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How to use ArcGIS Pro for Creating Watershed Shapefiles

For use with the Maryland Dam Safety's "PMP Evaluation Tool"

March 2025

INTRODUCTION

This document is being developed to assist in creating watershed shapefiles that can be used with the ArcGIS Pro based Maryland PMP Evaluation Tool. This is a more precise way to create the watershed than using StreamStats in determining PMP, however StreamStats is a good approximation tool. The methods discussed herein for watershed creation should provide better results in determining PMF (Probable Maximum Flood) values with the use hydrology packages such as HEC-HMS.

This document will discuss the following:

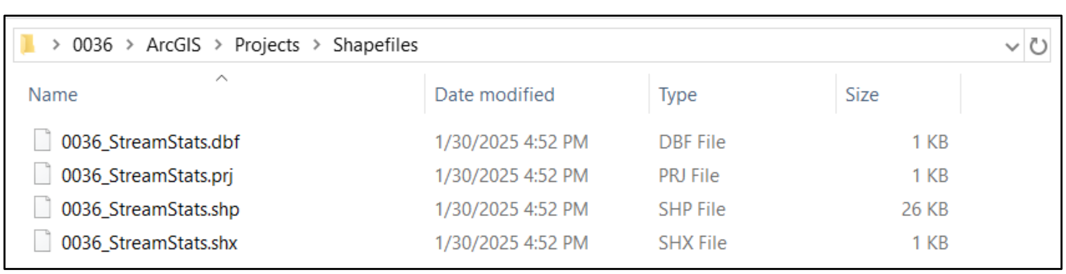
- Loading LiDAR Digital Elevation Models (DEM) into the ArcGIS Pro project.
- Clipping (Export) the DEM data for the watershed.
- Using the Fill Toolbox to prepare watershed development.
- Using the Flow Direction Toolbox.
- Using the Flow Accumulation Toolbox.
- Creating a Point File for selection of the watershed study point.
- Creating the final watershed raster file.
- Creating the final watershed shape file for use with the Maryland PMP Evaluation Tool.

INITIAL STEPS

It is recommended (not required) that a project directory be created before the work begins. For this example, a GIS folder for Broadford Dam (NID MD0036) will be created.

```
0036
└──► ArcGIS
      └──► Projects
            └──► Shapefiles
```

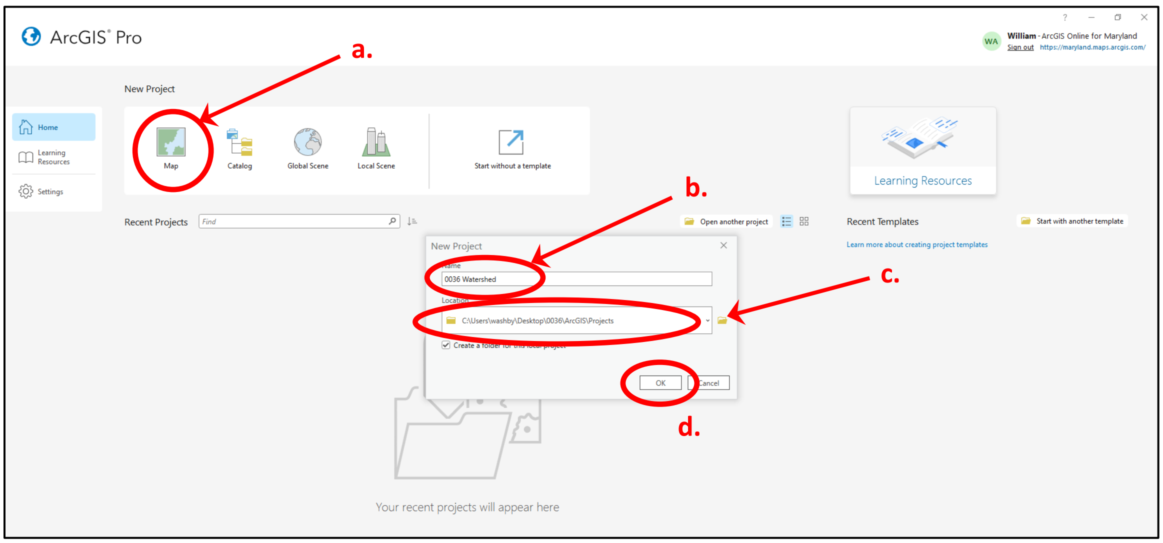
StreamStats can be used to develop a rough idea of the location the subject drainage area, so follow the StreamStats procedures in creating the watershed shapefiles and place the appropriate files in the "Shapefiles" folder. It is recommended to rename the files to differentiate them from the ArcGIS Pro files. In this example, the files will be named "0036_StreamStats".



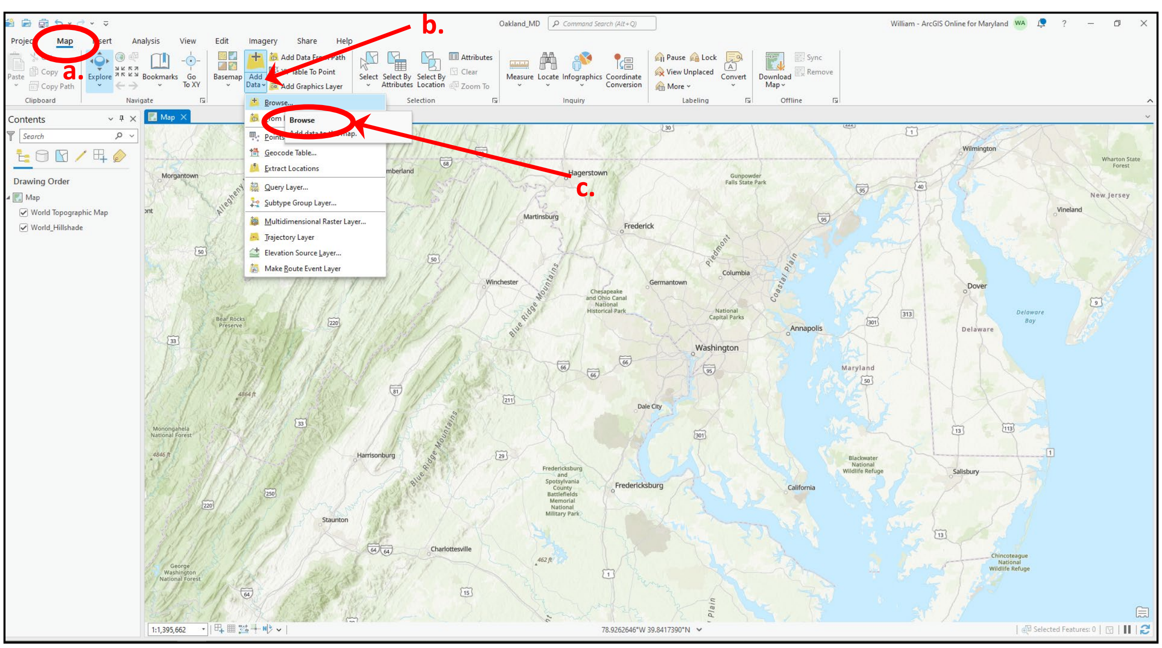
Name	Date modified	Type	Size
0036_StreamStats.dbf	1/30/2025 4:52 PM	DBF File	1 KB
0036_StreamStats.prj	1/30/2025 4:52 PM	PRJ File	1 KB
0036_StreamStats.shp	1/30/2025 4:52 PM	SHP File	26 KB
0036_StreamStats.shx	1/30/2025 4:52 PM	SHX File	1 KB

1. **Open ArcGIS Pro**

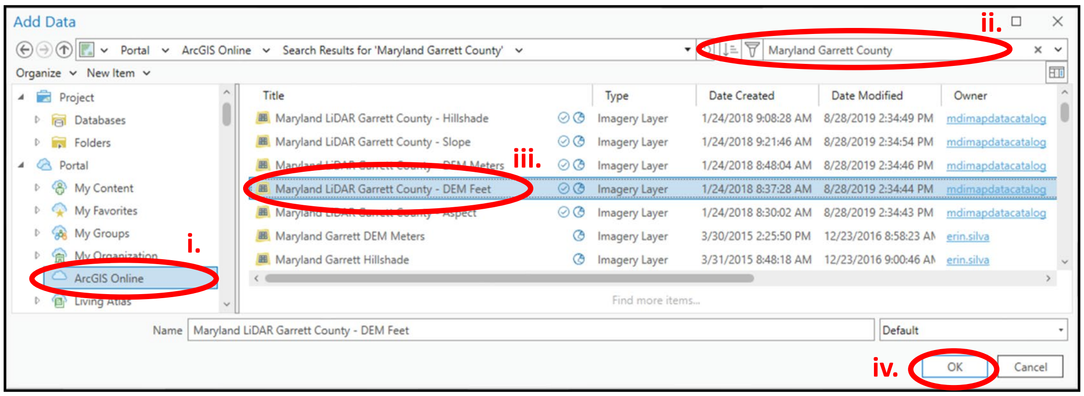
2. **Create a New Map Project.**
   a. Click on "**Map**".
   b. **Name** the project.
   c. **Browse** to the "Projects" directory that was created.
   d. Click "**OK**".



