LABORATORY TWO

Masking and Spectral Thresholds

University of Mississippi – Department of Geology and Geological Engineering

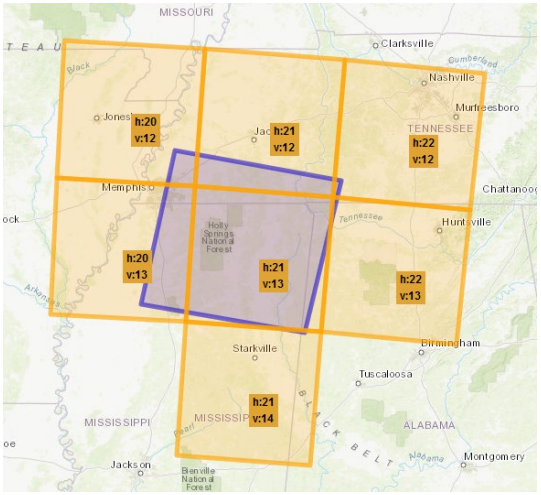
Purpose-

This exercise will attempt to accomplish the following goals:

- Spectral threshold
- Classification (water mask)
- Use of vectors for image clipping

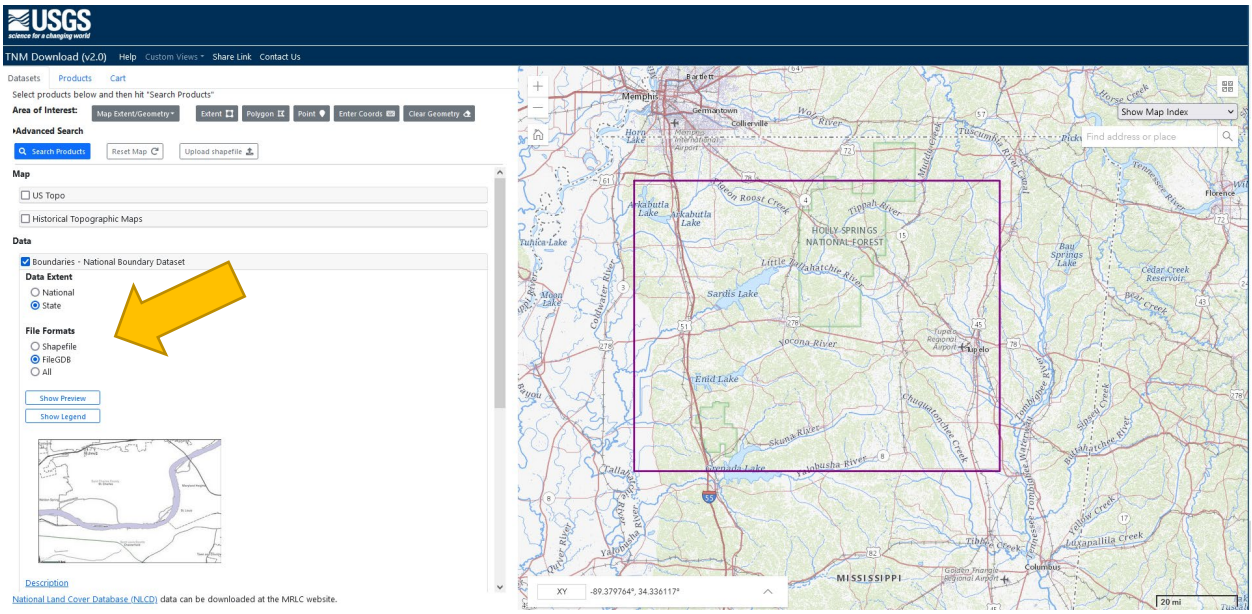
Laboratory introduction-

In this exercise, you will begin by importing a vendor provided data file with projection information. You will use a polygon vector file to clip the imagery and classify using a simple threshold. You will then create a rudimentary analysis of the extent of water bodies in each area. There are many methods of image classification from simple thresholding to more complex segmenatation with the assistance of machine learning (ML). This laboratory you will skip the "wizards" tools and dig into the spectral data or called feature space, of what the color coordinates are for each of the pixels in the image.

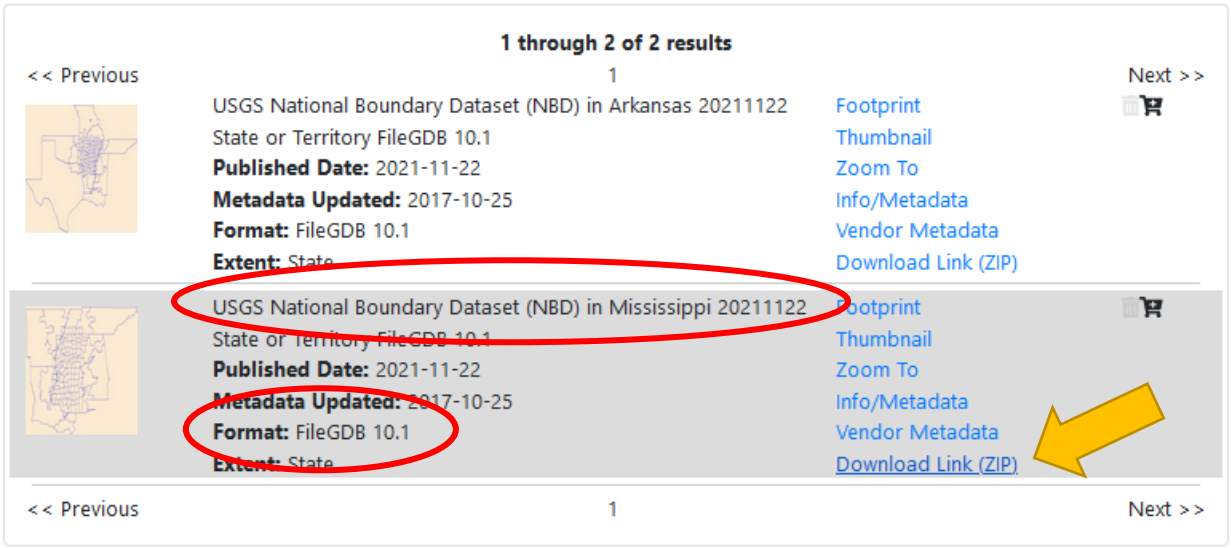


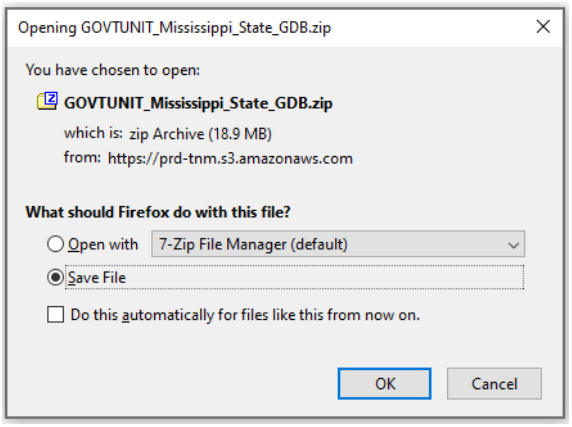
Feel free to coordinate with other course participants to select different dates and seasons. For this laboratory you are required to use Landsat 8 Collect 2 Level 1 data. These data are presented in the WRS path/row reference system. There is also the If you are using Landsat ARD tiles, visit the Landsat ARD tile conversion tool to determine which ARD tiles cover your area of interest or which WRS path and row the ARD horizontal (h) and vertical (v) tile index it covers. In addition to imagery, locate a vector file that contains a polygon vector of Lafayette County, Mississippi. Suggest you use a national boundary dataset (NBD). Best URL is: https://nationalmap.gov/

Exercise 1 (Locate vector and raster data sets)



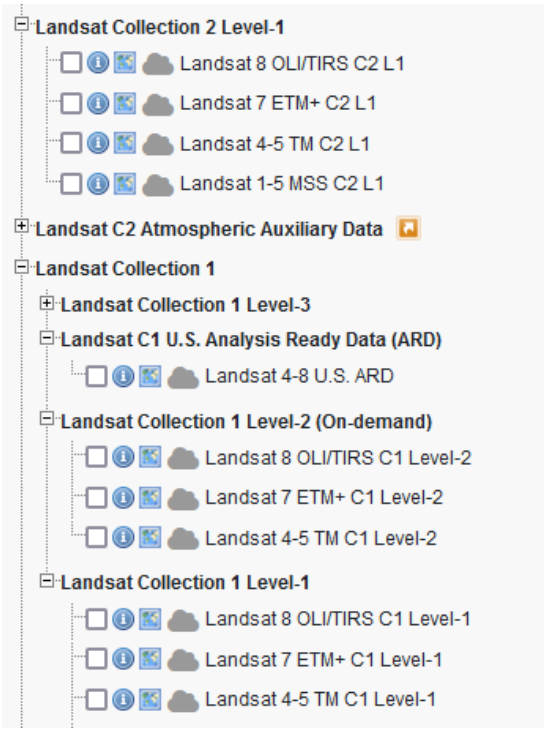
Select the USGS National Boundary Dataset (NBD) in Mississippi

