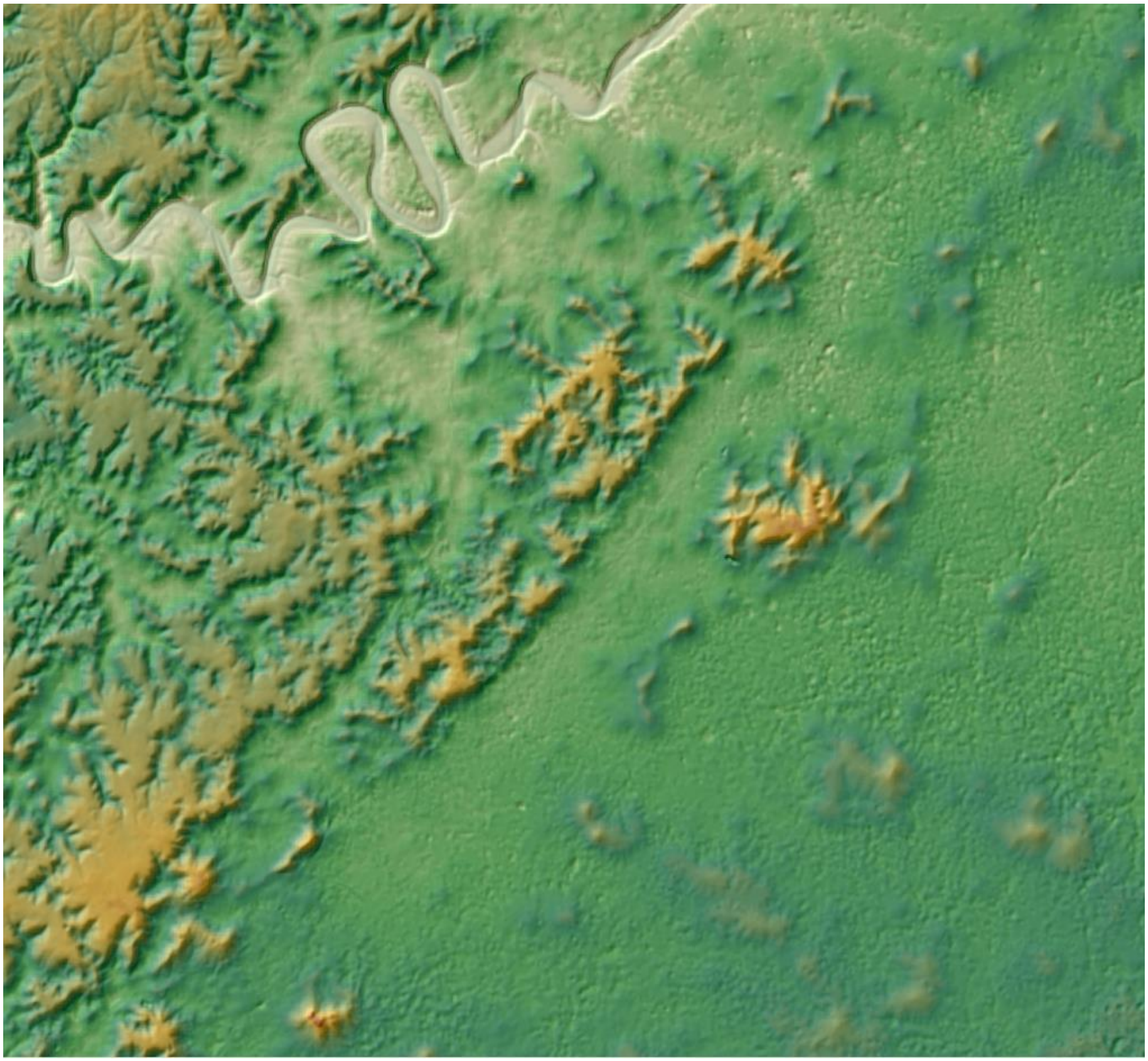
e. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NEDSnapshot\Ned05a\elev_cm. Say “Yes” to building pyramids.

f. Right click on elev_cm and select **Properties->Symbology**. Right click on the black-to-white **Color Ramp** and click **Graphic View**. The check mark beside **Graphic View** should disappear and the text descriptions of the items in the **Color Ramp** should appear in the pull down. From the **Color Ramp** pull down, select **Elevation # 1**.



g. Select the **Display** tab and change **Transparency** to 50%. Click **OK**.

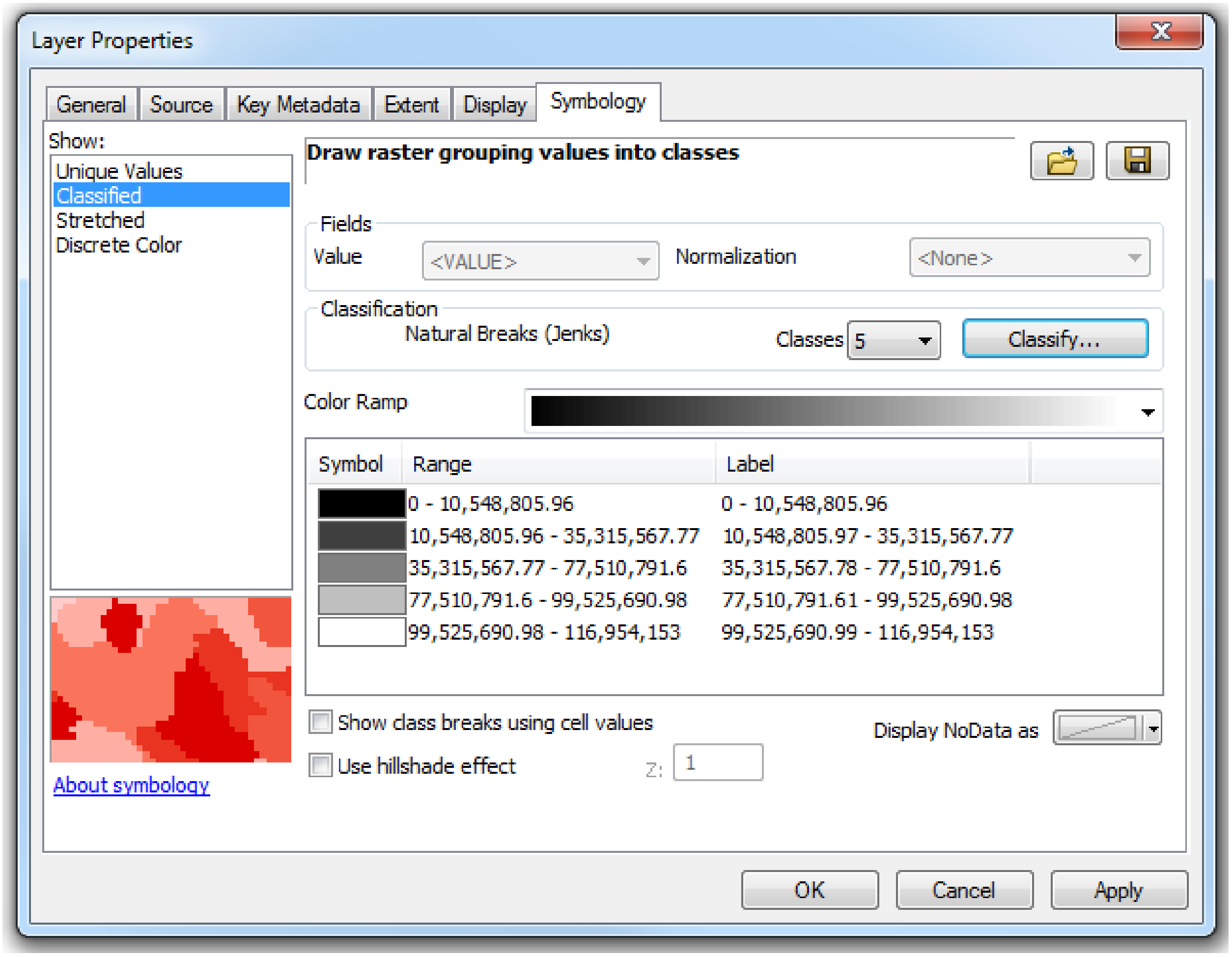
h. Set the **Map Scale** to **1:100,000**.



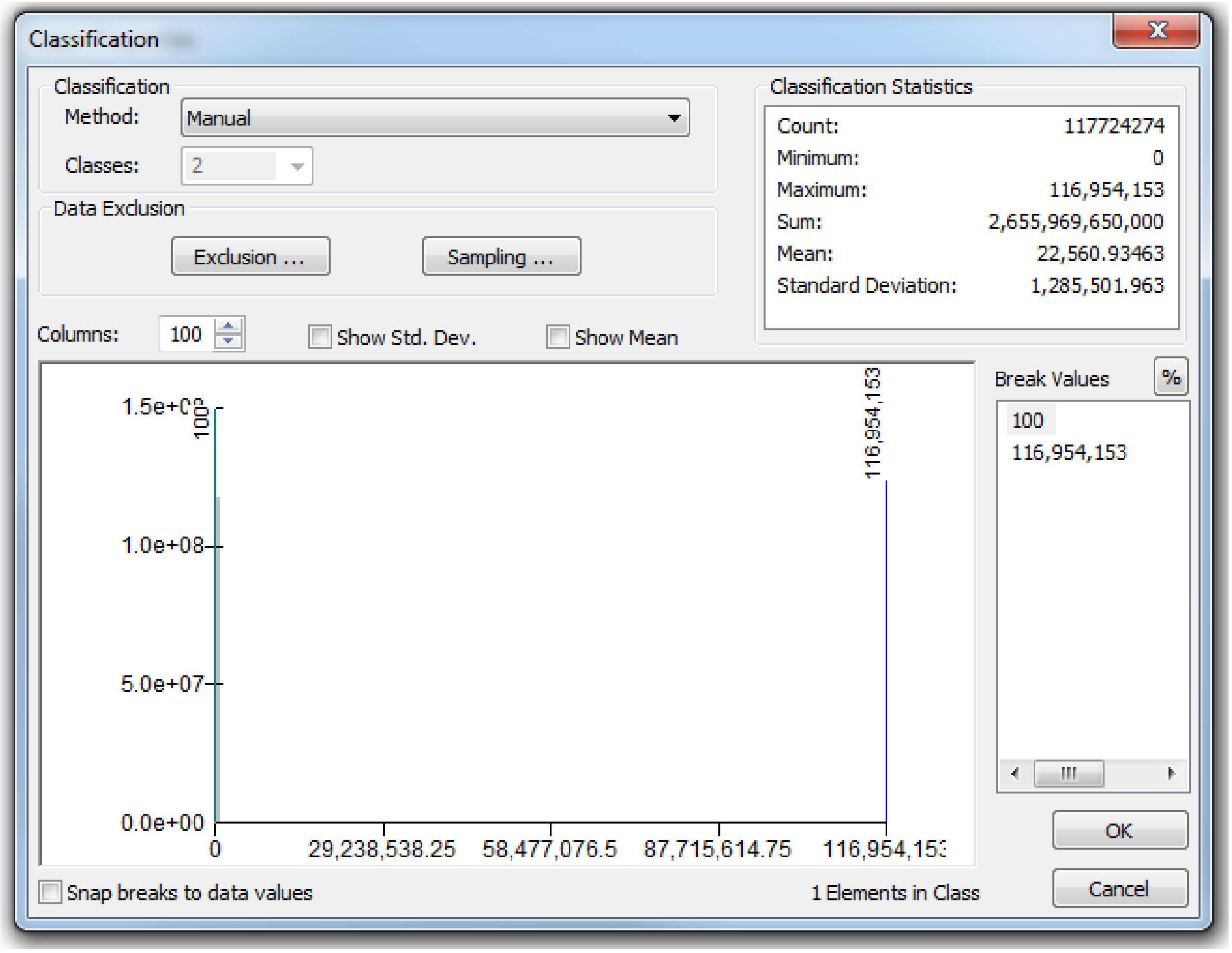
Note the nice shaded relief map created using the elevation layer draped over the shaded relief layer.

i. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusFdrFac05a\fac. Say "Yes" to building pyramids.

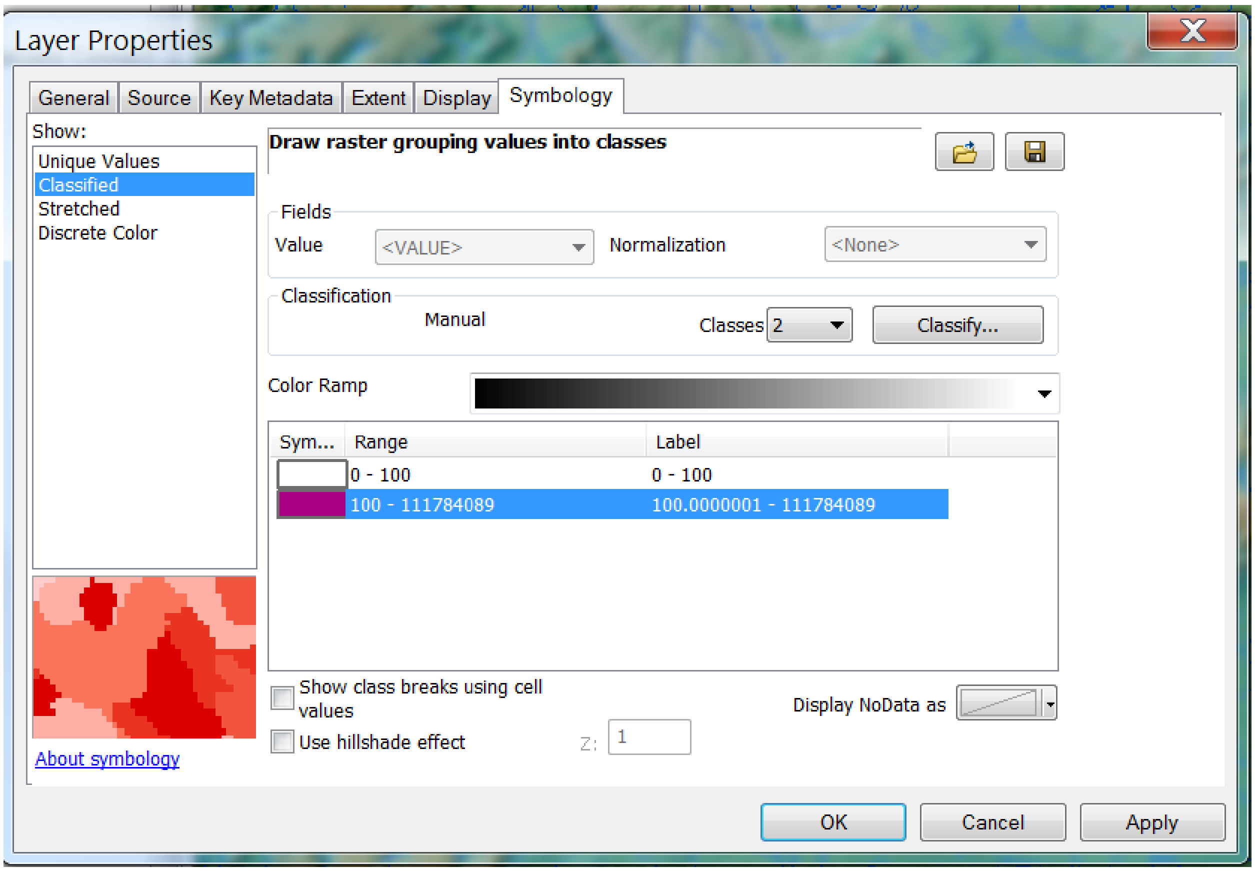
j. Right click on fac and select **Properties->Symbology**. Change the renderer from **Stretched** to **Classified**. **Build Histogram,** if prompted.

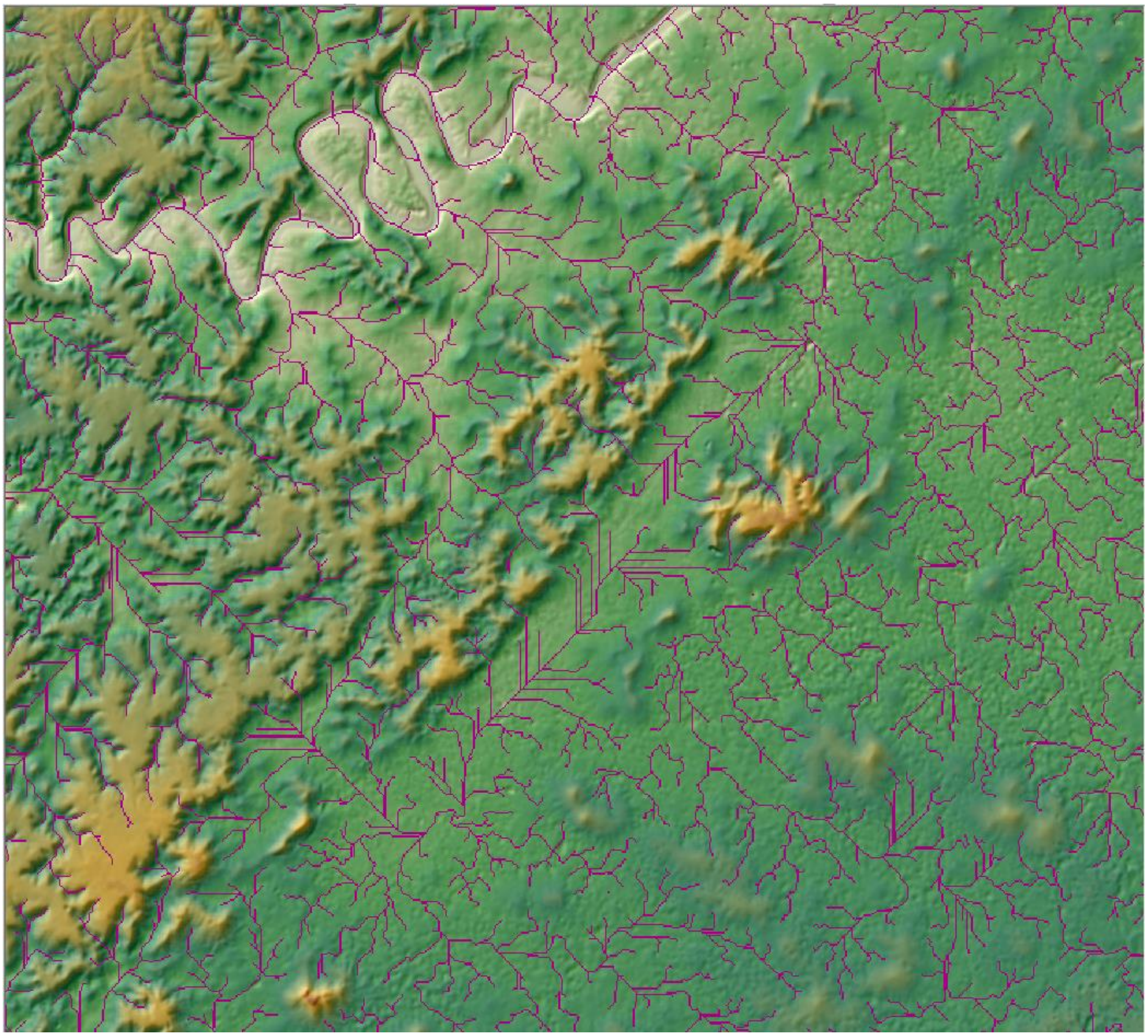


k. Click **Classify…** In the **Classification** dialog, change the number of **Classes** to 2 and change the first **Break Value** to 100. Click **OK**.



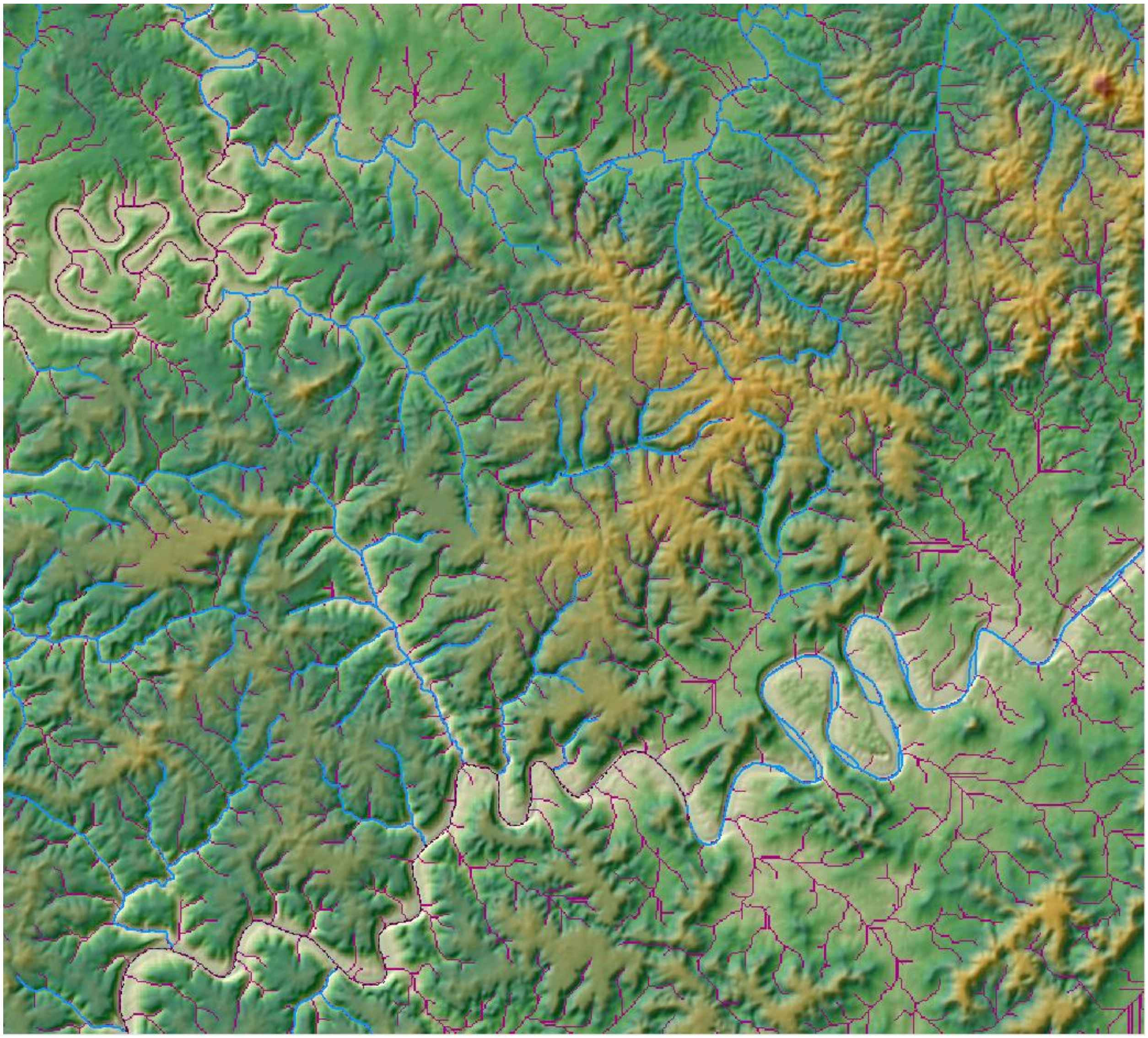
l. On the **Symbology** tab, double-click on the black box under **Symbol** next to the 0 - 100 **Range**, then choose **No Color** on the color menu that pops up. Double-click on the black box under **Symbol** next to 100 – 111784089, then choose a dark purple color on the color menu that pops up. Click **OK**.





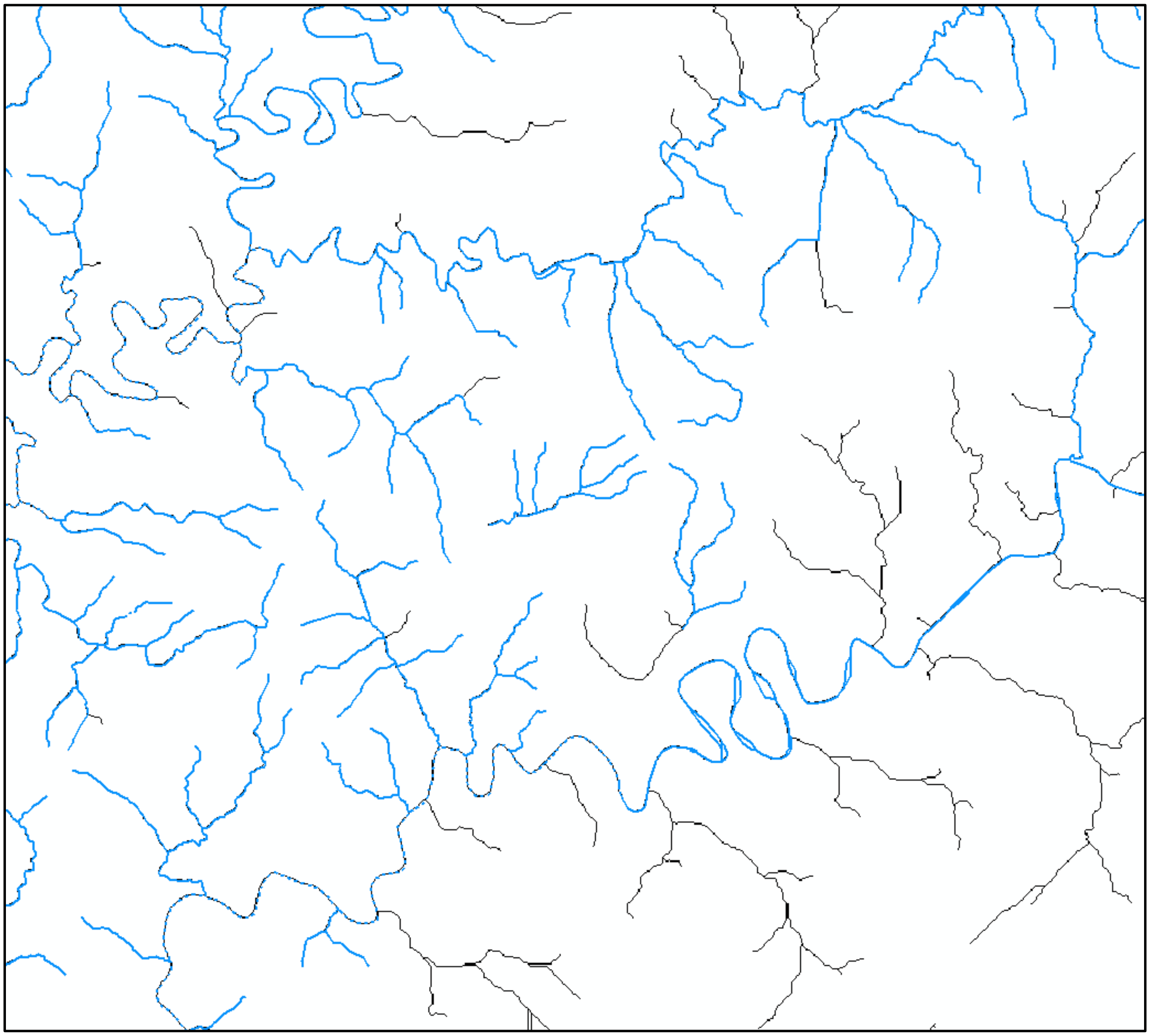
Note: The purple lines are made up of cells in the fac grid that have 100 or more cells upslope. These lines indicate where the drainage channels are on the HydroDEM. Turning off the elev_cm and shdrelief layers will enable you to see the channels better. These channels are sometimes referred to as synthetic streams because they are simply channels in the DEM which may or may not contain water. In general, where the channels and NHDFlowines coincide, the channels should follow the NHDFlowline features closely, since the networked NHDFlowline features were burned into the HydroDEM. The threshold of 100 is shown to illustrate the concept, but any threshold may be chosen.

m. Turn on the NHDFlowline layer. Pan NW to be able to see more NHDFlowline features. Turn off the Topo Map layer to get a better view.

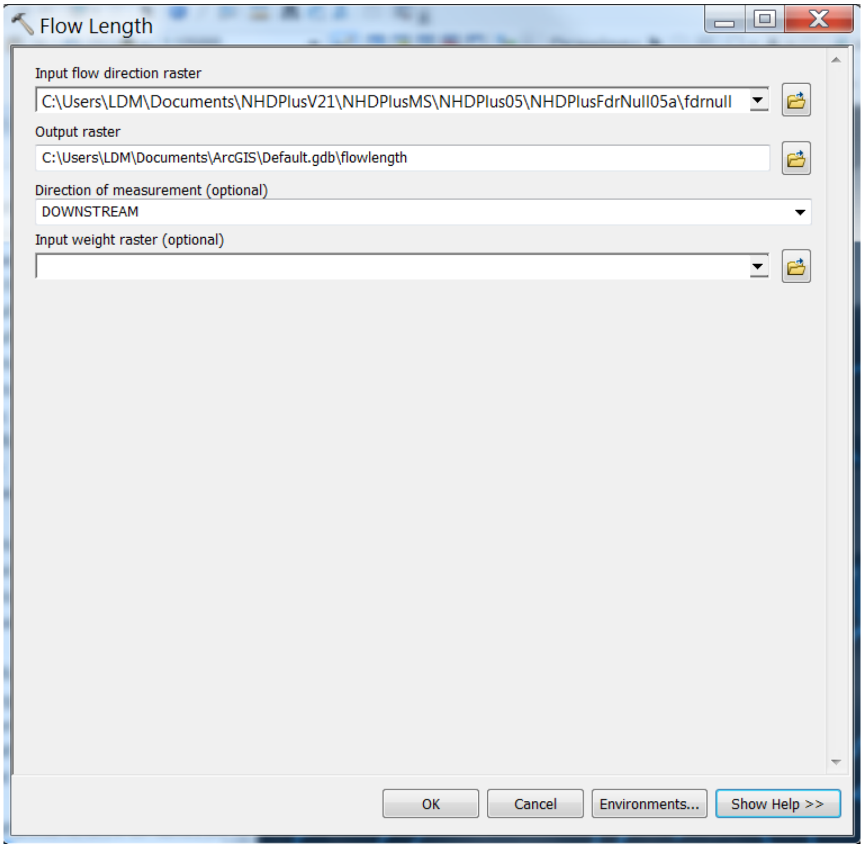


Note: The threshold of 100 creates many more channels (purple lines) than features in NHDFlowline (blue lines).

