

Sinks, Streams and Watersheds: “Prehistoric Worms Ate My Car!”

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GIS for You, Your Workflow and Your Career Path
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Summary of Exercise

This exercise will have you download data from (1) Kentucky’s Geoportal; (2) prepare data for processing; (3) generate sinkholes, streams, and watersheds; (4) convert raster to vector; (5) smooth out line features; and (6) select features from a buffer. Keep in mind that there are attendees in this workshop with a wide range of experience from beginner to advanced. You are welcomed to help out the person seated next to you so that we can continue on with the pace of this workshop. Step-by-step instructions will be minimized for this exercise in this document and further instructions will be given out during workshop. ArcGIS Spatial Analyst extension is required to do this exercise in ArcGIS for Desktop. You can simply click on links to launch a referenced web page in this PDF document. This exercise assumes basic navigation of ArcGIS for Desktop applications.

1 Data Acquisition

For this section of the exercise, we will download DEMs and roads for Daviess County from Kentucky’s Geoportal. “The Kentucky Geoportal is an award-winning Data Clearinghouse that provides easy and convenient ways to discover and share geospatial data resources. Use the powerful tools to locate maps and geographic data content for a particular part of the state or search based on keyword or theme type. The Geoportal allows you to create an account, save your searches, become a publisher, create metadata, and share your geospatial resources” (<http://kygissserver.ky.gov/geoportal/catalog/main/home.page>).

1.1 Getting Started

First let’s set up a project folder and subfolders for this exercise. You can use Windows Explorer or ArcGIS Catalog to do this. In the root directory of the K: drive, create a project folder named *SSW*. In *SSW*, create the following subfolders: *DWNLD*, *RASTER*, *VECTOR*, and *TEMP*. Always practice good file management in GIS and avoid using the Desktop for saving GIS data. When naming folders and files for use in Esri products, limit folder names to eight characters and thirteen for file names. Avoid using special characters. (For more information on naming conventions, click [here](#).)

1.2 Download Roads

We will download the roads for Daviess County and save in the *VECTOR* subfolder that we created earlier in section 1.1. Keep in mind that we will be downloading roads for the entire state. You can clip this layer to a polygon, but we won’t do it in this exercise. For more information on clipping features, click [here](#).

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- A. Go to the following web address: <http://kygissserver.ky.gov/geoportal/catalog/main/home.page>
- B. Type *Roads* in the *Search* input box under *Find Geospatial Data* and click *Search*. On the next page, click on *KYTC State Maintained Roads* and then click *Link*. *Link* will take you to an FTP site for downloading data.
- C. On the next pages, click *statewide | shape* and then right-click *Staterds.zip* and select *Save target as...* in the context menu that appears. Save this data in your *VECTOR* folder.
- D. Navigate to the file you just downloaded using Windows Explorer (or My Computer). Right-click *Staterds.zip* and extract into the same directory (or *VECTOR* folder). It is very important that you know where you're extracting this file because we will retrieve this file soon. (If Sweet Brown (youtube.com viral video sensation) was attending this workshop, she would say "Ain't nobody got time... [for you to figure out where you put your data!]" Avoid clicking buttons for the sake of clicking buttons. I tell my GIS students all the time: "Don't be a Default Warrior with stars in his eyes...") Take note to the .prj file, this means that the data's projection has already been defined.
- E. Launch ArcMap and load the *Staterds* layer into the data frame.

1.3 Download DEMs

For this section, we will download two digital elevation models (DEMs) in USGS SDTS format (.dem) for this exercise covering portions of Daviess County. This is a bit tricky because we need to know which DEMs to download out of a sea of DEMs. And so we will download a grid index shapefile to help us.