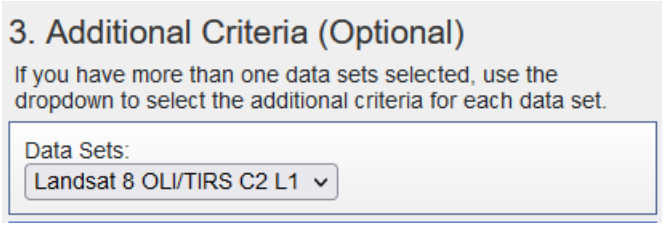


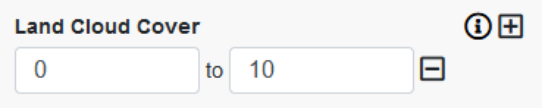


You will use this data to clip the imagery. A good practice is to create your own database

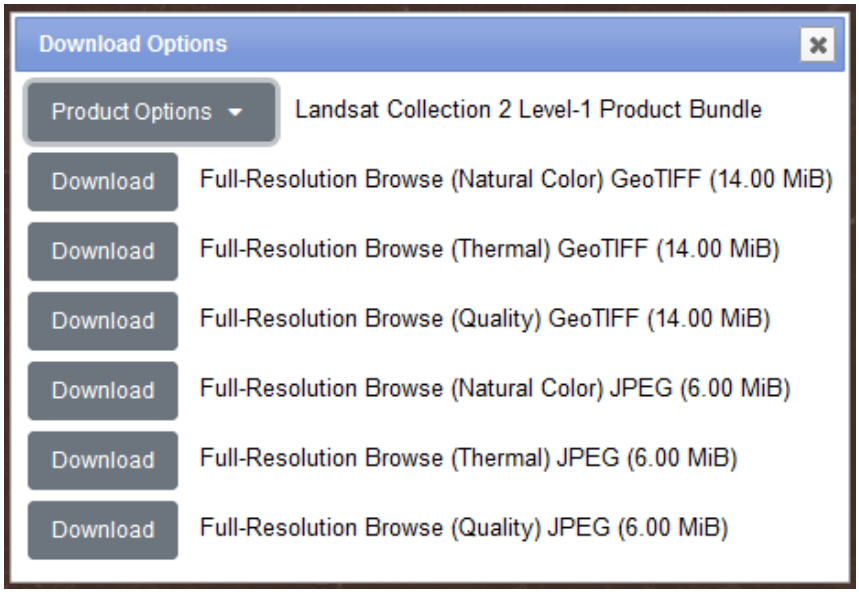
For the raster, select the Landsat 8 OLI Collection 2 Level 1 product. The DN values in C2L1 are in the units of scaled radiance and can be converted to Top of Atmosphere (TOA) reflectance or radiance using the radiometric scaling factors provided in each scene metadata file



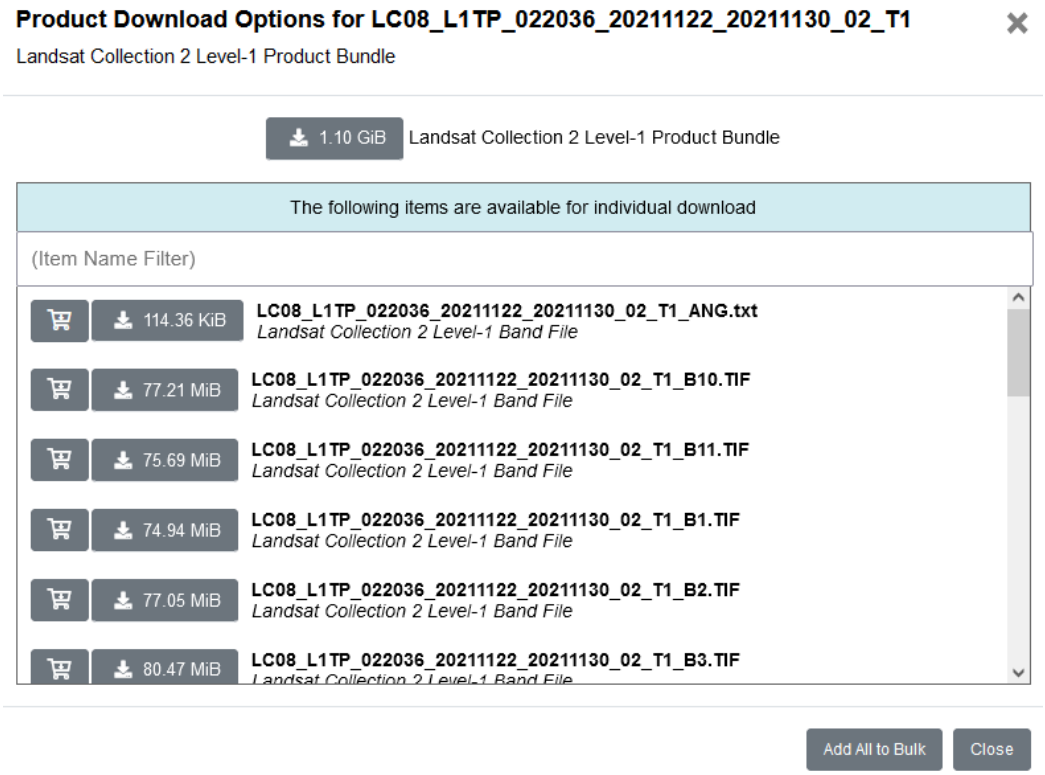




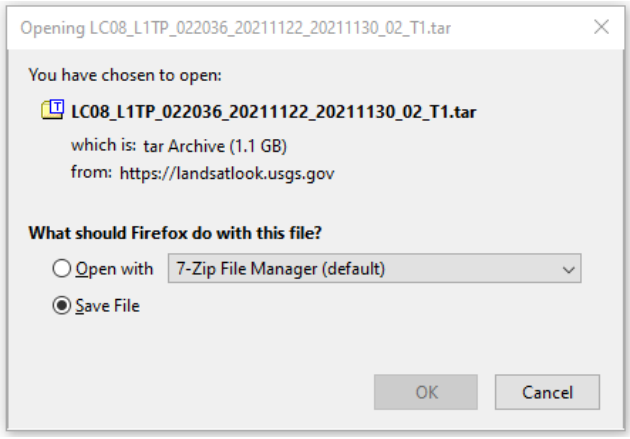
From the results, select an appropriate image. In the following example, we select a 22 Nov 2021 image of Path/Row (22/36).



Select the product options

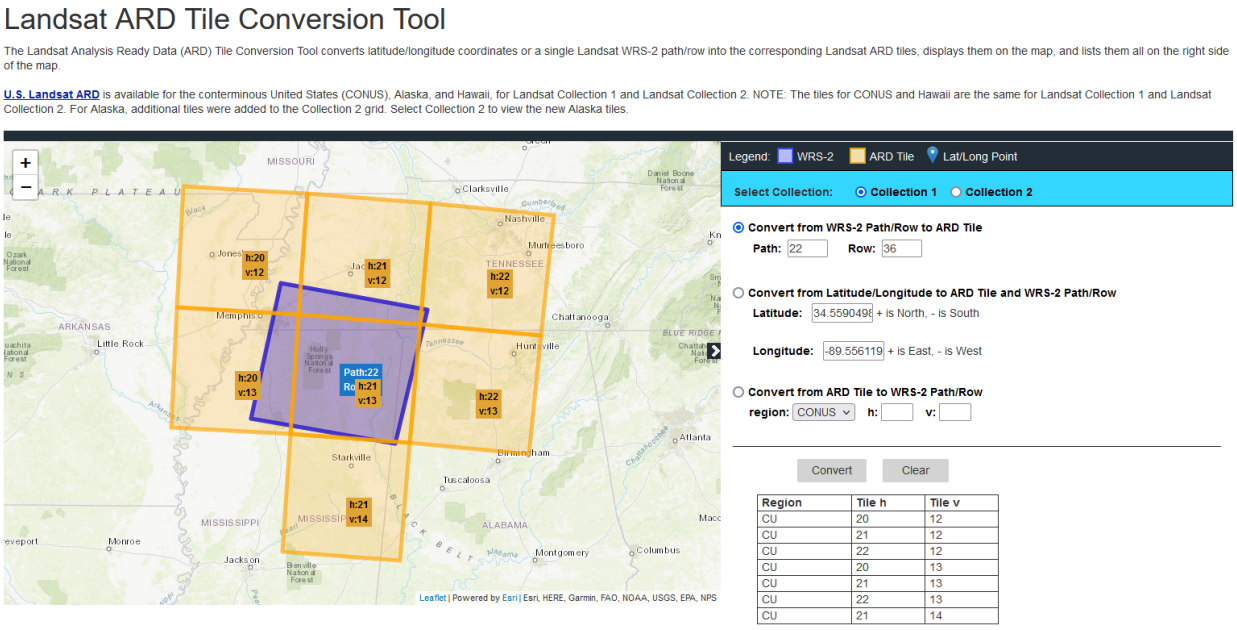


It is best practice to download the Collect 2 Level-1 product bundle. It is large and includes ALL the bands and metadata for the acquired Landsat scene. You can be more selective and only download the bands you need for your analysis. If you do not want the panchromatic band, you can save more 300 MB and only download everything else.