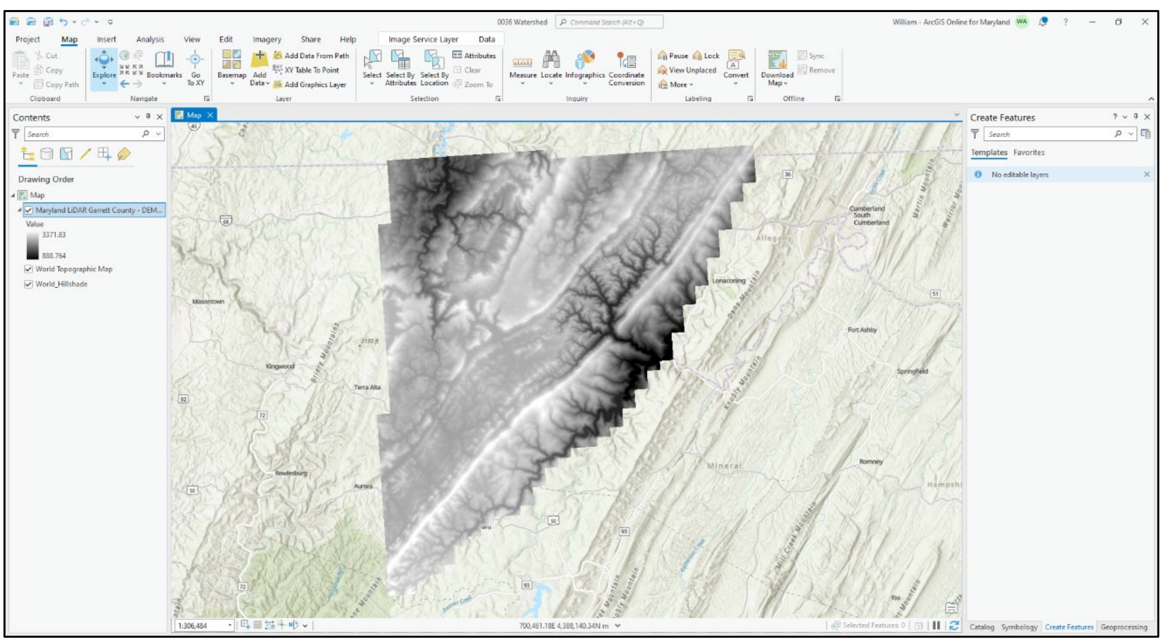
3. **Load the LiDAR DEM Data.**
   a. Select the <u>**Map**</u> tools along the menu bar.
   b. Select the drop-down arrow on the "<u>**Add Data**</u>" button.
   c. Click "<u>**Browse**</u>".



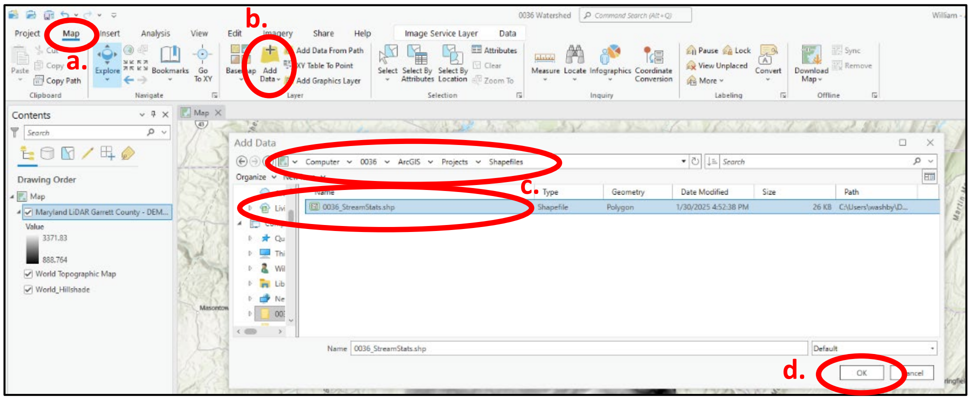
d. The pop-up window will have various selections:
   i. In the left-hand column, various data sources will appear. Select "**<u>ArcGIS Online</u>**".
   ii. In the search bar in the upper right, type in "Maryland (*desired)* County" for the desired DEM raster image. ("Maryland **<u>Garrett</u>** County" will be used in this example). Press **<u>enter</u>** on the keyboard and a selection of raster images should appear.
   iii. Select the desired raster image file (in this example, *Maryland LiDAR Garrett County – DEM Feet*). **Make sure the file you select is in FEET!!**
   iv. Click "**OK**" and the selected DEM file will now load.



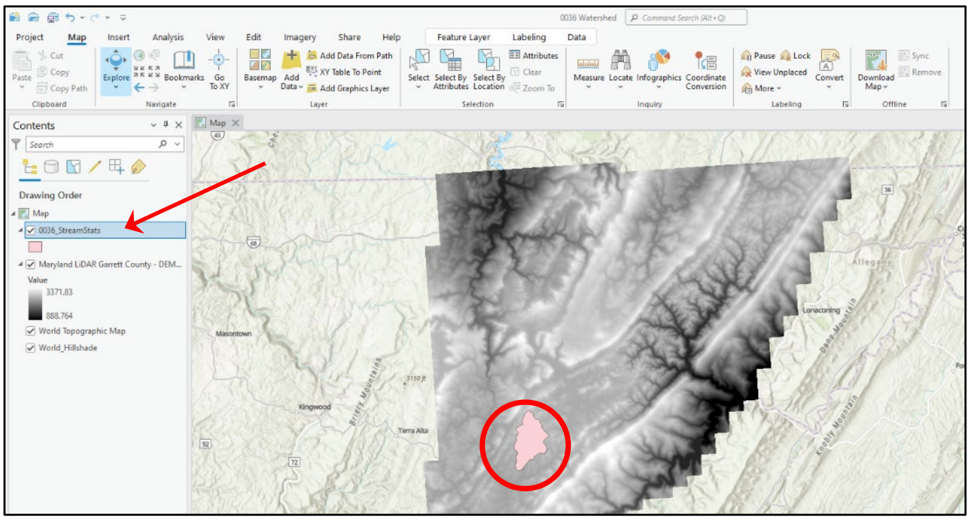
e. The DEM appears in the project window. Note that this LiDAR data is too big for processing. The local data requires exporting to a more reasonable size.



4. **Prepare for Exporting (Clipping) the data from the LiDAR DEM**
   NOTE: The shapefile previously developed from StreamStats will be used as a focus clip area. Remember that the StreamStats shapefile isn't precise so it will only be used as a guide for what needs exported. The StreamStats shapefile is added in the same way that was used for the LiDAR DEM.
   a. As was done in ***Step 3, a.***, from the **<u>Map</u>** toolbar.
   b. Select the drop-down arrow on the "**<u>Add Data</u>**" button.
   c. Select "**<u>Browse</u>**" but this time find and select the StreamStats shapefiles.
   d. Click "**OK**".

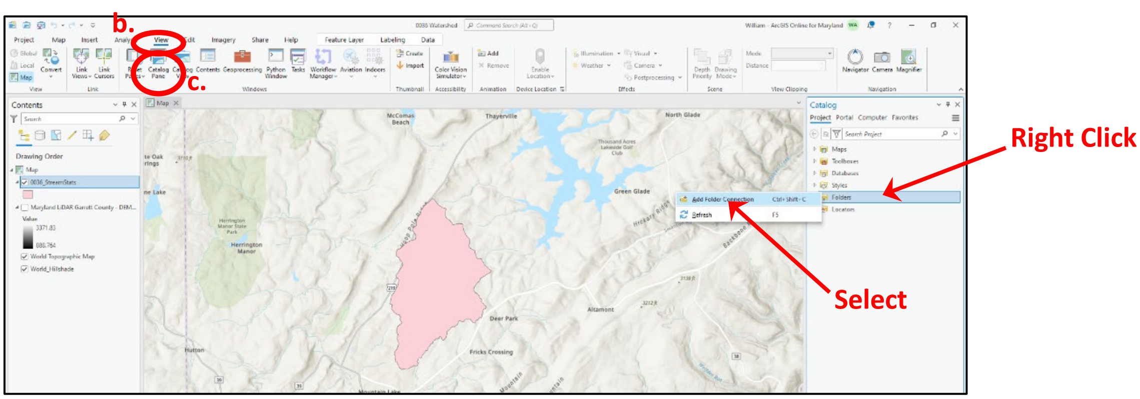


e. The StreamStats watershed should now be included in the data layers in the "Contents" window on the left of the project screen. It will also be shown on the map.



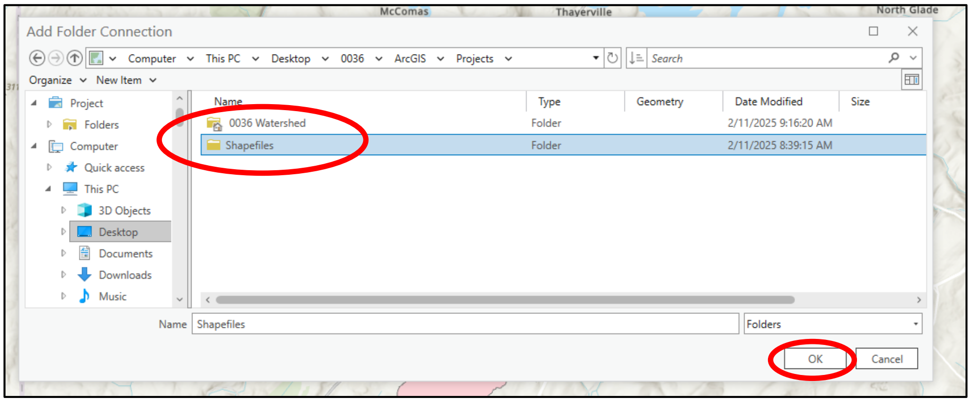
This location will be used to create another shapefile needed for extracting the LiDAR DEM data. A new shapefile needs to be created because of the lack of precision of the StreamStats shapefile. Note that using the StreamStats file may result in losing some information along the ridge lines.

5. **Creating the Clipping Shapefile**
    a. Turn off the LiDAR Map layer and zoom into the location of the StreamStats shapefile.
    b. Select the **<u>View</u>** tool along the top menu bar.
    c. Select the "**<u>Catalog Pane</u>**" button.
    d. In the "Catalog" window on the right of the screen, **<u>Right Click</u>** "Folders" and select "**<u>Add Folder Connection</u>**".