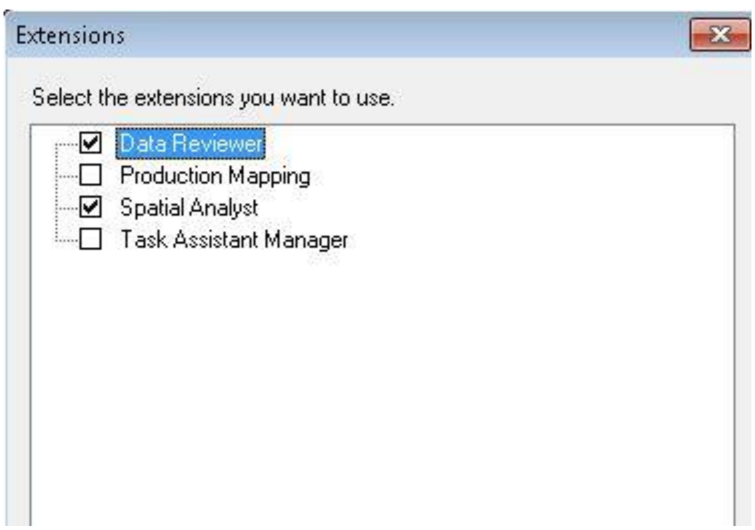
n. Repeat steps k and l, setting the threshold to 2000. You can see that, in this area of the country, a threshold of 2000 corresponds more closely with medium resolution NHD. Turn off the fac layer.



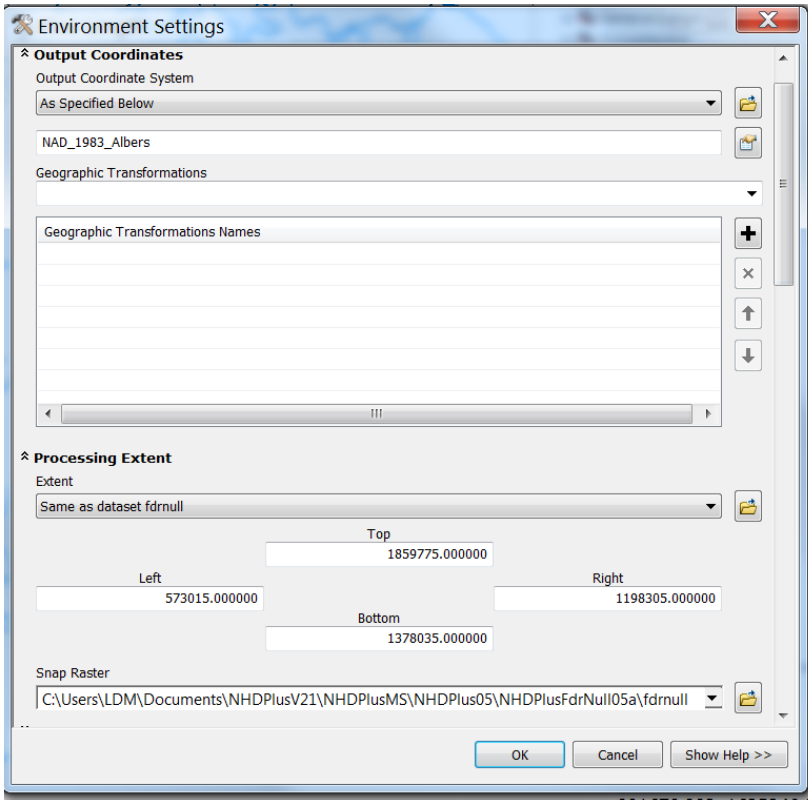
o. Let's measure the distances from locations within a catchment to the flowline within the catchment. This is a task for the fdrnull grid. Open **Spatial Analyst->Hydrology->Flow Length** tool and populate the dialog like this:



Note: Be sure to have the Spatial Analyst extension turned on. You can do this by clicking the **Customize** menu in ArcMap **-> Extensions ->** check the box next to **Spatial Analyst**.



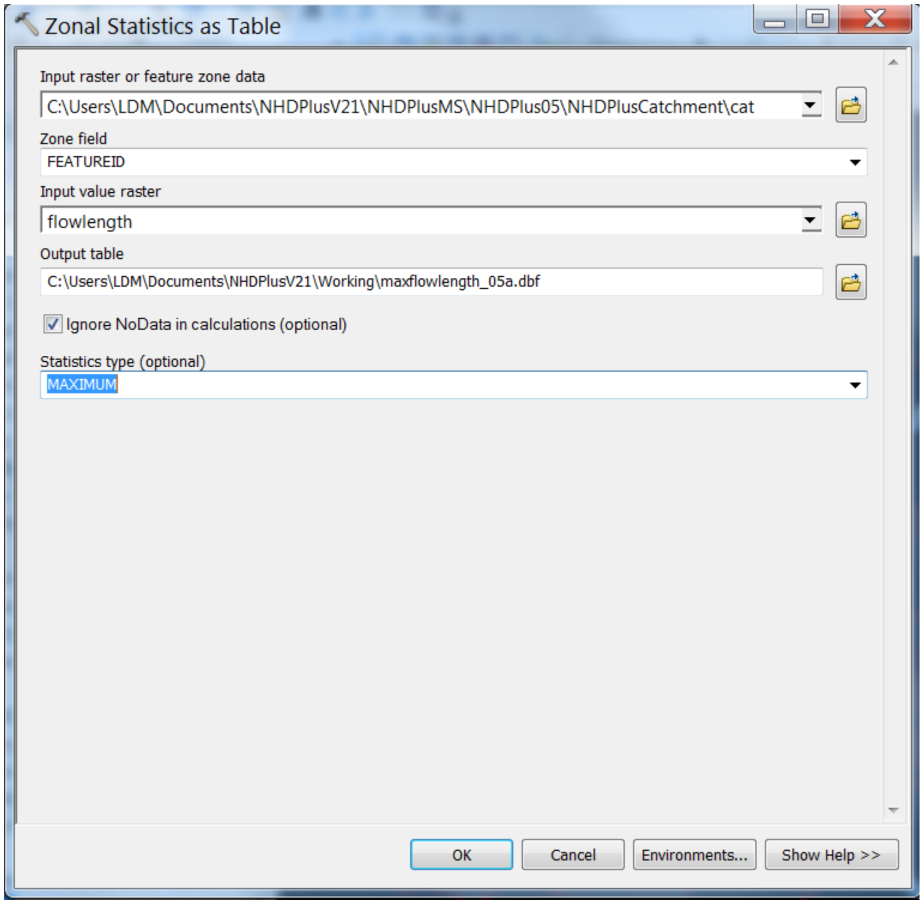
p. Click on **Environments…** and use the fdrnull grid to set the **Output Coordinate System**, the **Extent** and the **Snap Raster**:



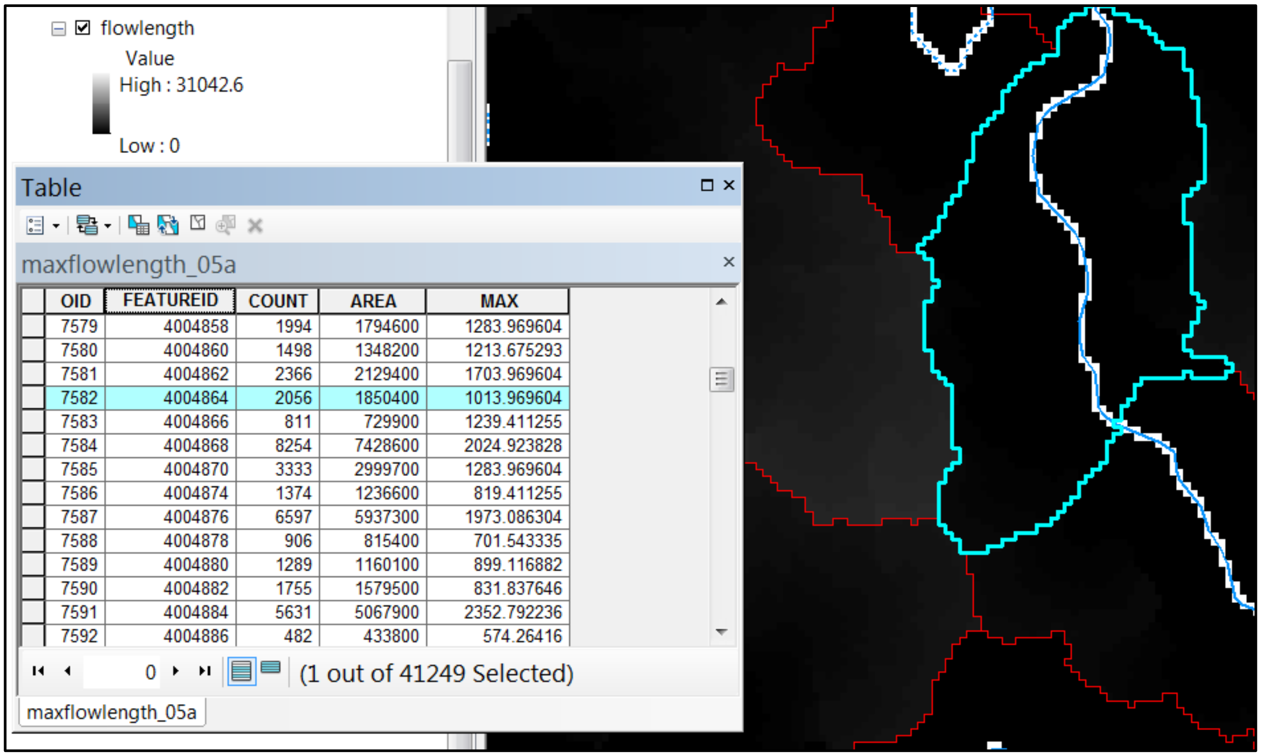
q. Click **OK** and **OK** again on the **Flow Length** tool dialog.
Note: It may take approximately10 minutes for the tool to run.

r. In the flowlength output grid, cells contain the length (in meters) of the downhill flow path from the cell to the flowline in the catchment. Zoom in and do an **Identify** on some flowlength grid cells.

s. At this point, we can use **Spatial Analyst->Zonal->Zonal Statistics as Table** to compute the maximum flow path distance to water for each catchment as follows and click **OK**:



t. The flowlength grid is displayed in the picture below. The white lines are the cells where the grid has a value of 0, i.e. 0 path length to the flowline. In other words, the white cells represent the flowlines. The maxflowlength_05a table is also shown. We can see that in the selected catchment, the maximum flow path distance to water is 1014 meters.



There are many other interesting analyses that can be done with the fdrnull grid.

Save the project as \NHDPlusV21\Working\Student2.mxd and close ArcMap.

Build a Geometric Network and Learn to Navigate

There are many approaches to navigating the NHDPlusV2 network:

- Using an ArcGIS geometric network,
- Using a specific group of network attributes: LevelPathI, Divergence, UpLevelPat, DnLevelPat, and DnMinorHyd (often referred to as VAA Navigation),
- Using the network attribute Hydroseq,
- Using the network attributes Fromnode and Tonode, and
- Using the PlusFlow table (See section "Create a Working ArcMap Document").

NHDPlusV21 has the capability to make network connections where there is no geometry in NHDFlowline. At present there are 102 of these no-geometry connections. These connections are represented in the network attributes and in the PlusFlow table, but not in the geometry. Therefore all the approaches above will "see" these connections and traverse them except the ArcGIS geometric network approach.

Most, but not all, no-geometry connections are on the international borders where a stream leaves the U.S. and then reenters the U.S. at another location. No-geometry connects exist in VPUs 04, 05, 06, 09, 10U, 16, and 17. They can be found by querying the PlusFlow table for HasGeo = "N".

This exercise is focused on the ArcGIS geometric network approach which offers some interesting navigation capabilities in the Utility Network Toolbar.

a. Create a new ArcMap document and add attributes to NHDFlowline

  i. Open ArcMap
  ii. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDFlowline to map.
  iii. Open the NHDFlowline table and click **Select by Attributes** NHDFlowline.FlowDir = "With Digitized". These are the flowlines that NHDPlus considers to be in the network. Flowlines that have FlowDir = "Uninitialized" are ignored by NHDPlus.
  iv. Right click on NHDFlowline and select **Data->Export** to save the selected flowlines to \NHDPlusV21\Working\NHDFlowline_KnownFlow.shp and add to map
  v. Remove NHDFlowline from map
  vi. Link NHDFlowline Artificial Path features to their NHDWaterbodies
    a. Open NHDFlowline_KnownFlow attribute table
    b. From **Table Options->Add field** NHDFlowline_KnownFlow.WBFType Text(24)

c. From **Table Options->Add Field**
NHDFlowline_KnownFlow.WBSize Double

d. From **Table Options->Join**
NHDFlowline_KnownFlow.WBAreaComI with
\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDWaterbody.ComID

e. Right click on NHDFlowline_KnownFlow.WBFType field and use **Field Calculator** to set it to NHDWaterbody.FType
If prompted, say "yes" to "the calculated value is invalid for …"
Note: Make sure to calculate the field using NHDWaterbody.FType, *not* NHDFlowline_KnownFlow.FType

f. Right click on NHDFlowline_KnownFlow.WBSize field and use **Field Calculator** to set it to NHDWaterbody.AreaSqKM
If prompted, say "yes" to "the calculated value is invalid for …"

g. Remove NHDWaterbody join.

h. Sort descending by right clicking WBFType column header and take note that now the Artificial Path features that are inside NHDWaterbodies such as Lake/Pond features have the Feature Type and Feature Size of the waterbody through which they flow. This will enable us to discover these waterbody features when we navigate.

vii. From **Table Options->Join** NHDFlowline_KnownFlow.ComID with \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusAttributes\PlusFlowlineVAA.ComID

viii. (Optional) Remove unwanted attributes from table: Right click NHDFlowline_KnownFlow, select **Properties->Fields** tab, unclick the PlusFlowlineVAA attributes OID, ComID, Fdate, Thinnercod, OutDiv, DivEffect, Reachcode, LengthKM, and Fcode. Click **OK**. These are either duplicate or unvalued attributes.

ix. From **Table Options->Join** NHDFlowline_KnownFlow.ComID with \NHDPlusV21\NHDPlusMS\NHDPlus05\EROMExtension\EROM_MA0001.ComID

x. (Optional) Remove unwanted attributes from table: Right click NHDFlowline_KnownFlow, select **Properties->Fields**, unclick all EROM_MA0001 attributes except Q0001A, V0001A, Q0001C, V0001C, Q0001E, V0001E, SMGageID, and SMGageq. Click **OK**. These are the only EROM attributes that will be useful in our navigation and analysis activities.

xi. In the table for NHDFlowline_KnownFlow, right click on the **Enabled** field and delete it.

xii. Right click on NHDFlowline_KnownFlow and use **Data->Export** to create \NHDPlusV21\Working\NHDFlowline_KnownFlow_Attrs.shp

xiii. Close ArcMap

b. Build NHDPlusV21 Junctions

NHDPlus contains virtual nodes. There is one at the top of each headwater flowline, and one at the bottom of each network terminous. (These are called Network Starts and Network Ends in NHDPlus.) And there is one at each place that one or more flowlines exchange water. Each node is uniquely numbered. The node numbers can be found in the PlusFlowlineVAA table in fields FromNode and ToNode. The NHDPlus nodes inherit the rich NHDPlus network attributes and can be used as highly functional junctions in a geometric network.

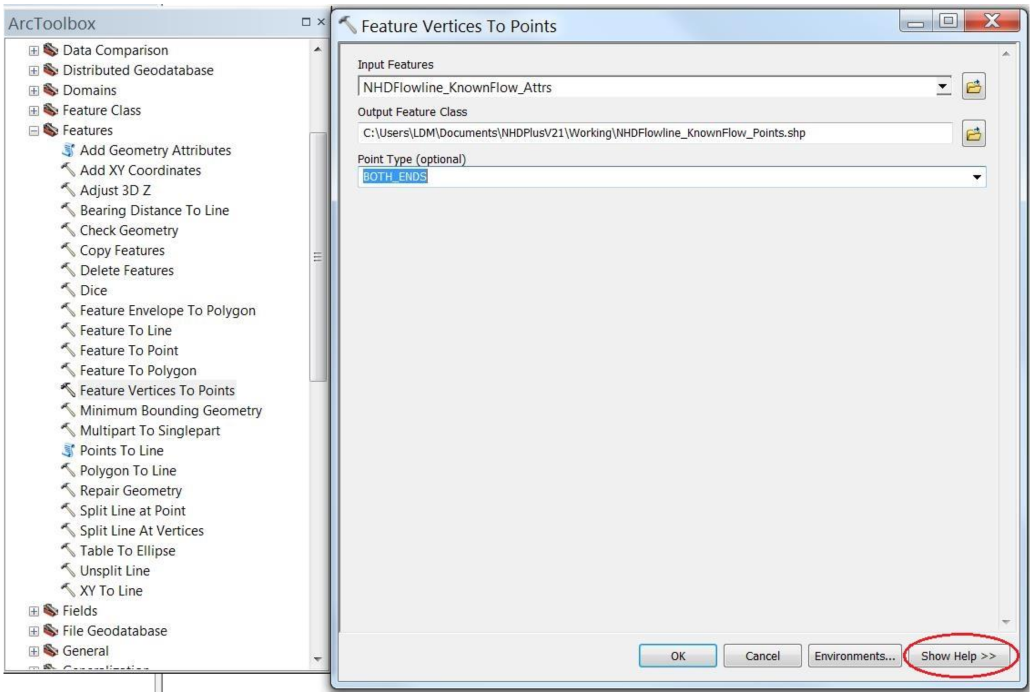
i. Open **ArcMap.**

ii. **Add Data** \NHDPlusV21\Working\NHDFlowline_KnownFlow_Attrs.shp to map

iii. Open **ArcToolbox** and use **Data Management->Features->Feature Verticies to Points** specifying:

Input: NHDFlowline_KnownFlow_Attrs
Output: \NHDPlusV21\Working\NHDFlowline_KnownFlow_Points.shp
Point Type: Both Ends.

Note: Click the **Show Help** button in the tool dialog to better understand the options and functionality.

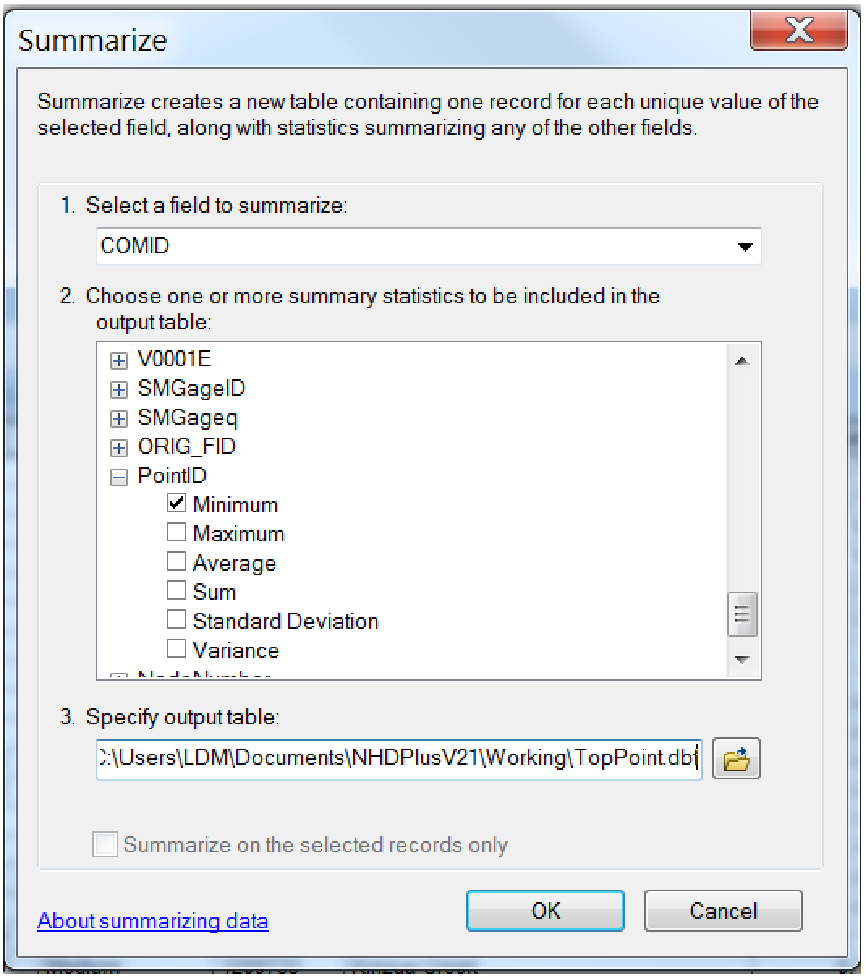


Note: The order of the output points is in the order of the features in NHDFlowline_KnownFlow_Attrs and in the digitized direction of the flowlines. For each feature, the start/top/from point is the first record followed by the record for the end/bottom/to point.

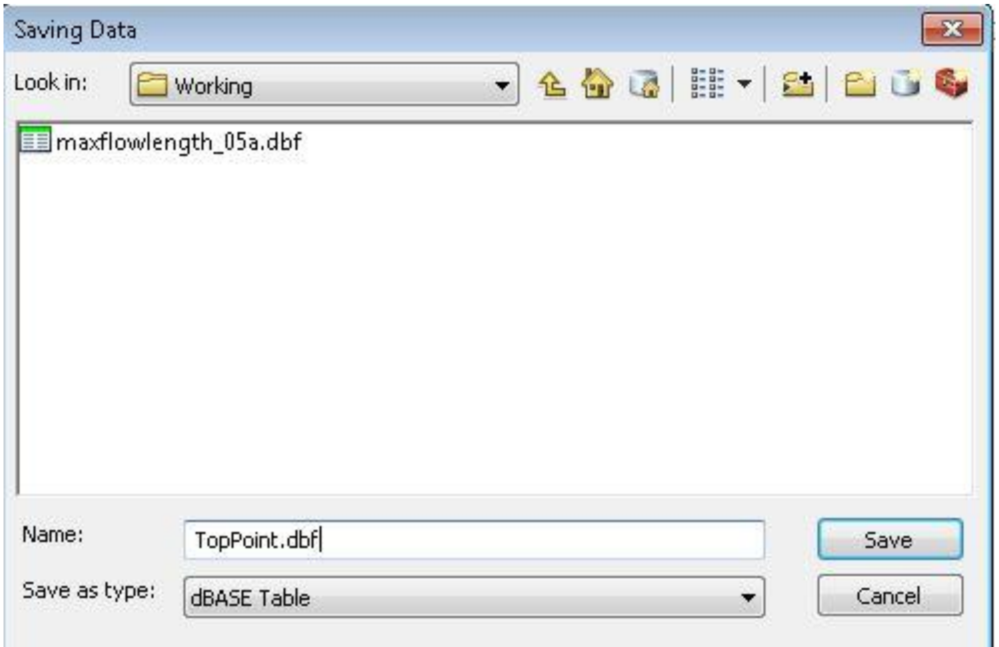
iv. Open table for NHDFlowline_KnownFlow_Points. From **Table Options->Add field** PointID Double(14,0) Right click on PointID and use **Calculate Field** to FID

v. From **Table Options->Add field** NodeNumber Double(14,0).

vi. Right click on NHDFlowline_KnownFlow_Points.ComID and **Summarize** computing minimum PointID (i.e. the ID of the Start/Top/From point) creating \NHDPlusV21\Working\TopPoint.dbf. When prompted, add the table to the map.



Note: Be sure to specify 'save as type' to dBASE Table as shown below.



vii. From **Table Options->Join** NHDFlowline_KnownFlow_Points.comid and TopPoint.comid

viii. From **Table Options->Select by attributes** NHDFlowline_KnownFlow_Points where NHDFlowline_KnownFlow_Points.PointID = TopPoint.Min_PointI. These will be the Start/Top/From point records. Half the records should be selected.

ix. For the selected records, right click on NHDFlowline_KnownFlow_Points.NodeNumber and use **Calculate Field** to set it to NHDFlowline_KnownFlow_Points.Fromnode.

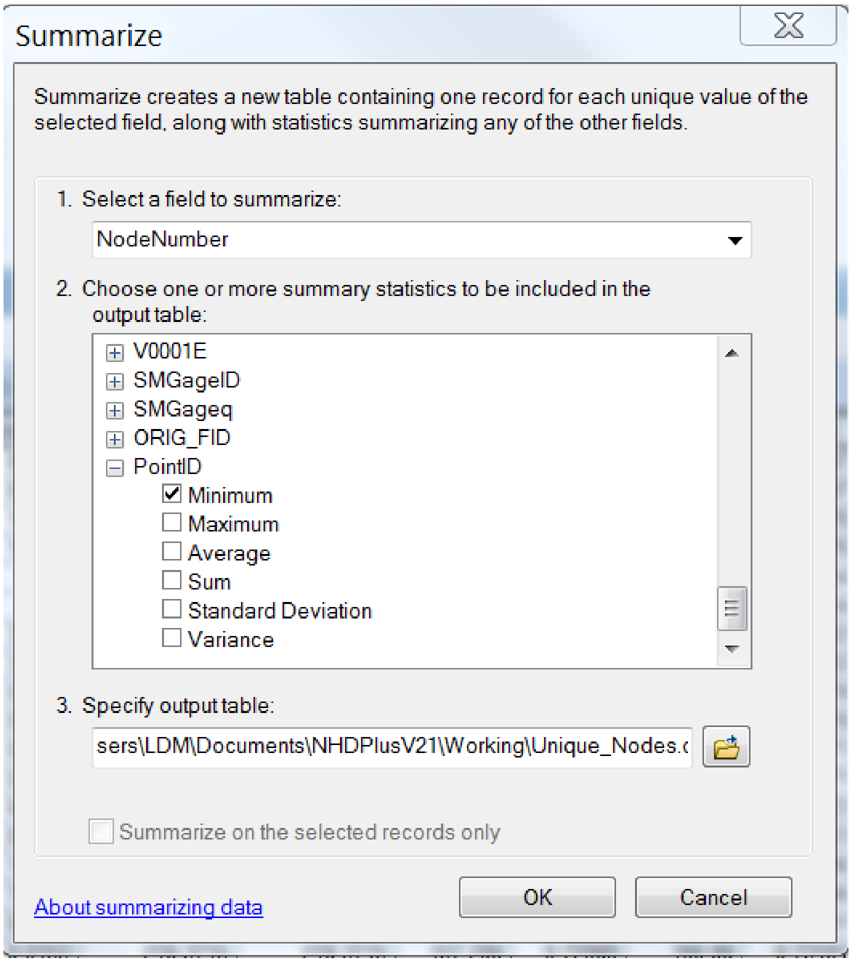
x. Switch selection

xi. Right click on NHDFlowline_KnownFlow_Points.NodeNumber and use **Calculate Field** to set it to NHDFlowline_KnownFlow_Points.ToNode

xii. Clear selection. Remove TopPoint Join.

xiii. To remove duplicate nodes:

1. Right click on NHDFlowline_KnownFlow_Points.nodenumber and **Summarize** computing minimum PointID creating \NHDPlusV21\Working\Unique_Node.dbf. When prompted, add the table to the map.



2. From **Table Options->Join** NHDFlowline_KnownFlow_Points.PointID and Unique_Nodes.Minimum_PointID.
3. Select records that received a join (i.e. Unique_Nodes.OID >= 0) The count should be:

172400 - The number of NHDFlowline tops
- 2354 - The number of minor paths (Divergence = 2) at network flow splits
+ 57 - The number of terminal flowlines (Terminalfl = 1)
+ 1 - At the bottom of the Ohio River

______
170104

Note: If there had been terminal flowlines that were also a confluence (e.g. a terminal lake with multiple inflows that meet in a point inside the lake), each lake terminus would be a single junction and would reduce the total number of junctions.

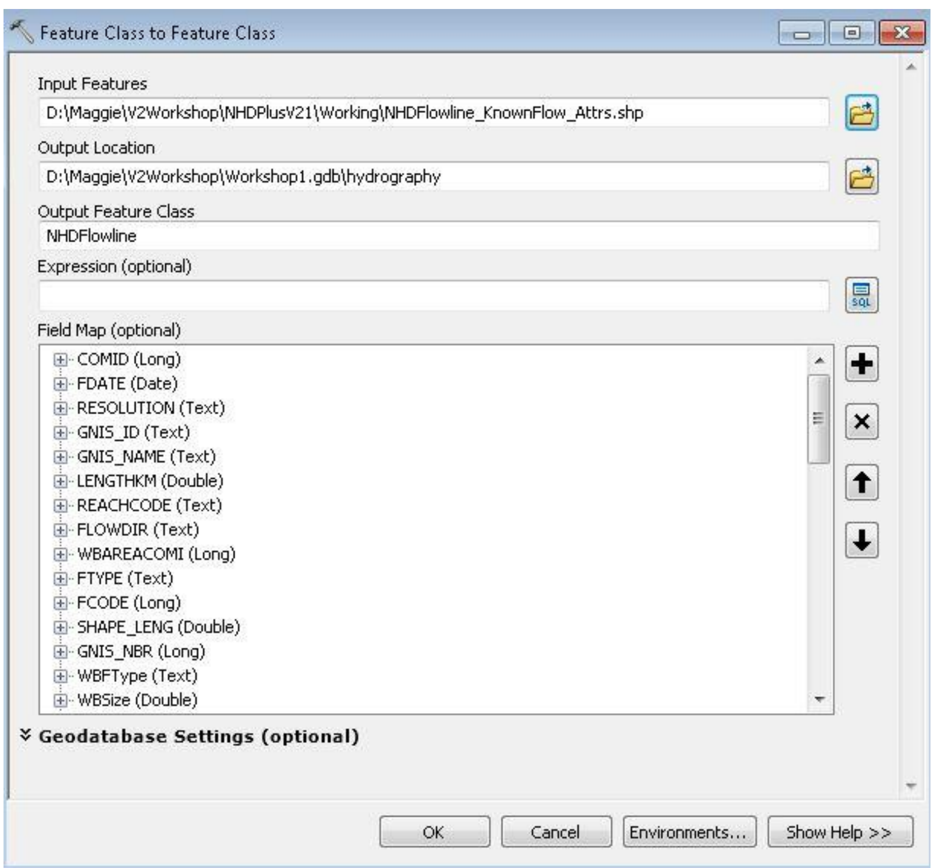
4. Remove Unique_Nodes join.
5. Right click on NHDFlowline_KnownFlow_Points **Data->Export** to \NHDPlusV21\Working\NHDFlowline_KnownFlow_Junctions
6. Close ArcMap

c. Create NHDPlusV21 NHDFlowline Geometric Network

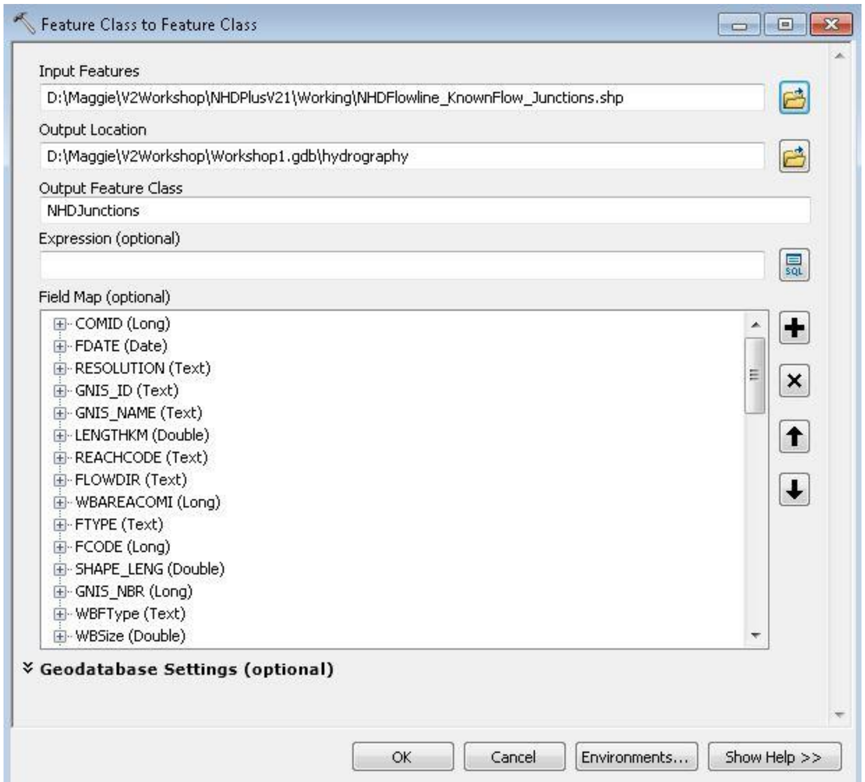
i. Open ArcCatalog

ii. Right click on Workshop1.gdb and add **New->Feature Dataset** called hydrography. Import the Coordinate System from \NHDPlusV211\Working\NHDFlowline_KnownFlow_Attrs.shp
Use defaults throughout the remainder of the dialog.

