QGIS

INTRO TO SPATIAL ANALYSIS WORKSHOP

WORKSHOP MATERIALS

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VIIGR
Vanderbilt Initiative for Interdisciplinary Geospatial Research

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Introduction

QGIS is an Open Source Geographic Information System (GIS) option. QGIS is an part of the Open Source Geospatial Foundation (OSGeo) and can run on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities.

QGIS provides users the functionality to analyze and edit spatial information, in addition to map creation. QGIS supports both raster and vector layers; vector data is stored as either point, line, or polygon features. Multiple formats of raster images are supported, and the software can georeference images.

QGIS supports shapefiles, coverages, personal geodatabases, dxf, MapInfo, PostGIS, and other formats. Web services, including Web Map Service and Web Feature Service, are also supported to allow use of data from external sources.

QGIS integrates with other open-source GIS packages, including PostGIS, GRASS GIS, and MapServer. Plugins written in Python or C++ extend QGIS's capabilities. Plugins can geocode using the Google Geocoding API, perform geoprocessing functions similar to those of the standard tools found in ArcGIS, and interface with PostgreSQL/PostGIS, SpatiaLite and MySQL databases.

https://qgis.org/en/site/index.html

Tutorial Data

1. Download the data here:

   https://drive.google.com/drive/folders/1rWy1f4_XTdIYUhD2OXpSlZDYjeFcnyZF

2. Save to your C: drive or main drive that you can easily locate
3. Unzip the folder
4. You will see two folders *VectorData* and *RasterData*
5. You will also see a file ending in .csv

Text Delimited Table

School_Demographics.csv – taken from data.nashville.gov (Nashville Open Data Portal). Shows Current student enrollment and demographic information for Metro Nashville Public Schools (MNPS) locations.

Vector Data (Shapefiles)

Vector data is split into three types: polygon, line (or arc) and point data. Polygons are used to represent areas such as the boundary of a city (on a large-scale map), lake, or forest.

Polygon features are two dimensional and therefore can be used to measure the area and perimeter of a geographic feature. Polygon features are most commonly distinguished using either a thematic mapping symbology (color schemes), patterns, or in the case of numeric gradation, a color gradation scheme could be used. Line (or arc) data is used to represent linear features. Common examples would be rivers, trails, and streets.

Line features only have one dimension and therefore can only be used to measure length. Point data is most commonly used to represent nonadjacent features and to represent discrete data points. Points have zero dimensions; therefore, you can measure neither length or area with this dataset. Examples would be schools, points of interest, and in the example below, bridge and culvert locations. Point features are also used to represent abstract points. For instance, point locations could represent city locations or place names.

Polygons:
School_Districts.shp – taken from data.nashville.gov (Nashville Open Data Portal). Contains outlines for Davidson County School Districts.

Buildings.shp - Nashville, Tennessee Building Footprints: Metropolitan GIS taken from koordinates.com

Lines:
Street_Davidson.shp – Nashville, Tennessee Road Centerlines: Metropolitan GIS taken from koordinates.com

Points:
Potholes.csv – delimited text file taken from data.nashville.gov (Nashville Open Data Portal). Service requests to hubNashville (311) from residents and visitors.