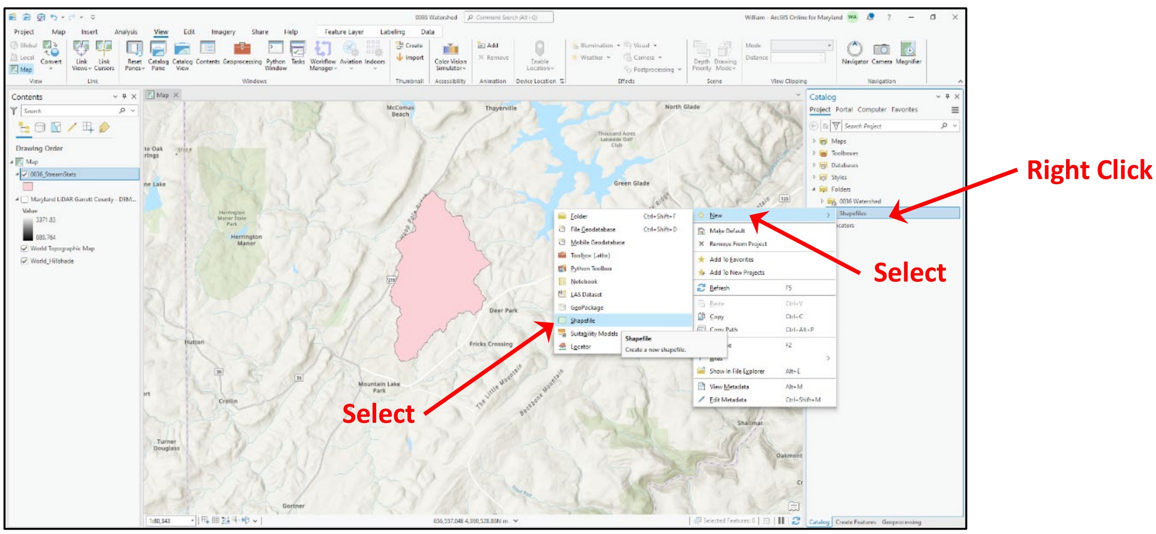


e. The Add Folder Connection pop-up window will open. Browse to the folder where the new shapefile will be located. In this example, the previously created "Shapefiles" folder will be used.

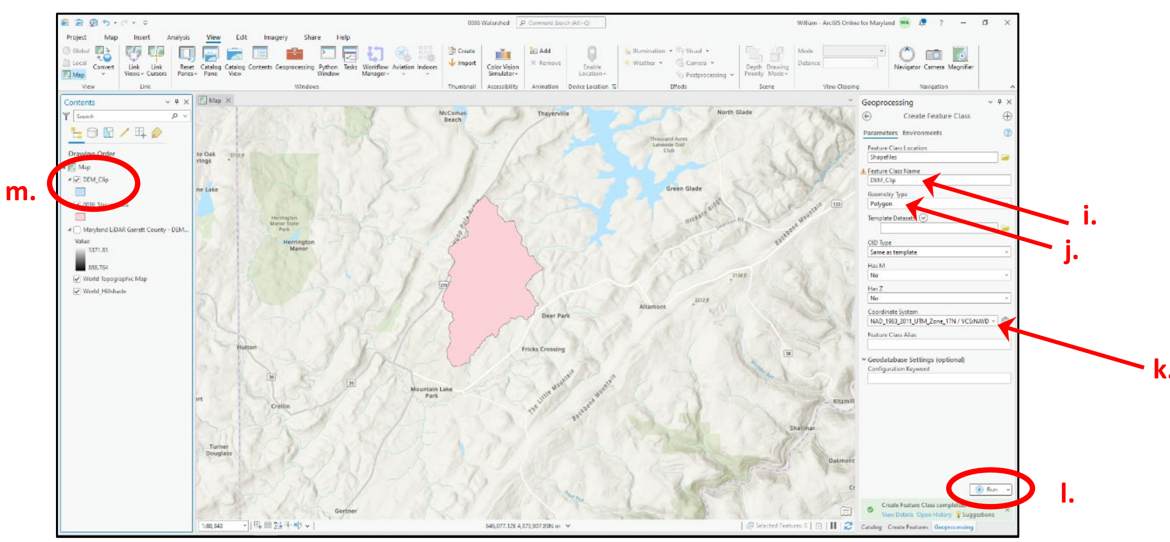
f. Click "**OK**".



g. Expand the "Folders" in the Catalog window to show the "Shapefiles" folder.

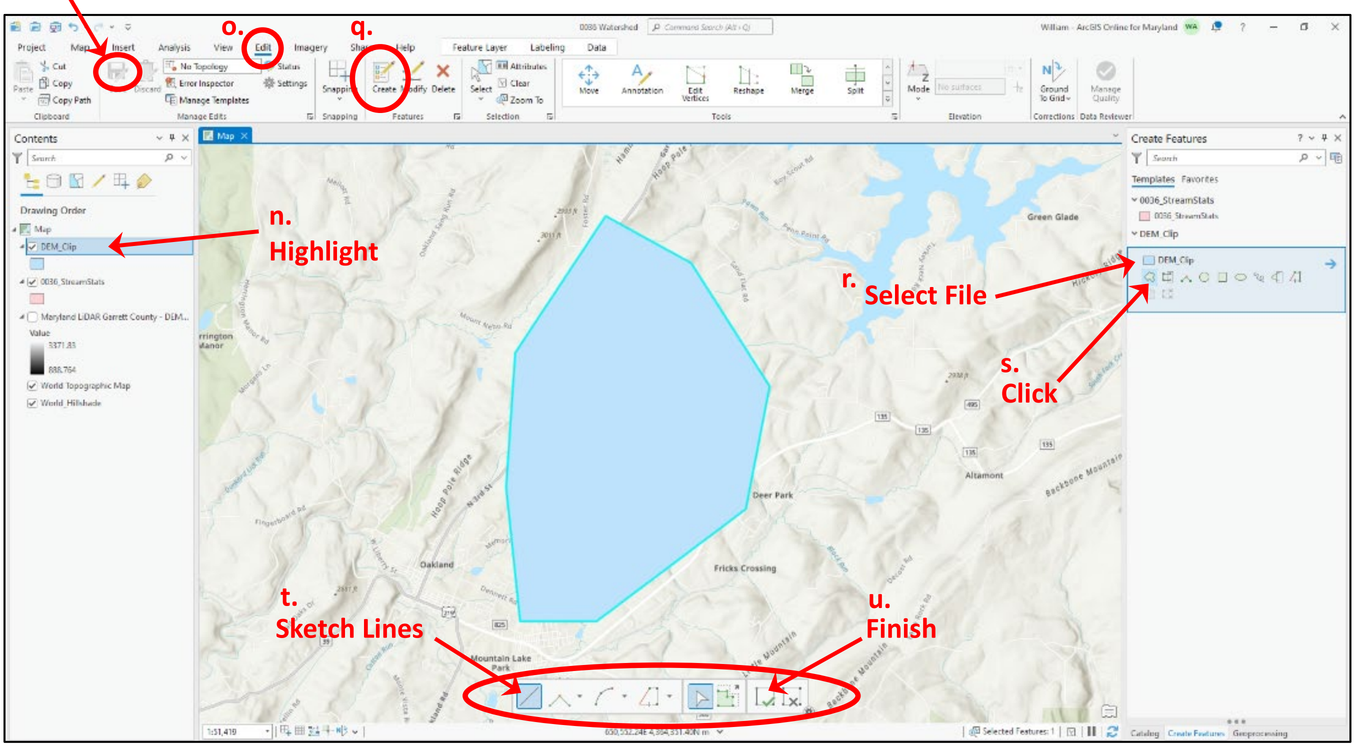


h. **Right Click** the "Shapefiles" folder and select "**New**", then "**Shapefile**". The "Geoprocessing" window will now open on the right of the screen.



i. In the "Geoprocessing" window, give the shapefile a name in the "Feature Class Name" box. For this example, the name "**DEM_Clip**" will be used.
j. Set the "Geometric Type" to "**Polygon**".
k. Set the "Coordinate System" to "**Current Map**" which yields "*NAD_1983_UTM_Zone_17N/VCS*".
l. All other fields may remain as default. Now select "**Run**".
m. This process creates an empty shapefile layer that is listed in the Contents window on the left. Next, the actual shapefile data needs to be created.

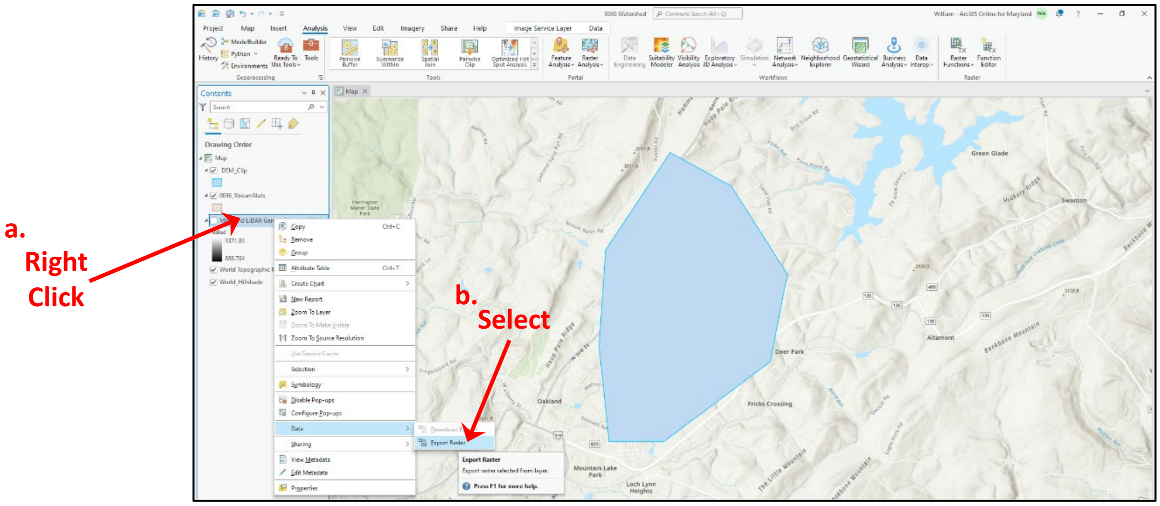
n. Highlight the new "**DEM_Clip**" layer file in the Contents window.
o. Select "**<u>Edit</u>**" on the top tool bar.
p. Zoom in to the map to view the previous StreamStats shapefile. If not previously performed, unselect (turn off) the LiDAR layer.
q. Select "**<u>Create</u>**". The "**Create Features**" window should open on the right of the project window.
r. Click on the "**<u>DEM_Clip</u>**" file in the Create Features Window.
s. Click on the "**Create a Polygon Feature**" icon and a drawing tool bar will appear at the bottom of the mapping window.
t. Click on the "**<u>Sketch Lines</u>**" icon and create the shapefile around the StreamStats shapefile. Double click the last point of the shapefile to finish the poloygon.
u. When finished, click the "**Finish**" icon.
v. Go back to the tool bar and click on the "**<u>Save"</u>** icon. When asked to save edits, click "**<u>Yes</u>**". The **DEM_Clip** shapefile has now been created. If desired, the StreamStats shapefile can be remove.