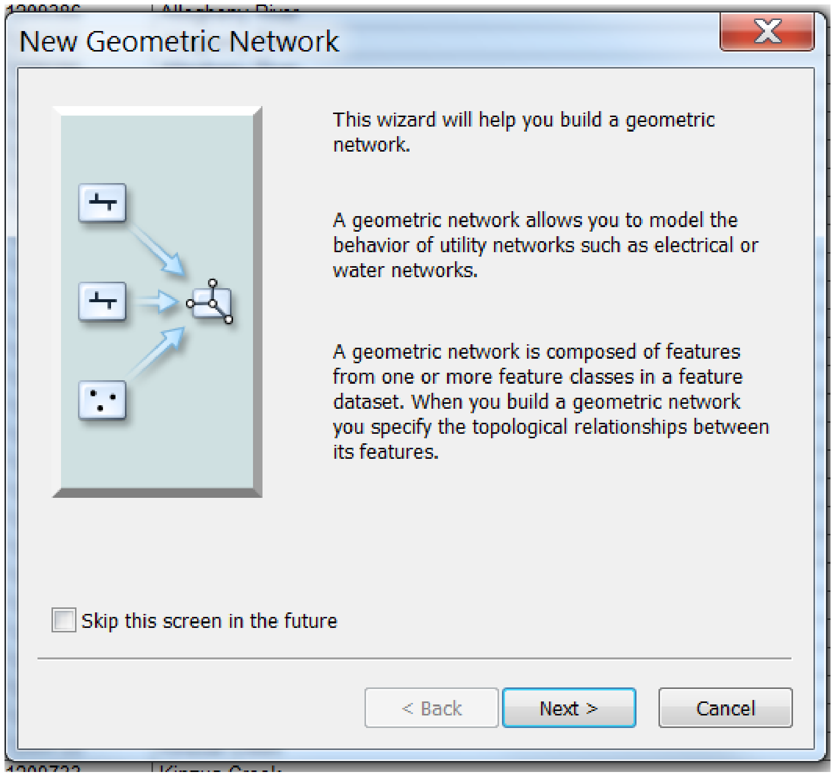
iii. Right click on Workshop1.gdb\hydrography and **Import Feature Class (single)**
Input Features: \NHDPlusV21\Working\NHDFlowline_KnownFlow_Attrs.shp
Output Feature Class: name it NHDFlowline

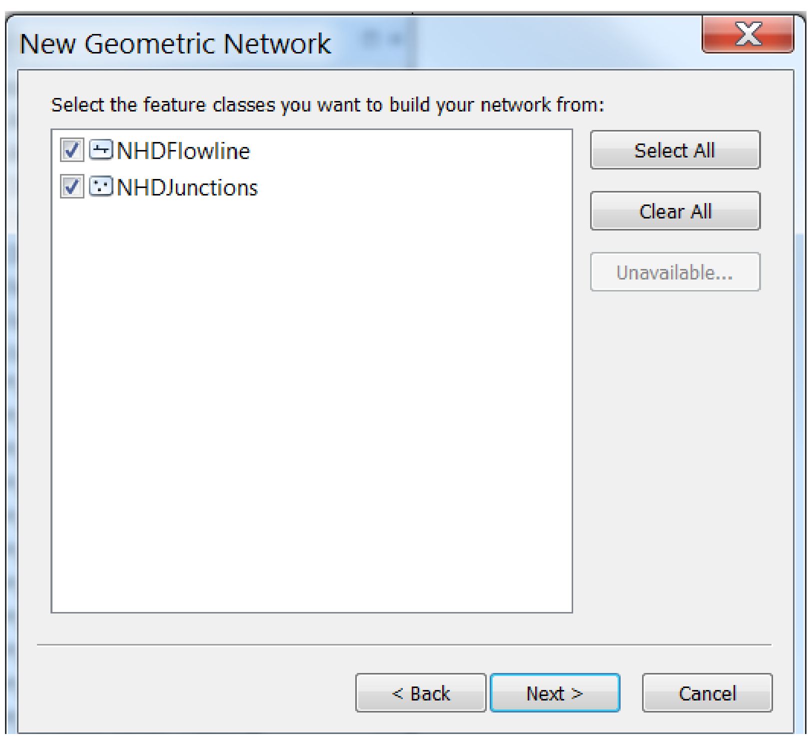


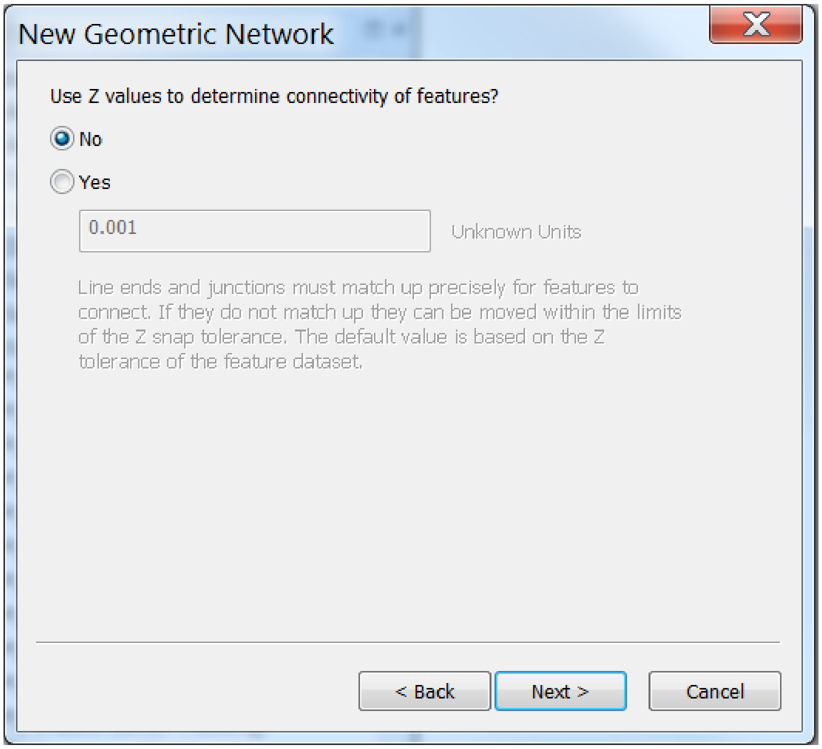
iv. Right click on Workshop1.gdb\hydrography and **Import Feature Class (single)**
Input Features: \NHDPlusV21\Working\NHDFlowline_KnownFlow_Junctions
Output Features: name it NHDJunctions



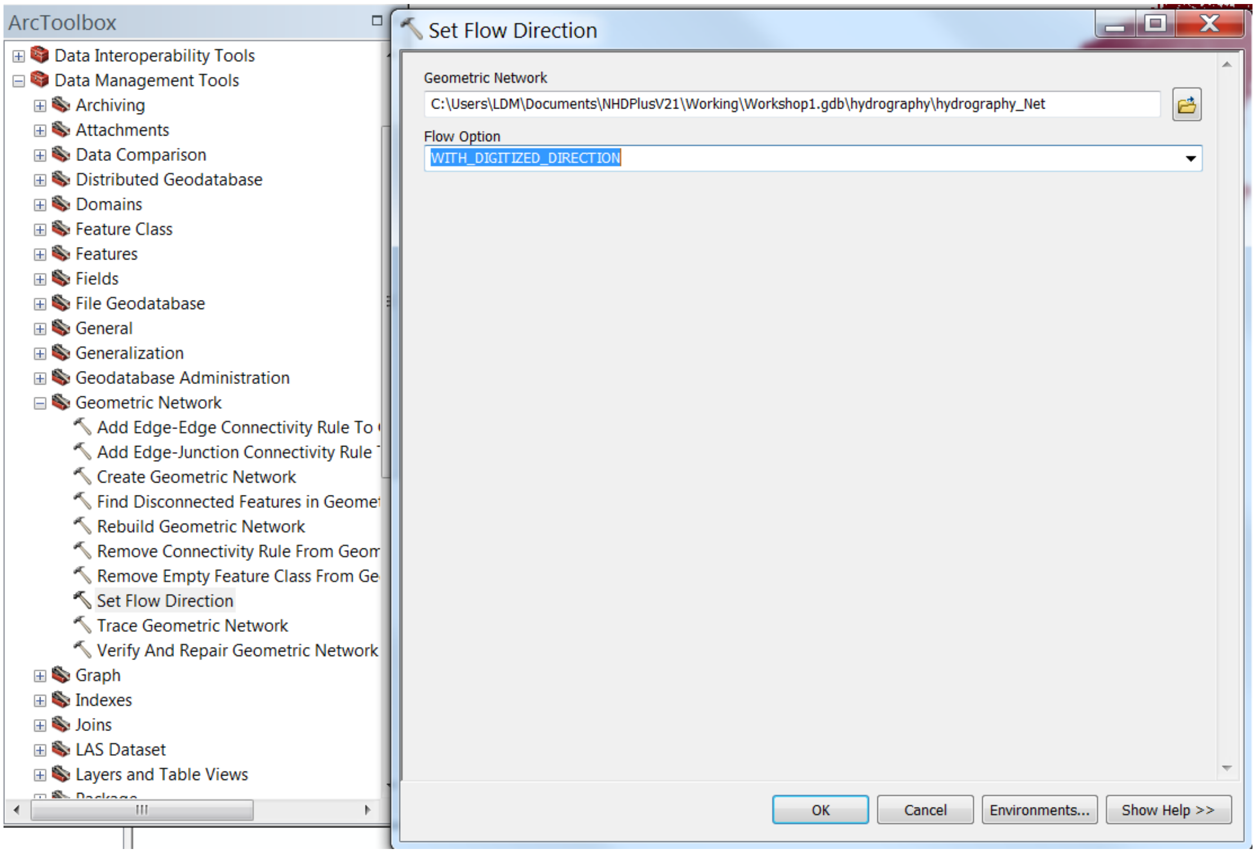
v. Right click on Workshop1.gdb\hydrography and add a **New-> Geometric Network**. In the New Geometric Network dialog, use defaults except as indicated below.


New Geometric Network
This wizard will help you build a geometric network.
A geometric network allows you to model the behavior of utility networks such as electrical or water networks.
A geometric network is composed of features from one or more feature classes in a feature dataset. When you build a geometric network you specify the topological relationships between its features.
Skip this screen in the future
< Back
Next >
Cancel


New Geometric Network
Select the feature classes you want to build your network from:
NHDFlowline
NHDJunctions
Select All
Clear All
Unavailable...
< Back
Next >
Cancel


New Geometric Network
Use Z values to determine connectivity of features?
No
Yes
0.001
Unknown Units
Line ends and junctions must match up precisely for features to connect. If they do not match up they can be moved within the limits of the Z snap tolerance. The default value is based on the Z tolerance of the feature dataset.
< Back
Next >
Cancel

i. Use ArcToolbox **Data Management->Geometric Network->Set Flow Direction** to establish the flow direction as being **WITH_DIGITIZED_DIRECTION** of the NHDFlowlines in the geometric network you just created. Close ArcCatalog.

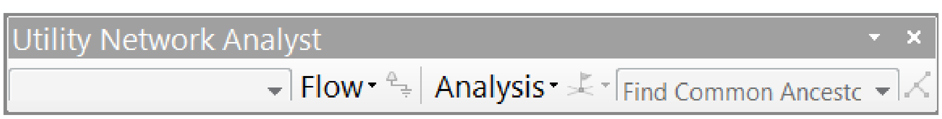


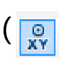
d. Navigate the Geometric Network

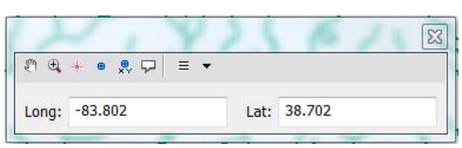
i. Open ArcMap.

ii. Add Data \NHDPlusV21\Working\Workshop1.gdb\hydrography\NHDFlowline

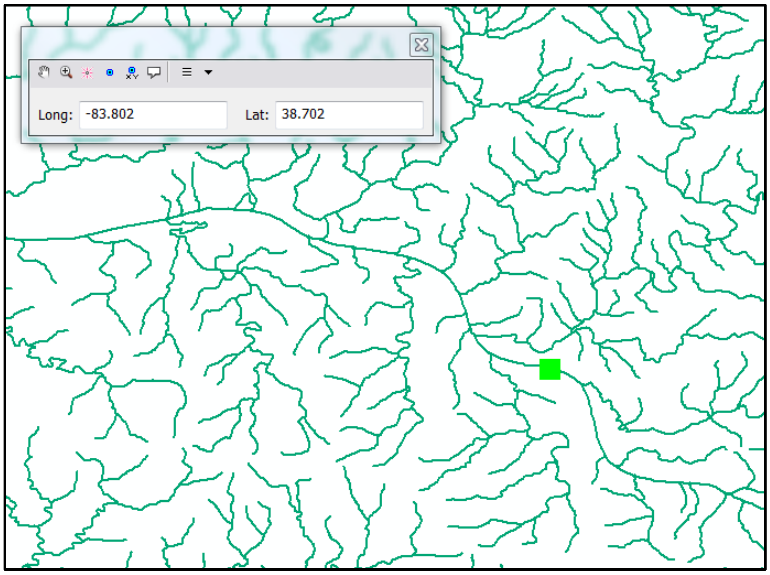
iii. Right click on an empty area of the ArcMap toolbar ribbon and add the **Utility Network Analyst** toolbar.



iv. Use the **GO To XY** tool () from the ArcMap standard toolbar to zoom to this location:



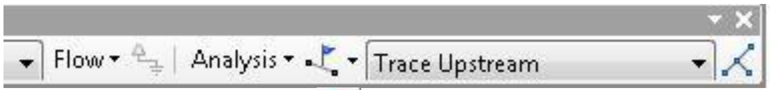
v. Use the **Edge Flag** () tool from the Utility Analyst toolbar to place a flag on the Flowline near this coordinate point.



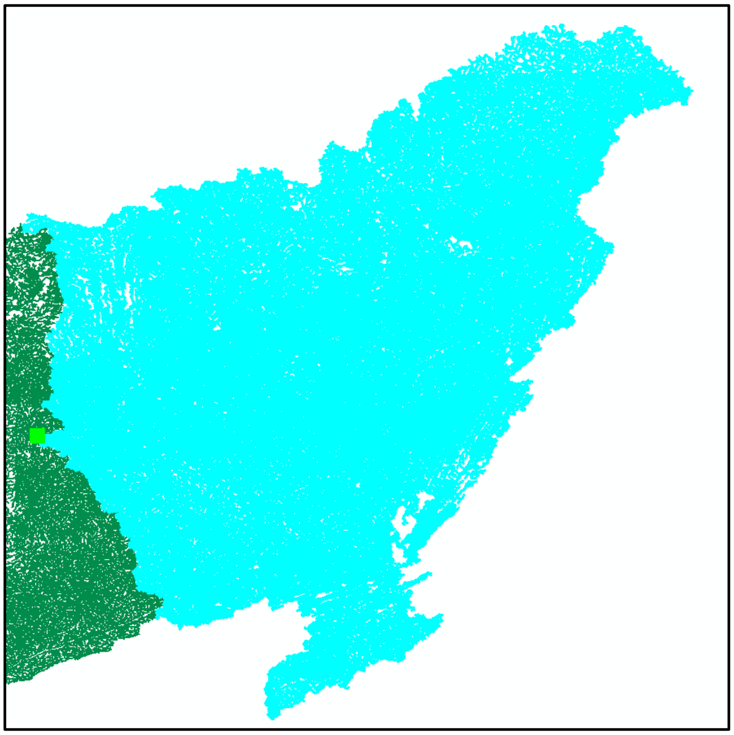
Note: To remove an unwanted flag, click Analysis dropdown -> **Clear Flags**.

vi. From the **Analysis** pulldown, select **Options->Results**. Select **Return Results as Selection**.

vii. Select “**Trace Upstream**” from the **Trace Tasks** drop down.

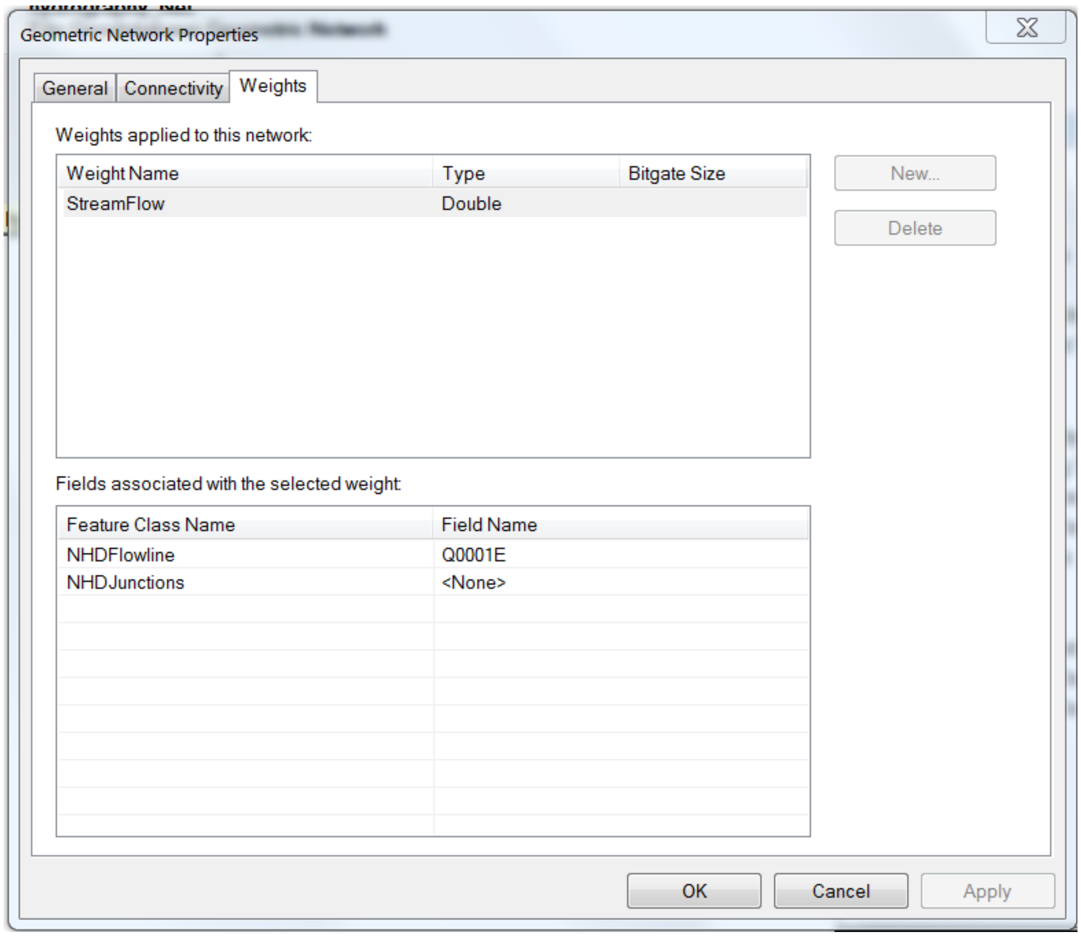


Click the **Solve** () button Right click NHDFlowline and **Selection->Zoom to Selected Features**.



e. Using Weights in the Geometric Network

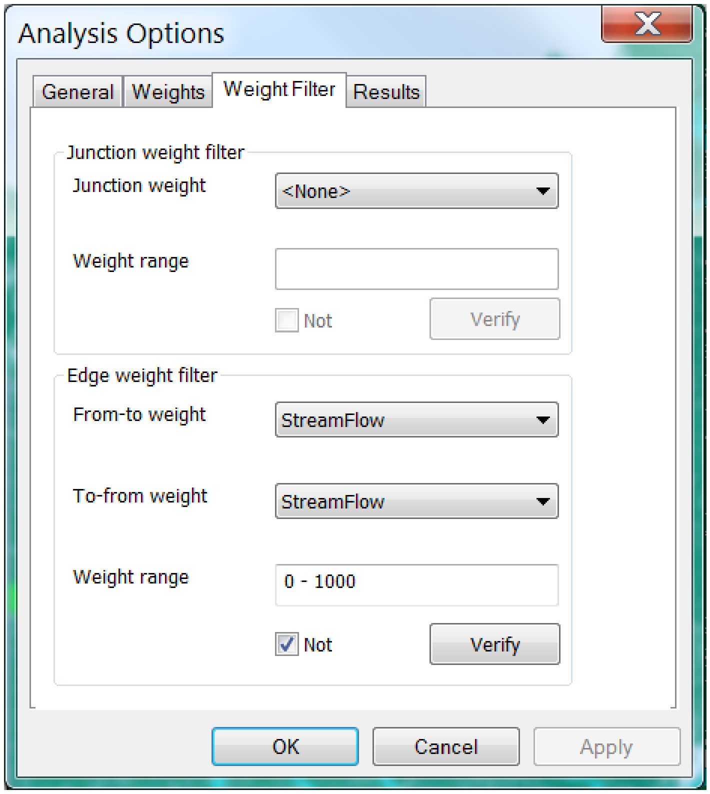
i. Save the ArcMap document as \NHDPlusV21\Working\Student3.mxd. Close ArcMap.
ii. Open ArcCatalog.
iii. Right click on \NHDPlusV21\Working\Workshop1.gdb\hydrography\hydrography_Net and select **Properties->Weights**
iv. Click **New** and **Add a Weight** called StreamFlow with type as Double.
v. In the pull down next to NHDFlowline, select Q0001E (i.e. NHDPlusV2 gage-adjusted stream flow). Click **OK**.
Note: Applying the weight will take some time.
Close ArcCatalog.



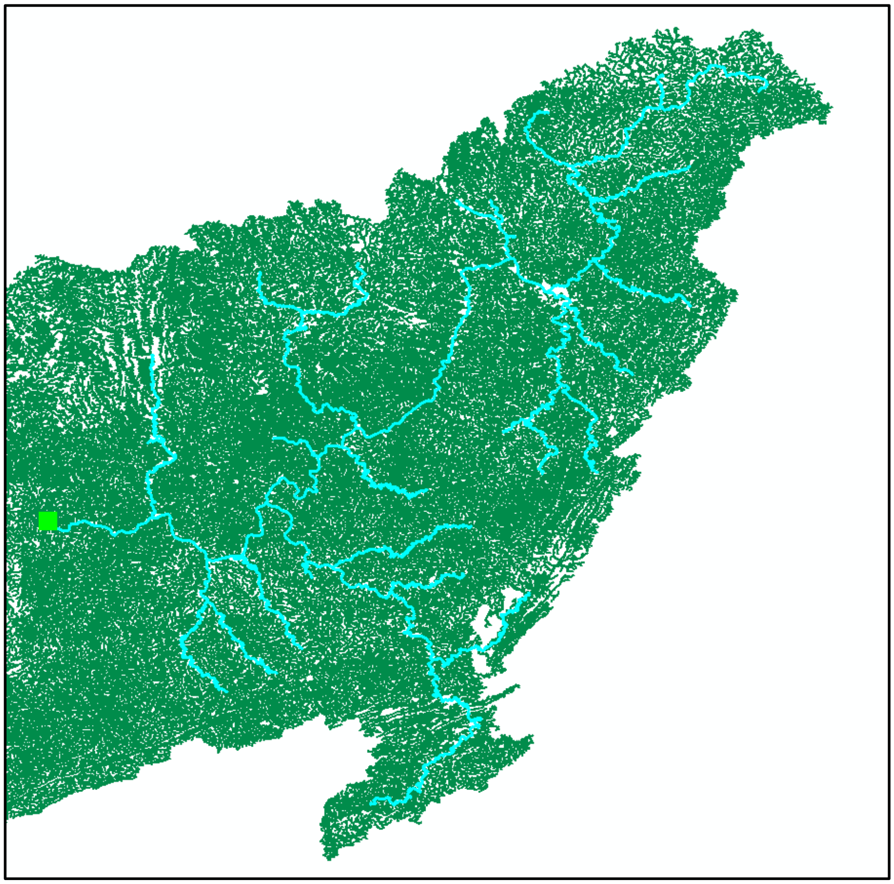
vi. Open ArcMap. Open \NHDPlusV21\Working\Student3.mxd.

vii. In the Utility Network Analyst Toolbar, click on **Analysis-> Options-> Weights** tab. Under **Edge Weights-> Weight Along Digitized Direction** and **Weight Against Digitized Direction of Edge**, select **StreamFlow** in the pull down.

viii. On the **Weight Filter** tab, under **Edge Weight Filter-> From-To Weight** and **To-from Weight**, select StreamFlow and in **Weight Range** put 0 – 1000 and checkmark **Not**.



ix. Under the **Results** tab, Select **Return Results as Selection**.
x. Click **OK**.
xi. Click **Solve**  button. Only flowlines with Streamflow > 1000 are navigated.



Note: Any attribute in your junctions or network edges can be added as a weight and used to control navigation.

Save the Student3.mxd and close ArcMap.

Put Network Attributes to Work

The Geometric network that we built in the previous segment contains many of the NHDPlus attributes joined to NHDFlowline. We're going to use those attributes now to do some interesting things.

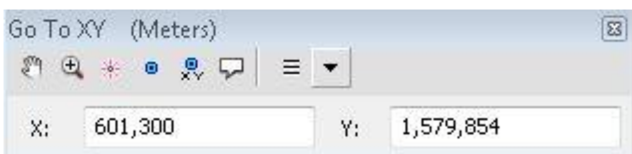
a. Create a working mxd.

   i. Open ArcMap. **Add Data** \NHDPlusV21\Working\Workshop1.gdb\hydrography\NHDFlowline. Symbolize with \NHDPlusV21\NHDFlowline.lyr.
   ii. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDWaterbody. Symbolize with \NHDPlusV21\NHDWaterbody.lyr.
   iii. **Add Data** \NHDPlusV21\ NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDArea. Symbolize with \NHDPlusV21\NHDArea.lyr.

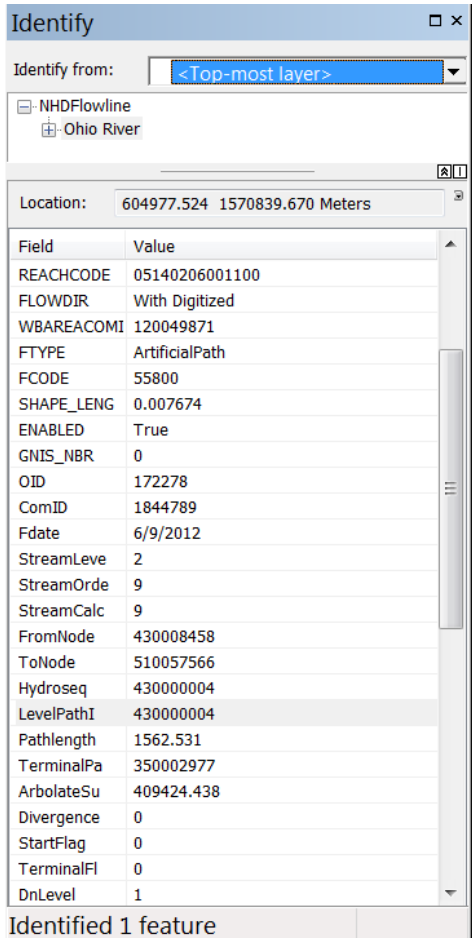
   Save ArcMap document as \NHDPlusV21\Working\Student4.mxd.

b. Find all the tributaries to the Ohio River.