- A. Go to Kentucky's geoportal: <http://kygissserver.ky.gov/geoportal/catalog/main/home.page>
- B. Type in *7.5 minute quadrangle index* in the *Search* input box and select *7.5-minute Quadrangle Index* from the results and then right-click on *Link*. select *Save target as...* in the context menu that appears. Save this data in your *VECTOR* folder.
- C. Navigate to the file you just downloaded using Windows Explorer (or My Computer). Right-click *QUADSKY.zip* and extract into the same directory (or *VECTOR* folder). Take note to the .prj file, this means that the data's projection has already been defined.
- D. Load the *quad* layer into the data frame.
- E. Next activate the labels for the *quad* layer and zoom into the Daviess County area. (R-click *quads* in the ToC of ArcMap and select *Label Features*.) For this exercise, let's download DEMs identified as M20 and M21.
- F. Now enter DEM in the Search input box at the Ky. Geoportal. Click on *Kentucky Single Zone 30ft DEM (USGS)* to expand and select *Link*.
- G. At the FTP site that opens, scroll down to *m20.dem.zip* and right-click it. select *Save target as...* in the context menu that appears. Save this data in your *DWNLD* folder. Navigate to the file you just downloaded using Windows Explorer (or My Computer). Right-click *Staterds.zip* and extract into the same directory (or *DWNLD* folder). Take note that the extracted ZIP file produces a file with a .dem extension, a USGS SDTS file format. With ArcGIS 10.1, .dem files are viewable, but not really usable.
- H. Repeat the previous step (G) for *M21*.
- I. In section 2, we will process the .dem files to be usable in ArcGIS for Desktop. "Giddy-up!"

2 Preparing *.dem Files

We downloaded a couple of .dem files from Kentucky's geoportal that are viewable¹, but we can't really do any processing or analysis of these files. We will convert each .dem file to an ERDAS file format (.img). After we convert them, we will mosaic them into one raster. After we mosaic, we will discover some gaps between them. We'll finally use the raster calculator to fill in the gaps. Before proceeding forward to the next steps, let's make sure ArcGIS Spatial Analyst extension is turned on (ArcMap | Customize | Extensions... and make sure that the extension is checked)

2.1 .dem to .img

For the following steps, we will remain in ArcMap, but these steps can be done in ArcCatalog too. Both ArcMap and ArcCatalog are applications of ArcGIS for Desktop. In ArcGIS for Desktop, there are a lot of ways of doing one thing, "six of one, half a dozen..."

- A. In ArcMap, launch the *Search* tool (Ctrl+F), because, frankly, I can't remember where all these tools are located especially on a frozen machine that prevents a user from personalizing it.
- B. Type in *DEM to Raster* in the *Search* input box. Click on the *DEM to RASTER (Conversion)* tool², which should be the first one listed in the results list³.
- C. In the *DEM to RASTER* tool⁴, for the *Input USGS DEM file* navigate to the *DWNLD* folder and select *M20*. For the output raster, navigate to the *RASTER* folder and name it *M20img.img* Change the *Output data type (optional)* to *INTEGER*⁵.
- D. Repeat previous step (C) for *M21*.
- E. The .img files should have been added to ArcMap automatically. We need to define its projection. (Both .img file can remain in ArcMap while we do the following.) Click on the *Catalog* tab located in the far right of ArcMap. Navigate to the *RASTER* folder. (You may have to right-click the *RASTER* to select *Refresh* to refresh its contents.) and we can do this as is in ArcMap. Right-click an .img file in *Catalog* and select *Properties...* Click on the *General* tab and scroll down to *Spatial Reference* and click the *Edit* button to define its spatial reference in the *Projected Coordinate Systems State Plane US (Survey) Feet Kentucky Single Zone (FIPS 1600)*.

2.2 Mosaic

Ready to mosaic these two .img files into one? Let's do it!

- A. In ArcMap, launch the *Search* tool (Ctrl+F). Type in *Mosaic to New Raster* in the *Search* input box. Click on *Mosaic to New Raster (Data Management)* tool.
- B. Input Raster: *m20img.img* and *m21img.img*
- C. Output Location: *K:\SSW\RASTER*
- D. Raster Dataset Name with Extension: *mosaic.img*
- E. Pixel Type: *16_BIT_SIGNED*
- F. Number of Bands: *1*

¹This may be a function of the Advance (or ArcInfo) license of ArcGIS for Desktop.