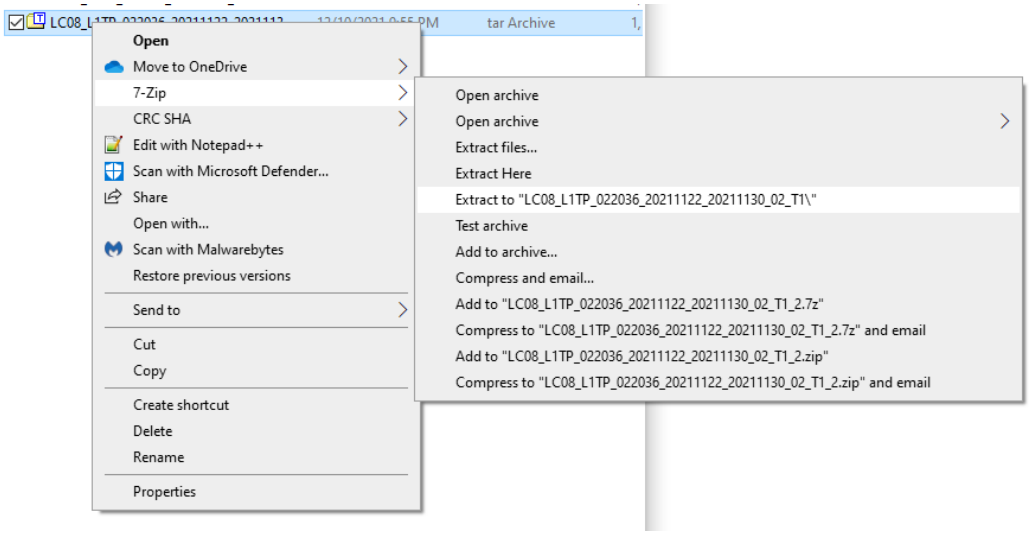


Once again, this is a tar compressed file so be sure to use a compression utility to properly decompress these types of files. Note in the above image, the 7-Zip file manager recognizes this to be a tar file. Save the file in a temporary location before you decompress it.

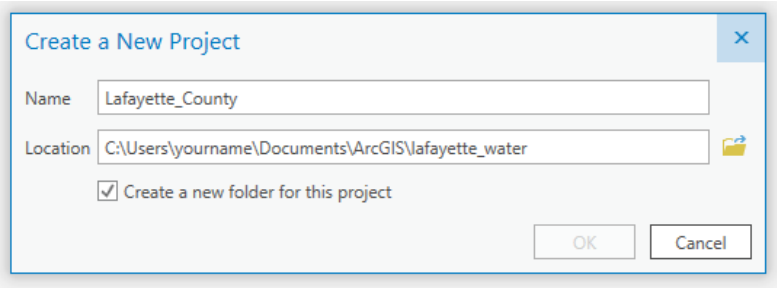
If you are using Landsat ARD tiles, visit the [Landsat ARD tile conversion tool] to determine which ARD tiles cover your area of interest or which WRS path and row the ARD horizontal (h) and vertical (v) tile index it covers.



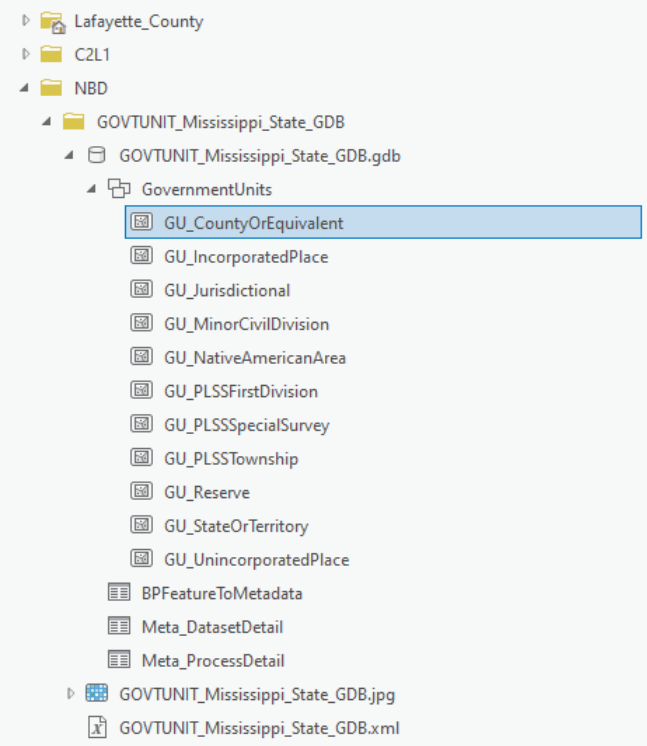
Extract your Landsat 8 data by selecting the tar file then right-mouse button to bring up the context menu. Next select the 7-Zip or similar compression tool and decompress the file.



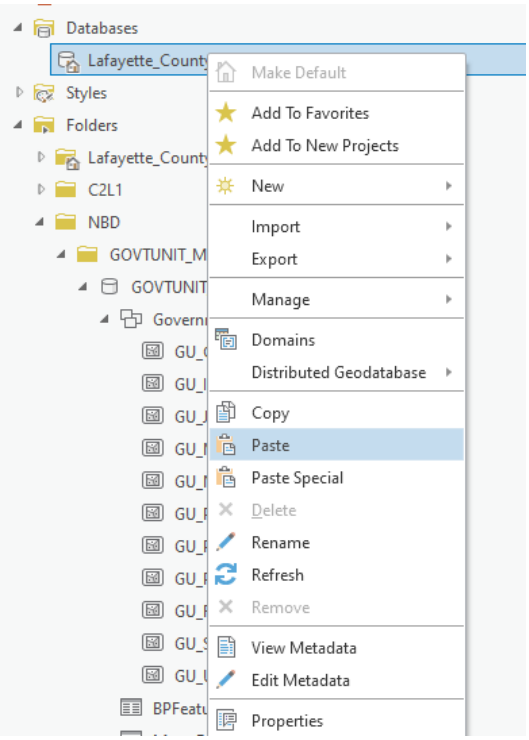
Do the same for the boundary file you downloaded from the National Map.

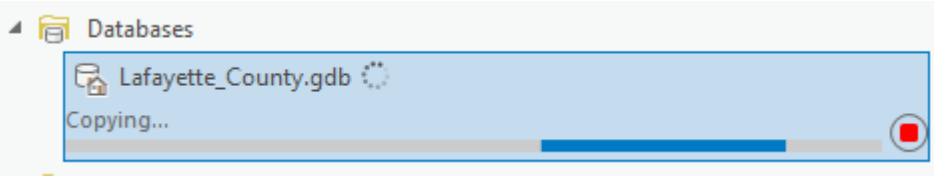


After the project is created, connect the imagery directory and where you save the vector data or the National Boundary Database (NBD).

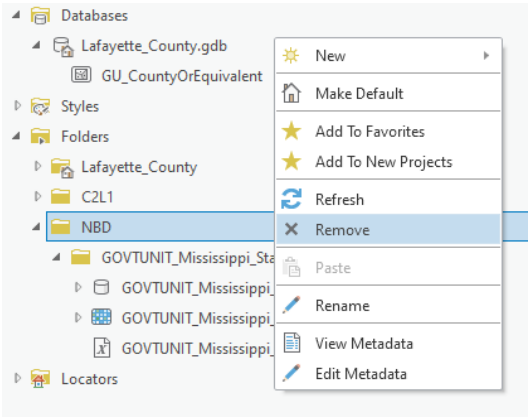


You can copy the GU_CountyOrEquivalent feature class from the GOVUNIT_Mississippi_State_GDB database you download





Once copied you can remove the connected folder and clean up our project Catalog tree.



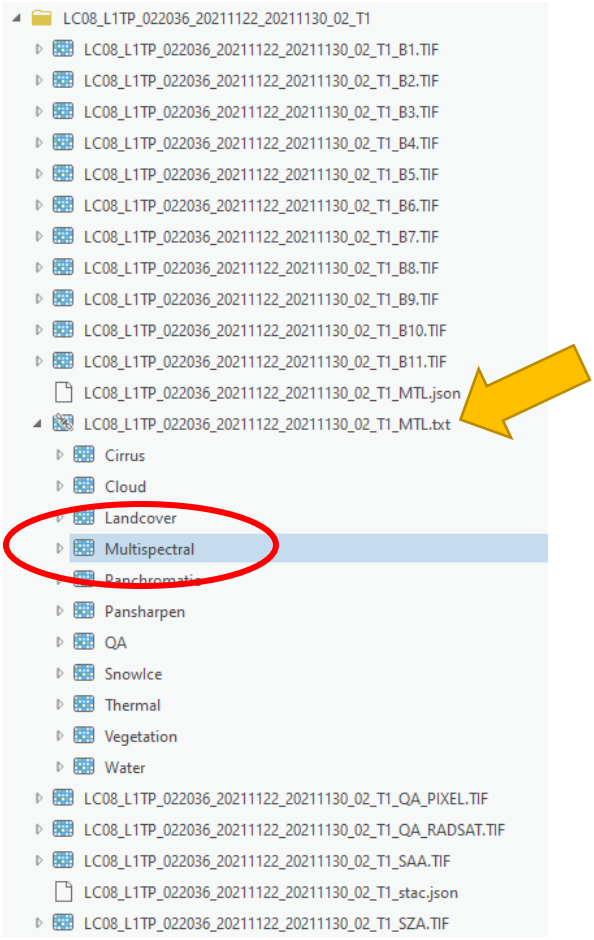
Exercise 2 (Create a water mask using a threshold classification)