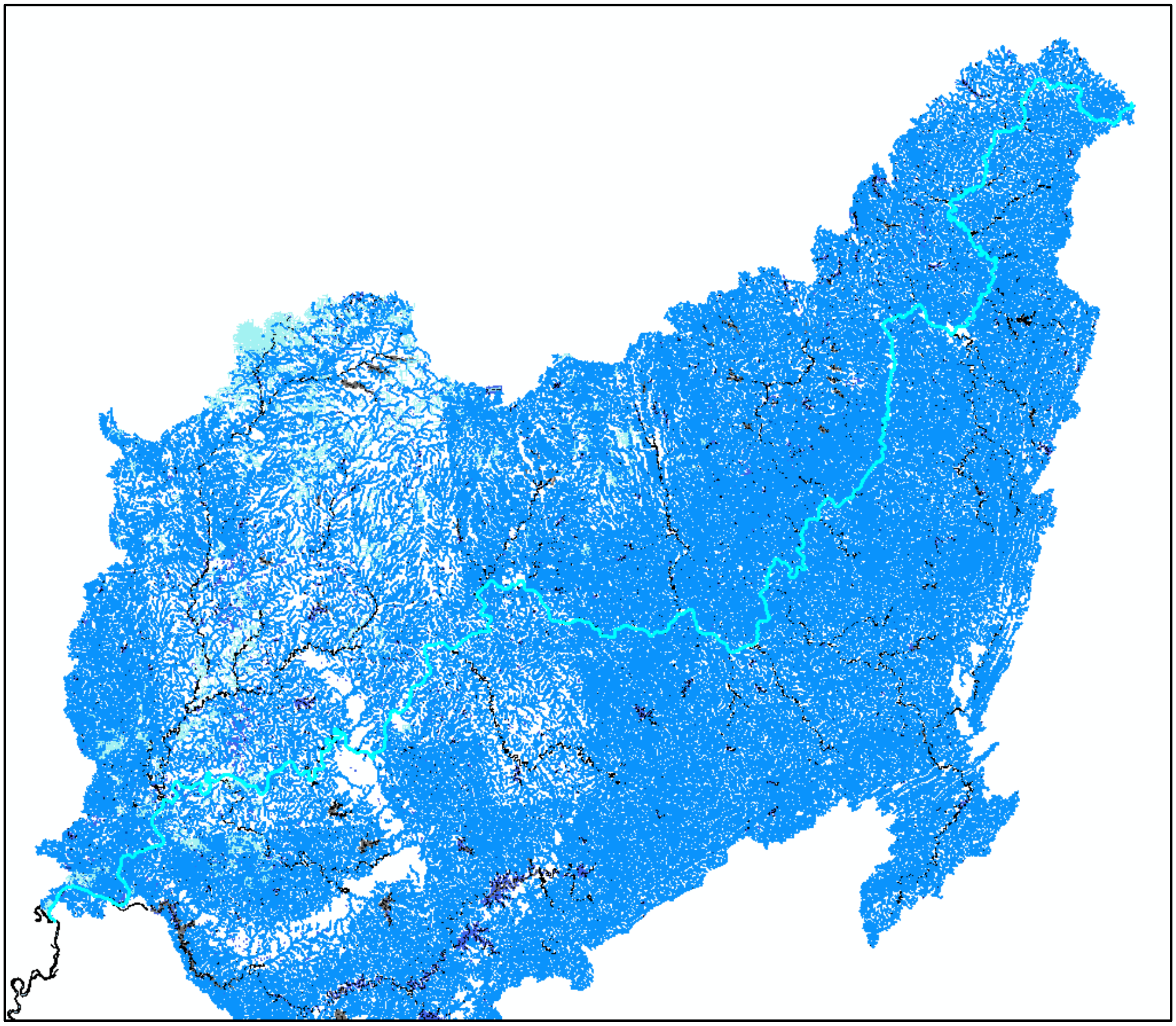
   i. Use the **Go To XY** tool on the ArcMap toolbar to zoom to the following coordinates. This is the mouth of the Ohio River.



ii. Use the **Identify** tool to display the NHDFlowline attributes for the most downstream flowline. Note that the LevelPathID is 430000004. This is a unique id that defines the main path from the mouth of the Ohio to the main head water flowline.

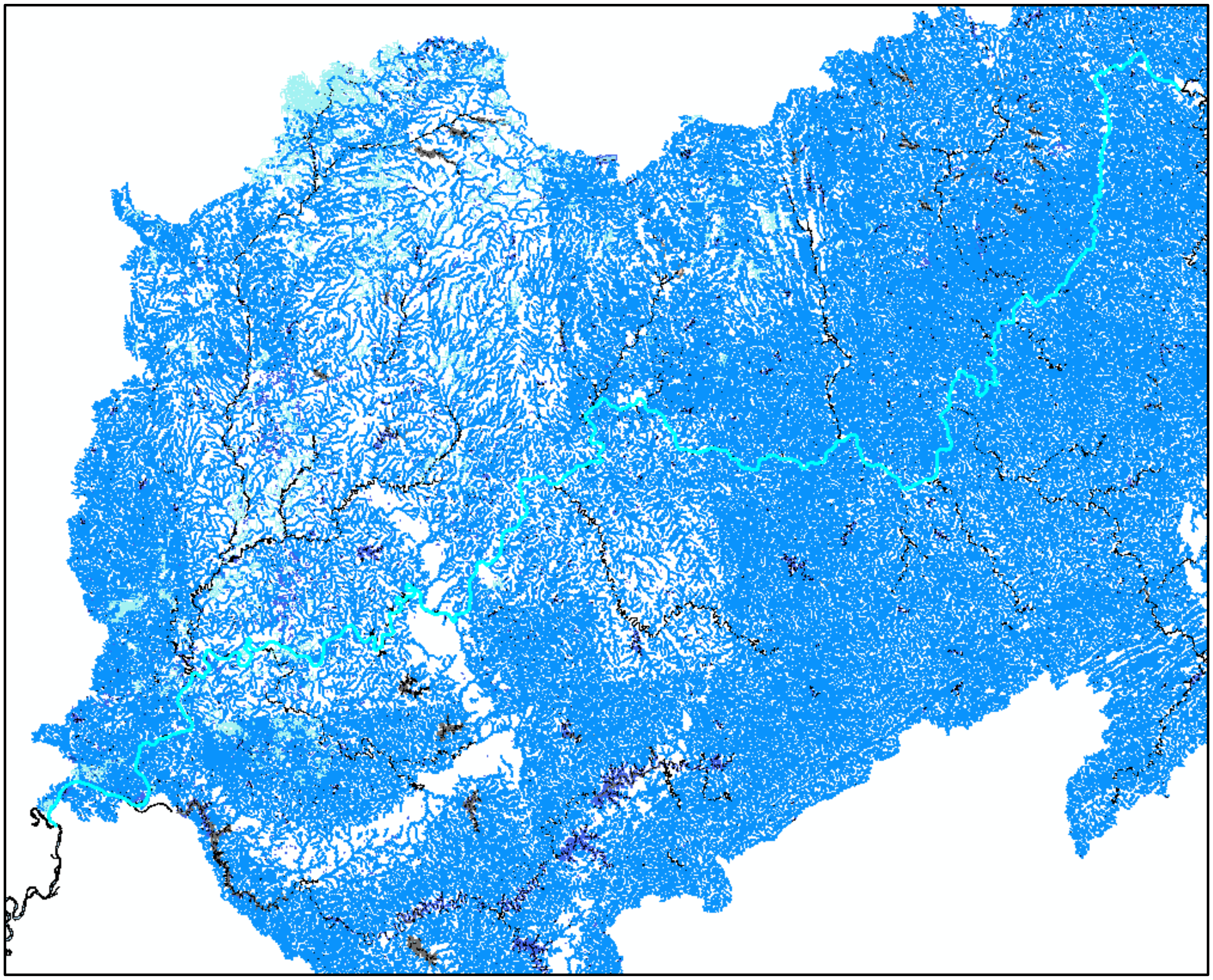


iii. To see the entire water course, from the mouth of the Ohio River to the main headwater, do a select "LevelPathI" = 430000004 and zoom to selected. This is the entire mainpath of Hydrologic Region 05.



iv. To see just the entire Ohio River, do a select "LevelPathI" = 430000004 AND "GNIS_ID" = '425264'. Right click on NHDFlowline, **Selection->Zoom to Selected**.

Note that when zooming to a named stream it's always best to use the GNIS_ID rather than the GNIS_Name. This is because the GNIS_ID is a unique identifier for the named feature and if there are multiple streams with the same name (e.g. Mill Creek is a very popular name), each named feature has a unique GNIS_ID.



v. Find the tributaries to the Ohio River: Opening the NHDFlowline attribute table. Display selected records. Sort ascending on Hydroseq. Record the minimum and maximum Hydroseq of the Ohio – 430000004 and 430001608.

vi. To find the tributaries, perform a selection as follow:

“DnLevelPat" = 430000004 AND "DnHydroseq" >= 430000004 AND "DnHydroseq" <= 430001608 AND "GNIS_ID" <> '425264'

In English, this statement says, select any NHDFlowline features whose immediate downstream flowline is the Ohio River and whose downstream hydroseq is greater than or equal to the minimum hydroseq on the Ohio and whose downstream hydroseq is less than or equal to the maximum hydroseq on the Ohio and which is not the Ohio itself.

NHDFlowline

COMID *	FDATE	RESOLUTION	GNIS_ID	GNIS_NAME
3408269	7/6/1999	Medium	485795	Agniels Creek
11050844	5/10/2009	Medium	1209386	Allegheny River
15434074	2/11/2009	Medium	1075253	Allen Run
10109483	2/17/2009	Medium	450631	Anderson River
11870020	2/17/2009	Medium	424572	Anthony Creek
3407463	7/6/1999	Medium	430276	Arnold Creek
19455283	7/29/1999	Medium	1535157	Baker Run
19442967	2/11/2009	Medium	1535205	Bar Run
10161976	3/9/2009	Medium	486338	Barebone Creek
15429776	2/11/2009	Medium	1075304	Bares Run
15429810	2/11/2009	Medium	1075307	Barnes Run
11870188	2/17/2009	Medium	424598	Barren Creek
11870184	2/17/2009	Medium	424607	Bay Creek
10157677	2/17/2009	Medium	430595	Bayou Creek
11870198	2/17/2009	Medium	510435	Bayou Creek
1840003	3/9/2009	Medium	486491	Bayou Creek
10157721	2/17/2009	Medium	430596	Bayou Drain
1922922	2/13/2009	Medium	1066562	Bear Creek
10164000	3/9/2009	Medium	486584	Beargrass Creek
1921952	2/13/2009	Medium	486596	Beasley Creek
19464504	3/8/2001	Medium	1169025	Beaver River
15429720	2/11/2009	Medium	1535454	Beaver Run
10157709	2/17/2009	Medium	430683	Beaverdam Creek

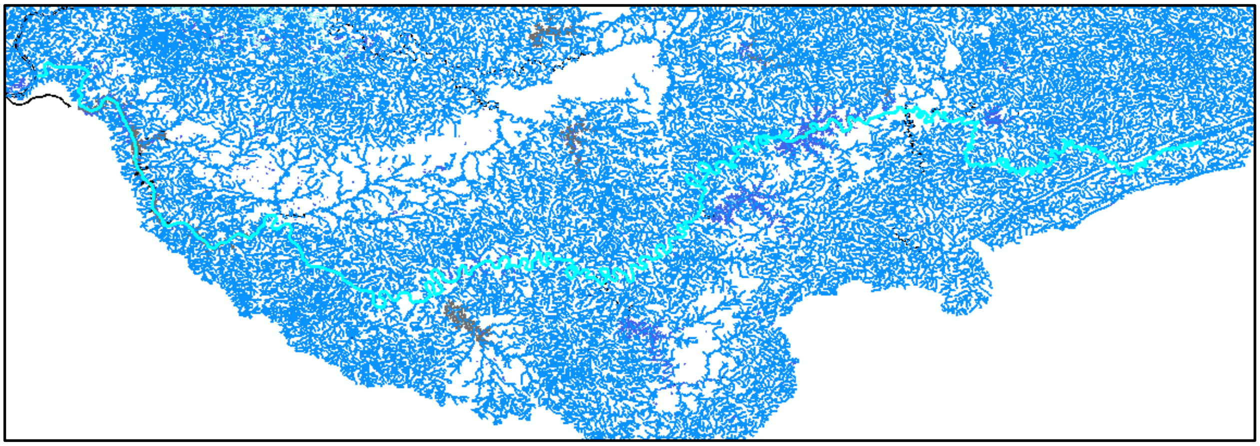
0 (799 out of 174433 Selected)

And we find that there are 799 tributaries to the Ohio in NHDPlus. Some of the named tributaries are in the list above. Note that Bayou Creek occurs three times. By looking at the GNIS_IDs, we can see that these are three different Bayou Creeks

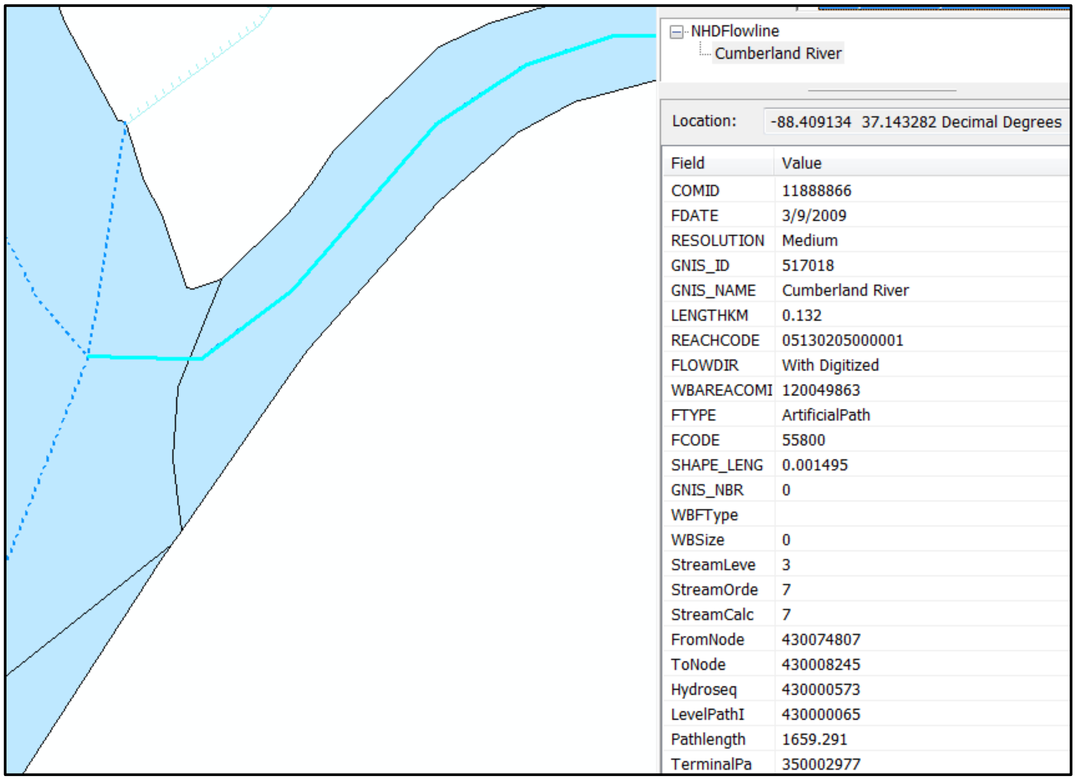
Save the Student5.mxd.

c. How many lakes are along the Cumberland River? How far are the lakes from the mouth of the Cumberland? How far apart are the lakes from each other?

   i. In NHDFlowline, find the Cumberland River using this select
      LevelPathI = 430000065 AND GNIS_ID = '517018'
      Zoom to selected.



   ii. Zoom in to the mouth of the Cumberland and do an **Identify** on the most downstream flowline. Make note of the PathLength (1659.291 kilometers) which is the distance from the mouth of the Cumberland to the mouth of the Mississippi.



iii. To find the lakes on the Cumberland River, start with the following selection from NHDFlowline:
LevelPathI = 430000065 AND GNIS_ID = '517018' AND WBFType = 'LakePond'
There are 395 NHDFlowlines inside lake features along the Cumberland.

NHDFlowline

COMID	FDATE	RESOLUTION	GNIS_ID	GNIS_NAME	LENGTHKM	REACHCODE	FLOWDIR	WBAREACOMI	FTYPE	FCODE	SH
3575808	3/9/2009	Medium	517018	Cumberland River	0.856	05130103010306	With Digitized	166899300	ArtificialPath	55800	
3574700	3/9/2009	Medium	517018	Cumberland River	2.558	05130103010331	With Digitized	166899300	ArtificialPath	55800	
3574686	3/9/2009	Medium	517018	Cumberland River	0.76	05130103010338	With Digitized	166899300	ArtificialPath	55800	
3574670	3/9/2009	Medium	517018	Cumberland River	0.116	05130103010345	With Digitized	166899300	ArtificialPath	55800	
3574668	3/9/2009	Medium	517018	Cumberland River	1.047	05130103010346	With Digitized	166899300	ArtificialPath	55800	
3574666	3/9/2009	Medium	517018	Cumberland River	1.518	05130103010347	With Digitized	166899300	ArtificialPath	55800	
3574662	3/9/2009	Medium	517018	Cumberland River	0.094	05130103010348	With Digitized	166899300	ArtificialPath	55800	
1017709	8/3/1999	Medium	517018	Cumberland River	1.657	05130106000825	With Digitized	10175533	ArtificialPath	55800	
9351300	8/3/1999	Medium	517018	Cumberland River	3.774	05130106000826	With Digitized	10175533	ArtificialPath	55800	
9351300	8/3/1999	Medium	517018	Cumberland River	3.226	05130106000826	With Digitized	10175533	ArtificialPath	55800	

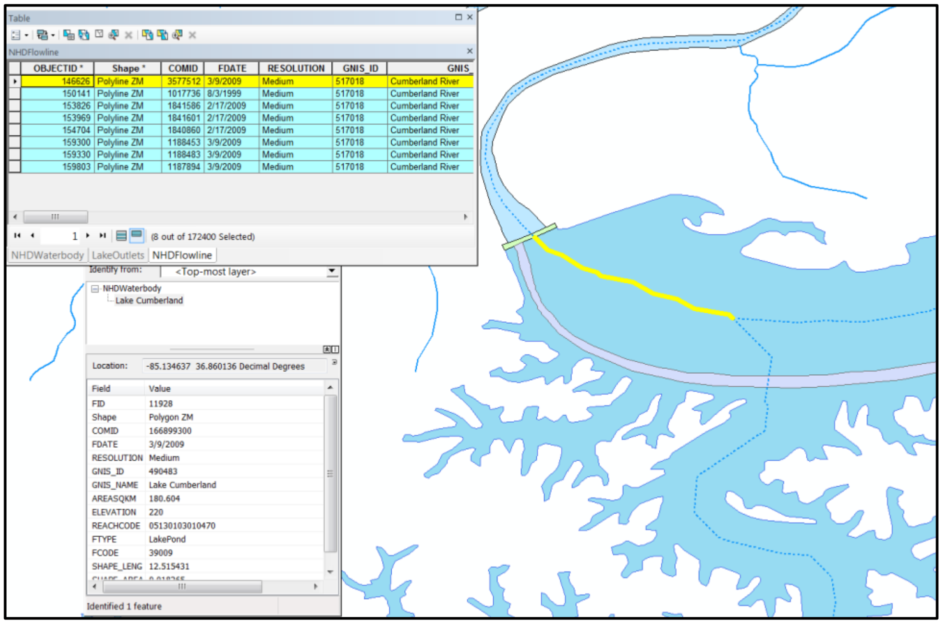
0 (395 out of 172400 Selected)

iv. Determine the lake outlets. Right click on the NHDFlowline table WBAreaComID and **Summarize** computing minimum Hydroseq and minimum Pathlength creating \NHDPlusV21\Working\LakeOutlets.dbf.

WBAREACOMI	Count_WBAREACOMI	Minimum_Hydroseq	Minimum_Pathlength
166899385	119	430000645	1705.687
11882216	36	430000946	1859.244
19551084	16	430001059	1891.635
18421865	51	430001105	1916.406
18415569	56	430001278	2000.658
18421871	3	430001567	2137.605
10175533	40	430001611	2155.143
166899300	74	430002667	2392.443

There are a total of 8 lakes on the Cumberland. Each lake's outlet is the NHDFlowline that has the Hydroseq value in the Minimum_Hydroseq column.

v. Open LakeOutlets table. From **Table Options, Joins and Relates->Relate**, relate LakeOutlets.Min_Hydros to NHDFlowline.Hydroseq. Select all LakeOutlet records and execute the relate. Highlight the first selected NHDFlowline and Zoom to Highlighted. Perform an **Identify** on the lake. This is the outlet to Lake Cumberland.



vi. For LakeOutlets, **Table Options**, **Add Field** RiverKM double. Right click on RiverKM and use **Field Calculator** set it to

(Minimum_PathLength – 1659.291).

PathLength is the distance from the bottom of the NHDFlowine feature to the network terminous and, in this case, that's the mouth of the Mississippi River. Remember from above that 1659.291 is the PathLength for the mouth of the Cumberland. Therefore, RiverKM now contains the distance from the mouth of the Cumberland for each of the eight lakes. And, of course, by subtracting any two values in this column, we know how far apart the outlets of the lakes are from each other.

LakeOutlets

OID	WBAREACOMI	Count_WBAREACOMI	Minimum_Hydroseq	Minimum_Pathlength	RiverKM
7	166899385	119	430000645	1705.687	46.396
1	11882216	36	430000946	1859.244	199.953
5	19551084	16	430001059	1891.635	232.344
3	18421865	51	430001105	1916.406	257.115
2	18415569	56	430001278	2000.658	341.367
4	18421871	3	430001567	2137.605	478.314
0	10175533	40	430001611	2155.143	495.852
6	166899300	74	430002667	2392.443	733.152

Save the Student5.mxd.

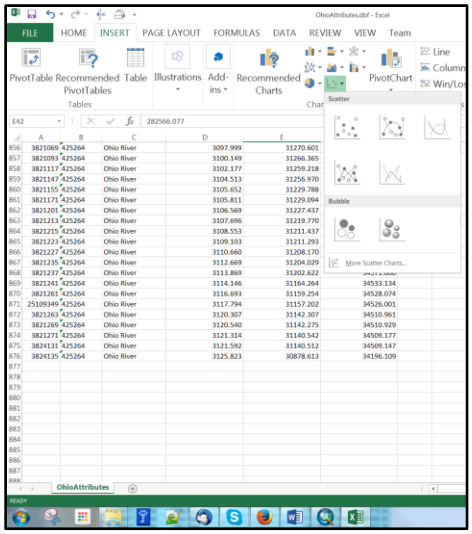
d. Make a profile plot of stream flow in the Ohio River.

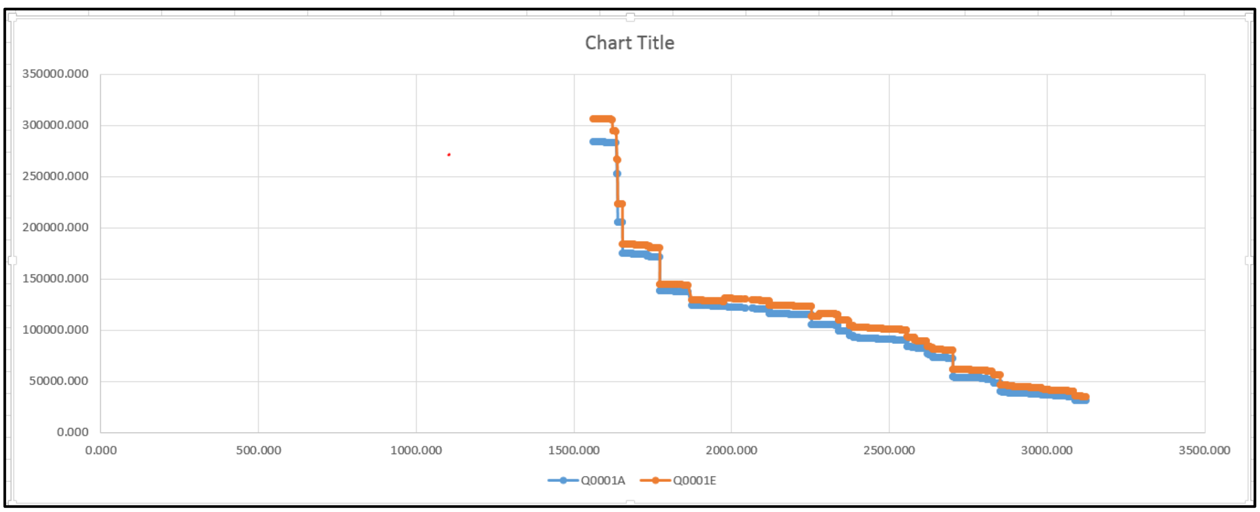
i. From NHDFlowline, select the flowlines for the Ohio River GNIS_ID ='425264' and LevelPathI = 430000004
ii. Open NHDFlowline **Properties->Fields**. Turn off all the fields except ComID, GNIS_ID, GNIS_NAME, PathLength, Q0001A and Q0001E
Note: Q0001A values are flow from runoff estimates and Q0001E values are flow from gages adjustments.
iii. Export selected NHDFlowline table records to OhioAttributes.dbf
iv. Open Excel.
v. Open \NHDPlusV21\Working\OhioAttributes.dbf in Excel. Make sure to show 'All Files' so Excel will recognize the dbf.

	A	B	C	D	E	F
1	COMID	GNIS_ID	GNIS_NAME	Pathlength	Q0001A	Q0001E
2	1844789	425264	Ohio River	1562.531	283557.635	306436.967
3	1842647	425264	Ohio River	1563.328	283557.298	306436.630
4	1841447	425264	Ohio River	1565.682	283555.609	306434.941
5	1841445	425264	Ohio River	1568.391	283553.154	306432.486
6	1841439	425264	Ohio River	1573.205	283522.224	306401.556
7	1841437	425264	Ohio River	1575.130	283519.617	306398.949
8	1841431	425264	Ohio River	1576.459	283517.802	306397.134
9	1841427	425264	Ohio River	1577.474	283517.353	306396.684
10	1841423	425264	Ohio River	1577.778	283490.719	306370.051
11	1841419	425264	Ohio River	1582.424	283464.688	306344.020
12	1841415	425264	Ohio River	1584.415	283331.218	306210.550
13	1841403	425264	Ohio River	1591.697	283314.074	306193.406

vi. Sort Pathlength in column D from smallest to largest.
vii. Highlight columns E and F, right click and select **Format Cells**. Change the decimal places to 3.
viii. Highlight all the values from row 1 to row 876 in the columns for Pathlength, Q0001A and Q0001E.

ix. **Insert->Charts->Scatter Chart**. Select one with lines connecting the points (the second choice).





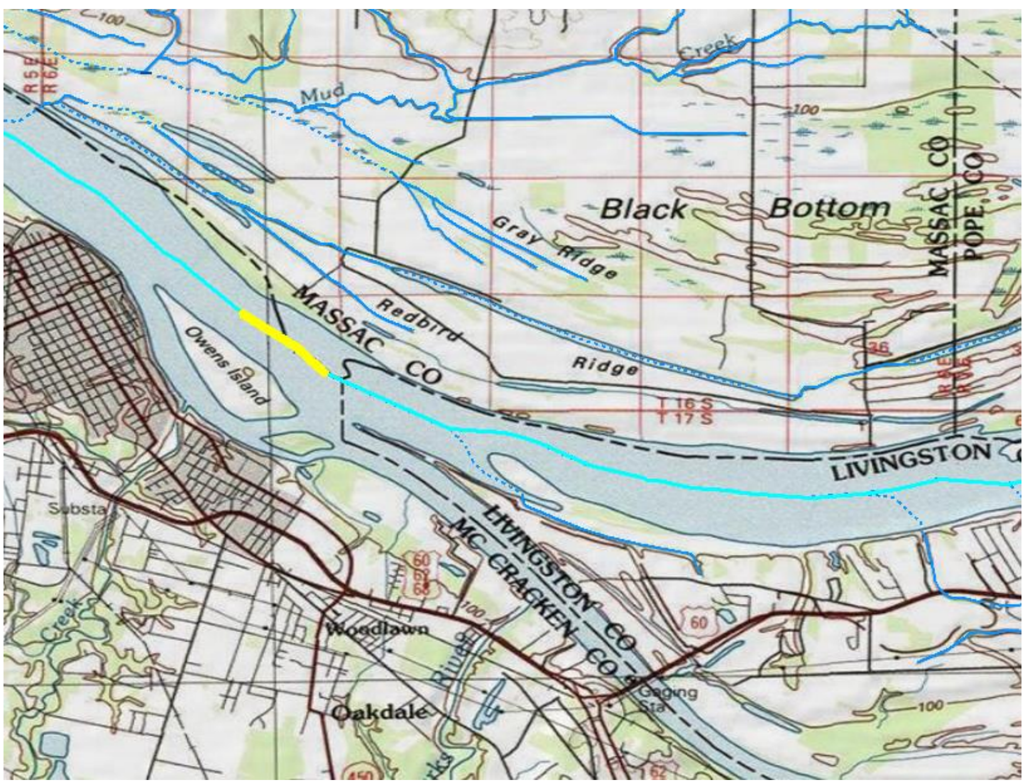
x. The chart x axis is from mouth (on the left) to headwaters (on the right). Notice the places where the flow Q0001A or Q0001E have large changes in value. For example, from the Excel chart we see one around a pathlength of 1600.

xi. Return to ArcMap. **Add Data** \NHDPlusV21\US_Topo_Maps.lyr to the map. Ignore the “Geographic Coordinate Systems Warning” by clicking **OK**. In the NHDFlowline table, sort the Pathlength column ascending.

xii. Scroll down to approximately 1600 in the Pathlength column. Highlight the flowline where the large change in Q0001A value (flow volume) occurs (COMID 1840095)

COMID	GNIS_ID	GNIS_NAME	Pathlength	Q0001A	Q0001E
1840043	425264	Ohio River	1628.943	282510.63	294119.48
1840053	425264	Ohio River	1630.178	282509.82	294118.68
1840057	425264	Ohio River	1631.082	282505.92	294114.77
1840069	425264	Ohio River	1632.05	282452.41	294061.20
1840191	425264	Ohio River	1634.556	282437.44	293773.65
1840075	425264	Ohio River	1637.055	252270.69	266387.36
1840193	425264	Ohio River	1637.61	252270.45	266387.11
1840095	425264	Ohio River	1638.479	252269.98	266135.57
1840097	425264	Ohio River	1639.684	205154.58	223191.18
1840105	425264	Ohio River	1641.261	205152.86	223189.47
1840103	425264	Ohio River	1645.906	205147.37	223183.96
1840099	425264	Ohio River	1647.545	205144.81	223181.40
1840087	425264	Ohio River	1649.85	205140.69	223177.28
1840079	425264	Ohio River	1650.759	205137.99	223174.57
1840061	425264	Ohio River	1653.523	205134.71	223171.3
1840047	425264	Ohio River	1654.204	205130.45	223167.03
1840035	425264	Ohio River	1655.276	174840.06	183938.24
1187023	425264	Ohio River	1658.184	174829.92	183928.09
1187023	425264	Ohio River	1659.262	174829.50	183927.67
1187028	425264	Ohio River	1659.864	174829.33	183927.50

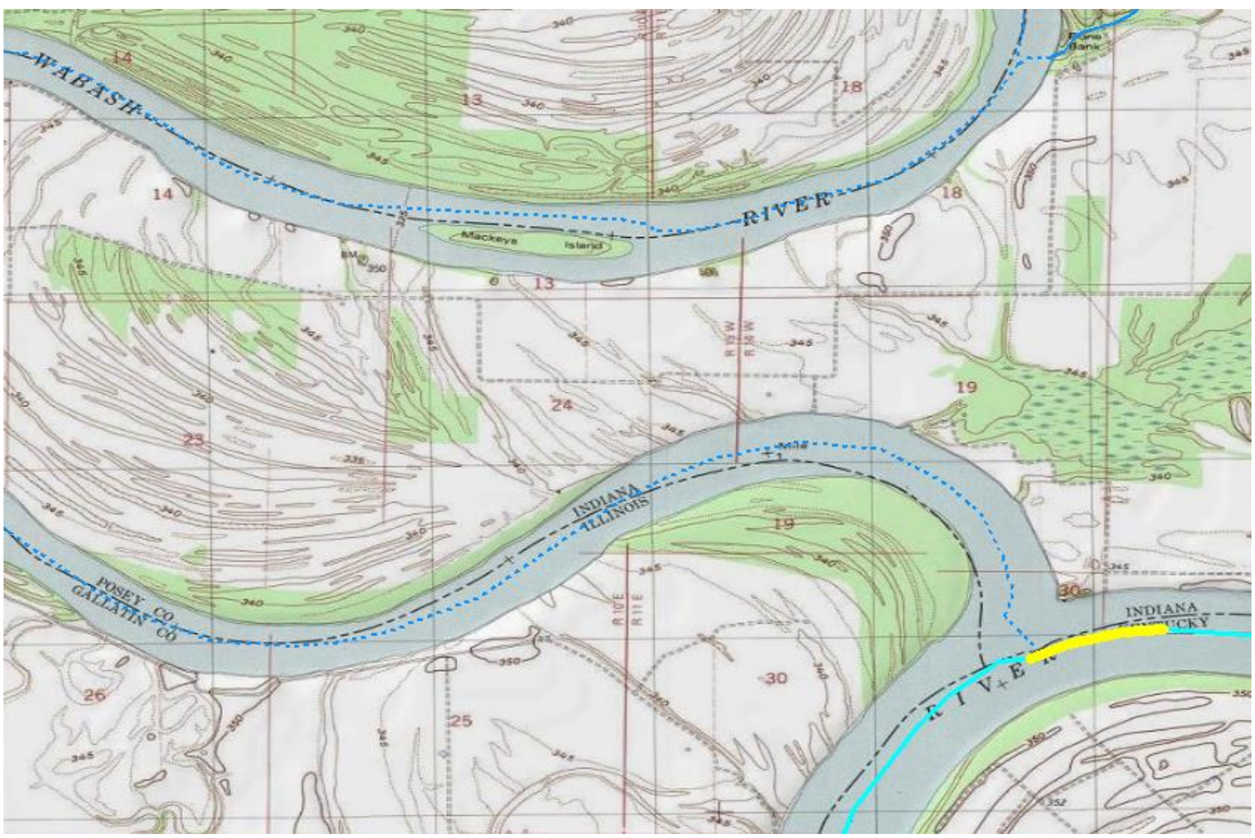
xiii. Zooming to the highlighted flowline, we see that this is where the Tennessee River (Region 06 to the south) is discharging to the Ohio.



xiv. Examining the Excel plot, we see another extreme flow change at a Pathlength of 1750.