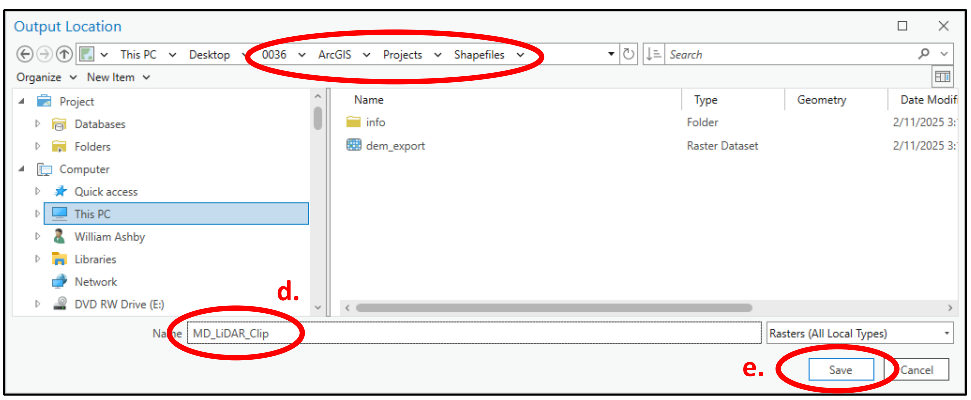
Drawing Tool Bar

Now that the clipping shapefile is created, it will be used to export DEM data from the original LiDAR DEM file.

6. **EXPORT (Clip) the DEM DATA**
   a. Right click on the original LiDAR file name (*Maryland LiDAR Garrett County – DEM Feet)*.
   b. On the menu that appears, select on the "**Data**", then "**Export Raster**".

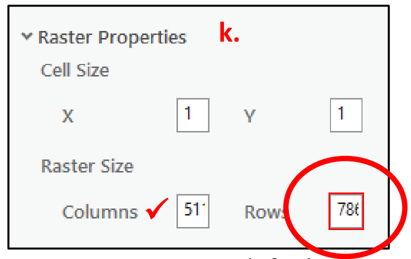


   c. The "**Export Raster**" tool will appear on the right side of the project window with various data input boxes.
   d. The first data input will be for the *Output Raster file*. Use the browse icon to verify the location of the output file and enter the desired shapefile name. For this example, "**MD_LiDAR_Clip**" will be used as the filename. Make sure it is stored in the Shapefiles folder of the project.
   e. Click "**Save**".

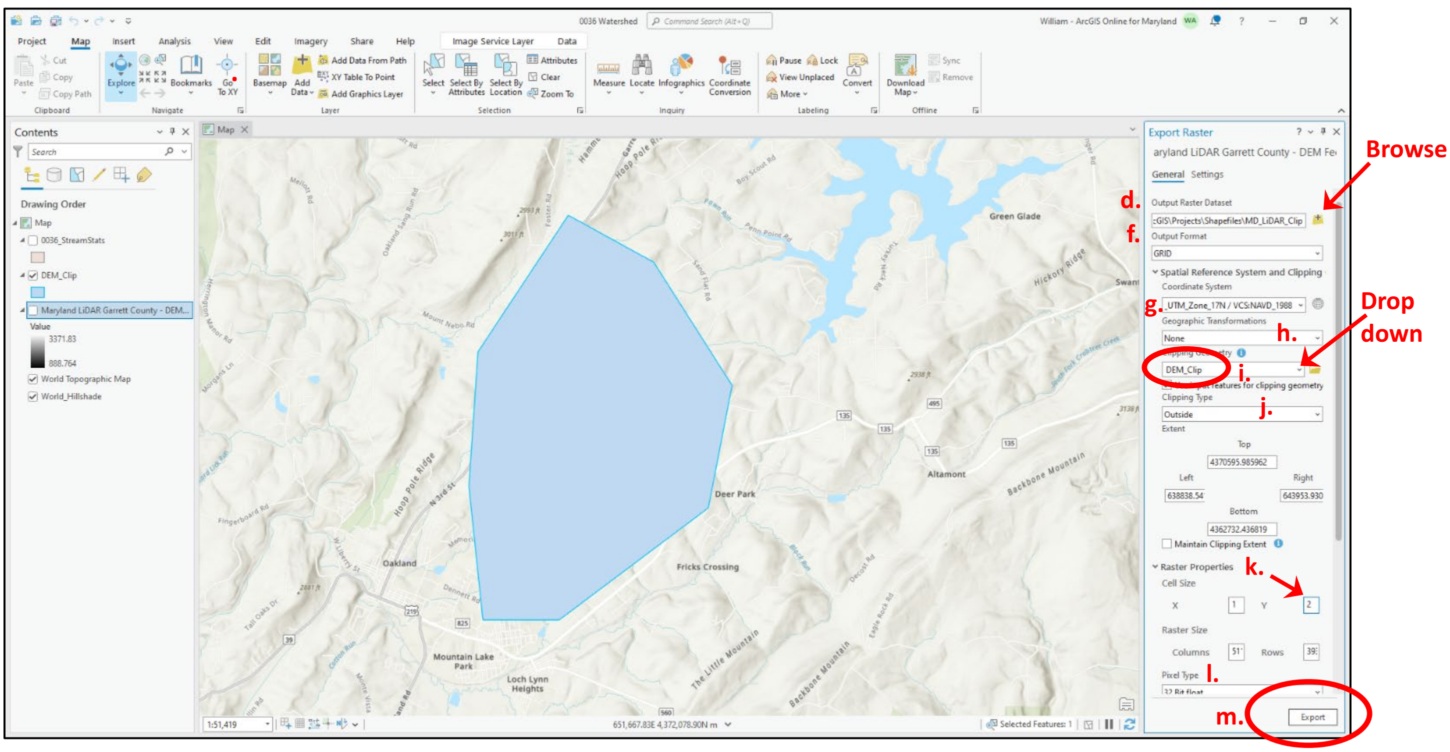


   f. Leave the Output Format as the default value "Grid"
   g. Select the Coordinate System that is associated with the original LiDAR file, which yields "*NAD_1983_UTM_Zone_17N/VCS*".
   h. Geographic Transformation may stay as the default.
   i. The Clipping Geometry is the important input. Browse to find the **DEM_Clip** shapefile. It should be listed on the drop-down button. Find the **DEM_Clip** file and select it.
   j. The routine defaults to clipping the original LiDAR file for everything outside the clipping shapefile. It isn't necessary to check that box. If it is, make sure the value is set for "Outside". The values for the north, south, east and west coordinates of the clipped output raster image will now appear.

k. “Raster Properties” will also appear, which include Cell Size and Raster Size. Raster size is limited to 15000 columns and 4100 rows. If one of the two boxes for rows or columns are **red**, then that value must be reduced. Adjust the value for either X or Y in order to reduce the column or row size. In this example, we will change the Y value to “2” in order to bring the row value below 4100.