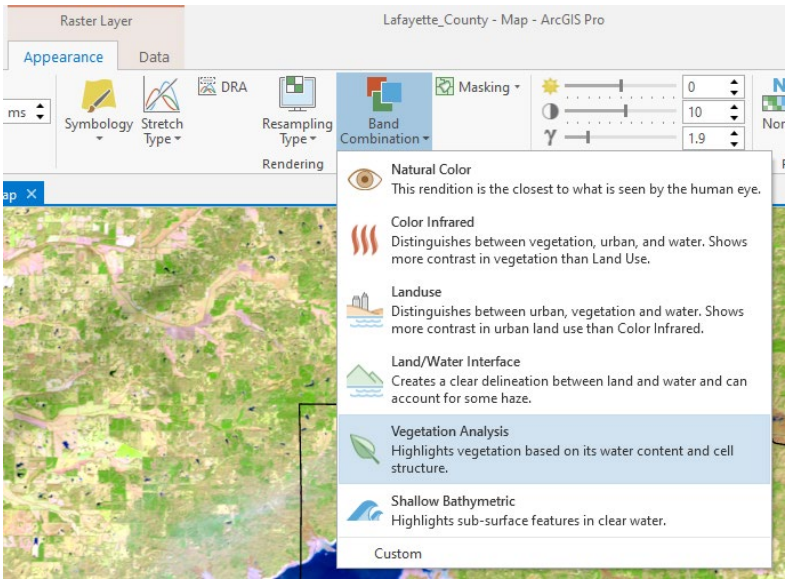
You can run Exercise 2 or 3 next but you must complete BOTH. You can subset the Landsat 8 scene OR you can first perform threshold analysis to create the water mask. There are many ways to create a subset. The quickest method is to use the Image Analysis Tool and follow Chapter 15 of the textbook. Subset using a polygon representing Lafayette County Mississippi.

To create a water mask, you will make a simple band threshold using the near-infrared spectral band of Landsat 8. This is a less complex method than others masked and only required the NIR band.

Open the Raster Calculator. Be sure to activate the Spatial Analysis Extension from the Customize menu. Access the ArcTOOLBOX and use the Raster Calculator.

In the Catalog View, extend the MTL.txt file and drag the Multispectral band combination to the Map View of your Project. When asked, calculate the statistics of the files. This may take a while.

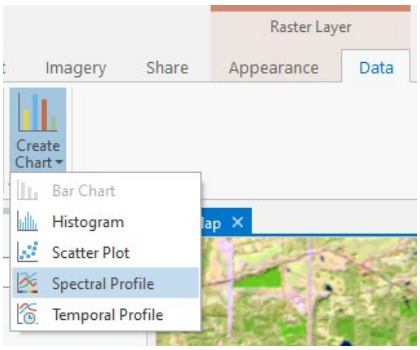




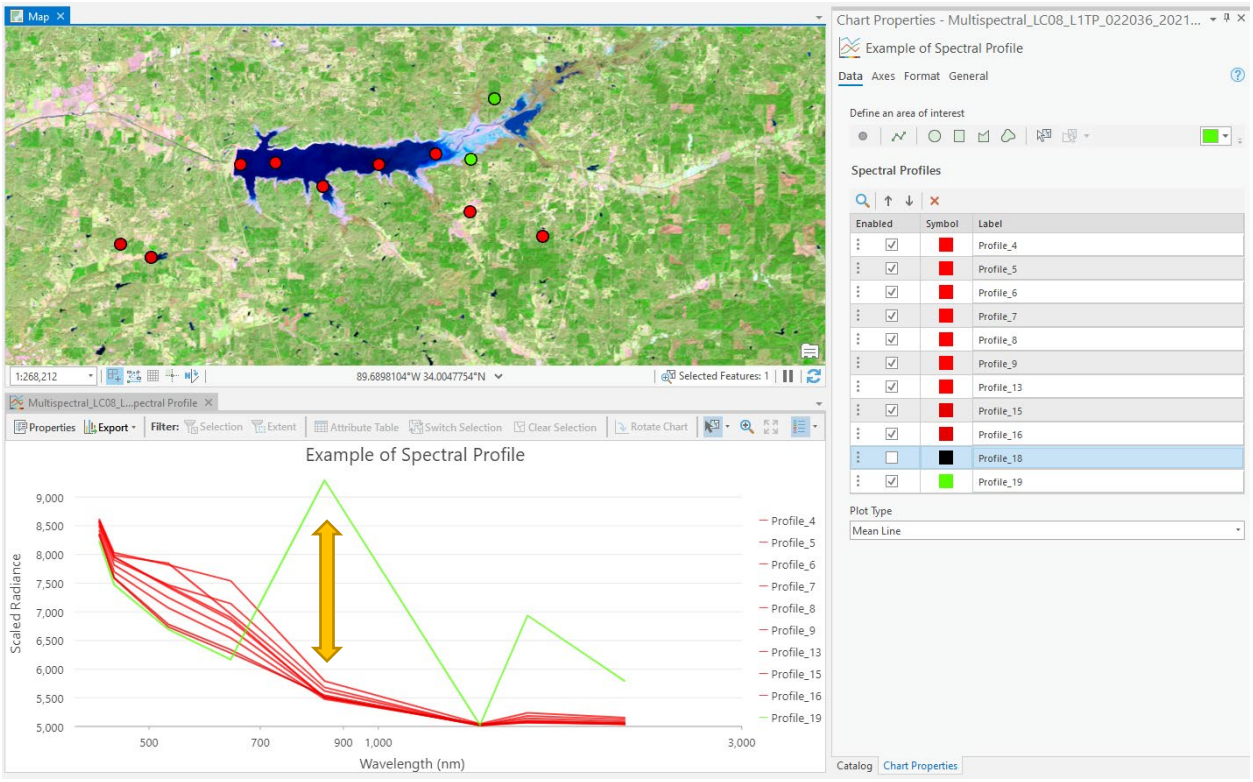
Select the multispectral imagery and in the top menu ribbon select the Raster Layer>Appearance tab. Next select the Band Combination drop down and chose the Vegetation Analysis symbology. This is a preset for red-green-blue (RGB) display to be using the data from spectral band representing shortwave-infrared (SWIR), near infrared, and red, respectively. For Landsat 8 OLI sensor, this is band 6, 5, and 4, respectively.

	Bands	Wavelength (micrometers)	Resolution (meters)
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) **Launched February 11, 2013**	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

Select the multispectral imagery and in the top menu ribbon select the Raster Layer>Data tab. Next select the Spectral Profile tool in the Create Chart drop down.



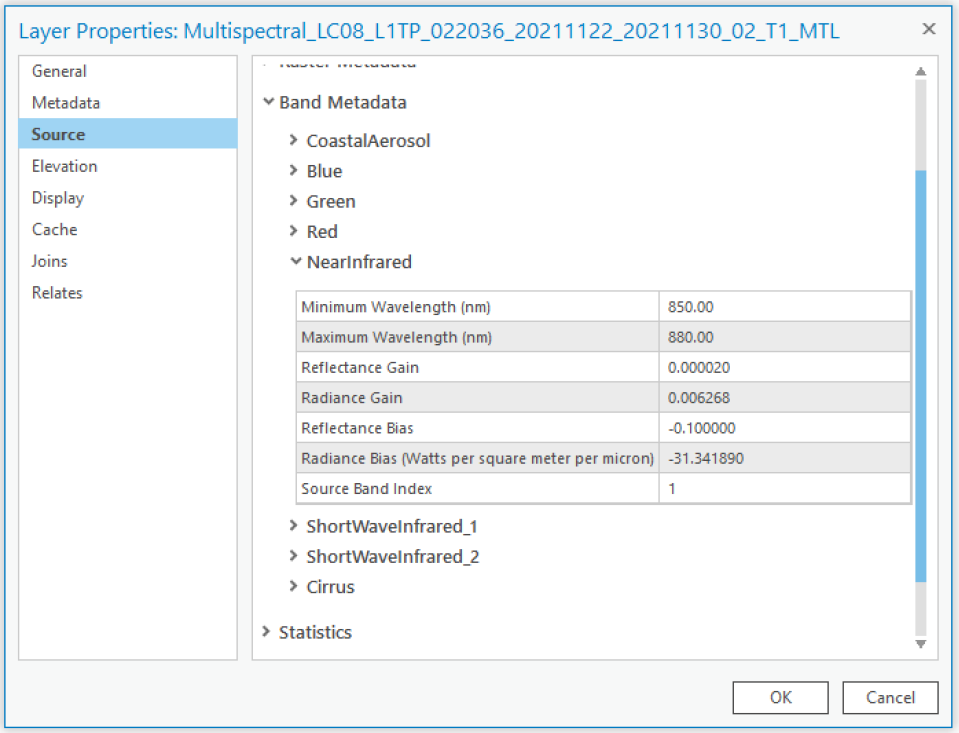
Zoom into an area of the imagery containing water. Select the point to define an area of interest and begin identifying locations that depict water. Select locations in large lakes and small. Next change the area of interest color to green and select a field or somewhere with significant vegetation.



Note the dramatic difference in DN values between the vegetation and water pixels at approximately 850 nm.