COMID	GNIS_ID	GNIS_NAME	Pathlength	Q0001A	Q0001E
1186672	425264	Ohio River	1762.993	170969.2	180113.51
1186671	425264	Ohio River	1765.008	170966.13	180110.44
1186671	425264	Ohio River	1767.893	170944.37	180088.66
1186671	425264	Ohio River	1767.923	170930.71	180074.98
1186681	425264	Ohio River	1772.633	170925.83	180070.1
1015862	425264	Ohio River	1772.782	138164.48	144615.79
1015862	425264	Ohio River	1773.413	138164.26	144615.57
1015777	425264	Ohio River	1775.137	138159.92	144611.22
1015772	425264	Ohio River	1775.869	138159.67	144610.97

xv. If we zoom in to the highlighted flowline above, we see that this is where the Wabash River discharges to the Ohio. The confluence of the Wabash River and the Ohio River explains the sudden change in flow volume.



Profile plots are just one of the many ways that NHDPlusV2 data can be charted to visualize information about the river network.

Save the Student5.mxd.

e. Navigating with Network Attributes

   i. Navigating Upstream Mainstem is relatively easy. Open the NHDFlowline table options and turn on LevelPathID, Hydroseq, DnLevelPat and DnMinorHyd. Then select the level path of the Green River – LevelPathI = 430001637. This selects 390 flowlines from where the Green discharges into the Ohio to the top of this level path. This is an Upstream Mainstem navigation.

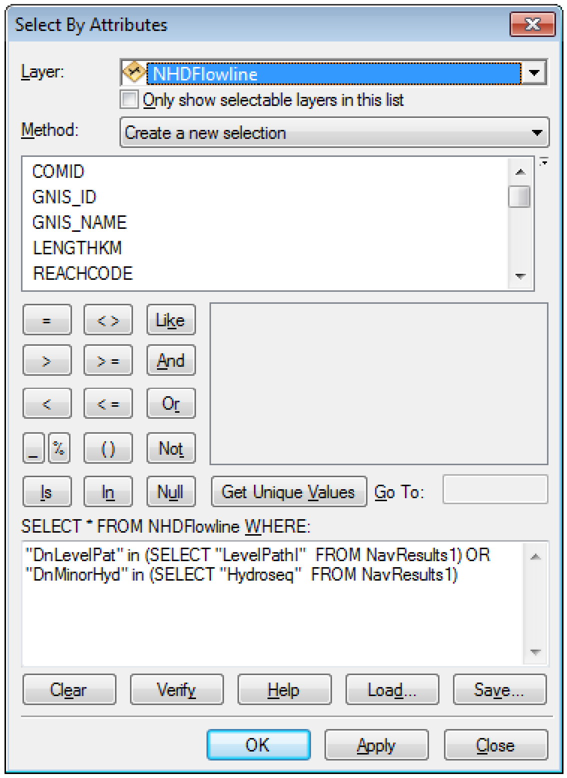
   Save the Student5.mxd.

   ii. To navigate Upstream with Tributaries from the bottom of a level path is more complex and requires an iterative process.

      A. Starting with the Mainstem navigation from above. Export the selected NHDFlowlines (for Green River's LevelPathI = 430001637) to \NHDPlusV21\Working\Workshop1.gdb\NavResults1, adding NavResults1 to the map.

      B. This iterative process involves performing a **Select By Attributes** query on **NHDFlowline.** Enter the following text in the Select By Attributes Dialog:

      "DnLevelPat" in (SELECT "LevelPathI" FROM NavResults1) OR "DnMinorHyd" in (SELECT "Hydroseq" FROM NavResults1)



The selection statement above involves a SQL sub-query, which only works on geodatabase feature classes. This code will not work on shapefiles.

The query is looking for any records from NHDFlowline whose “DnLevelPat” value is also located in the “LevelPathI” field in the NavResults1 feature class, OR any records from NHDFlowline whose “DnMinorHyd” value is also located in the “Hydroseq” field from NavResults1.

Basically, since NavResults1 is the mainstem of the Green River, this Select By Attributes query is looking for any tributaries in NHDFlowline that flow into that mainstem.

Proceeding to the next step (C), use 1 as the value for m.

C. Compare the number of selected records in NHDFlowline to the number of records in NavResults<m>.

If the number of selected records in NHDFlowline is less than or equal to the number of records in NavResults<m>, then the process ends because all of the waters have been found that flow into the starting stream. The final results should look like the picture below.

If the number of selected records in NHDFlowline is greater than the number of records in NavResults<m>, then the Upstream with

Tributaries navigation is still finding new waters that flow into the starting stream's network, so the process needs to continue.

Export the selected NHDFlowline records to a new geospatial feature class called **\NHDPlusV21\Working\Workshop1.gdb\NavResults<m+1>**, where the number <m+1> is m incremented by 1 each time through this step.

So, the file name should be NavResults2 the first time through this step, then NavResults3 the next time, etc.

When prompted, add NavResults<m+1> to the map.

D. Incremented m by 1. Substitute m's new value in the query below. Cut and paste the query into a new Select By Attributes from NHDFlowline.

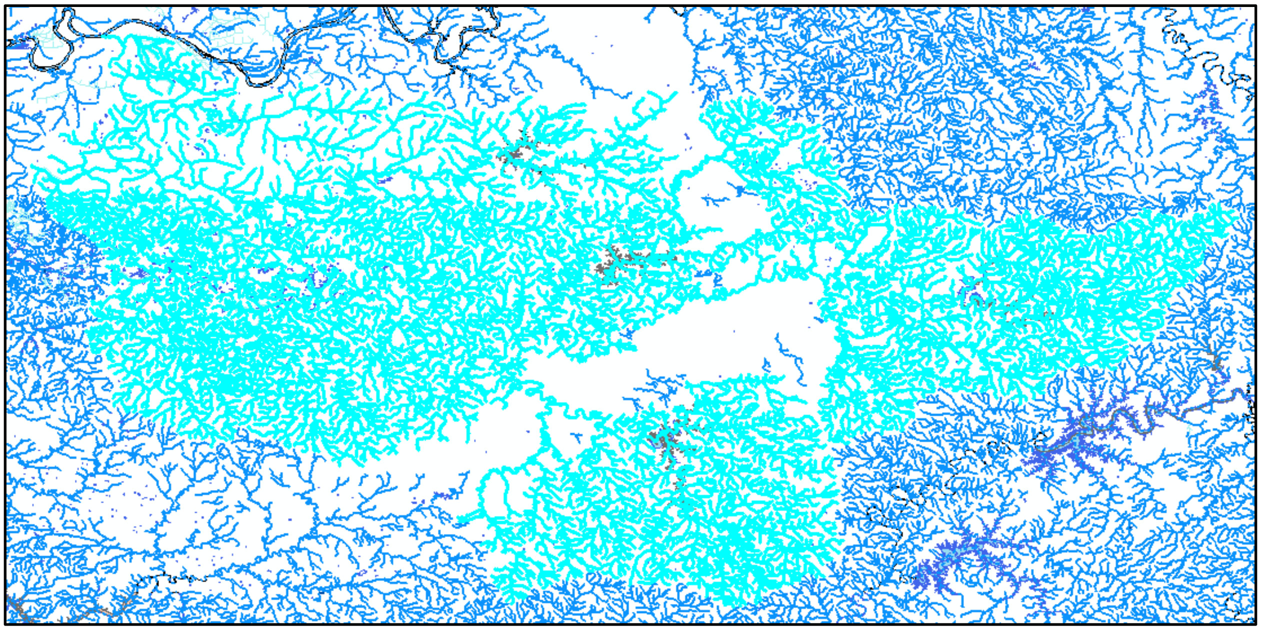
"DnLevelPat" in (SELECT "LevelPathI" FROM NavResults<m>) OR "DnMinorHyd" in (SELECT "Hydroseq" FROM NavResults<m>)

The query is looking for any records from NHDFlowline whose "DnLevelPat" value is also located in the "LevelPathI" field in the NavResults<m> feature class, OR any records from NHDFlowline whose "DnMinorHyd" value is also located in the "Hydroseq" field from NavResults<m>.

Basically, each time the Select By Attributes is performed another level of tributaries is added to the select. We started with the Green River, then added the tribs to the Green River and then added the tribs to the tribs, and so on until we reach the top of the network that drains into the Green River.

After the Select By Attributes is executed, go to Step C.

iii. The final result of this Upstream with Tributaries navigation from the bottom of the level path looks like this.



Homework assignment: Develop the steps necessary to perform the following navigations:

1. Upstream with Tributaries beginning in the middle of the Green River (i.e. up the Green River level path.
2. Downstream mainstem from the top and middle of the Green River.
3. Downstream with Divergences from the top and middle of the Green River.

There is an NHDPlus desktop tool that performs all of these VAA navigations from an ArcMap toolbar. This navigator performs point-to-point navigations and has many options. The tool is callable from Python. The NHDPlusV2 VAA Navigator is available from the NHDPlusV2 Tools web page.

Save the Student5.mxd and close ArcMap.

Link Information the Network

Note: If you have not performed the section above entitled “Build Geometric Network and Learn to Navigate”, please perform steps a through c of that section now.

During this section of the exercise, we’re going to create point and line events that link to the NHD/NHDPlus network. Events use NHDFlowline.Reachcodes and the measure values imbedded in the NHDFlowline coordinates to link external information to a point along the network or a linear section of the network.

A point event is linked to a Reachcode and a measure. A line event is linked to a Reachcode, a from-measure (the starting endpoint of the event) and a to-measure (the ending endpoint of the event).

Note that measures along the one or more flowlines that have a given Reachcode begin at 0 at the downstream end of the Reach and stop at 100 at the upstream end of the Reach.

Events are entries in a table without geometry. The events can be rendered (and the geometry saved) by using the ArcGIS Linear Referencing Toolbox. The event geometry comes from the NHDFlowlines based on the Reachcode and measure values.

a. Open ArcCatalog.

b. Create a shapefile for point events:
   Right click on **\NHDPlusV21\Working**, select **New->shapefile** and create a point shapefile called **MyPoints**. Use GCS North American 1983 as the coordinate system.
   Right click on **MyPoints,** select **Properties->Fields**, add fields:

EventID	Text(20)
EventDesc	Text(100)
ComID	Long

c. Create a shapefile for line events:
   Right click on **\NHDPlusV21\Working**, select **New->Shapefile** and create a line shapefile called **MyLines**. Use GCS North American 1983 as the coordinate system.
   Right click on **MyLines**, select **Properties->Fields**, add fields:

EventID	Text(20)
Reachcode	Text(14)
FromMeas	Double(9,5)
ToMeas	Double(9,5)
EventDesc	Text(100)
ComID	Long

d. Create a shapefile for the line event endpoints. Event endpoints will be used to determine the beginning measure and ending measure of the event.

Right click on **\NHDPlusV21\Working**, select **New->Shapefile** and create a point shapefile called **MyLineEndPoints**. Use GCS North American 1983 as the coordinate system.
Right click on **MyLineEndPoints**, select **Properties->Fields**, add fields:

EventID	Text(20)
WhichEnd	Text(1)

e. Close ArcCatalog.

f. Open ArcMap.

g. **Add Data** \NHDPlusV21\Working\Workshop1.gdb\ hydrography\NHDFlowline.

h. Create some point events:

   i. **Add Data** \NHDPlusV21\Working\MyPoints

   ii. Add ArcGIS **Editor** toolbar, if necessary.

   iii. From **Editor** toolbar pulldown, select **Snapping** and add **Snapping Toolbar**. From **Snapping** pulldown, make sure that **Use Snapping** is checked.

   iv. From **Editor** toolbar pulldown, select **Start Editing** and then **MyPoints**.

   v. From **Editor** toolbar pulldown, select **Editing Windows** and open **Create Features** window. Select **MyPoints**.

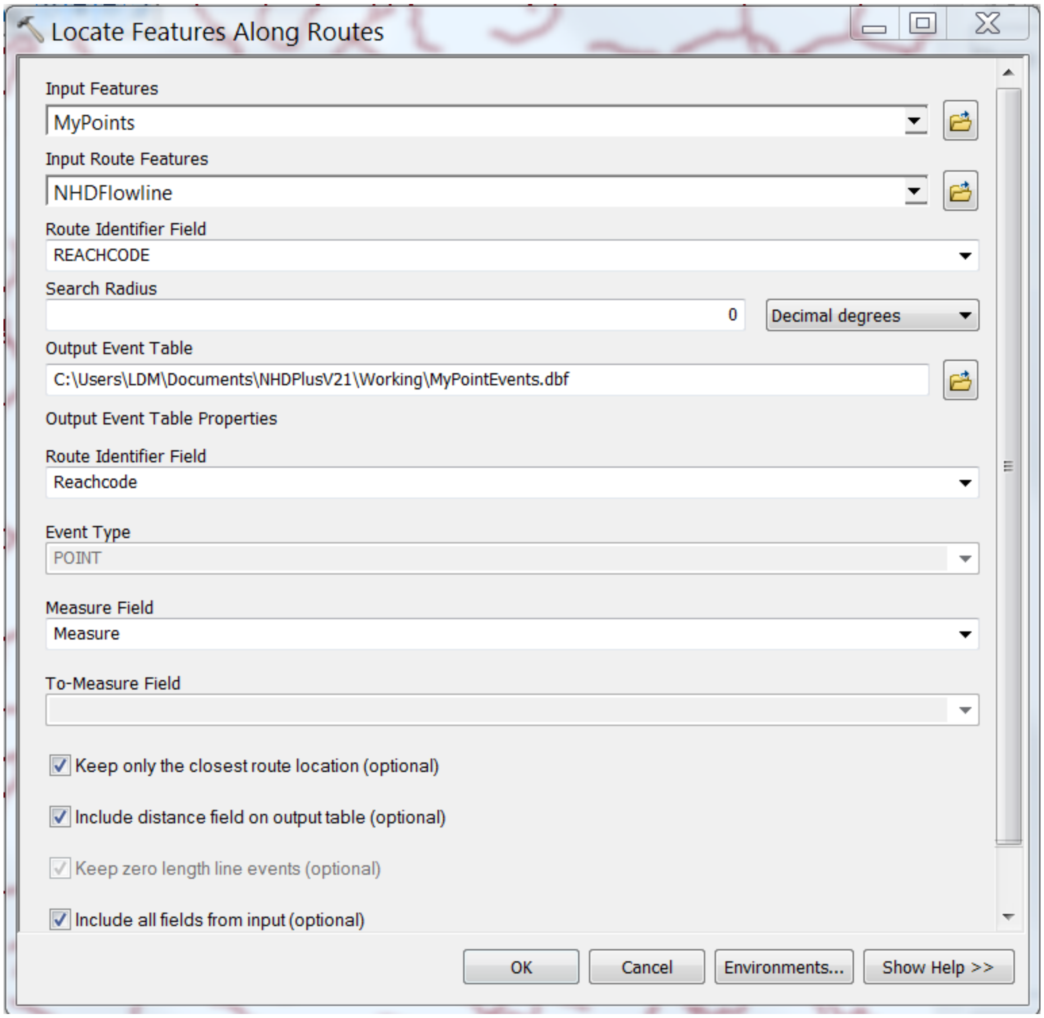
   vi. Use the **Map Scale** window to zoom in to about 1:250,000 scale somewhere in the NHDFlowline layer.

   vii. Click on **Construction Tools**, then **MyPoints** in the **Create Features** window. Now point and click on NHDFlowline features creating points where you would like to have point events. Populate **MyPoints.EventID** with a unique value for each point. Optionally, populate the MyPoints.EventDesc field

   viii. From **Editor** toolbar, **Save Edits a**nd **Stop Editing**.

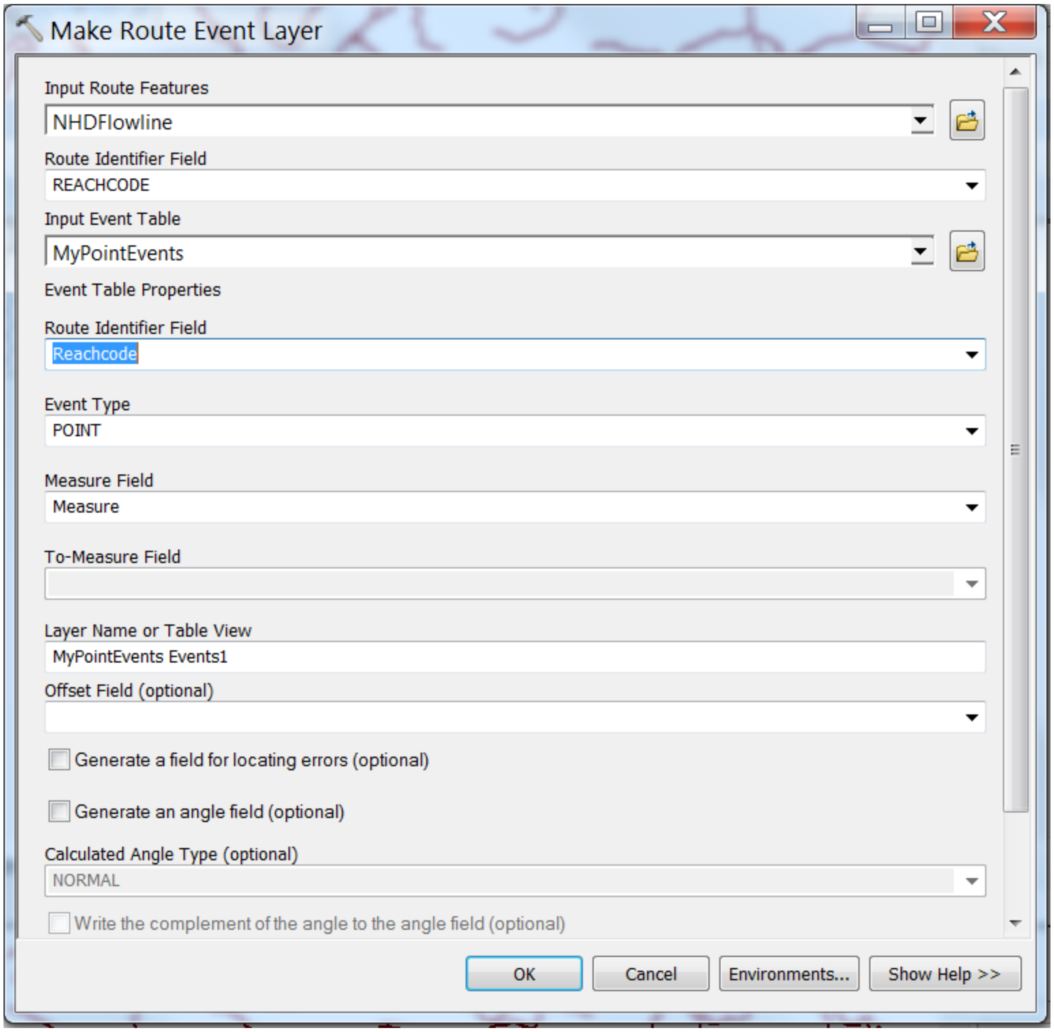
   ix. Open ArcToolbox, **Linear Referencing Tools**.

   x. Open **Locate Features Along Routes** and fill in the dialog as follows:



This creates an event table called **MyPointsEvents** and adds it to the map. Open the attribute table and note that the NHDFlowline Reachcode and Measure location for each point have been added to the table.

xi. To render the events in the map, open the **Linear Referencing**->**Make Route Event Layer** tool dialog and fill it out like this:



This creates a temporary layer in the map called **MyPointEvents Events**. To permanently save the point events with geometry, export the layer to **\NHDPlusV21\Working\MyPointEvents_Rendered.shp**.

xii. Remove all the point event tables and layers from the map, leaving only NHDFlowline.

i. Create some line events:

i. **Add Data** \NHDPlusV21\Working\MyLineEndPoints and \NHDPlusV21\Working\MyLines to the map.

ii. Add the **Utility Network Analyst** toolbar to ArcMap if necessary.

iii. From the **Utility Network Analyst** toolbar, use the **Analysis** pulldown and select **Options**. On the **Results** tab select **Return Results as Selection**. Click **OK**.

iv. From the **Editor** toolbar, **Start Editing** and select **MyLineEndPoints.**

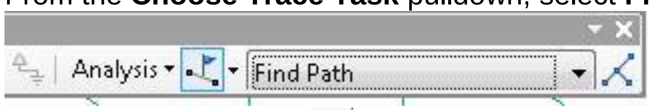
v. From **Editor** toolbar pulldown, select **Editing Windows** and open **Create Features** window and select **MyLineEndPoints** in the **Create Features** window.

vi. Create a bottom point and a top point for your event. By convention, the bottom point should be downstream of the top point. Open the **MyLineEndPoints** table and populate the WhichEnd field with “B” for Bottom and “T” for Top.

vii. Populate EventID for both the Bottom and Top points with the same unique identifier.

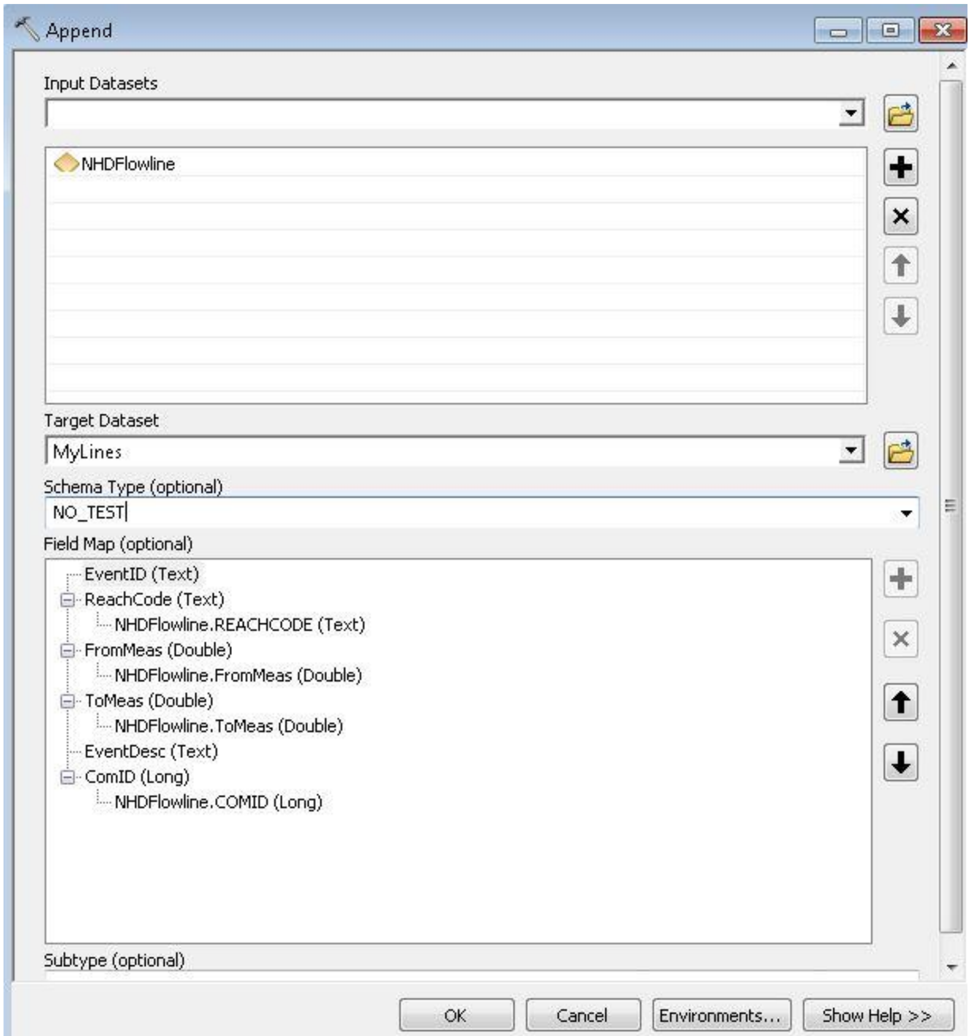
viii. From the **Utility Network Analyst** toolbar, select the **Add Edge Flag** tool . Place an edge flag over your bottom point and another over your top point.

ix. From the **Choose Trace Task** pulldown, select **Find Path**.



Click the **Solve** button.  The flowlines between your bottom and top points are selected.

x. Use the **Data Management->General->Append** tool as follows:



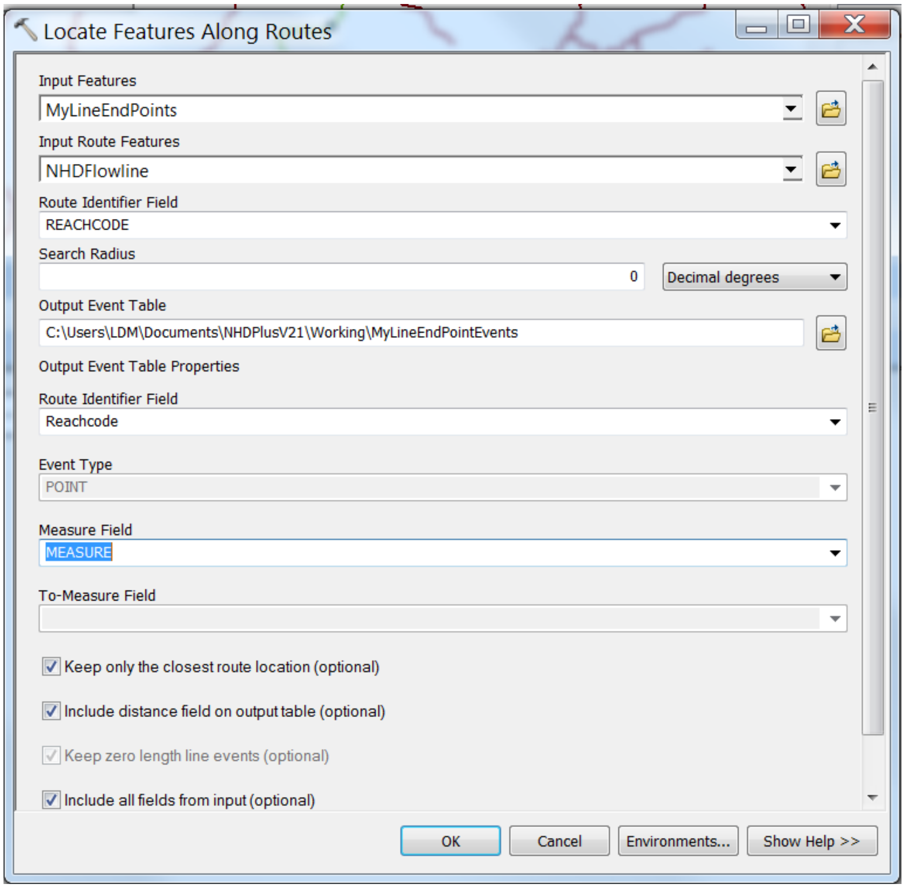
xi. From the **Editor** toolbar, click **Save Edits**.
Note that the selected flowlines from the **Find Path** solution are now in your MyLines shapefile.

xii. Calculate the EventID for these records to the EventID you used for the Bottom and Top points.

xiii. At this point, you may continue to create line events by repeating steps (v) through (xii). When you are finished, continue on with the instructions below.

xiv. From the **Editor** toolbar, click **Stop Editing**. **Save edits**, if prompted.

xv. Use **Linear Referencing->Locate Features Along Routes** to obtain the exact measure values for your Bottom and Top points as follows:



i. Open MyLines table. This contains the lines between the Bottom point and the Top point of the linear events.

ii. Open MyLineEndPointsEvents table. These are the Bottom and Top points of the new linear events.

iii. If you created more than one line event, you may have two or more line events on a given reach. Therefore the unique id for each reachcode/event combination in MyLines and MyLineEndPointsEvents is a combination of Reachcode and EventID. To make a join on two fields, one easy way is to combine the fields into one field (called ComboKey below).

   a. **Add field** MyLines.ComboKey Text(34). Use **Field Calculator** value ComboKey to [Reachcode] + " " + [EventID]. This create a unique ComboKey for each line event on a Reach.

   b. **Add field** MyLineEndPointsEvents.ComboKey Text(34). Use **Field Calculator** to value ComboKey to [Reachcode] + " " + [EventID]

iv. Now we need to populate the From measure and To measure values on each line in MyLines. **Join** MyLines with MyLineEndPointsEvents on ComboKey.