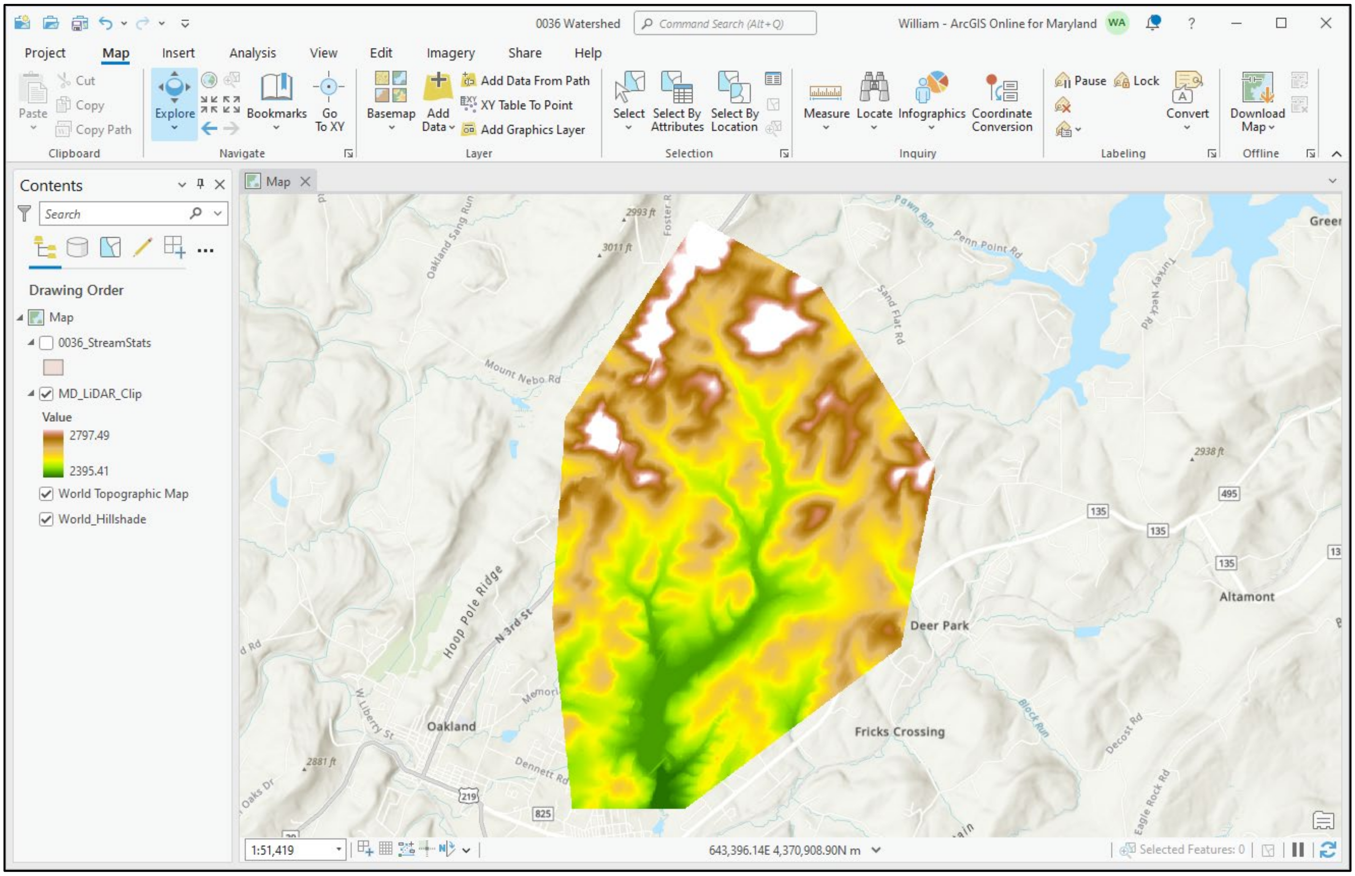
l. Pixel Type and NoData value inputs may stay as default.
m. Click Export to create the clipped raster image file.



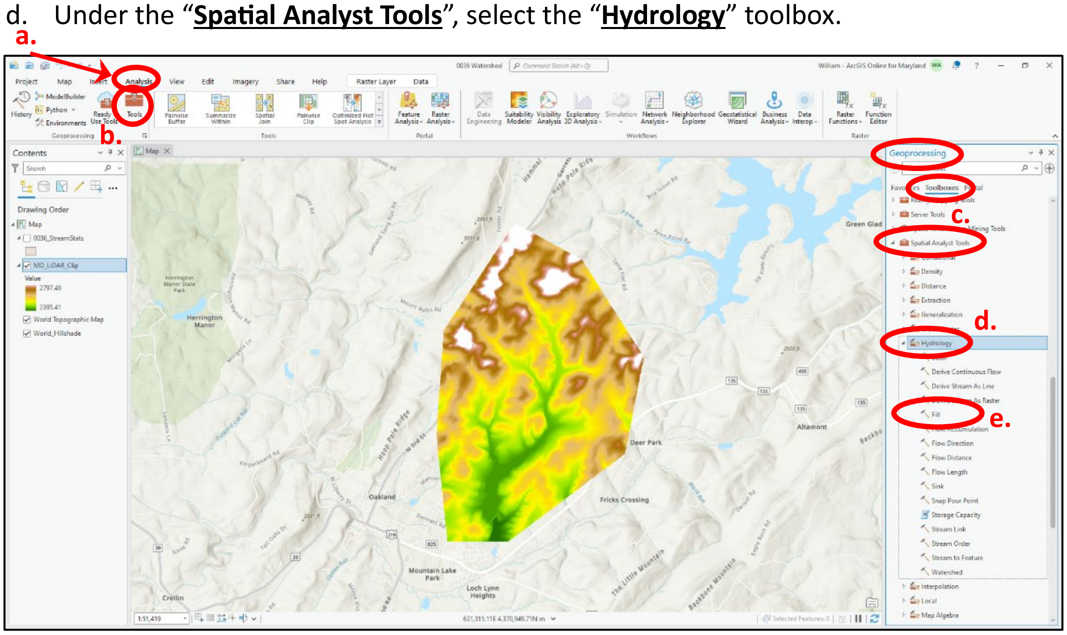
n. The processing may take a few minutes. Once complete, the exported DEM file will appear in the Contents window and on screen. If it doesn’t appear on the screen, turn off all layers except the exported file.
o. Close the Export Raster window on the right.
p. The color scheme of the clipped raster file may be changed by clicking on the symbology of the file and changing the color scheme to what is desired. For this example, “Elevation #10” color scheme will be used.

The clipped file is ready to be used to create the watershed.

A word about file clean-up. The original LiDAR file is no longer needed, nor the DEM_Clip file and can be removed from the project. The StreamStats file may also be removed. Right click the files that aren’t needed and select “Remove”.

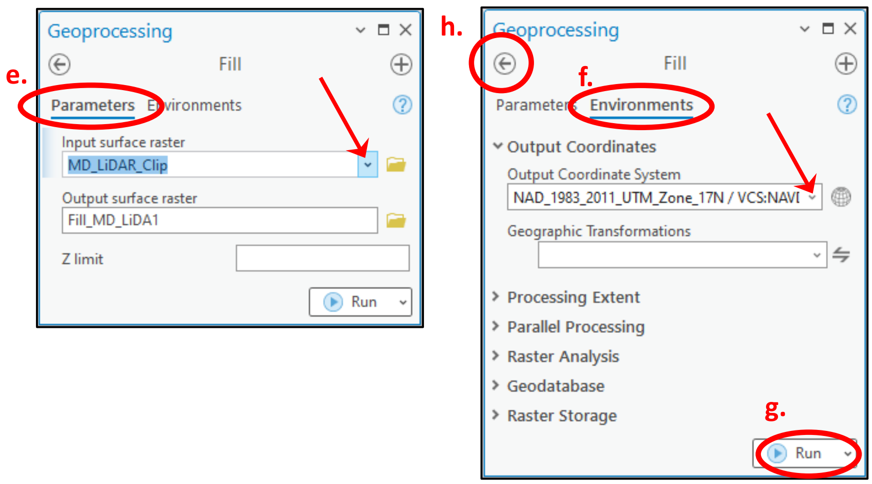


7. **Using the Fill Toolbox**
NOTE: To create the watershed boundary, all extraneous depressions within the newly created DEM need to be filled. The "Fill" routine, and many of the following procedures, are performed using the "Hydrology" Toolbox.
   a. On the top toolbar, select "**Analysis**"
   b. Select "**Tools**" and the "**Geoprocessing**" window will appear on the right of the project window.
   c. Under the "**Toolboxes**" tab, scroll down and **select** the "**Spatial Analyst Tools**".
   d. Under the "**Spatial Analyst Tools**", select the "**Hydrology**" toolbox.



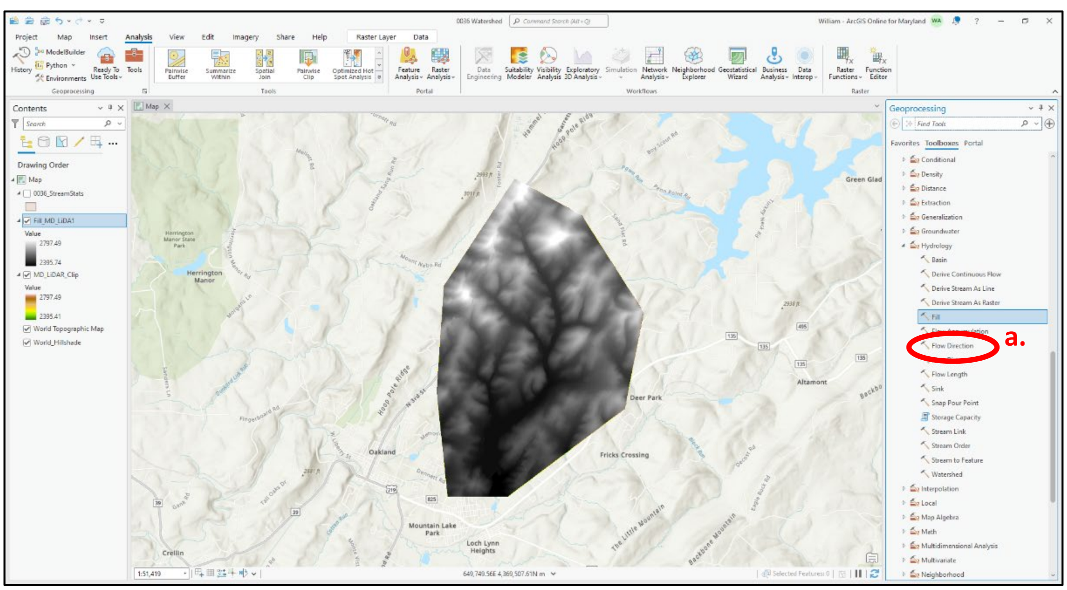
e. Next, select the "**<u>Fill</u>**" tool. The **<u>Fill</u>** window will appear where the inputs are simply the newly created "***MD_LiDAR_Clip***" file. Select it from the dropdown list. The default name of "**<u>Fill_MD_LiDA1</u>**" will appear as the output raster. We will use that name. No "Z limit" is necessary.

f. Click on the "**<u>Environments</u>**" tab at the top of the **<u>Fill</u>** window to select the "Output Coordinate System". The value in the dropdown list for the "**<u>Current Map</u>**" is appropriate. No other input is necessary.



g. Click "Run". Once the Fill Tool has finished processing, a new raster DEM will appear in the Contents window and on the project screen named "**<u>Fill_MD_LiDA1</u>**".

h. Exit out of the "Flow" tool back to the "Hydrology Tool" list.