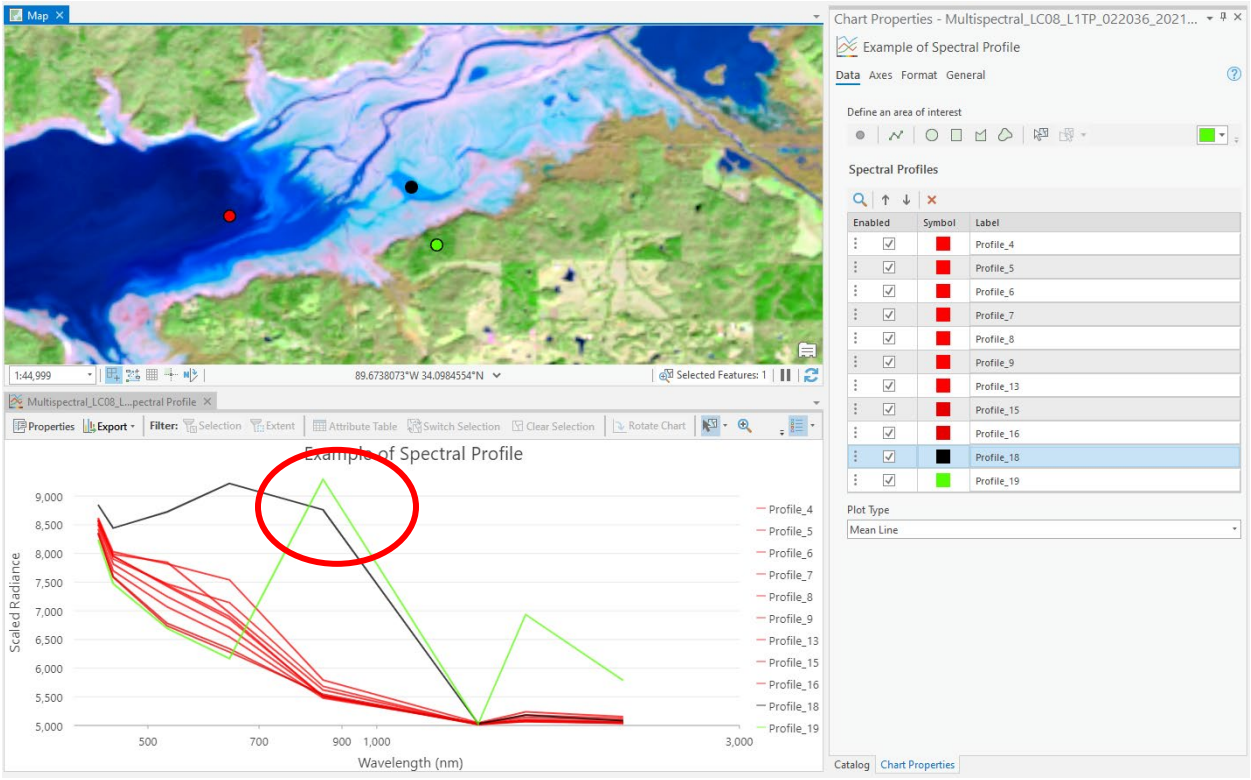
Select the imagery layer and right-mouse button to access the context window. From there select Properties and then select Source. Scroll to the Band Metadata to look at each of the eight (8) reflective

bands on the Landsat 8 OLI sensor. Click the NearInfrared (NIR) band to see that its wavelength in approximately 850 nm. This is the same band you saw in the spectral profile with the large difference between the water and vegetation signatures.



This difference makes sense as the NIR wavelength of light is absorbed by water (i.e. not reflected) and is highly reflected from vegetation due primarily from chlorophyll-alpha. You can use this different to create threshold mask for water.

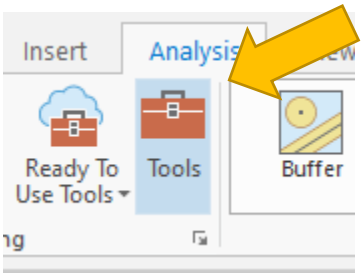
This method is not without uncertainty. Take for example shallow water bodies where the bottom sediment has a spectral return that is different from deeper water. Smaller ponds that have vegetation flowing in it; turbid water; swamps with mixed vegetation and water signatures; or edges of water bodies with overhanging trees all create uncertainty when using the threshold method.

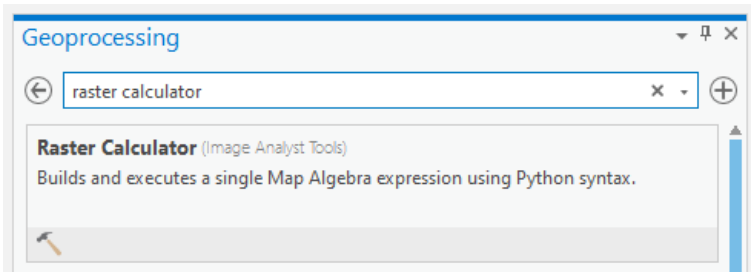


In the above screenshot, look at the spectral curves from the red, green, and black. The black location is shallow water and will be difficult to threshold using the shallower water pixel as a guide.

Zooming into the spectral profile you can see the average value of water for the 850 nm band is approximately between 5,400 and 5,800 units. This helps identify the threshold to use for the water mask. If we select only the pixels that have this range of values, most should represent water.

You are now ready to create a threshold raster from the Landsat imagery. Select the imagery in the Table of Contents then the Analysis tab. Select the Raster Functions dropdown and then Raster Functions.





Using the Conditional Statement (CON) in the Raster Calculator function of ArcGIS Pro, create a function that will create a new raster whose pixel values are a water mask. The most common nomenclature is value 1 = water; 0 = non-water. Example:

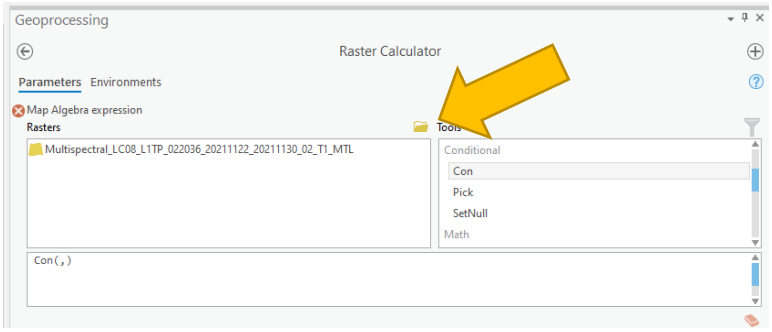
Con("*name_of_file_containing_NIR_data*" < *selected_thershold_value*, 1, 0)

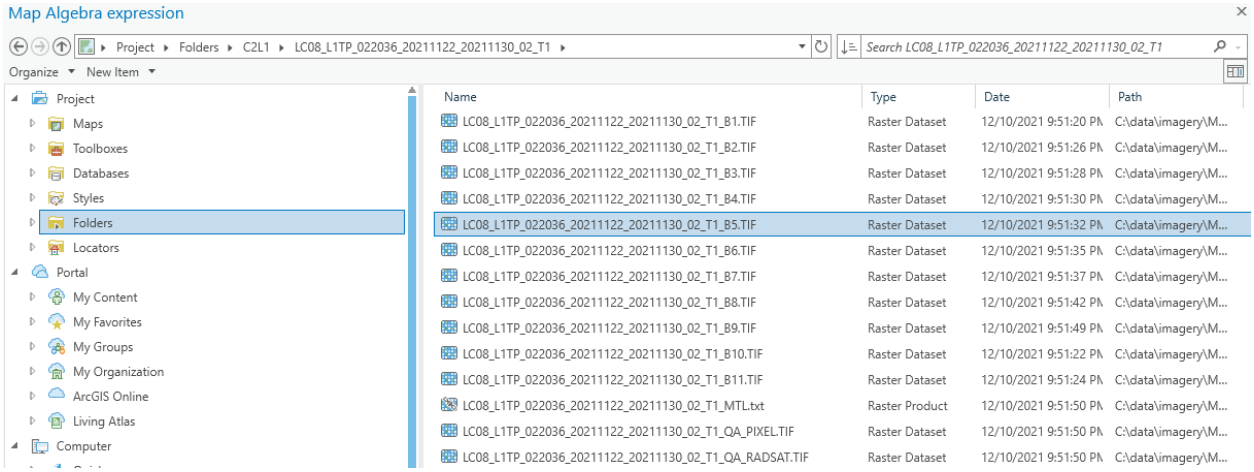
Since the imagery you are using contains integer values, the *selected_thershold_value* will be an integer. The general syntax of the conditional statement is as follows:

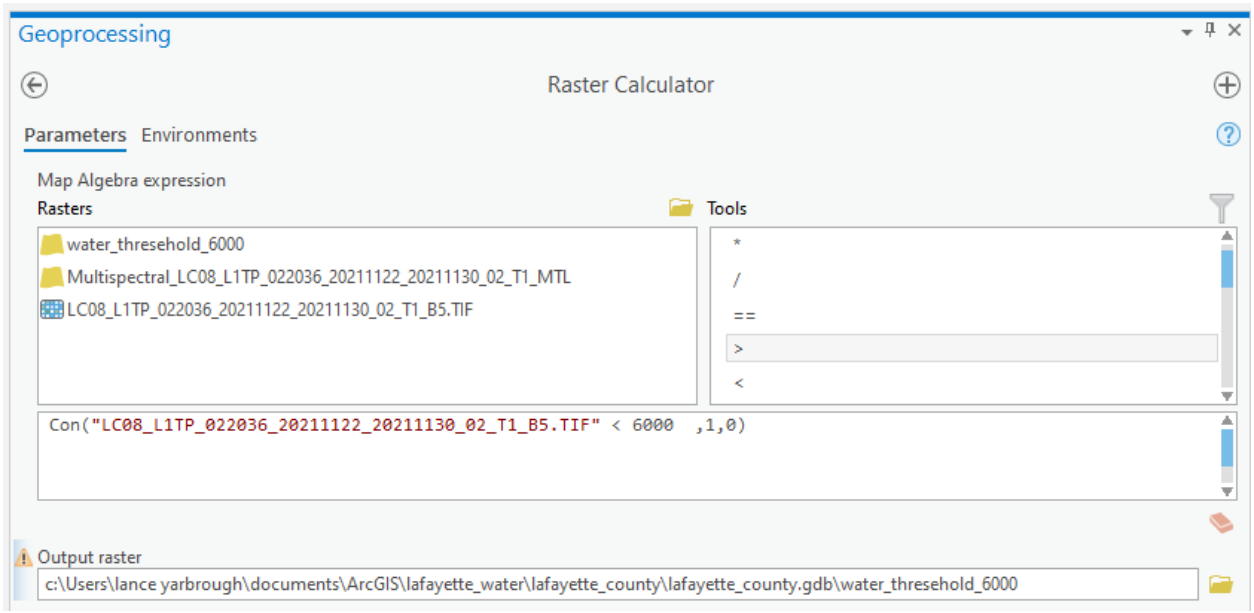
CON(Boolean function, if true, if false)

If no value or expression is given for the "***false***" expression then a "***NoData***" is assignment, which might be more helpful to your analysis and workflow.

Because you have loaded a MTL.txt file in the viewer, the raster calculator does not display the separate bands. You will need to load the Landsat OLI band 5 (NIR) separately.







For this example and the scene chosen, a NIR value of 6,000 appears to be the threshold of water reflection of the pixels.

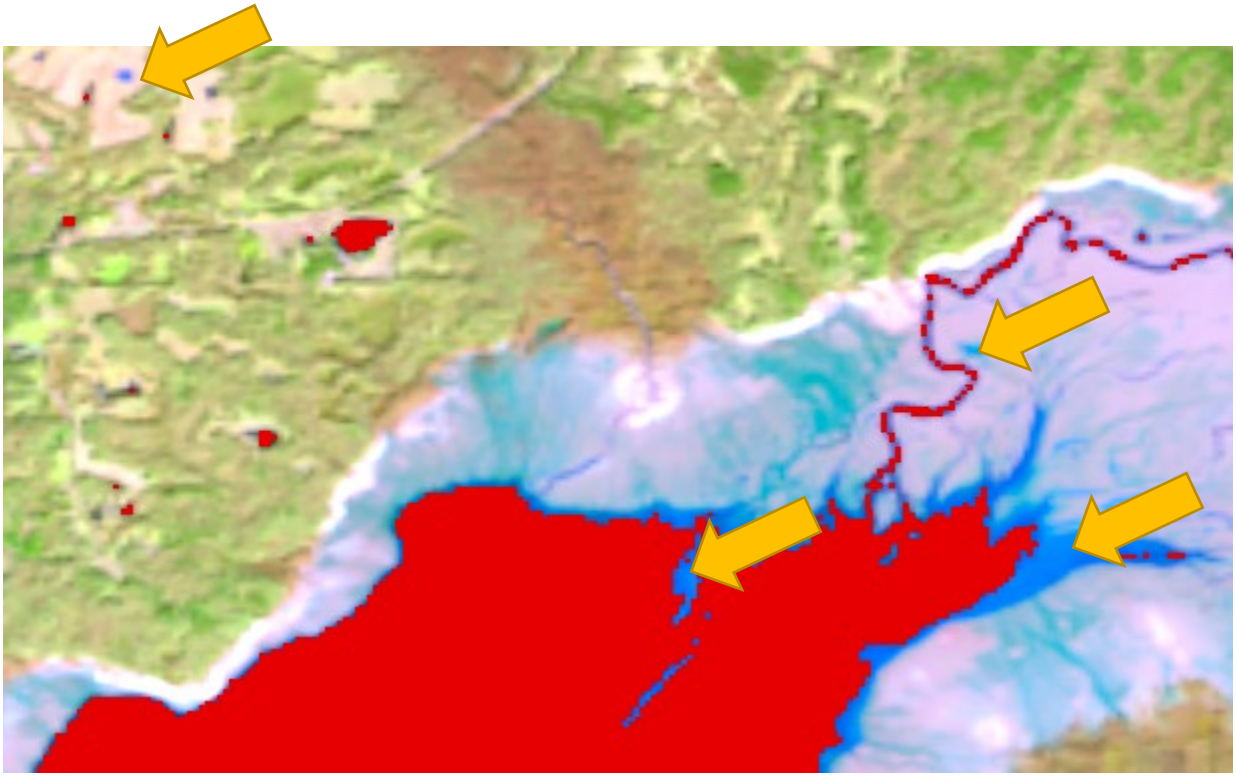
You will need to explore the data to determine the appropriate threshold value for the water mask. Run the function using several different values and same the results as individual rasters. Be sure to employ a useful naming convention as there may be many due to trial and error. For this example, the file name has “6000” to indicate we have used that value as the threshold. Select the threshold image mask and in the tool ribbon, select Raster Layer>Appearance and select “flicker” to compare the masks to the imagery.

Some questions you should think about as you review your results:

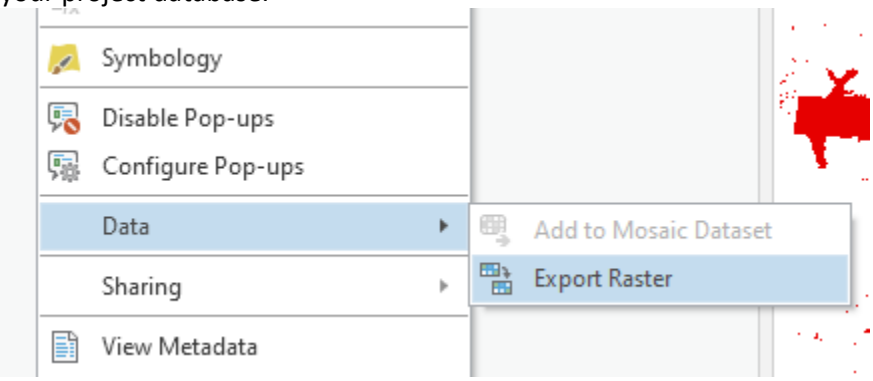
- Note how each mask covers the water in the scene. Are areas not water covered by a mask?
- How much error are you willing to tolerate?

In the example, several water bodies were not included in the first interaction. Parts are Sardis Lake require a greater threshold than 6000 to capture the water. This is likely due to turbidity. Using the Spectral Profile tool, add additional locations in the areas of water that were NOT included in the mask for the first iteration. It appears maybe a value of 7000 will include more water pixels. Rerun the Raster Calculator Conditional statement using a new threshold value.

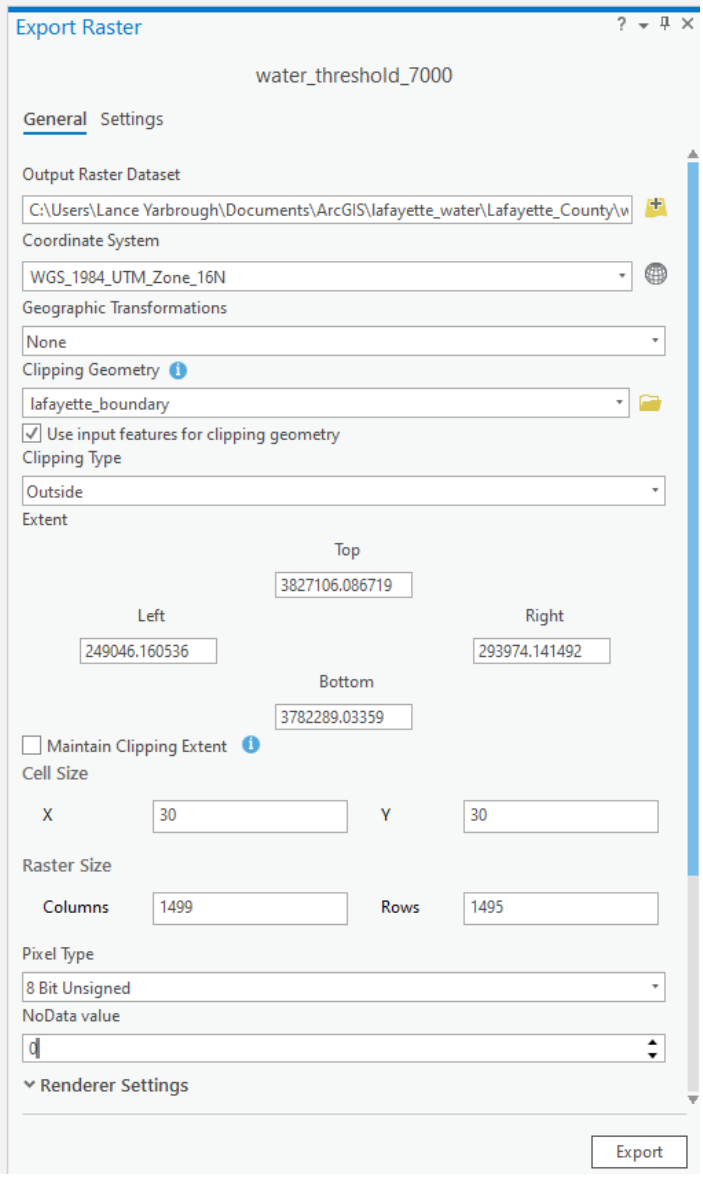
Note there are many obvious water pixels there were not included in the mask. Again, how much error are you willing to tolerate? How much time are you will devote to finding the optimum threshold value? What is your measure of “optimum” when you know you have reached it? Does this method work for all images? Does this method work for only certain types of the water bodies? Does this method work for only certain parts of water bodies?