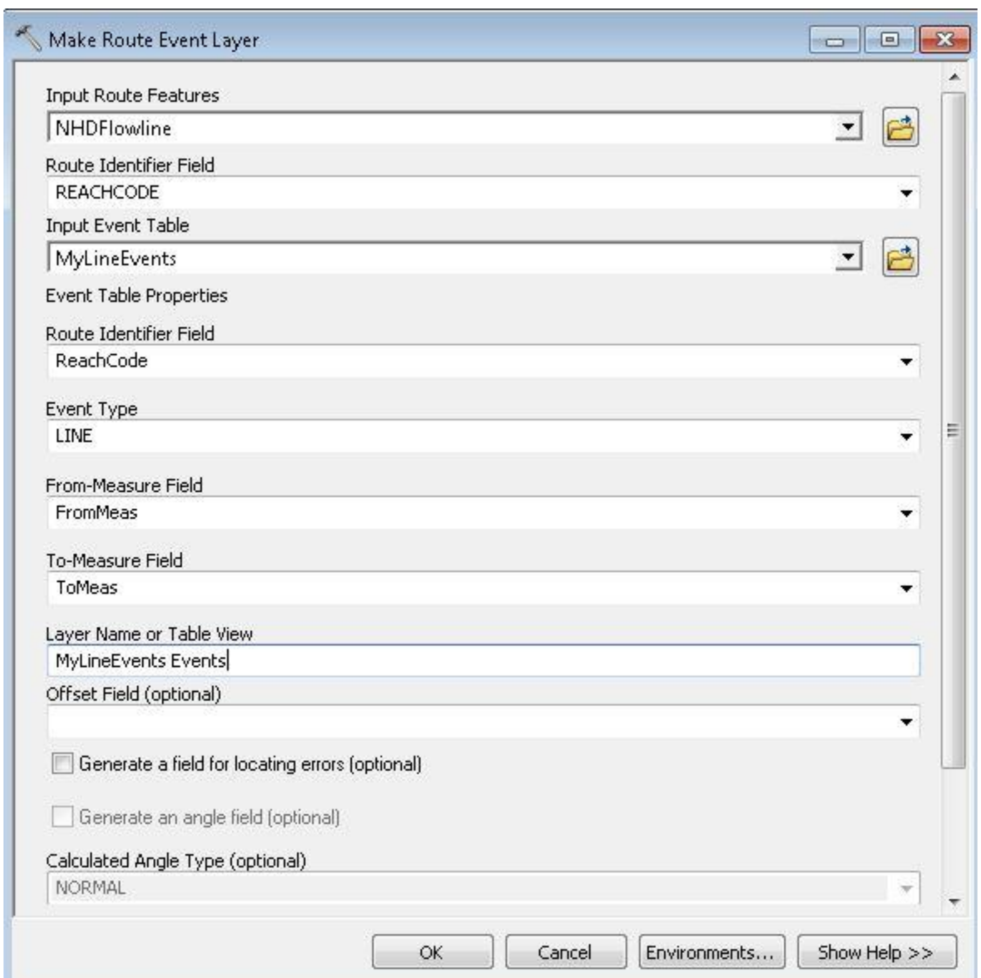
   a. **Select** WhichEnd = 'B' and use **Field Calculator** to value FromMeas = Measure.

   b. **Select** WhichEnd = 'T' and use **Field Calculator** to value ToMeas = Measure.

v. Remove Join.

vi. From **Table Options**, select **Export** for MyLines table to MyLineEvents.dbf

vii. To render the events, open the **Linear Referencing->Make Route Event Layer** tool dialog and fill it out like this:



viii. This creates a temporary layer in the map called MyLineEvents Events. To permanently save the line events with geometry, right click and

Export the layer to \NHDPlusV21\Working\MyLineEvents_Rendered.shp.

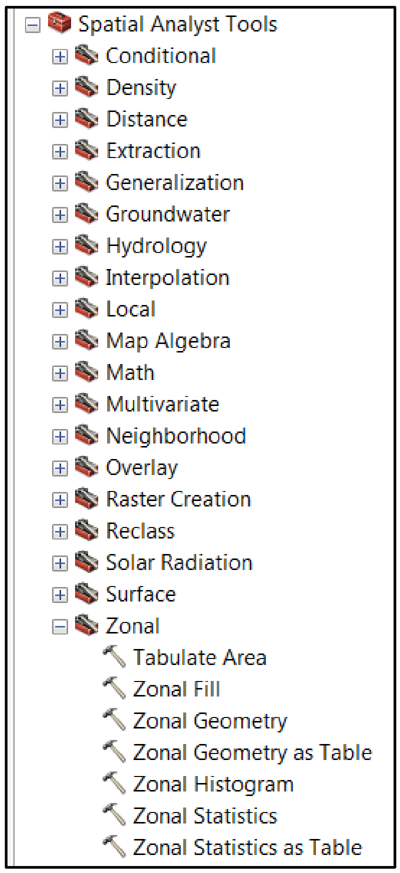
ix. Remove all the line/point event tables and layers from the map, leaving only NHDFlowline.

j. Link Data to Catchments:

Except for catchments associated with Sinks, each catchment is associated with an NHDPlus network feature. Therefore, another way to link data to the network is to link the data to catchments.

Any landscape raster data can be used to compute catchment attributes. As an illustration, let's use the NHDPlus elevation grids to compute some elevation statistics for NHDPlus catchments.

i. Open the **Spatial Analyst Tools->Zonal->Zonal Statistics as Table**.



ii. In the **Zonal Statistics as Table** dialog:

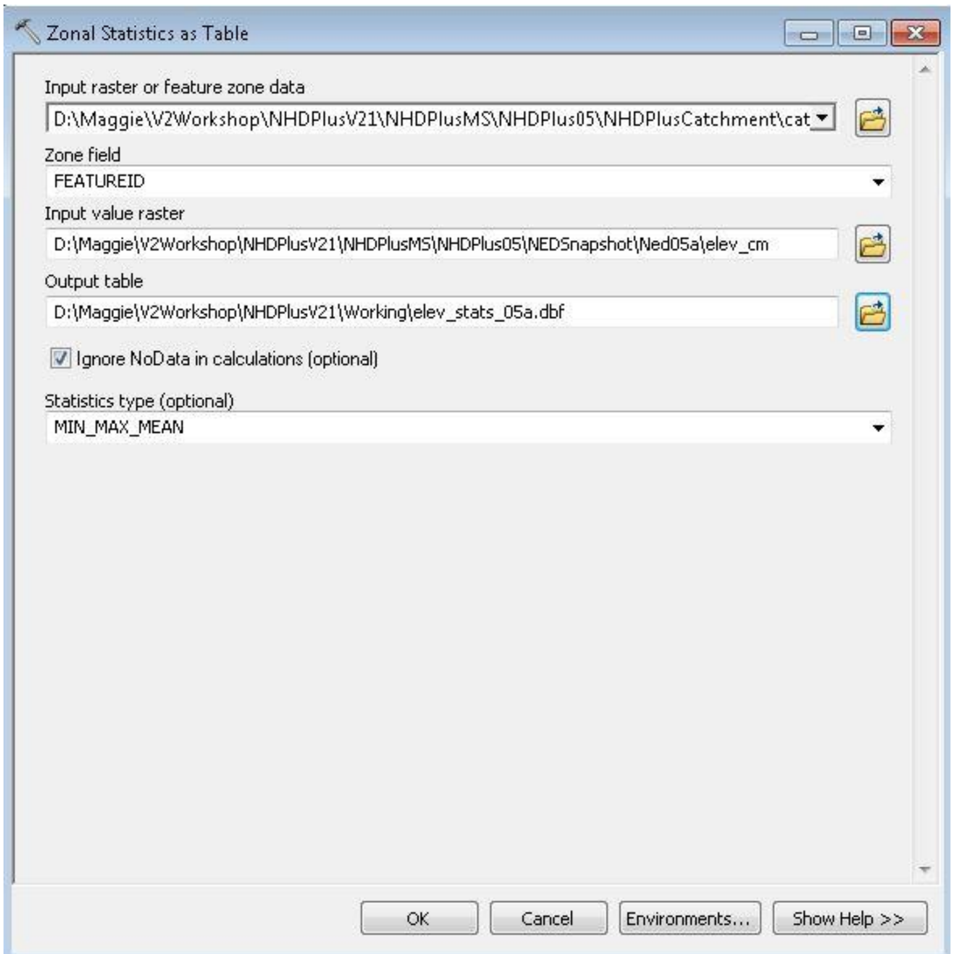
Input raster or feature zone data is the NHDPlus cat grid - \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\cat

Zone Field is FeatureID which is the direct link between catchments and other NHDPlus components,

input Value Raster is \NHDPlusV21\NHDPlusMS\NHDPlus05\NEDSnapsot\NED05a\elev_cm
The elevation grids are by RPU. To create these attributes for all catchments, it would be necessary to run this process for each of the 4 RPUs in Region 05 – 05a, 05b, 05c, and 05d.

Create the **Output table** as \NHDPlusV21\Working\elev_stats_05a.dbf.

Set **Statistics Type** to "MIN_MAX_MEAN". Do not use **All** or **Median**, because the elev_cm grid contains too many values to compute median and all 32-bit versions of ArcMap will crash with an "Out of Memory" error.
NOTE: Do not click OK. Environment settings need to be changed.



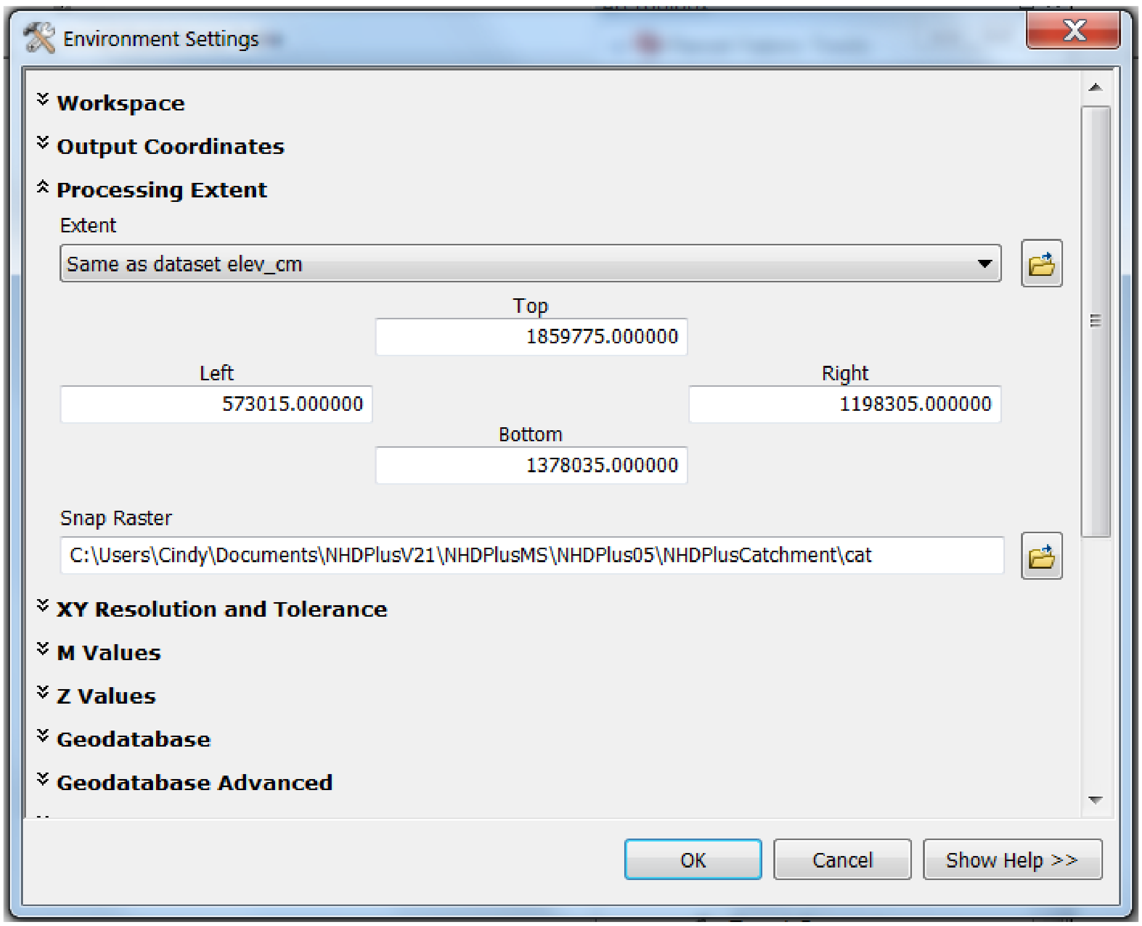
iii. It's not always necessary, but it's always wise to set several environment settings before running Zonal tools. Click the **Environments…** button.

Set the **Processing Extent** to the extent of the elev_cm grid.

Set the **Snap Raster** to the cat grid.

Press **OK**.

Press **OK** on the **Zonal Statistics as Table**.



iv. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\Catchment.shp to the map.

v. **Join Catchment.shp.FeatureID with** \NHDPlusV21\Working\elev_stats_05a.dbf.FeatureID

vi. Right Click on **Catchment** and select **Properties**, **Symbology** tab. Select **Quantities-Graduated Colors.** Under **Fields-Value,** select **MEAN.** Set **Classes** to **10** and click **Classify.** In the **Classification** dialog, Click **Sampling** and change the default value from **10,000** to **500,000.** Click **OK.** The elevation values are large. This is due to the units of the **elev_cm** grid which is centimeters.

vii. Back on the **Symbology** tab, right click on **Color Ramp** and un-check **Graphic View.** Then select **Elevation #2** from the **Color Ramp** dropdown.

Note: Attributes like Mean, Minimum and Maximum elevation are just a few of many potential attributes that can be allocated to catchments for useful analysis.

Save the project as \NHDPlusV21\Working\Student6.mxd and close ArcMap.

Analyze Linked Data

a. Start ArcMap.

b. Open \NHDPlusV21\Workshop2.mxd.

c. Add linked data to the map:

   i. **Add Data** \NHDPlusV21\LinkedData\EPA\303d_NHDPlus05_Lines.shp and NHDPlusV21\LinkedData\EPA\TMDL_NHDPlus05_Lines.shp

      Symbolize 303d_NHDPlus05_Lines with red. These are waters that have been found to be impaired by states.

      Symbolize TMDL_NHDPlus05_Lines with green. These are impaired waters for which a Total Maximum Daily Load (TMDL) has been computed and possibly implemented.

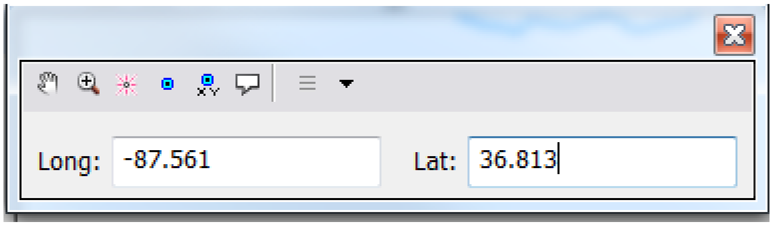
   ii. **Add Data** \NHDPlusV21\LinkedData\USGS\WaterQualityStationsLoc.shp. These are water quality monitoring sites found in the USGS National Water Information System.

   iii. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\VPUAttributeExtensions\CumTotNLCD2011.txt.

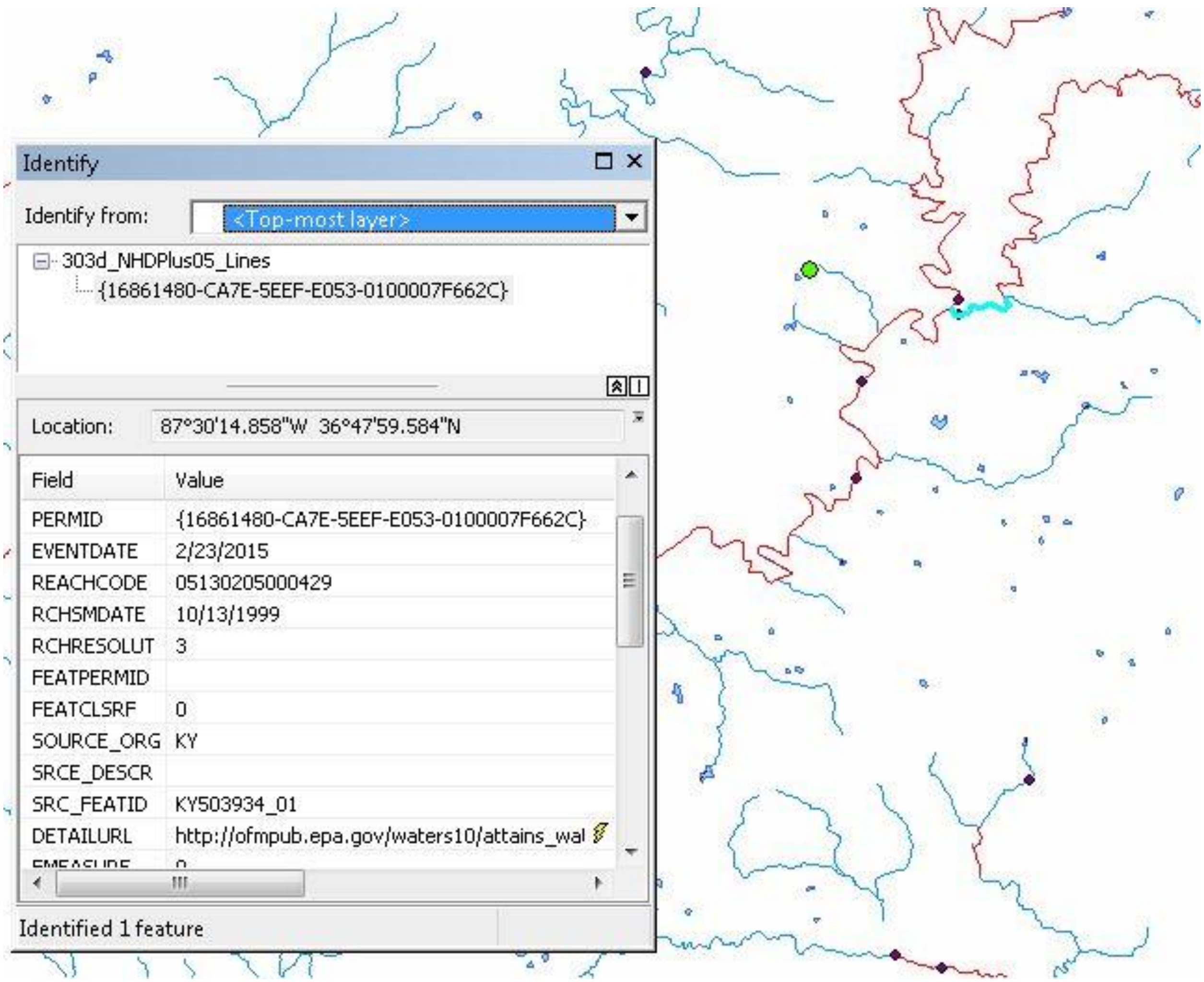
   iv. Right Click on CumTotNLCD2011.txt and **Export** to \NHDPlusV21\Working\CumTotNLCD2011.dbf (this may take a few minutes). Remove .txt file from map.

d. Investigate impaired waters and TMDLs.

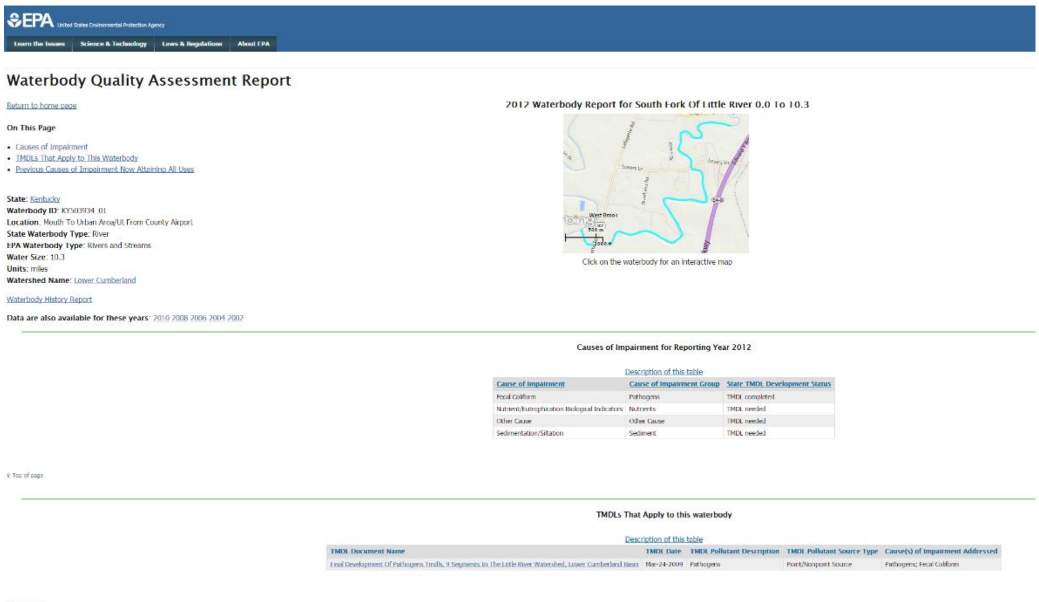
i. Use the **Zoom to XY** tool to go to this location. Set **Map Scale** to 1:125,000.



ii. Turn off the TMDL layer. Note that there are a number of red 303d impaired waters here. Perform an **Identify** on the 303d water shown below.



iii. Note the field **Src_FeatID**. This is the identifier assigned by the state to the impaired water. The **DetailURL** field contains a link to more information. If you're connected to the internet, copy the URL and paste it into a browser and examine the EPA data that tells us the impairments and tells us that a TMDL has been completed. The TMDL report is available from a link on the page.



EPA United States Environmental Protection Agency

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Waterbody Quality Assessment Report

Return to home page

On This Page

- Causes of Impairment
- TMDLs That Apply to This Waterbody
- Previous Causes of Impairment Now Attaining All Uses

State: Kentucky
Waterbody ID: KY503934_01
Location: Mouth To Urban Area/Ut From County Airport
State Waterbody Type: River
EPA Waterbody Type: Rivers and Streams
Water Size: 10.3
Units: miles
Watershed Name: Lower Cumberland

Waterbody History Report

Data are also available for these years: 2010 2008 2006 2004 2002

2012 Waterbody Report for South Fork Of Little River 0.0 To 10.3

Click on the waterbody for an interactive map

Causes of Impairment for Reporting Year 2012

Description of this table

Cause of Impairment	Cause of Impairment Group	State TMDL Development Status
Fecal Coliform	Pathogens	TMDL completed
Nutrient/Eutrophication Biological Indicators	Nutrients	TMDL needed
Other Cause	Other Cause	TMDL needed
Sedimentation/Siltation	Sediment	TMDL needed

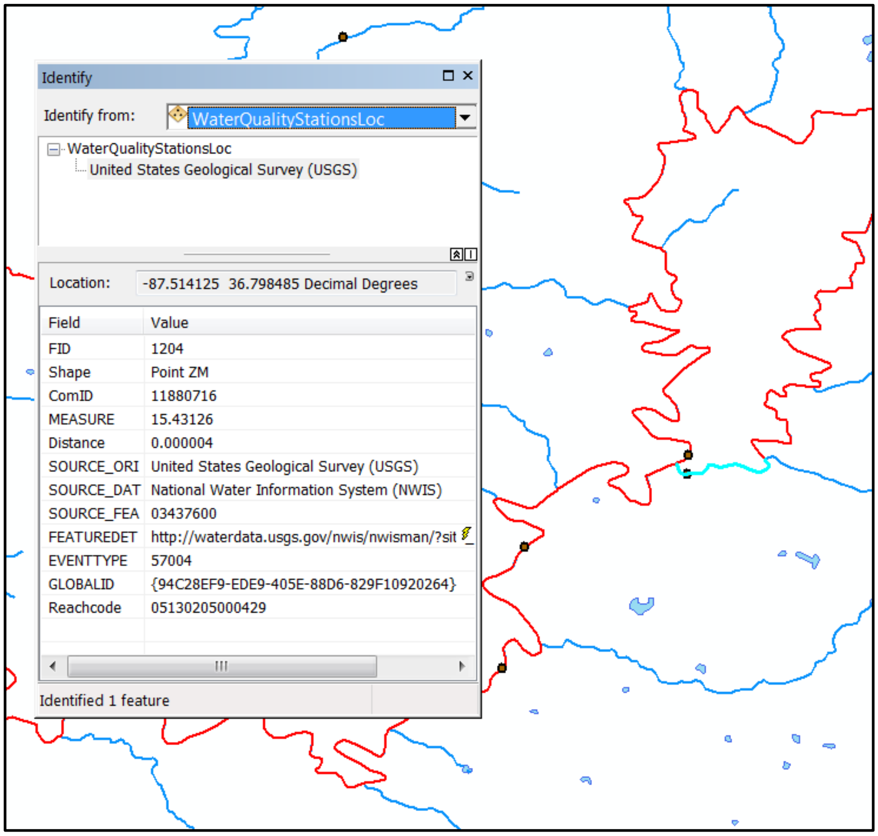
TMDLs That Apply to this waterbody

Description of this table

TMDL Document Name	TMDL Date	TMDL Pollutant Description	TMDL Pollutant Source Type	Cause(s) of Impairment Addressed
Final Development Of Pathogens Tmdls, 9 Segments In The Little River Watershed, Lower Cumberland Basin	Mar-24-2009	Pathogens	Point/Nonpoint Source	Pathogens; Fecal Coliform

iv. Do an **Identify** on the water quality station near the bottom of this stream.

v. Like the 303d data, the NWIS data also provides a URL in the **FeatureDET** field.



vi. Copy and paste the NWIS URL into a browser.

USGS science for a changing world

National Water Information System: Web Interface

USGS Water Resources

Click to hide News Bulletins

- June 20, 2016
- **Changes coming this summer** to some water-data formats on this website. The changes are minor for most end users. Learn More
- Use our Mobile-friendly water data site from your mobile device!
- Full News

USGS 03437600 S FK LITTLE R AT KY 107 NR HOPKINSVILLE, KY

Stream Site

DESCRIPTION:

Latitude 36°47'54",   Longitude 87°30'52"   NAD27
Christian County, Kentucky, Hydrologic Unit 05130205
Drainage area: 58 square miles

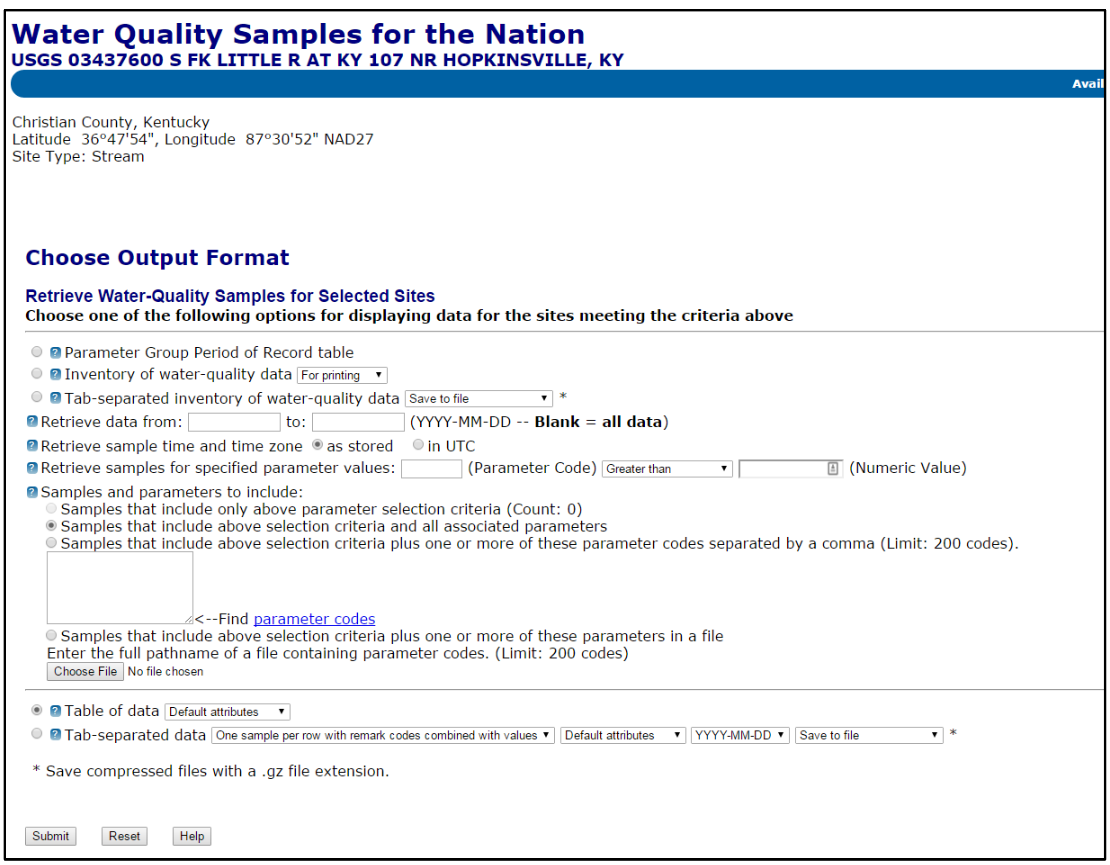
AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Field measurements	2012-11-15	2013-07-16	9
Field/Lab water-quality samples	2003-03-20	2014-11-06	76

OPERATION:

Record for this site is maintained by the USGS Kentucky Water Science Center
Email questions about this site to Kentucky Water Science Center Water-Data Inquiries

vii. If we click on the **Field/Lab Water Quality Samples**, we are taken to a page where we can chose to view or download the data.