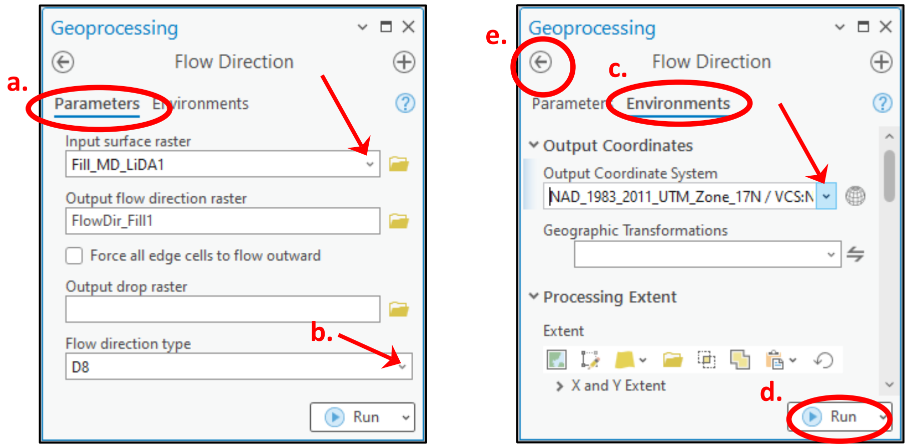


8. **Using the Flow Direction Toolbox**

a. Next, select the "**<u>Flow Direction</u>**" tool. The **<u>Flow Direction</u>** window will appear where the inputs are the newly created DEM "**<u>Fill_MD_LiDA1</u>**". Select it from the dropdown list. The default name of "**<u>FlowDir_Fill1</u>**" will appear as the output raster. We will use that name. Since the original clipped DEM is outside of the boundaries of the "*<u>0036_StreamStats</u>*" shapefile, we do not need to "<u>Force all edge cells to flow outward</u>". This can stay unchecked. Additionally, no "<u>Output drop raster</u>" is required.

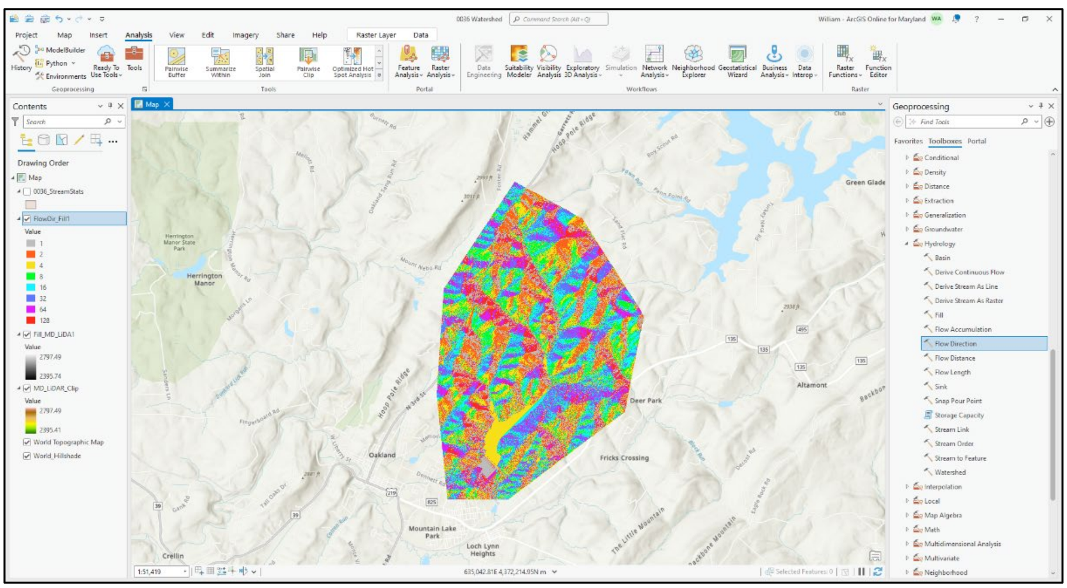
b. It is important to select the "**<u>Flow direction type</u>**". **<u>D8</u>** is an appropriate value for most work in determining watersheds.

c. Click on the "**Environments**" tab at the top of the **Flow Direction** window to select the "Output Coordinate System". Once again, the value in the dropdown list for the "Current Map" is appropriate.



d. Click "Run". Once the Flow Direction Tool has finished processing, a new raster DEM will appear in the Contents window named "**FlowDir_Fill1**", and on the project screen.

e. Exit out of the "Flow" tool back to the "Hydrology Tool" list.

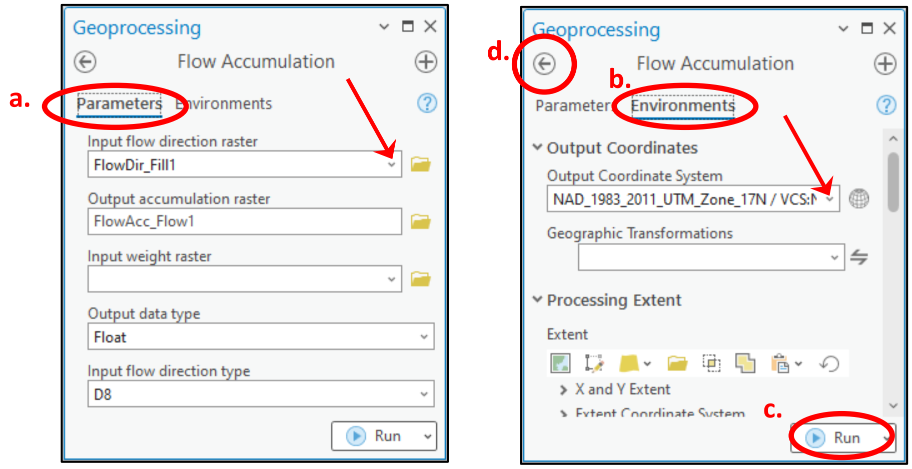


NOTE: Since the "Flow direction type" was selected as D8, eight colors were created in the **FlowDir_Fill1** file that correspond to the various flow directions of each cell in the DEM (1=E, 2=SE, 3=S, etc.).

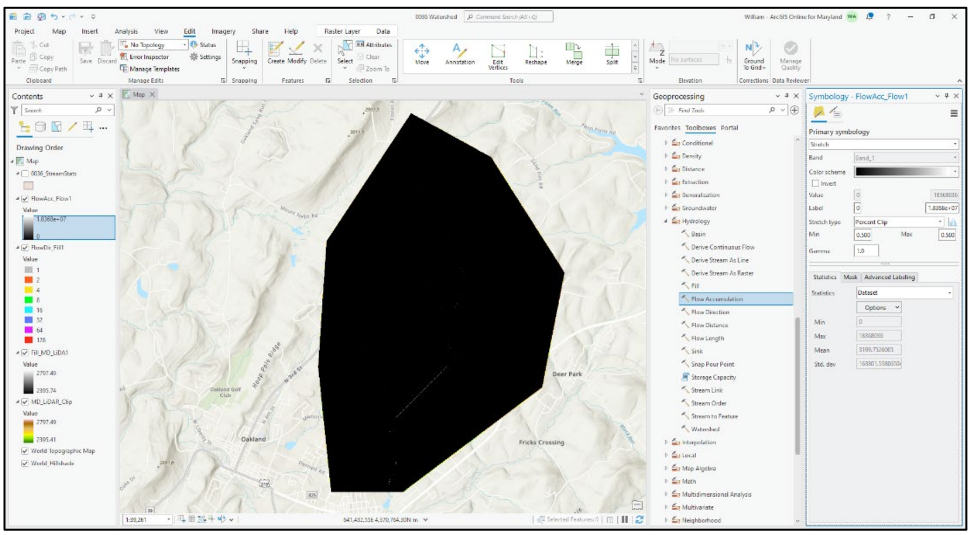
9. **Using the Flow Accumulation Toolbox**

a. Next, select the "**Flow Accumulation**" tool. The **Flow Accumulation** window will appear where the input will be the newly created DEM "**FlowDir_Fill1**". Select it from the dropdown list. The default name of "**FlowAcc_Flow1**" will appear as the output raster. We will use that name. All other values may remain as the default.

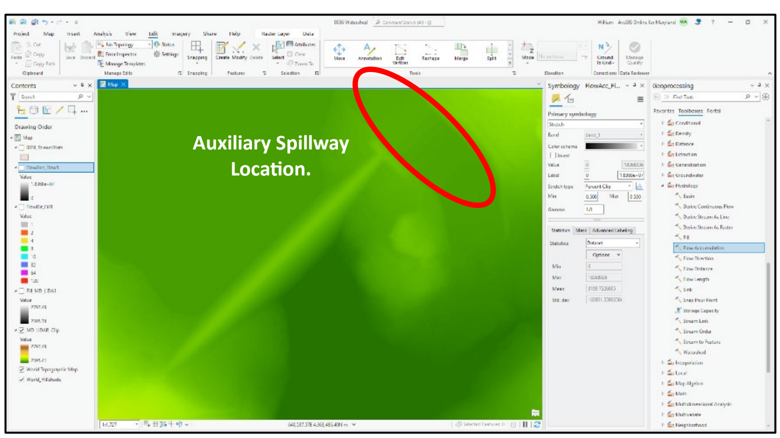
b. Click on the "**Environments**" tab at the top of the **Flow Accumulation** window to select the "Output Coordinate System". Once again, the value in the dropdown list for the "Current Map" is appropriate.