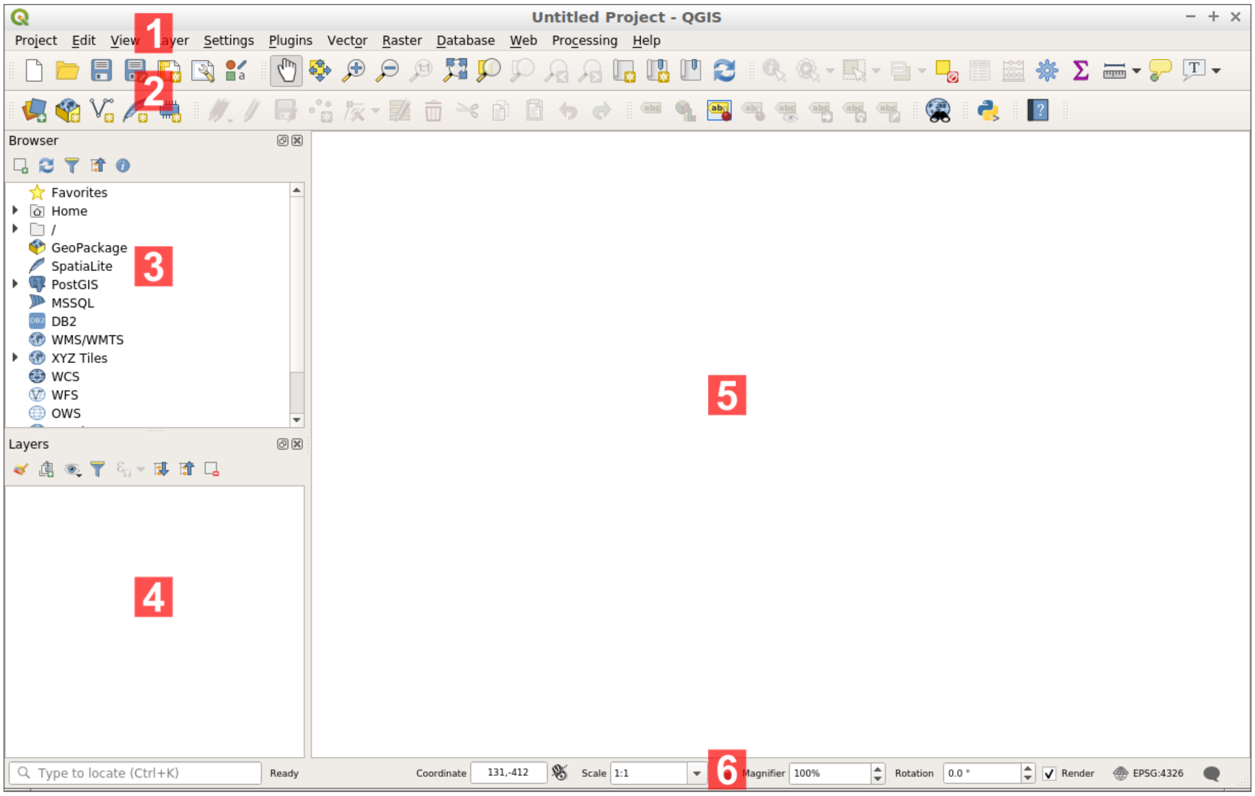
Raster Data

Raster data consists of cells which represent values. The resolution of a raster dataset is determined by the size of the cells. For example, a 2.5m resolution DEM, like the ones used in this exercise, means that each cell that makes up that raster is 2.5m by 2.5m. There are two major types of raster data, discrete and continuous. Discrete raster data tends to be categorical, whereas continuous raster data is representative of a surface.

In this exercise we will look at continuous raster data in the form of digital elevation models (DEMs) and digital surface models (DSMs). Data for this exercise was downloaded from the TN State data repository at: https://tnmap.tn.gov/.

1730653NE.img
1730653NW.img

Getting to Know the QGIS Interface



1. Menu bar: Access to various QGIS features using a standard hierarchical menu.
2. Toolbars: For interaction with the map, layers, attributes and selections.
3. Browser Panel: A spatial file browser allowing drag and drop content into the map frame.
4. Layer Panel: Controls the map layers, their order, and visibility.
5. Map View: View spatial data
6. CRS/Coordinate Bar: Change coordinate reference system on the fly and coordinate display

Vector Data

Adding data

Navigate to VectorData folder in the browser panel (If the browser panel is not visible right click the top menu and select the Browser Panel.)

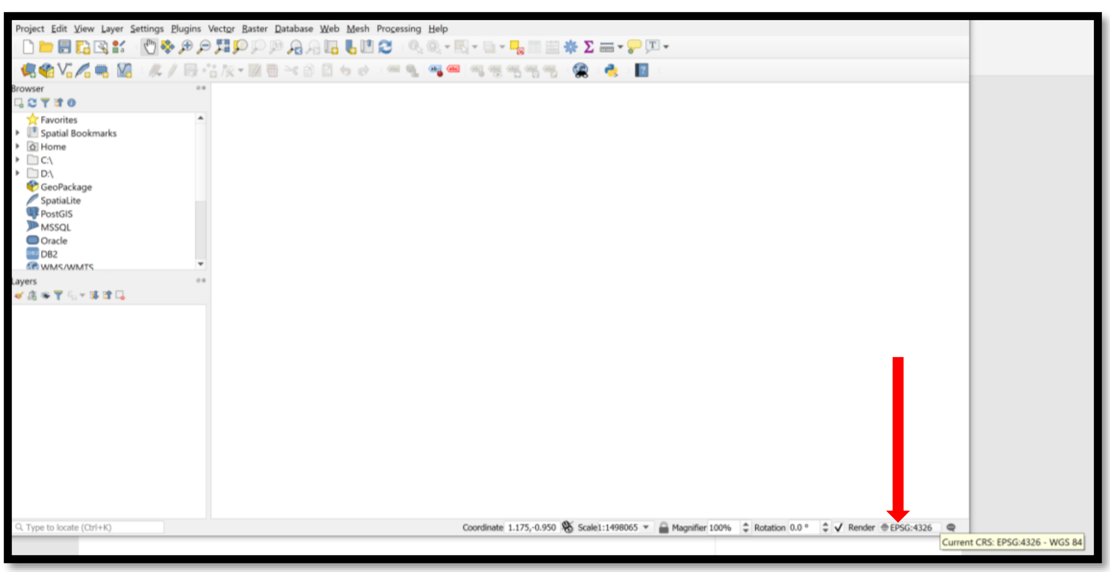
1. Select **Zipcodes.shp** and drag to the main view or to the layer panel
2. Select **School_Demographics.csv** and add to the map