²In almost every tool window, there is a button labeled 'Tool Help' to give you more information about the tool and there are hints about the parameters of the tool as you click on each with the hint displayed to the right.

³Click on the green colored hyper link to see exactly where this tool is located.

⁴Right-click a tool in ArcToolbox and select *Batch...* for batch processing files. It's a little bit glitchy, but once you figure it out it should be easy.

⁵ESRI products works best with integer rasters; however, when converting over from a decimal format (or float), it will truncate the decimal number. It's almost always a dead-end street with a float raster in ArcGIS.

- G. Make sure the above match (steps B – F) and click on the *OK* button.
- H. *mosaic.img* should have been added to ArcMap. (Uncheck or remove *quad*, *m20img.img* and *m21img.img*.) Zoom to your mosaic layer and then zoom in more to where the original DEMs meet. Do you see some gaps? We'll get rid of these null values in the next section.

2.3 Filling in the Gaps

Now that we've mosaicked the two DEM rasters into one, we discovered that it's not seamless. Let's make it seamless.

- A. In ArcMap, launch the *Search* tool (Ctrl+F). Type in *Raster Calculator* in the Search input box. Click on *Raster Calculator (Spatial Analyst)*.
- B. Insert the following Python script (Python is CaSe SeNSiTiVe) into the raster calculator expression input box:

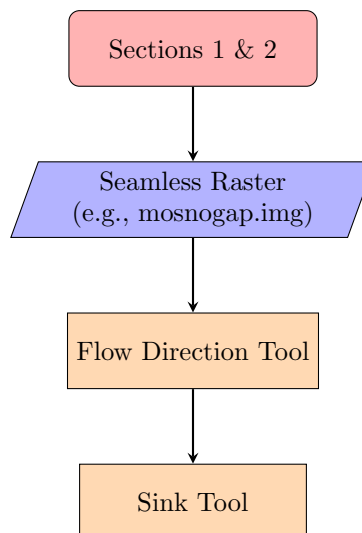
```
Con(IsNull("mosaic.img"), FocalStatistics("mosaic.img",
NbrRectangle(5,5, "CELL"), "MEAN"), "mosaic.img")
```

Note: Copying and pasting above code from PDF will not work. Click [here](#) to copy and paste, but you will need to replace your mosaic raster wherever you see "raster" in the script.