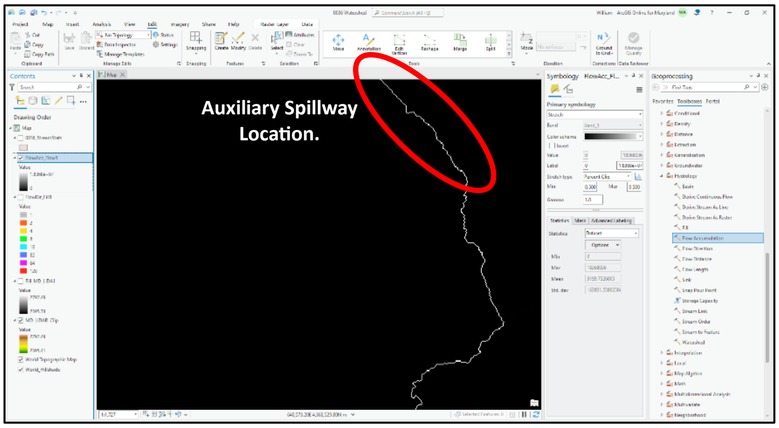
c. Click “Run”. Once the **Flow Accumulation** tool has finished processing, a new raster DEM layer will appear in the Contents window and on the project screen named “**FlowAcc_Flow1**”.
d. Exit out of the “Flow” tool back to the “Hydrology Tool” list.



The color scheme of this raster image may not make sense. The values indicate how many other cells are flowing (accumulating) to that cell. The larger the value, the more cells are flowing to it. The values range from 0 (zero) (black) to the tens of millions (white) in this file. If desired, you can adjust the color scheme to make some sense of the values, but this example will use the current color scheme. Zoom into the area at the dam where we know the most accumulation will occur.

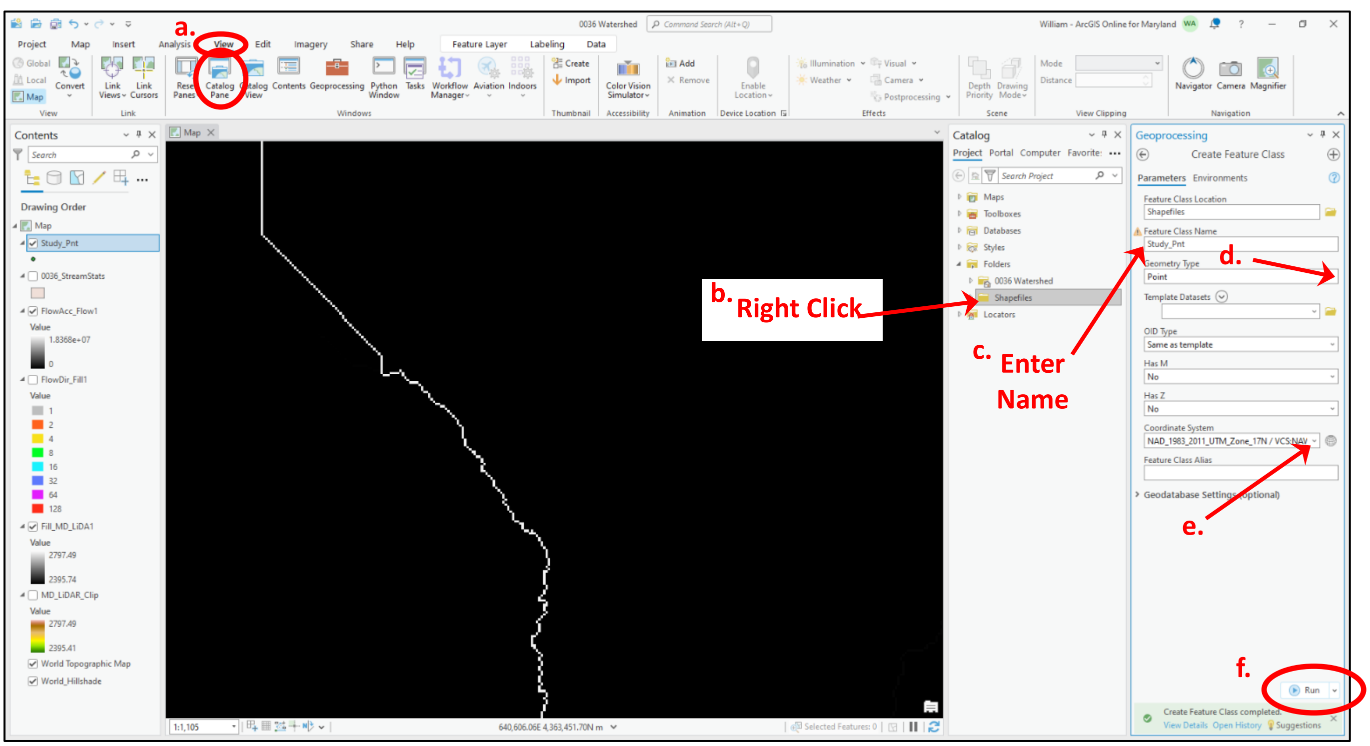


Toggle between the MD_LiDAR_Clip layer and the FlowAcc_Flow1 layer to see where the most flow accumulation occurs.



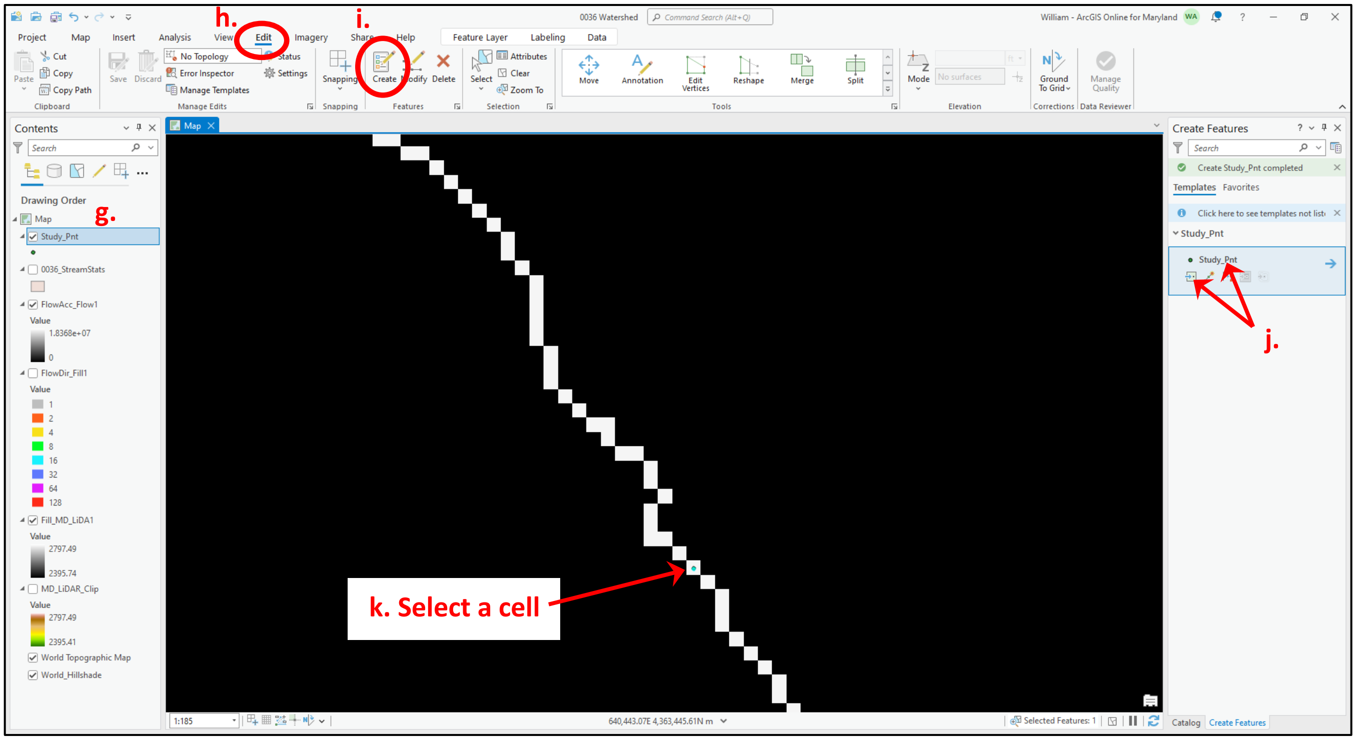
In this case, the most flow accumulation is passing through the auxiliary spillway of the dam. A point needs to be identified that will be used as the outlet point of the watershed. The point used for this example will be in the auxiliary spillway.

10. **Create a Point File for determining the watershed.**
    a. As in Step 5, "Creating a Shapefile" select "**View**", and **Catalog Pane**".
    b. Right click Shapefiles and select "**New**", then "**Shapefile**". The Geoprocessing window will appear.
    c. Enter a name in the "Feature Class Name". For this example, "**Study_Pnt**" will be used.
    d. In the "Geometry Type", select "**Point**" from the drop-down list.
    e. Under the "Environments" tab, set the Coordinate System to "Current Map".
    f. Click Run and a new empty file named "**Study_Pnt**" will appear in the Contents list.