Water Quality Samples for the Nation

USGS 03437600 S FK LITTLE R AT KY 107 NR HOPKINSVILLE, KY

Avail

Christian County, Kentucky
Latitude 36°47'54", Longitude 87°30'52" NAD27
Site Type: Stream

Choose Output Format

Retrieve Water-Quality Samples for Selected Sites
Choose one of the following options for displaying data for the sites meeting the criteria above

- Parameter Group Period of Record table
- Inventory of water-quality data [For printing]
- Tab-separated inventory of water-quality data [Save to file] *

Retrieve data from: [ ] to: [ ] (YYYY-MM-DD -- **Blank** = **all data**)

Retrieve sample time and time zone (•) as stored ( ) in UTC

Retrieve samples for specified parameter values: [ ] (Parameter Code) [Greater than] [ ] (Numeric Value)

Samples and parameters to include:
- Samples that include only above parameter selection criteria (Count: 0)
- Samples that include above selection criteria and all associated parameters
- Samples that include above selection criteria plus one or more of these parameter codes separated by a comma (Limit: 200 codes).

<--Find parameter codes

- Samples that include above selection criteria plus one or more of these parameters in a file

Enter the full pathname of a file containing parameter codes. (Limit: 200 codes)
[Choose File] No file chosen

- Table of data [Default attributes]
- Tab-separated data [One sample per row with remark codes combined with values] [Default attributes] [YYYY-MM-DD] [Save to file] *

* Save compressed files with a .gz file extension.

[Submit] [Reset] [Help]

viii. Click on **Table of Data** and **Submit** (both near the bottom of the page). This takes us to a table of the results of all the water quality samples taken at this monitoring site. If you scroll across you can find the coliform measurements which were cited in the list of impairments on the EPA website.

Water Quality Samples for the Nation

To view additional data-quality attributes, output the results using these options: one result per row, expanded attributes.
Additional precautions are here.

USGS 03437600 S FK LITTLE R AT KY 107 NR HOPKINSVILLE, KY

Available data for this site Water-Quality: Field/Lab samples GO

Christian County, Kentucky
Hydrologic Unit Code 05130205
Latitude 36°47'54", Longitude 87°30'52" NAD27
Drainage area 58 square miles

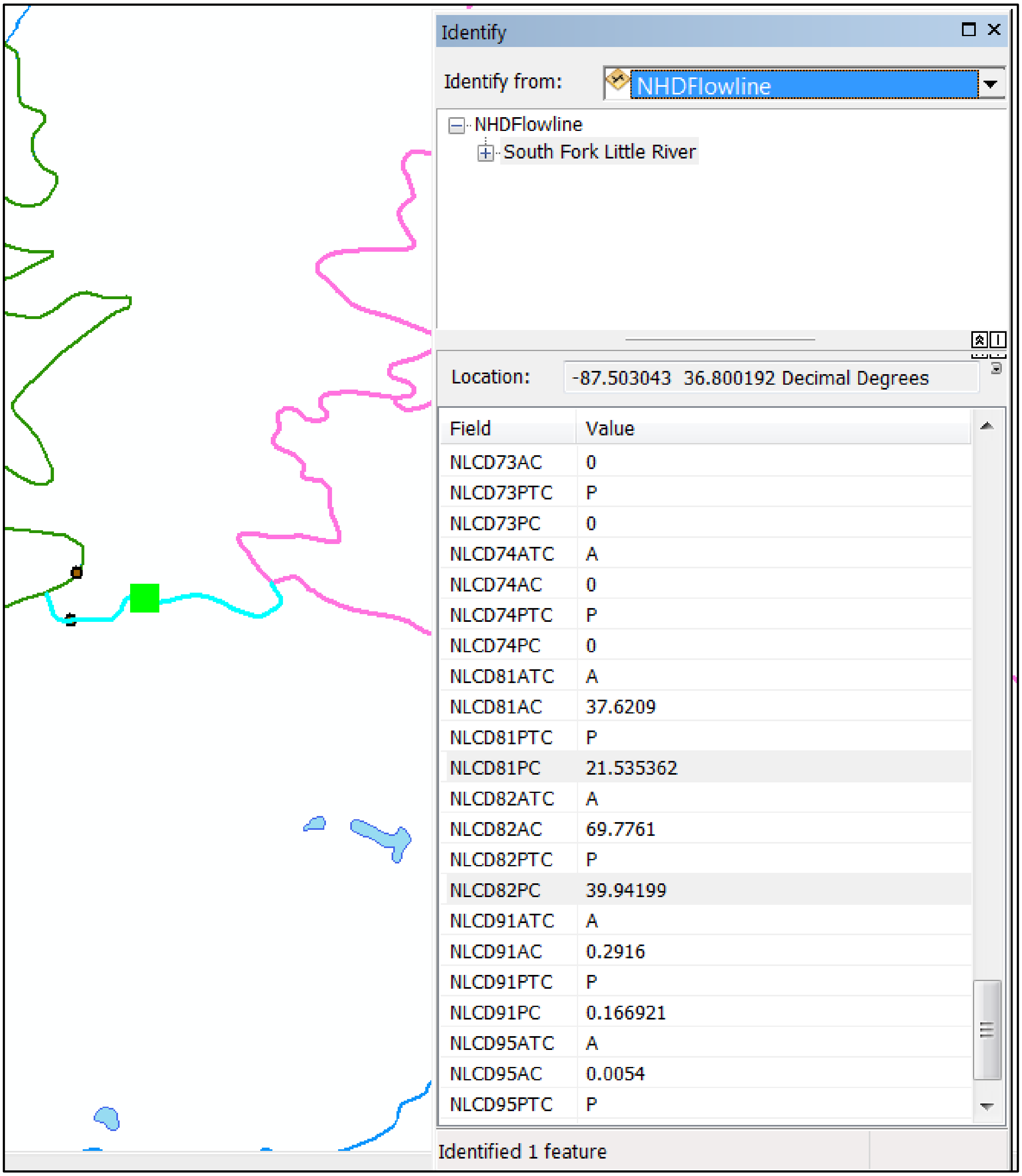
- Parameter Group Period of Record table
- Inventory of available water-quality data for printing
- Inventory of water-quality data with retrieval
- Tab-separated data, one result per row
- Tab-separated data one sample per row with remark codes com
- Tab-separated data one sample per row with tab-delimiter for r
- Reselect output format

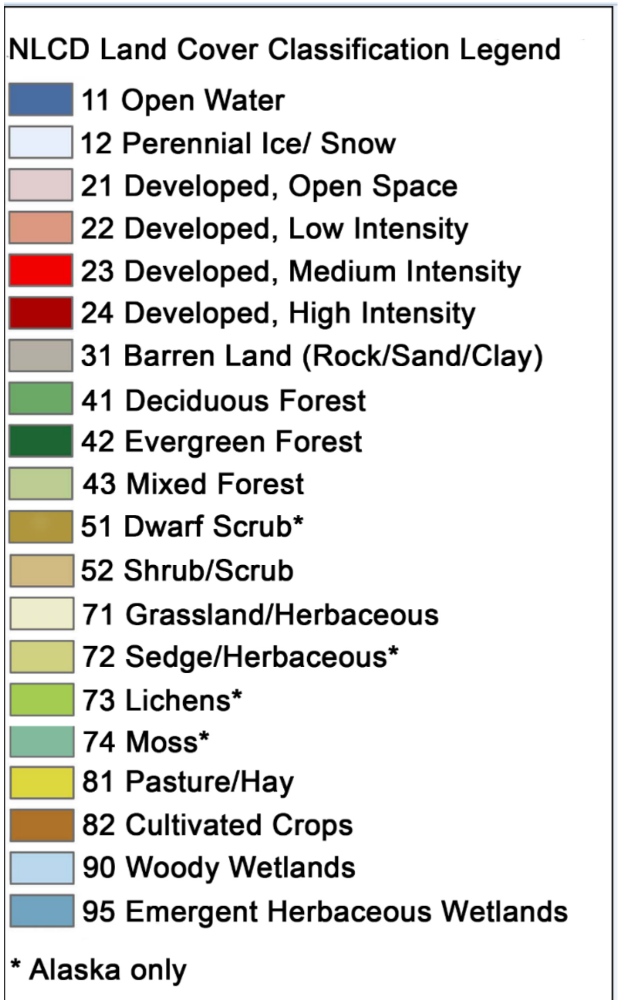
Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	Stream width, feet (00004)	Temperature, water, deg C (00010)	Temperature, air, deg C (00020)	Barometric pressure, mm Hg (00025)	Agency analyzing sample, code (00028)	Instantaneous discharge, ft3/s (00061)	Number of sampling points, count (00063)	Gage height, feet (00065)	Specific conductance, wat unf uS/cm @ 25 degC (00095)	Hydrogen ion, water, unfltrd calcd, mg/L (00191)	Dissolved oxygen, mg/L (00300)	Dissolved oxygen, percent of saturation (00301)
2003-03-20 16:50	CST	T	WS	USGS-WRD		7.5	19.0	747	80020	144			324	0.00002	9.4	80
2003-04-02 16:20	CST	T	WS	USGS-WRD		15.5	23.0	764	80020	84		15.50	427	0.00001	12.3	123
2003-05-01 13:45	CDT	K	WS	USGS-WRD		17.0	27.2	746	80020	191			332	0.00003	9.0	94
2003-05-08 14:30	CDT	K	WS	USGS-WRD		16.0	29.5	757	80020	560			323	0.00004	9.3	95
2003-06-18 13:30	CDT	K	WS	USGS-WRD	52.0	18.9	27.4	763	80020	70	5		454	0.00002	8.6	93
2003-07-08 12:50	CDT	K	WS	USGS-WRD	29.0	23.7	35.0	755	80020	12	5		499	0.00001	8.8	105
2003-08-20 09:30	CDT	K	WS	USGS-WRD		22.4	28.5	747	80020	15			502	0.00002	11.4	132
2003-08-26 12:40	CDT	K	WS	USGS-WRD	50.0	22.2	28.3	766	80020	27	5		478	0.00001	7.7	88
2003-09-16 12:30	CDT	K	WS	USGS-WRD	16.0	21.1	32.8	762	80020	22	5		519	0.00002	9.0	101
2003-10-15 12:10	CDT	K	WS	USGS-WRD	15.0	18.9	29.7	761	80020	9.8	5		523	0.00003	9.0	97
2003-11-12 12:10	CST	K	WS	USGS-WRD	14.0	16.1		762	80020	E 19	7		520	0.00002	9.0	91
2004-02-17 12:10	CST	K	WS	USGS-WRD	42.0	8.0	7.6	772	80020	83	5	4.12	467	0.00002	14.5	121
2004-03-16 12:10	CST	K	WS	USGS-WRD	41.0	11.3	7.2	769	80020	56	5	5.21	451	0.00001	16.0	144
2004-04-14 15:30	CDT	K	WS	USGS-WRD	76.0	9.5	16.7	748	80020	242	6		296	0.00015	12.4	110
2004-04-30 13:10	CDT	K	WS	USGS-WRD	70.0	16.2	24.9	764	80020	E 200	5	7.54	372	0.00003	9.3	94
2004-05-06 14:20	CDT	K	WS	USGS-WRD	48.0	16.2	27.8	765	80020	E 226	5		426	0.00003	10.1	102
2004-06-15 12:30	CDT	K	WS	USGS-WRD	31.0	20.7	28.3	762	80020	E 50	5		464	0.00002	5.4	60
2004-07-14 08:40	CDT	K	WS	USGS-WRD		22.1	28.9	745	80020	85			375	0.00005	7.1	83
2004-07-27 11:30	CDT	K	WS	USGS-WRD		19.8	30.8	766	80020	E 80		1.25	479	0.00003	8.5	92
2004-08-10 11:10	CDT	K	WS	USGS-WRD	41.0	19.9	31.2	764	80020	E 90	7	3.65	485	0.00002	8.1	88
2004-09-14 11:00	CDT	K	WS	USGS-WRD	32.0	19.9	30.0	767	80020	E 80	5	2.99	466	0.00004	6.9	75

ix. Let's look for a clue about what might be going on in this stream's drainage area.

x. **Join** NHDFlowline.ComID with CumTotNLCD2011.ComID

xi. Do an **Identify** on the flowline underneath the selected impaired stream. We can see that over 60% of the basin for this stream is either Pasture land (NLCD81PC) or Cultivated Crops (NLCD82PC). These can help explain the coliform and nutrient impairments here.





This short exercise illustrates the nearly unlimited capabilities that can be achieved as the water resources community links more and more data to the NHDPlus network.

Save the project as \NHDPlusV21\Working\Student7.mxd and close ArcMap.

Delineate a Basin/Drainage Area

Note: If you have not performed the section above entitled "Build Geometric Network and Learn to Navigate", please perform steps a through c of that section now.

The basic steps for delineating a basin are:

Establish a Pourpoint on a drainage channel defined by the flow accumulation raster.

Run the ArcGIS Watershed tool to create a basin polygon.

Optionally, fill holes that represent non-contributing areas.

If necessary, add areas in upstream Raster Processing Units:
Navigate the network.
Select catchments based on navigation results.
Dissolve basin polygon and selected catchments.

a. Create a Pourpoint file.

   i. Open ArcCatalog.

   ii. Right click on \NHDPlusV21\Working\ and select **New->Shapefile**.

   iii. Create a point shapefile called MyPourpoints.shp. Set the coordinate system to GCS North America 1983.

   iv. Open ArcMap.

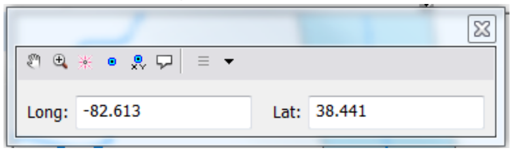
   v. **Add Data** \NHDPlusV21\Working\Workshop1.gdb\hydrography\NHDFlowline to map. Symbolize with \NHDPlusV21\NHDFlowline.lyr

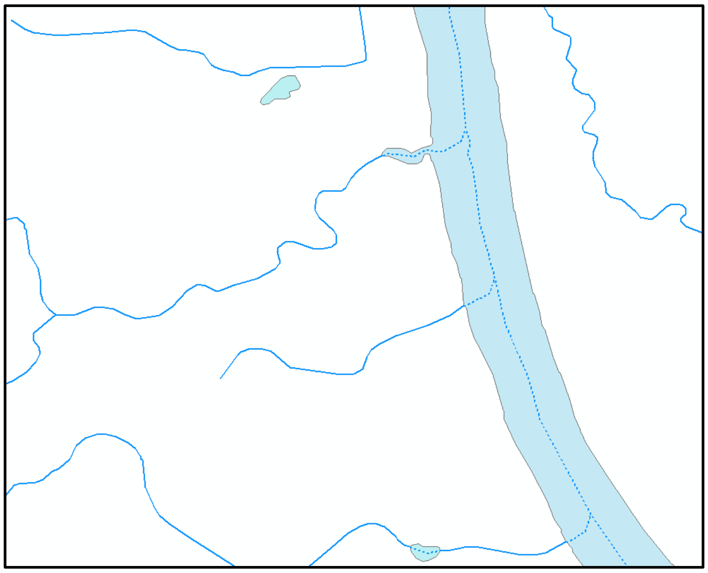
   vi. **Add Data** \NHDPlusV21\Working\MyPourpoints.shp to map

   vii. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDWaterbody and NHDArea to map. Symbolize with corresponding layers: \NHDPlusV21\NHDWaterbody.lyr and \NHDPlusV21\NHDArea.lyr

   viii. **Add Data** \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusfdrfac05c\fac and fdr. No need to build pyramids. Turn fac and fdr layers off in **Table of Contents**.

ix. Use the **Go To XY** tool on the ArcMap toolbar to zoom to the following coordinates. Then use the **Map Scale** window on the ArcMap Toolbar and zoom in to 1:30,000.





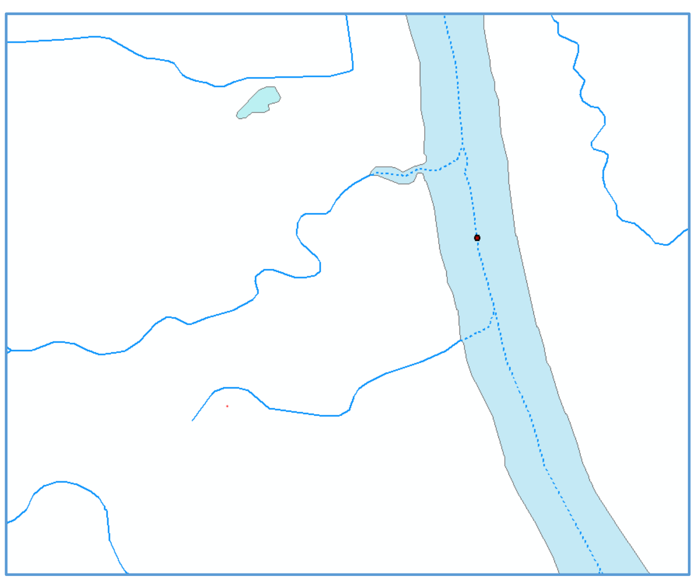
x. Using the **Editor** toolbar, **Editor** pulldown

a. **Start Editing**, choose MyPourpoints.

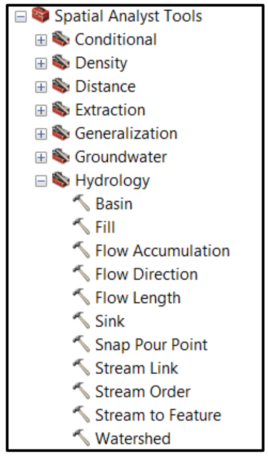
b. **Editing Windows->Create Features**

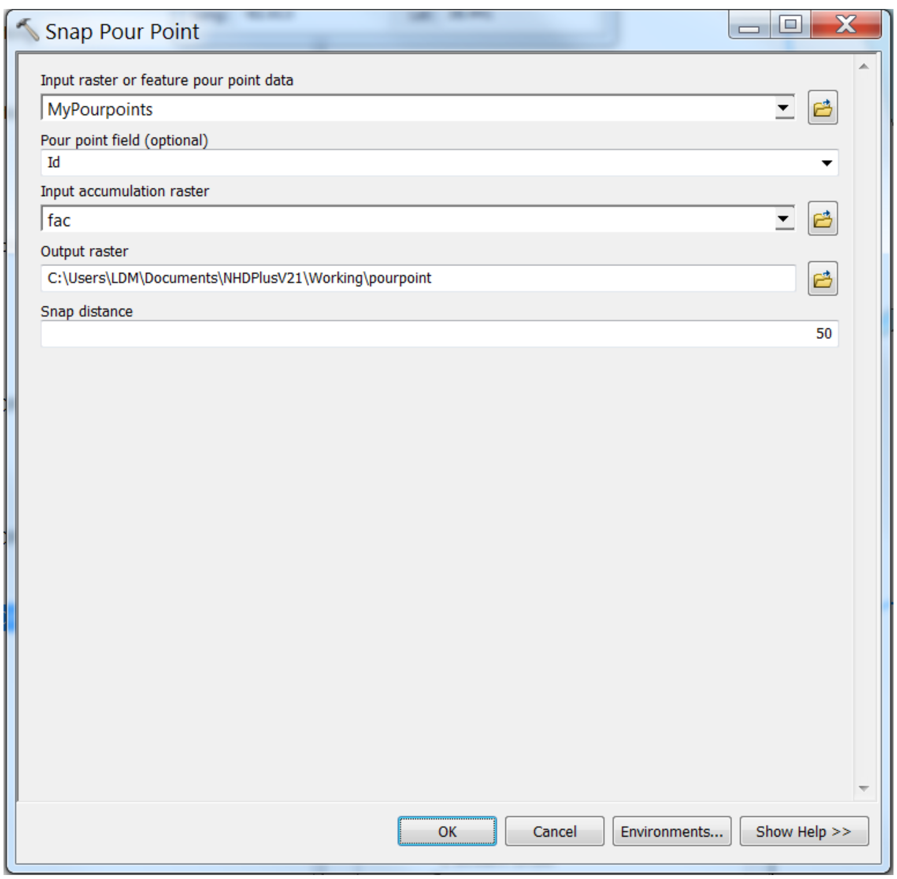
c. In **Create Features** window, Select MyPourpoints

xi. Using **Edit Tool**, create a point on the network. **Save edits**, **Stop Editing**. Close **Create Features** window.



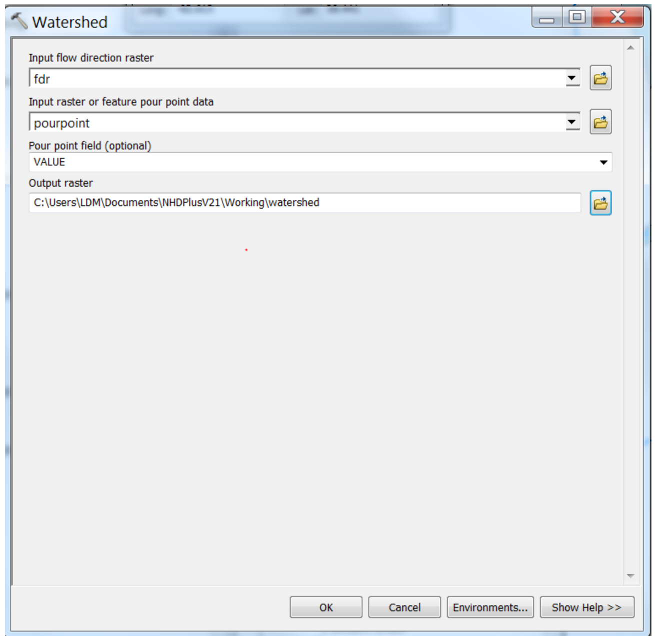
xii. Use ArcToolbox **Spatial Analyst-> Hydrology->Snap Pour Point** to ensure that the pourpoint is located on a high value FAC cell. Save the output raster as \NHDPlusV21\Working\pourpoint.





b. Create Basin Polygon

i. Use ArcToolbox **Spatial Analyst-> Hydrology->Watershed** to delineate the basin in RPU 05c. Save the output raster as \NHDPlusV21\Working\watershed.

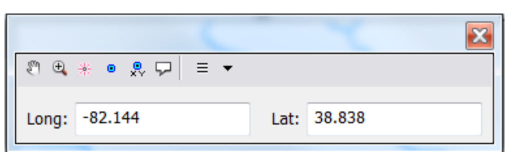


Note: The Watershed command will run for about 15 minutes.

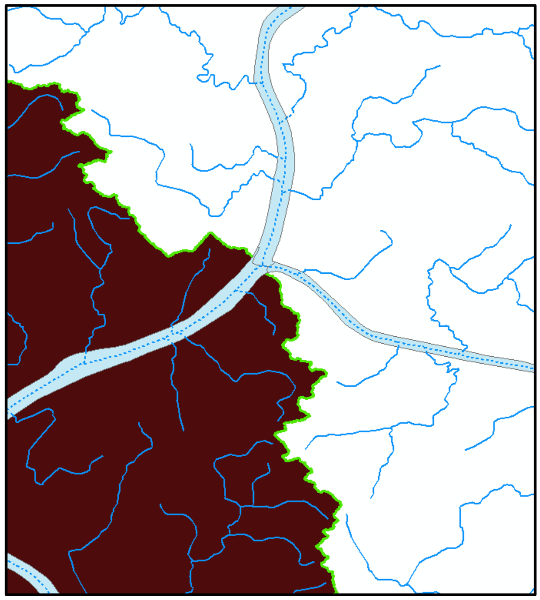
ii. Zoom to watershed layer. Turn off the NHDFlowline layer to improve the view.

iii. This basin does not have holes, but it does stop at the RPU boundary. We need to add the upstream portion to have a full basin. To do this, we're going to navigate the network upstream from the top of our current basin and gather the NHDPlus catchments to complete the basin.

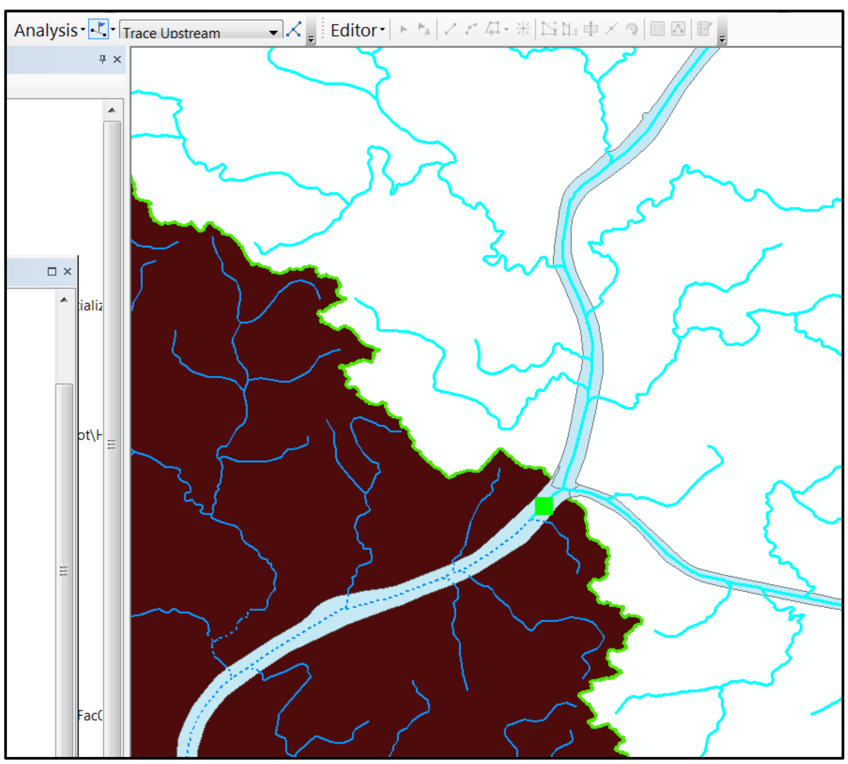
iv. Use the **Go To XY** tool on the ArcMap toolbar to zoom to these coordinates.



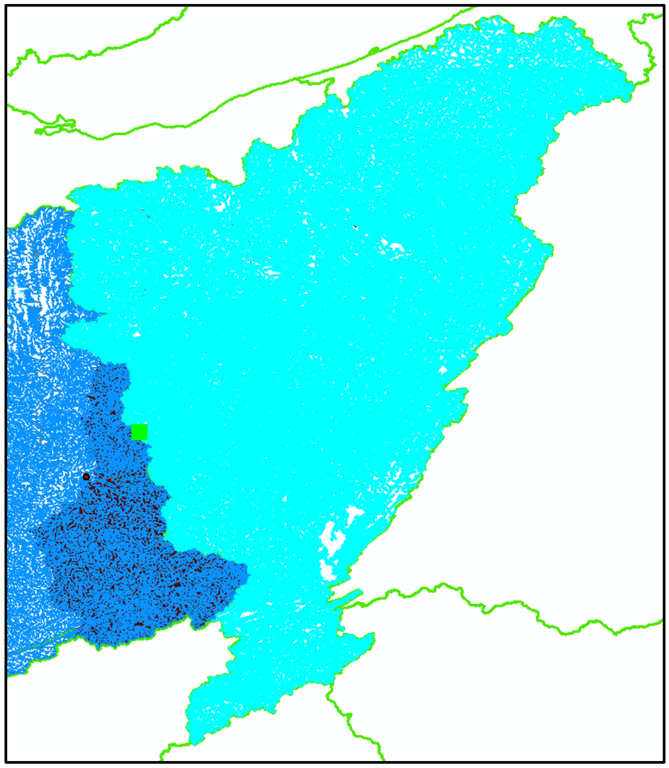
Then use the **Map Scale** window on the ArcMap Toolbar to zoom in to 1:100,000. Turn back on NHDFlowline layer.



v. From the **Utility Network Analyst** Toolbar, use the **Add Edge Flag** tool to place a flag just inside the basin. From the **Analysis** pulldown, select **Options->Results**. Click on **Return Results As->Selection**. Select **Trace Upstream** from the **Choose Trace Task** pulldown. Click the **Solve** button.



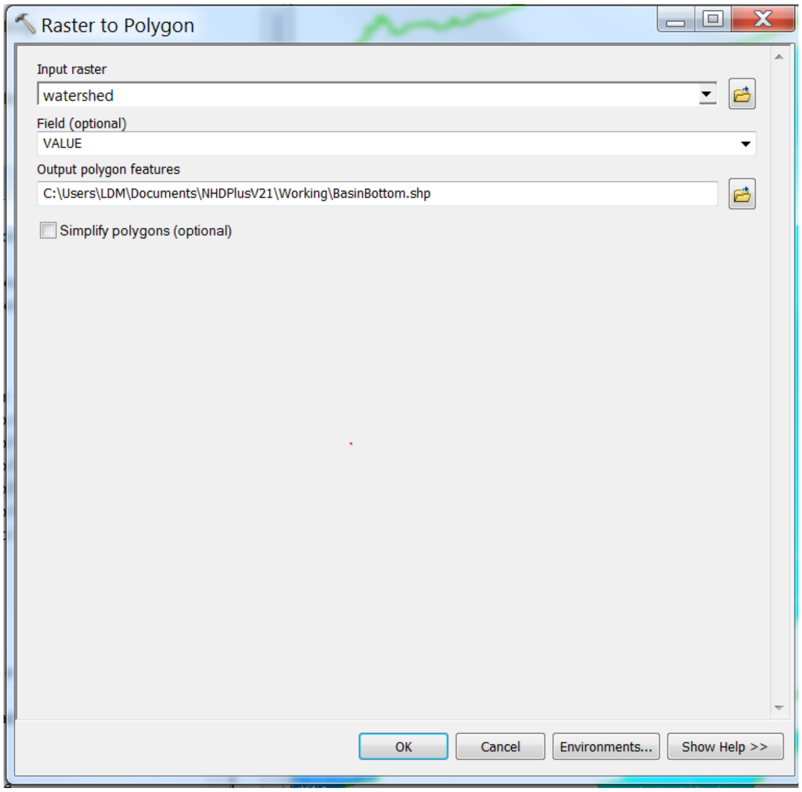
vi. Zoom to the extent of the selected NHDFlowlines.