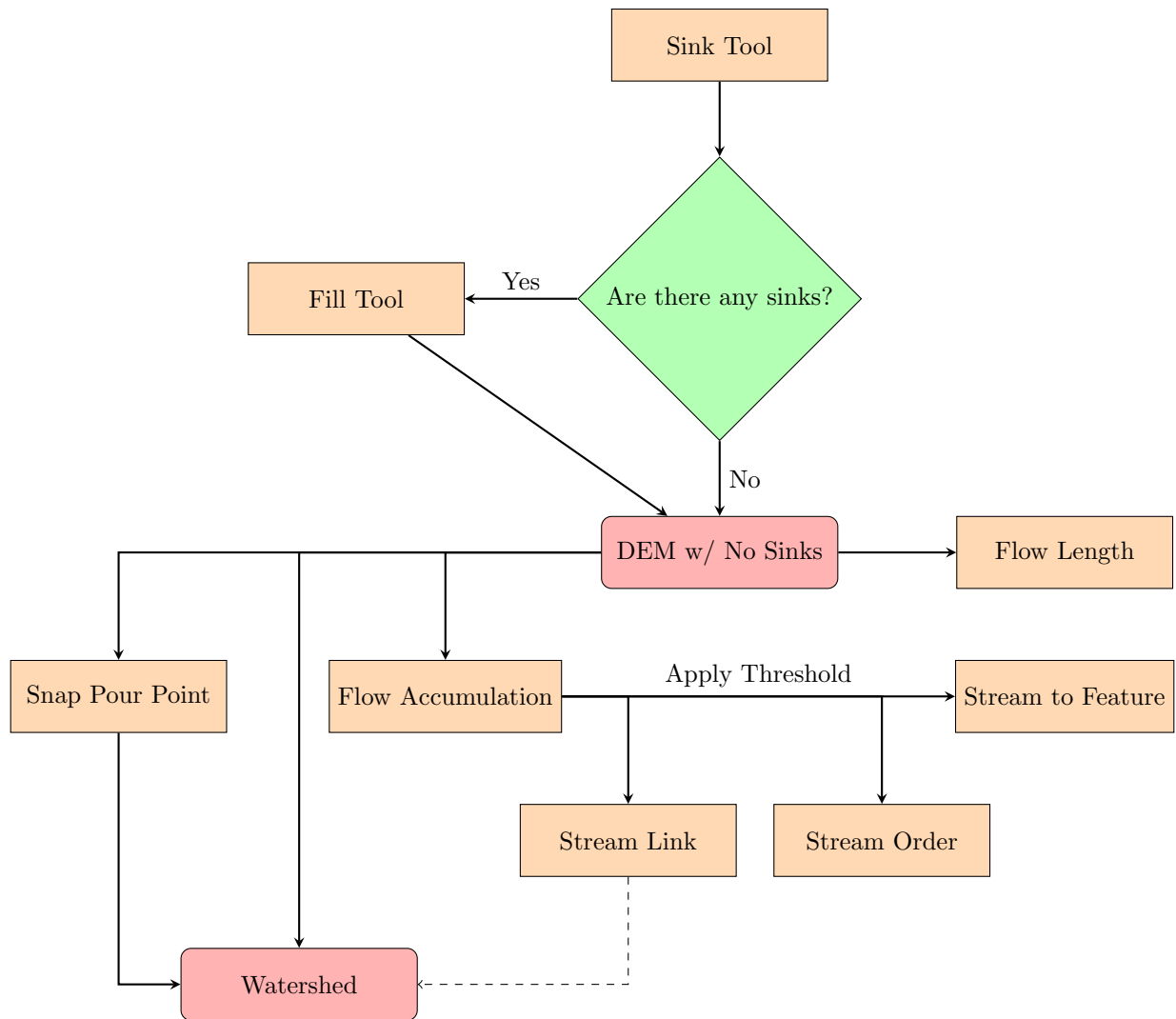
- C. Output raster: K:\SSW\RASTER\mosnogap.img
- D. Remove old mosaic raster from ArcMap and symbolize (if needed) newly created mosaic with filled in gaps.

3 Sinks, Streams and Watersheds

We begin with our mosaicked gap-filled raster to produce a raster identifying sinkholes, streams, and watersheds. We can convert these rasters to features if needed for further analysis. Below is a flowchart showing the work-flow to derive these rasters. You can find the below flowchart and detailed descriptions at ArcGIS resources by clicking [here](#).



Flowchart continues on next page.



3.1 Delineate Watersheds

Let's get started on delineating watersheds. During the process, we will fill the existing sinks so that we can have an uninterrupted flow of runoff. Then we'll identify streams before delineating watersheds.

- A. Open your **Hydrology Toolset** (ArcToolbox | Spatial Analyst Tools | Hydrology). The set of tools found in this toolset are referenced in the below steps.
- B. Launch the **Flow Direction Tool**. Input surface raster is *mosnogap.img* and save your outputflow raster in your *RASTER* folder. Name your flow direction raster *flowd.img*
- C. Launch the **Sink Tool** so that sinks can be identified. Enter the flow direction raster you just created as the input. Save your output as *sink.img* in your *RASTER* folder. After you created your sinks raster, turn off the other raster layers in your data frame to see where the sinks are located.
- D. Let's fill the sinks. Launch the **Fill Tool** and enter *mosnogap.img* as the *Input surface raster* and save your output raster as *mfilled.img* in the *RASTER* folder.
- E. Let's run the **Flow Direction Tool** one more time, but this time using the DEM raster with the sinks filled or the "DEM with no sinks." Save your file as *flowfinal.img* in your *RASTER* folder. [Click here](#) for more information on decoding your new flow directional raster.