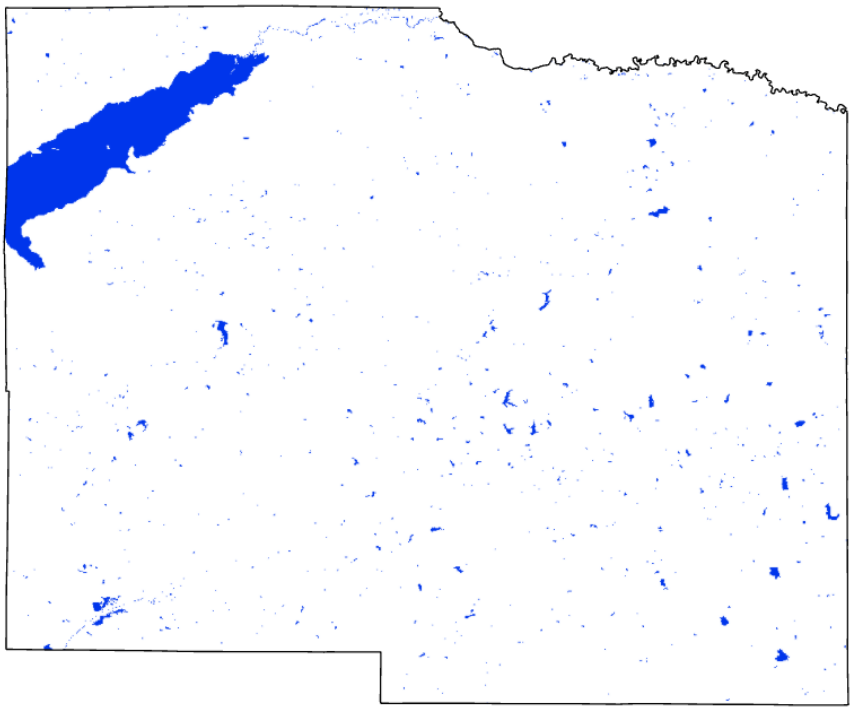
Now that you have a water mask for the entire Landsat scene, it is time to create a permanent raster in your project database.



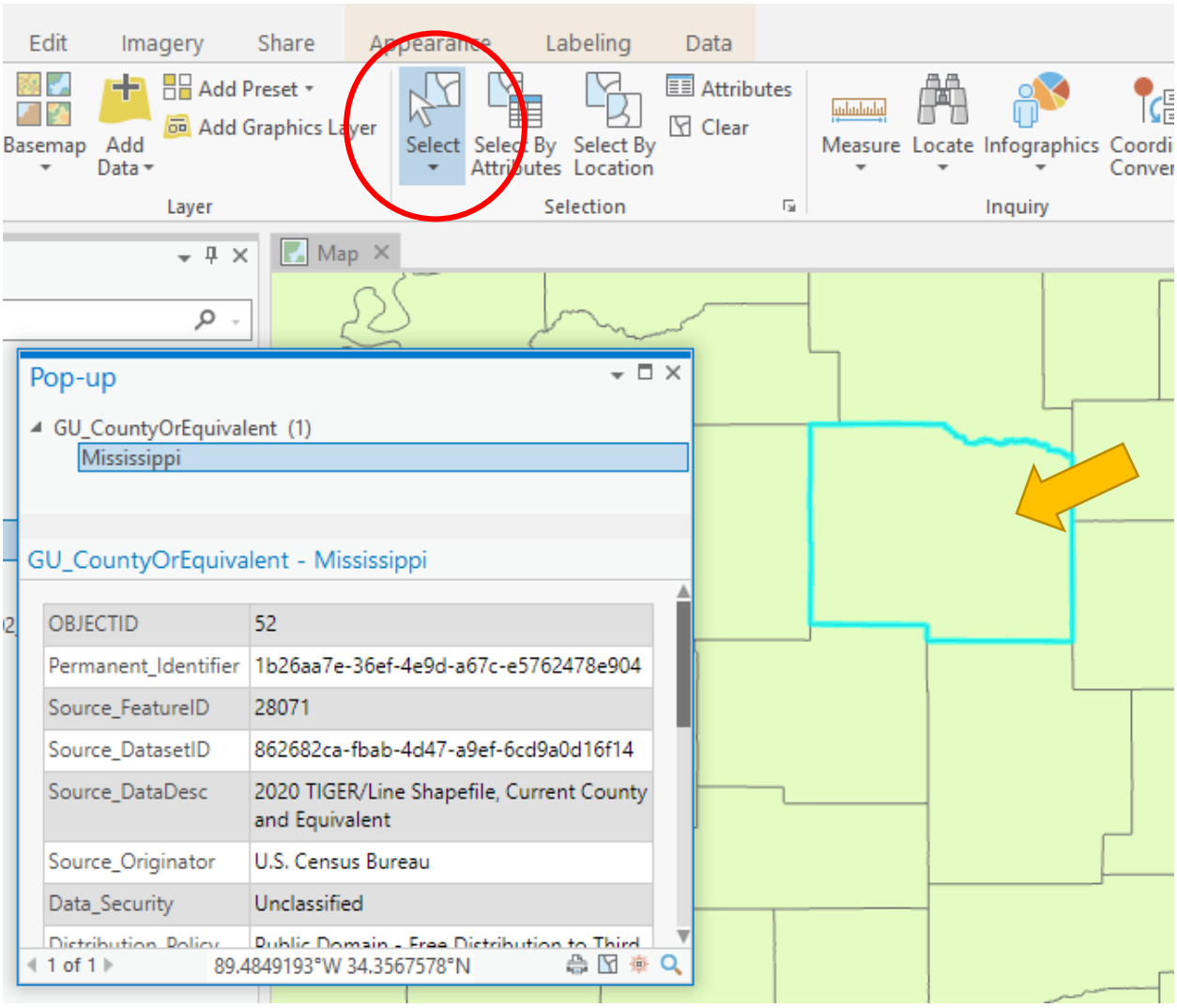
Bring up of the Context window of the water mask and Export the raster.



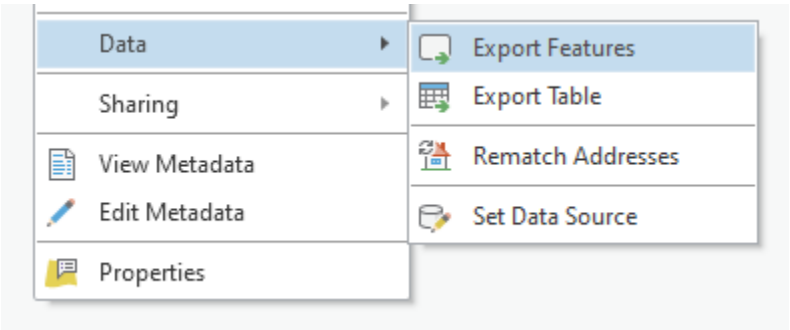
Be sure to use the Clipping Geometry of the county boundary and select the Use input feature for clipping geometry option.

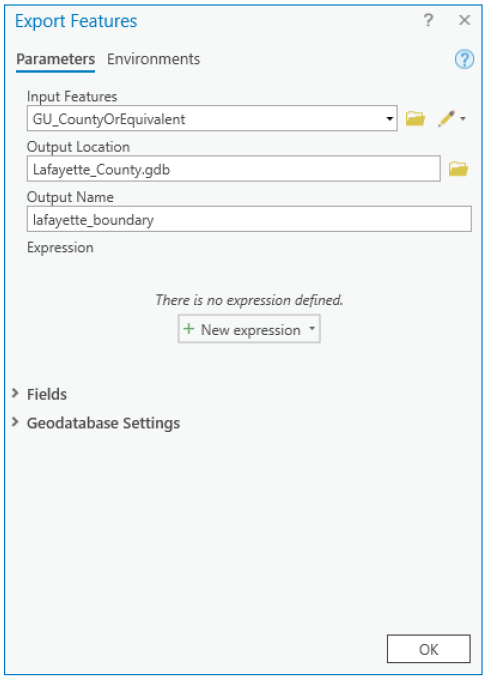


In the feature class, GU_CountyOrEquivalent, select the polygon that represents Lafayette County.