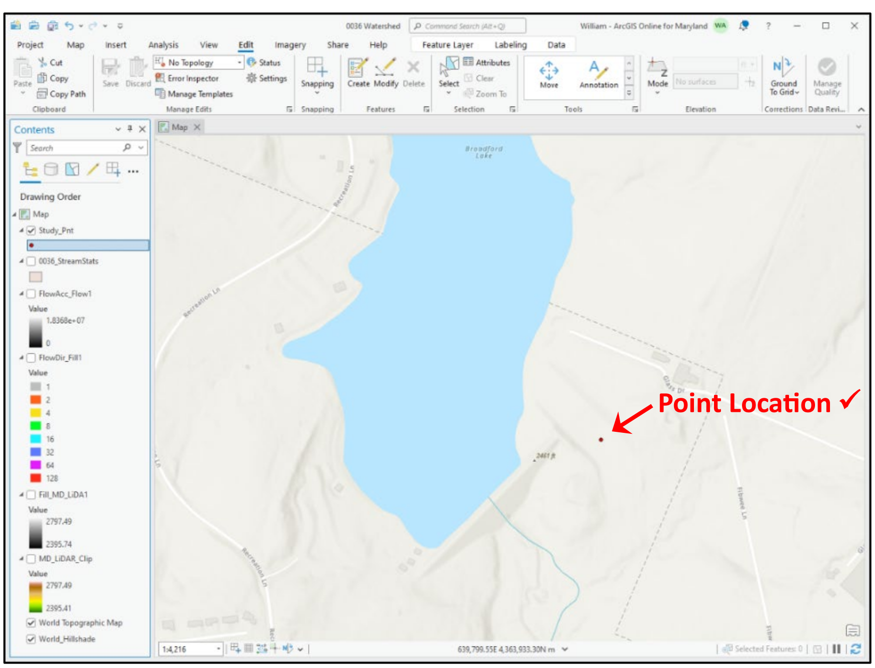


    g. To add a point to the empty "**Study_Pnt**" shapefile, make sure the file is highlighted under Contents.

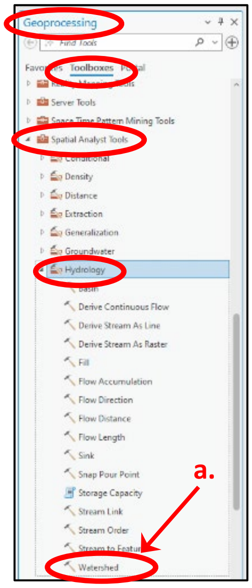
h. Select the **Edit** tool along the top menu bar.
i. Select the "**Create**" button. The Create window appears on the right of the project window.
j. Select the file "**Study_Pnt**", then the "Point" tool.
k. Zoom into the cell you want to select as the point. Make sure it's on a high accumulation cell.
l. Select Finish, then Save. The point has now been included with the shapefiles.



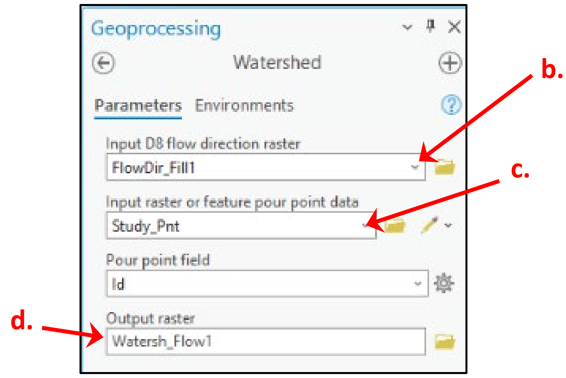
m. The color of the created point may be changed by clicking the symbology. For this example, the color is changed to red. Check that the point is in the proper location by turning off all shapefile layers except the point and see if it is in the desired location.
The location shown on the map is within the auxiliary spillway and will be used for the watershed.



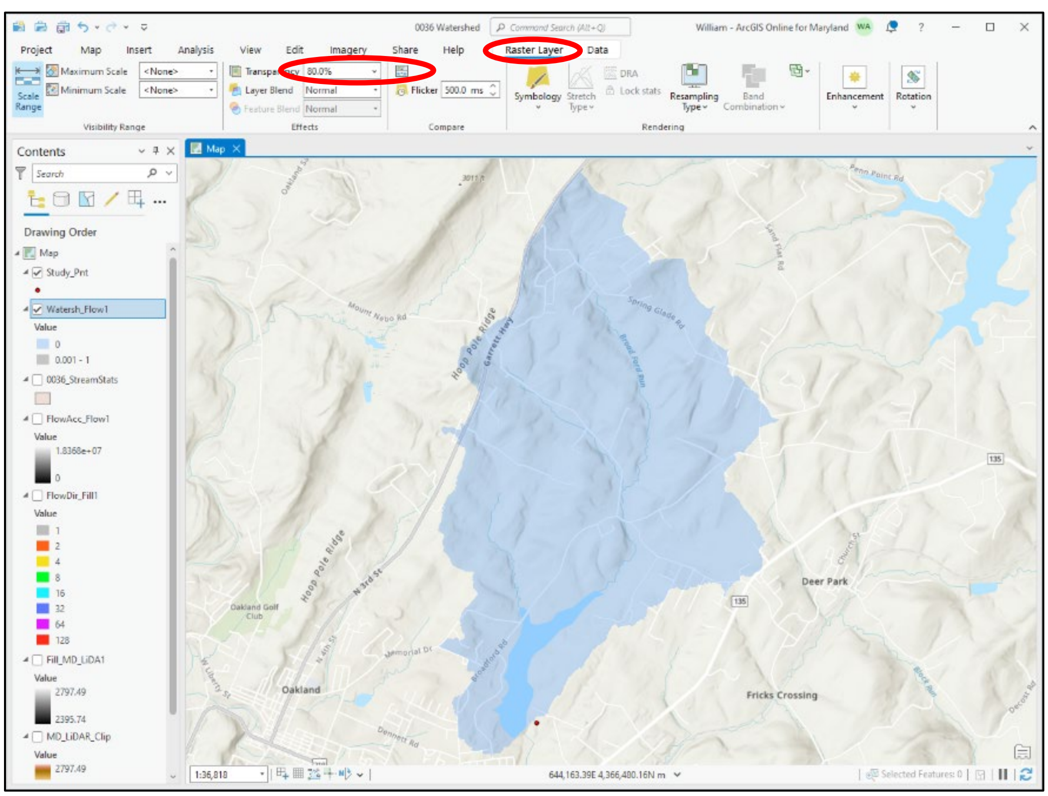
11. **Create the Watershed Raster.**
    a. Follow the same procedures that were discussed in **Steps 7a. through 7d.** to get to and select the "**Watershed**" toolbox.



    b. In the **Watershed** window select the "Input D8 flow direction raster" as "**FlowDir_Fill1**" from the drop down menu.

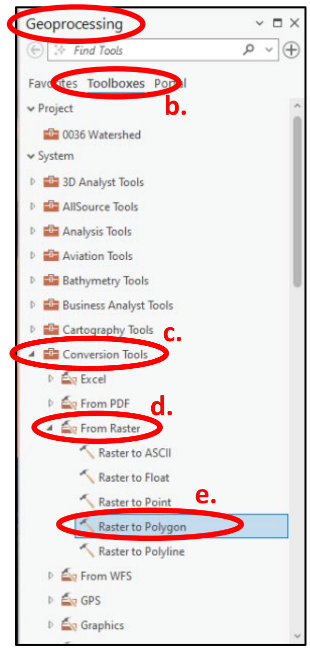


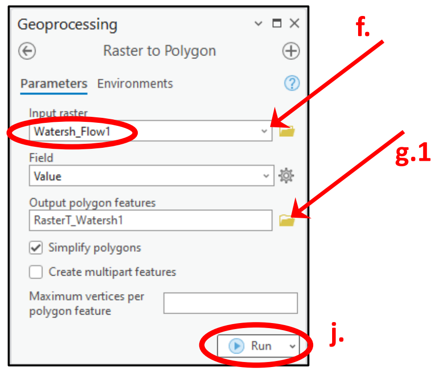
    c. Select the newly created point file "**Study_Pnt**" for "Input raster of feature point data" from the drop-down menu.
    d. The other defaults values may be used including the Output raster name, "**Watersh_Flow1**". If a different name is desired, this is where it can be changed.
    e. Under the "Environments" tab, set the Coordinate System to "Current Map".
    f. Click "**Run**".
    g. Once the Watershed raster file has been created, the symbology may be adjusted. "Raster Layer" on the top toolbar, can be used to adjust the transparency.



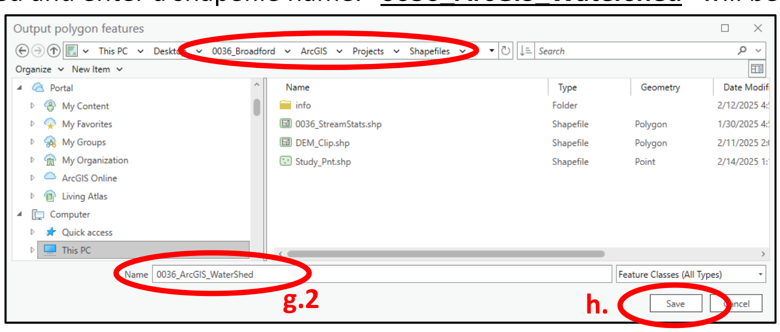
The ArcGIS Pro watershed raster file "**Watersh_Flow1**" is now complete.

12. **Create the Watershed Shapefile.**
To convert the watershed raster to a shapefile, follow the procedures found in the "**<u>Conversion Tools</u>**" Toolbox.
    a. On the top toolbar, select "**<u>Analysis</u>**"
    b. Select "**<u>Tools</u>**" and the "**<u>Geoprocessing</u>**" window will appear on the right of the project window. Once again, select "**<u>Toolboxes</u>**".
    c. Under the "**<u>Toolboxes</u>**" tab, scroll down and **<u>select</u>** the "**<u>Conversion Tools</u>**".
    d. Under the "**<u>Conversion Tools</u>**" select the "**<u>From Raster</u>**" toolbox.
    e. Select the "**<u>Raster to Polygon</u>**" tool.





    f. Select the newly created "Input raster" file "**<u>Watersh_Flow1</u>**".
    g. For the "Output polygon feature" name, navigate to the folder location where the shapefile is to be stored and enter a shapefile name. "**<u>0036_ArcGIS_Watershed</u>**" will be used for this example.



    h. Select "**<u>Save</u>**" when complete.
    i. Under the "Environments" tab, set the Coordinate System to "Current Map"
    j. Select "**Run**" and the final watershed shape file will be created and available for use with the Maryland PMP Evaluation Tool.