- F. Now let's run a tool that I think is pretty neat. It's going to calculate how many cells in the raster flow into any given cell. Launch the **Flow Accumulation Tool**. Input your flow direction raster and save the output raster as *accumu.img* in your *RASTER* folder. Output data type is INTEGER.
- G. In order for us to begin seeing the streams from the previous step, we need to select only the cells with more than 500 flowing into them. (Of course you don't have to always use this number.) Open the Conditional Toolbox under Spatial Analyst Tools and launch the **Con Tool**. Your input conditional raster is your *accumu.img* raster. Use the expression *Value > 500* and enter 1 for the input true raster or constant value. Save your output raster as *conrslt.img* in your *RASTER* folder. After ArcGIS creates your output raster, turn off all the other layers to see your streams!
- H. We can also identify each section of a stream separately. Back in the Hydrology Toolbox, launch the **Stream Link Tool**. Enter the inputs and save your output raster as *strmlnk.img* in your *RASTER* folder.
- I. Finally, let's delineate some watersheds. Launch the **Watershed Tool**. Your input flow direction raster is *flowfinal.img* and your input raster or feature pour point data is *strmlnk.img*. Save your output raster as *wtrshd.img* in your *RASTER* folder.
- J. Convert your raster stream layer into a feature by using the **Stream to Feature Tool**. Input stream raster is *strmlnk.img* and input flow direction raster is *flowfinal.img*. Save your features as *streamshp.shp* in your *VECTOR* folder. "How 'bout them apples?" (You could actually use the **Raster to Polyline (Conversion) Tool** for this step too.) Notice the number of streams, this can be reduced by adjusting the threshold value in step G.
- K. Zoom into a stream in your stream vector layer, around 1 : 7000. Notice that it's step-like in shape. Not aesthetically appealing to the eye. You can smooth it out by taking advantage of the **Smooth Tool** in the **Advanced Editing Toolbar** while in editing mode of your feature class (or shapefile).

3.2 Watersheds Upstream from a Pour Point

In this section, we can identify watersheds upstream from a "pour point."

- A. Zoom into a pour point or where you want to identify watersheds upstream from the point of a stream.
- B. Create a point shapefile and save it as *pourpoints.shp* in your *VECTOR* folder. Edit *pourpoints.shp* and drop a point on a stream (your *conrslt.img* raster stream), you don't have to snap to it, but get as close as possible. Save your edit(s) and stop editing.
- C. Launch the **Snap Pour Point Tool**. Enter *pourpoints.shp* as the input raster or feature pour point data and enter *accumu.img* as the input accumulation raster. Save your output raster as *pptrast.img* in your *RASTER* folder. Type in 100 for the snap distance. (The snap distance is measured in map units.) Snap distance assures us that our pour point will snap to a stream if within the snap distance of the stream of interest. Your output raster is basically a cell representing your vector pour point.
- D. Let's identify the watersheds upstream from this pour point. Launch the **Watershed Tool**. Enter *flowfinal.img* as the input flow direction raster and *pptrast.img* as the input raster or feature pour point data. Save your output raster as *pptwtrshd.img* in your *RASTER* folder. Right-click your output raster and zoom to layer. Convert *pptwtrshd.img* to a polygon by using the **Raster to Polygon (Conversion) Tool** so that you can select features and create buffers for selecting features. Save your vectorized pour point watershed as *pptwtrshdv.shp* in your *VECTOR* folder to do the steps in the next section.

4 Select Features by Location

In this section, you will learn how to select features based upon location. We will use *pptwtrshdv.shp* from the last step (D) in the previous section (3.2) and your roads layer from section 1.2 to do the following steps below.

- A. Select by Location: ArcMap | Selection | Select by Location. There are plenty of options in this tool to meet any criteria. You can even apply a search distance that functions as a buffer. If using the search distance, it may select a lot more features than expected. To avoid this create a buffer (see next step) and cookie cut those features or have buffer as a “base map” highlighting the area of concern.
- B. Creating a buffer: ArcMap | Geoprocessing | Buffer. There are lots of parameters in this tool that will meet any need. Once your buffer is created as a shapefile or feature class, see the previous step (A) in this section to select by location.
- C. For more information on clipping features, click here.

5 Further Reading

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