Projection of Layers and Project

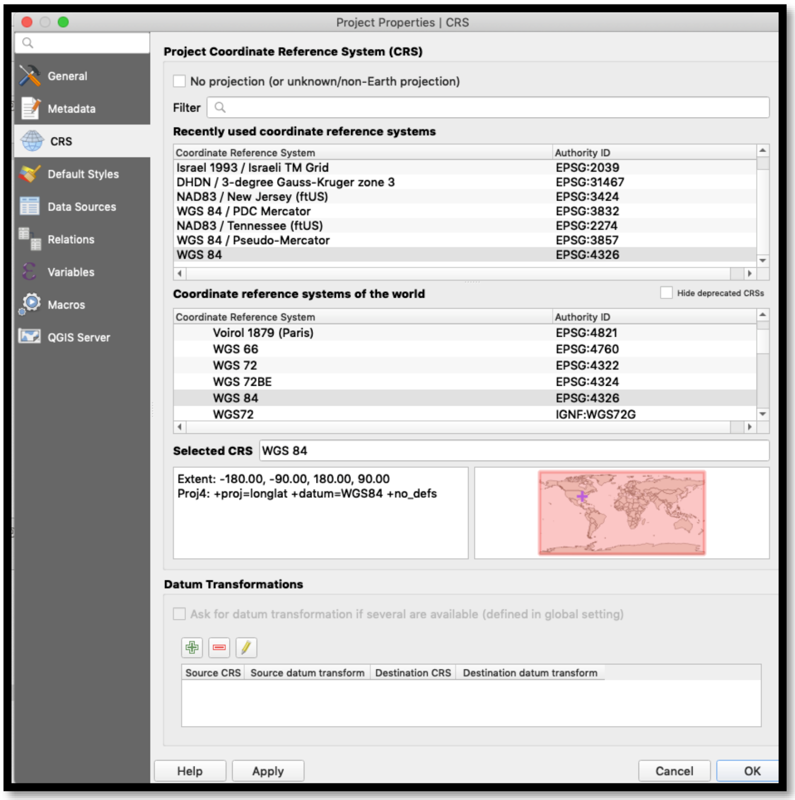
QGIS automatically reads projection information (i.e., the Coordinate Reference System [CRS]), if available, from respective layer files. For shapefiles, it relies on the ".prj" file; for raster data, it is often embedded in the file. If you load data without built-in projection information (e.g., a Delimited Text File), it generally assumes a geographic coordinate system (Lat/Long), and uses the World Geodetic Survey 1984 (WGS84) datum, or may use the Project CRS the user to specify. It is always a good idea to check that the projection information is interpreted correctly by QGIS.

By default, QGIS uses "Projection on the Fly" – for visualization (but not necessarily analysis) of multiple layers in different CRSs, they are automatically transformed to be in the same coordinate space.

Look to the bottom right corner of your viewer. Notice the EPSG (coordinate system designation code). To change the CRS of your map, click the world icon  next to the designation code.