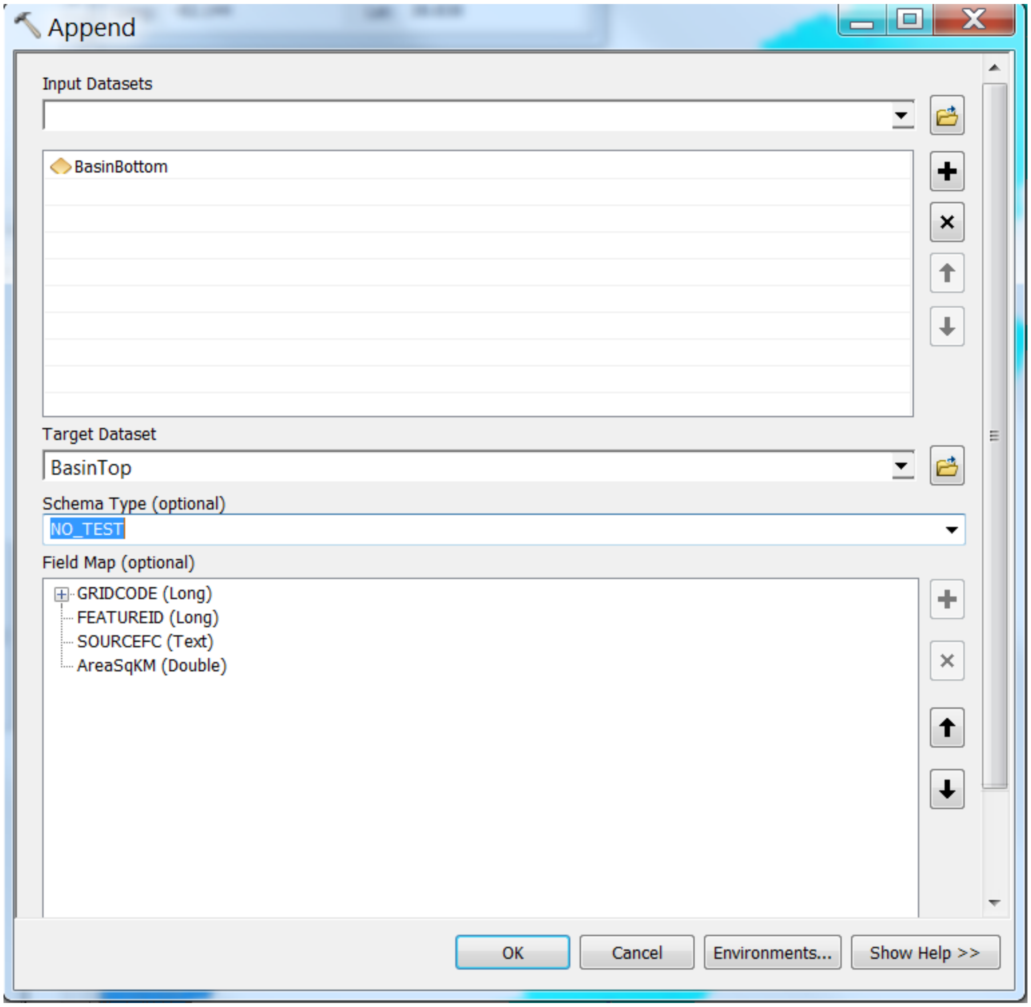
vii. **Add Data**
\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\Catchment.shp

viii. **Relate** NHDFlowline.ComID to Catchment.FeatureID. Open the NHDFlowline table and execute the relate. Zoom to selected Catchment. Right click on Catchment and export selected to \NHDPlusV21\Working\BasinTop.shp

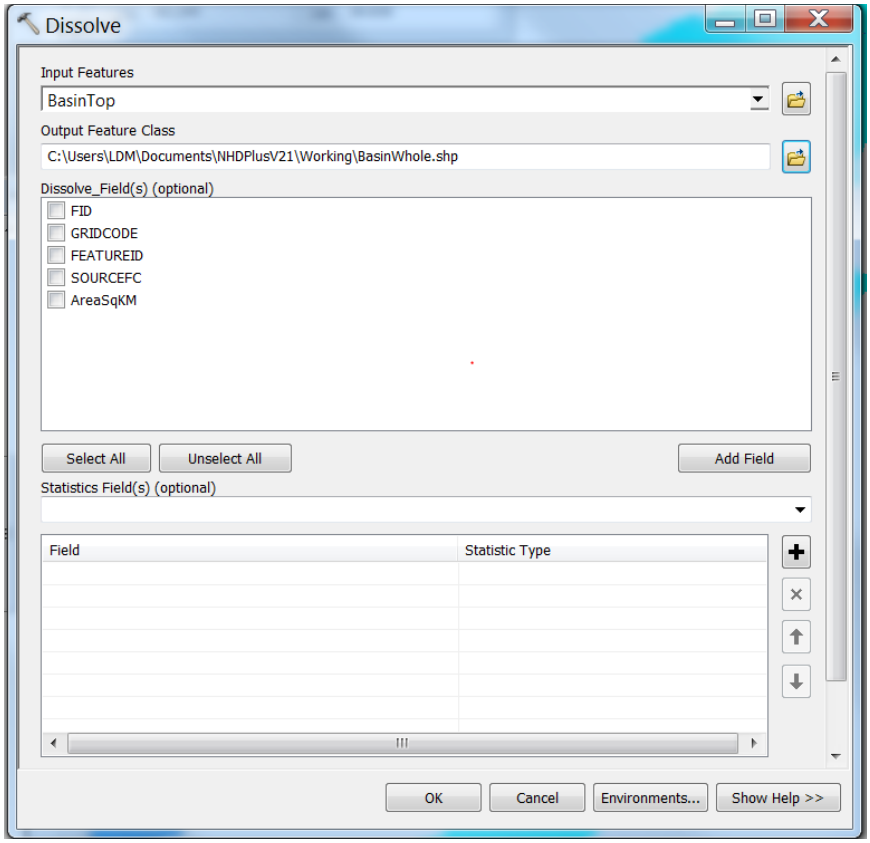
ix. In ArcToolbox, use **Conversion->From Raster->Raster To Polygon** to convert the partial basin to a polygon called \NHDPlusV21\Working\BasinBottom.shp.



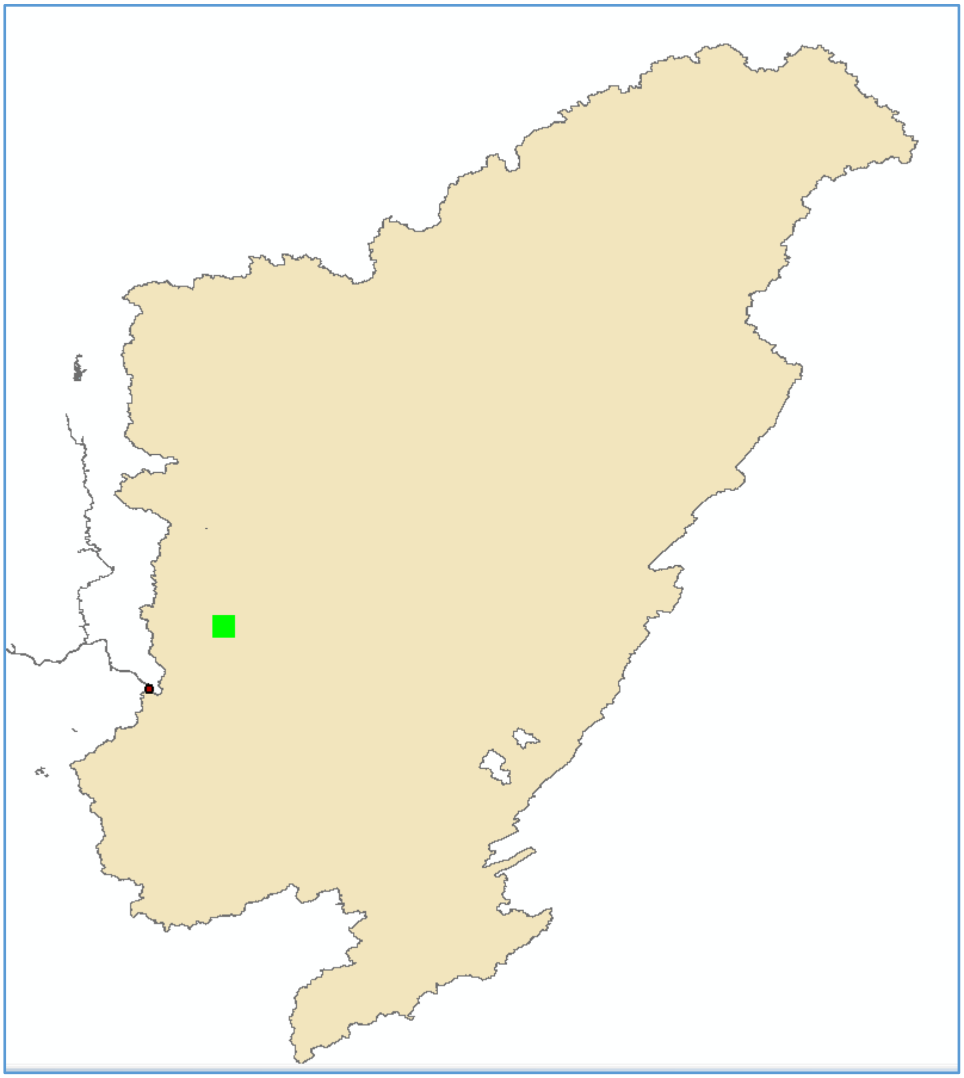
x. Using **Data Management->General->Append**, add BasinBottom into BasinTop.



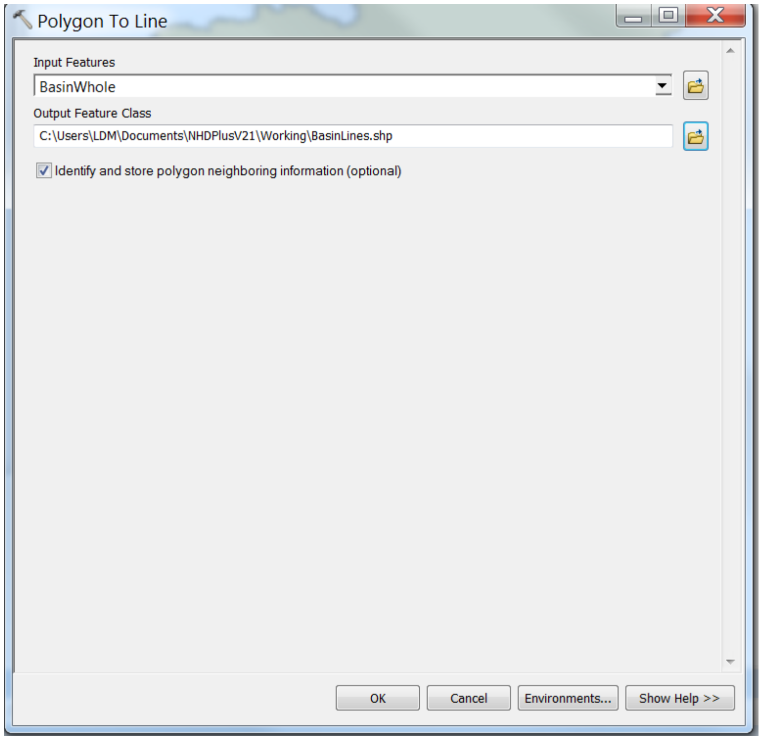
xi. Using **Data Management->Generalize->Dissolve**, dissolve BasinTop into a single polygon called BasinWhole.



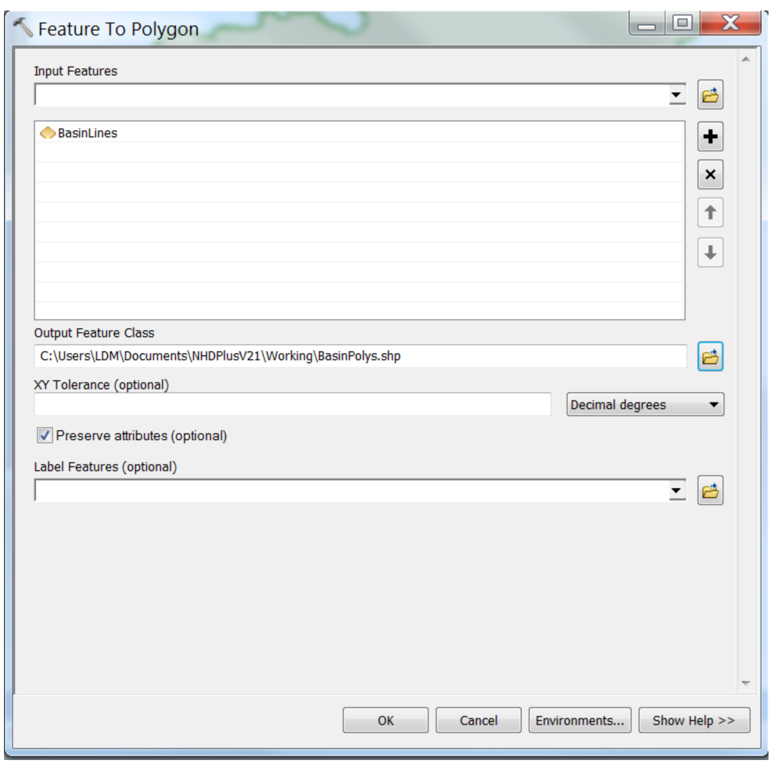
xii. Note that the basin contains some holes.



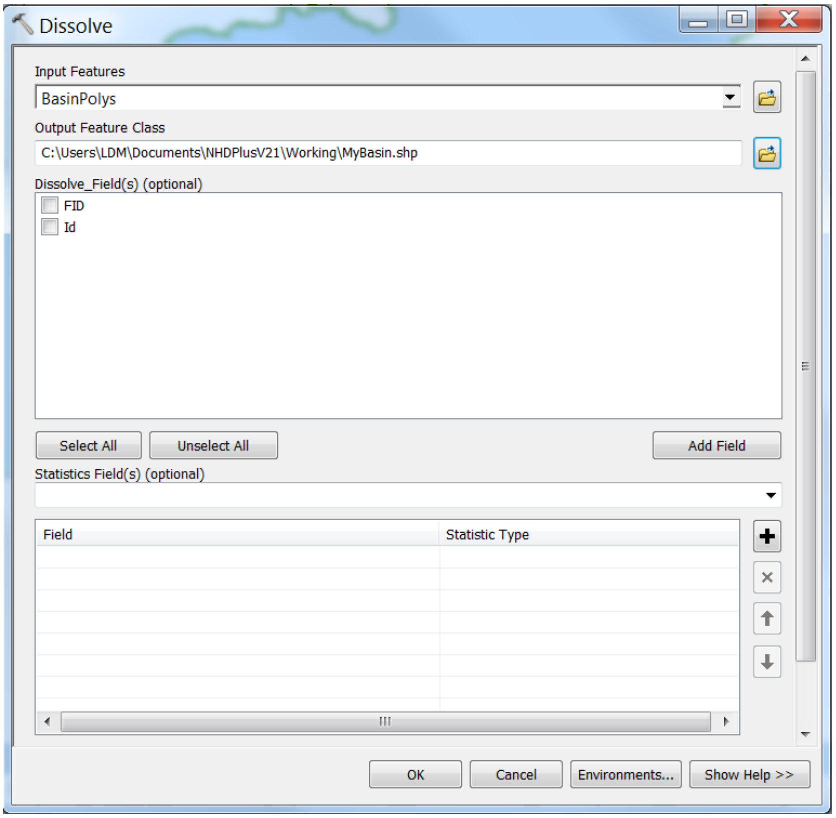
xiii. To get a solid basin, use **Data Management->Features->Polygon to Line** creating BasinLines.shp

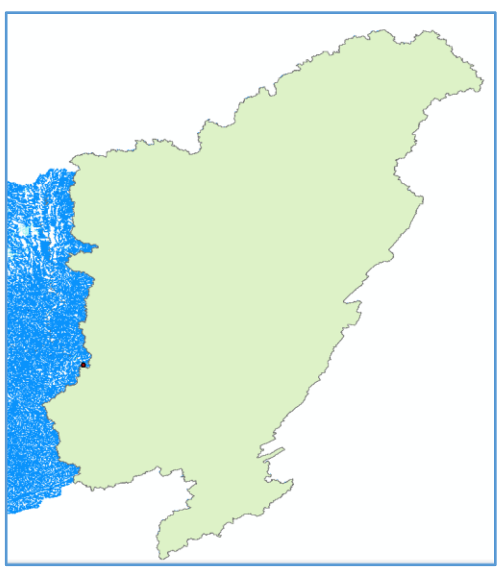


xiv. Use **Data Management->Features->Feature to Polygon**, creating BasinPolys.shp



xv. Finally, use **Data Management->Generalize->Dissolve** to create our final basin called MyBasin.





MyBasin.shp should look like the figure shown above.

Save the project as \NHDPlusV21\Working\Student7.mxd and close ArcMap.

Basin characterization is another exploration of information that has been linked to the NHDPlus network and catchments. Save BasinDelineation.mxd.

As a homework assignment see how many attributes you can develop for this basin. The workshop data already contains a wealth of information in \LinkedData (impaired waters, TMDLs, dams, road crossings, many stream characteristics in StreamCat), \NHDPlusAttributes (slope, streamflow, elevation, stream order), and \VPUAttributesExtension (NLCD, Runoff, Temperature, Precip). Go beyond these sources and search the internet for information that has been generated by 1000's of NHDPlus users.

We hope you've enjoyed the hands-on exercise. Hopefully, you'll be able to take the techniques we've used to further your own NHDPlus applications.

NHDPlusV2 VAA Navigator – Extra Credit

The best and most complete way to navigate the NHDPlusV2 network is using the NHDPlusV2 VAA Navigator tool. This tool comes with its own ArcMap toolbar and it can also be called from an application you might write in Python. If you anticipate an application that requires navigation, you may want to consider learning about the VAA navigator.

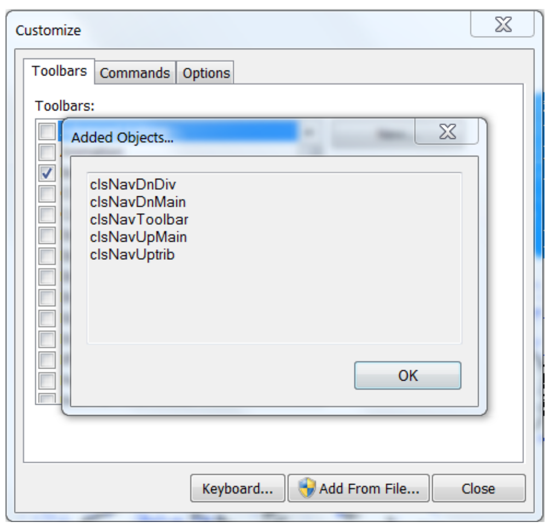
1. Visit the NHDPlus website Tools page. Download the NHDPlusV2 VAA Navigator, other required software components, and install/user guides.

2. Follow the instructions for installing the VAA navigator. When you install the VAA navigator you get the ArcMap Toolbar and the Python-callable tool.

3. Open ArcMap

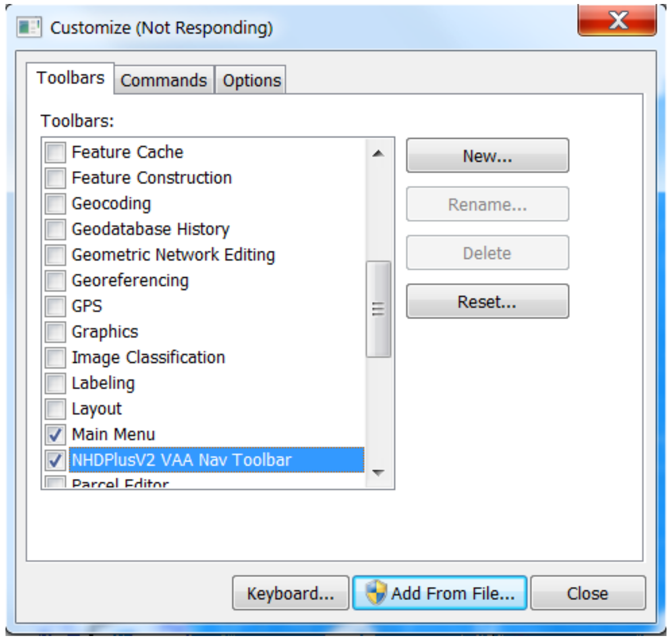
4. Add NHDPlusV2 VAA Navigator Toolbar to ArcMap
   a. Right Click on an empty spot on the ArcMap Toolbar. Choose **Customize**.

   b. Click **Add from File**. Browse to where the VAA Navigator is installed (default directory is C:\NHDPlusTools\NHDPlusV2VaaNavigatorToolBar). Choose NHDPlusV2VAANavToolbar.tlb. You should see the following response:



   c. Click **OK**.

d. Checkmark **NHDPlusV2VAANavToolbar**. Click **Close**.

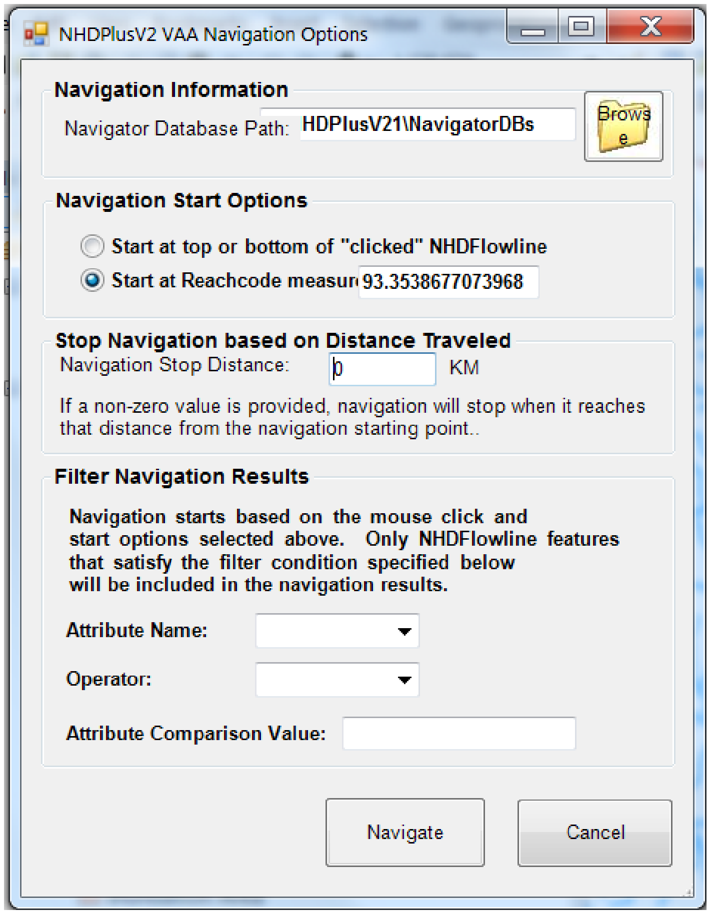


e. Dock navigator toolbar.

f. Open \NHDPlusV21\Working\Student1.mxd

g. Zoom in to see individual flowlines – about 1:200,000 map scale.

h. Select the **NHDPlusV2 VAA Navigator Up Mainstem** navigation tool. Make NHDFlowline the active layer. Point and click on a flowline. The **Navigation**



Options dialog will appear.

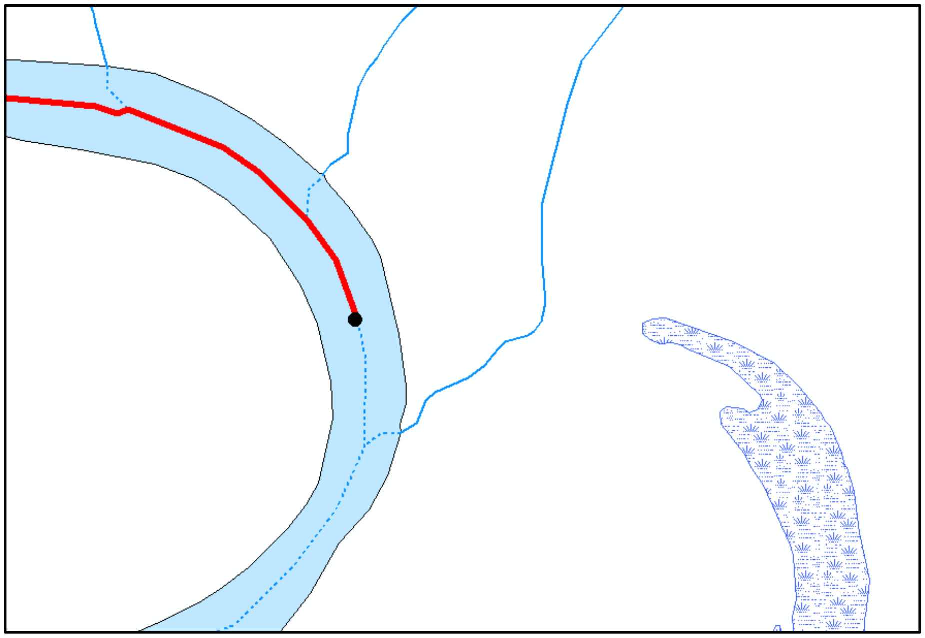
i. During the first navigation in a VPU, the navigator will build a SQL database that it will use for all future navigations in that VPU. In the **Navigation Information->Navigator Database Path** window, browse to a disk location where you have full read/write access. The recommended location is the folder where you have your NHDPlusV2 data installed, which for the workshop is <your path>\NHDPlusV21. Right click on that folder and **Add->New->Folder** naming it \NavigationDBs. Select this new folder.

j. Click **Navigate** and wait for the **Navigations Results** to appear in the map **Table of Contents**.

k. Zoom to the **Navigation Results** layer to see the extent of this first navigation.

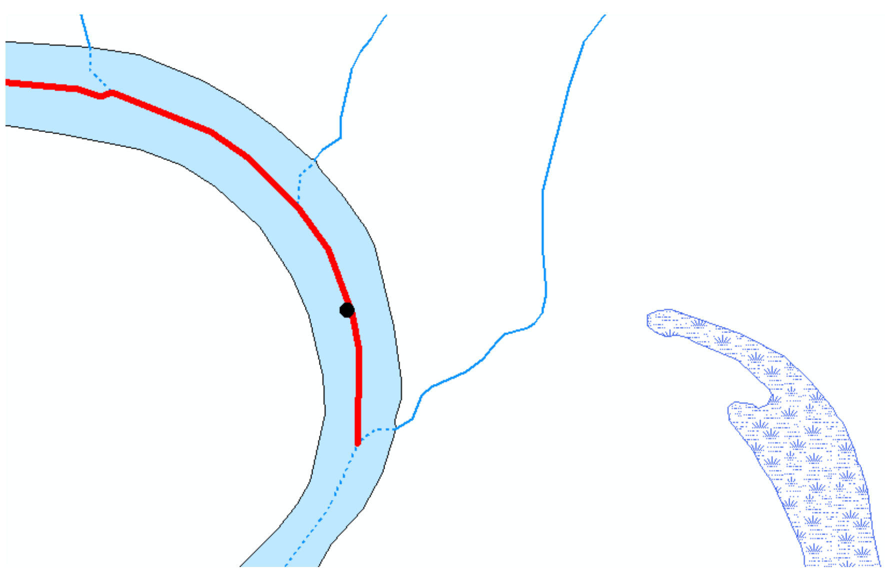
l. Click the **Go Back to Previous Extent** button.

m. Zoom in to the navigation start point (the black dot). Note how the navigation began at the exact point where you clicked on the flowline. This is because we used the default option **Start at Reachcode Measure** in the **Navigation Options**



dialog

n. Using the Up Mainstem navigation tool, click on the same spot again and select the **Start at Top or Bottom of "Clicked" NHDFlowline**. Click **Navigate**. Note that this time, the navigation includes the full flowline. This option starts at the bottom of the flowline for upstream navigations and at the top of the flowline for downstream navigations.



o. Right click on **Navigation Results** and open the attributes table. Note that it contains Reachcode, From Measure, and To Measure. In other words, it's an event table.

Navigation Results

OID	comid	reachcode	frommeas	tomeas	hydroseq	Shape *
18	10286344	05120111000065	0	100	430001614	Polyline ZM
282	20100942	05120105000095	0	4.15942	430003465	Polyline ZM
79	18507600	05120101000058	0	100	430008410	Polyline ZM
46	10286212	05120111000980	0	72.49387	430001706	Polyline ZM
88	18507660	05120101000077	0	100	430009292	Polyline ZM
0	10286960	05120111000001	52.04425	100	430001528	Polyline ZM
180	18508910	05120101000683	0	9.46631	430005527	Polyline ZM
34	10286436	05120111000954	70.73265	100	430001696	Polyline ZM
241	10380153	05120113000599	0	100	430001490	Polyline ZM
206	10382135	05120113000296	0	1.97392	430001324	Polyline ZM
131	18509618	05120101000119	0	100	430019106	Polyline ZM
111	18509526	05120101000099	0	100	430012698	Polyline ZM

p. **Add Data** \NHDPlusV21\NationalData\GageLoc.shp.

q. Join NHDFlowline,ComID with

r. \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusAttributes\PlusFlowlineVAA.

s. Join NHDFlowline.ComID with \NHDPlusV21\NHDPlusMS\NHDPlus05\EROMExtension\EROM_MA0001.dbf.ComID.

t. Let's discover which stream flow gages are along the navigation results:
   i. Join Navigation Results.Reachcode with GageLoc.Reachcode.

   ii. Select Navigation_Results.Reachcode = GageLoc.Reachcode and Navigation_Results.Frommeas <= GageLoc.Measure and GageLoc.Measure <= Navigation_Results.ToMeas. Note that each of the Flowlines in the Navigation Results which are now selected are the location of stream flow gages.

u. Join GageLoc.SourceFea with GageInfo.GageID.

v. Symbolize GageLoc with GageInfo.DASQKM in red text.

w. Symbolize NHDFlowline with TotDASQKM in blue text.

x. Highlight individual selected records in Navigation Results. **Zoom to Highlighted**. Compare the red and blue drainage area labels. When the labels have similar values, it's safe to assume that the gage was used to perform EROM stream flow gage adjustment.