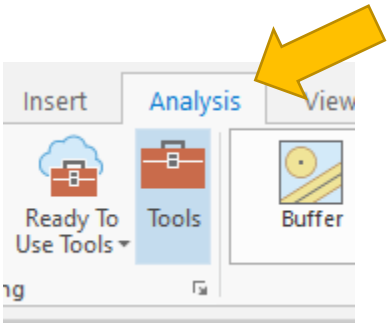


Next select the Multispectral image in the Table of Contents. In the Raster Layer ribbon, select Clip.

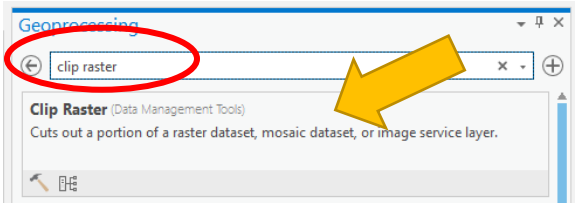




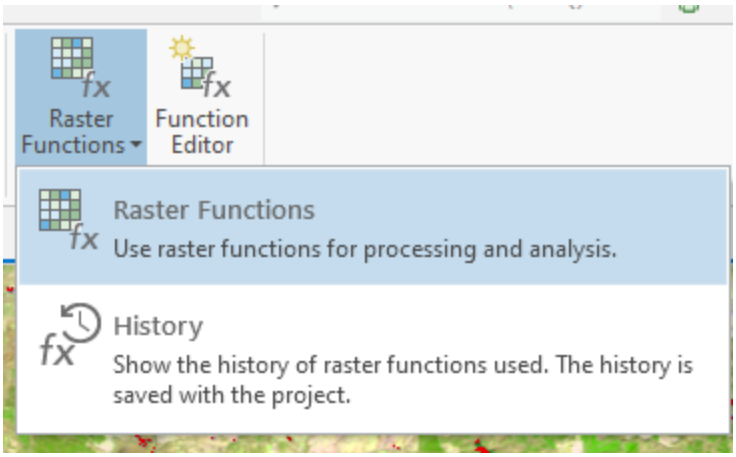
Save the selected polygon in the Lafayette_County.gdb geodatabase. Now to crop the imagery, select the imagery in the Table of Contents then the Analysis tab. Select the Tools Toolbox.

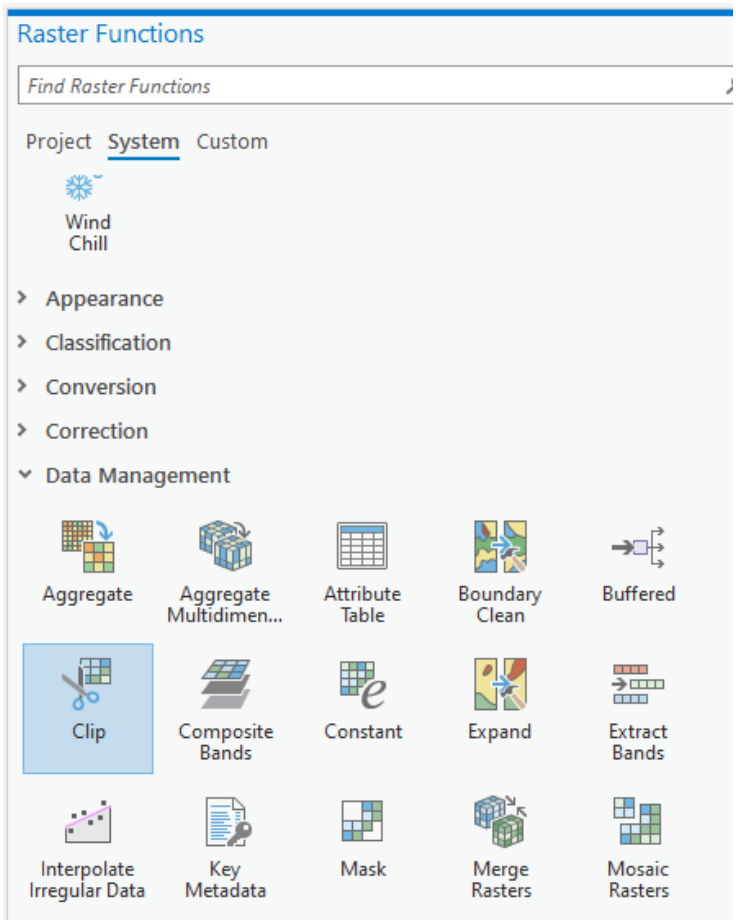


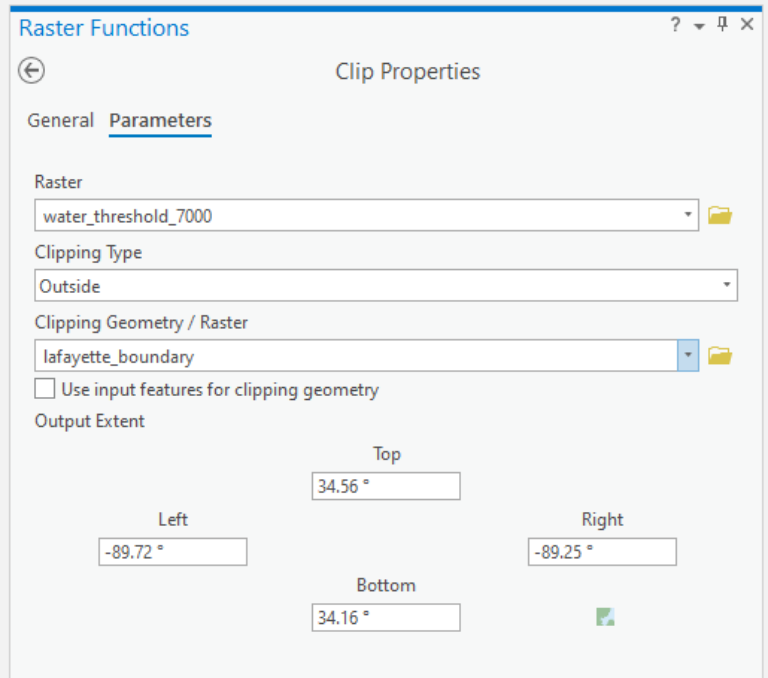
In the Geoprocessing search tool, use the search window with search terms “clip raster”/



Select the Clip Raster tool in the results.







Save the output in the project geodatabase as L8_2021112_subset_nir. Click Run.

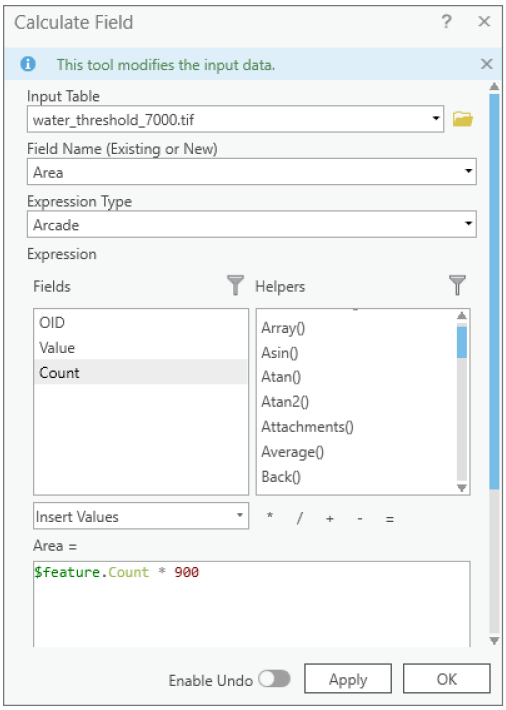
Exercise 2 (Create a water mask using a threshold classification)

(Subset using a vector)

You can run Exercise 2 or 3 next but you must complete BOTH. You can subset the Landsat 8 scene OR you can first perform threshold analysis to create the water mask. There are many ways to create a subset. The quickest method is to use the Image Analysis Tool and follow Chapter 15 of the textbook. Subset using a polygon representing Lafayette County Mississippi.

Exercise 4

After you have selected the appropriate water mask and its has been clipped to the Lafayette County boundary, make a final calculation of total land area and water covered area. This information can be found in the attribute table of the selected water mask raster file. The numbers are the total pixels (cells) in the layer assigned with each value. Select Attribute Table and click Calculate.



Using the Arcade expression type, create a new field call “Area” by multiplying the number of pixels in the mask by the size of the pixels. These are Landsat 8 OLI pixels, so they are 30 m by 30 m or 900 m^2. You can also review the properties to discover the pixel size.

Deliverables:

For the laboratory report, provide screen captures of the water mask over the imagery. Create transparencies of the mask so that the imagery can be seen below. The complete water mask of the county (only within the county) must be displayed in a map and included in the appendix of your laboratory report. Report the total area covered by water and non-water and compare to published values. Provide reference(s) of published land cover data you compared. Comment on the accuracy of your chosen water

mask and provide possible methods of reducing error. Create a **single** PDF of the short report and submit via BlackBoard.

Your report must include the following:

- A cover page or transmittal memorandum
- Report must include sections of a typical report:
    - Introduction, data, method, analysis, summary/discussion, appendix

Screen shot(s) showing exemplars of issues and highlights you have identi