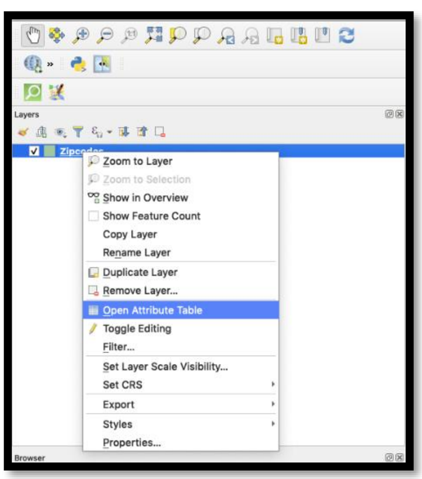


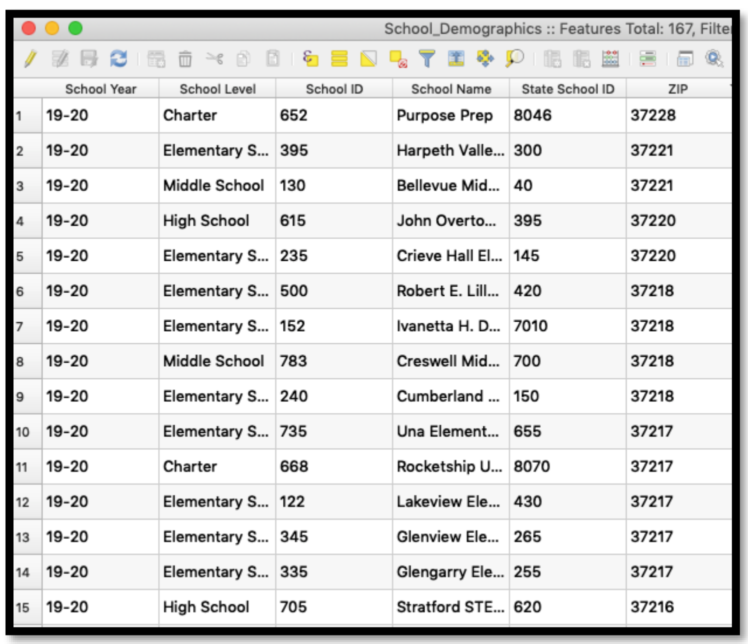
Then select EPSG: 4326 (WGS84)



Working with Attribute Tables

1. Open Attribute Table for **School_Demographics.csv** by right clicking the layer → Open Attribute Table

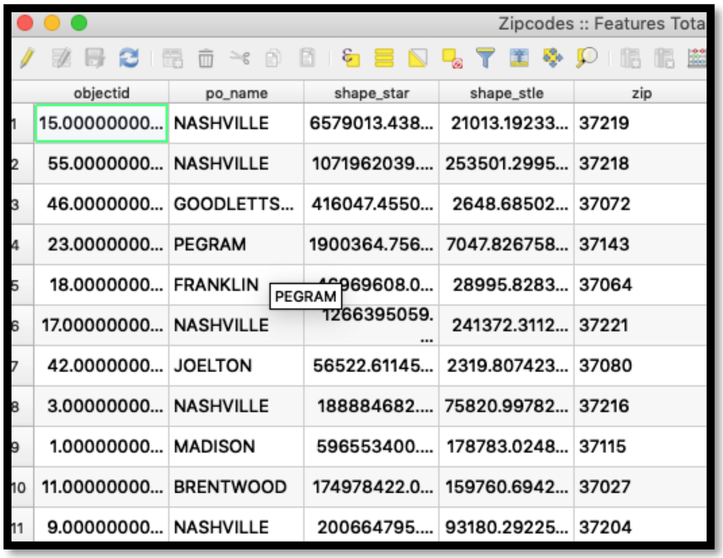



School_Demographics :: Features Total: 167, Filte

	School Year	School Level	School ID	School Name	State School ID	ZIP
1	19-20	Charter	652	Purpose Prep	8046	37228
2	19-20	Elementary S...	395	Harpeth Valle...	300	37221
3	19-20	Middle School	130	Bellevue Mid...	40	37221
4	19-20	High School	615	John Overto...	395	37220
5	19-20	Elementary S...	235	Crieve Hall El...	145	37220
6	19-20	Elementary S...	500	Robert E. Lill...	420	37218
7	19-20	Elementary S...	152	Ivanetta H. D...	7010	37218
8	19-20	Middle School	783	Creswell Mid...	700	37218
9	19-20	Elementary S...	240	Cumberland ...	150	37218
10	19-20	Elementary S...	735	Una Element...	655	37217
11	19-20	Charter	668	Rocketship U...	8070	37217
12	19-20	Elementary S...	122	Lakeview Ele...	430	37217
13	19-20	Elementary S...	345	Glenview Ele...	265	37217
14	19-20	Elementary S...	335	Glengarry Ele...	255	37217
15	19-20	High School	705	Stratford STE...	620	37216

2. Close attribute table.

3. Open the attribute table for **Zipcodes.**



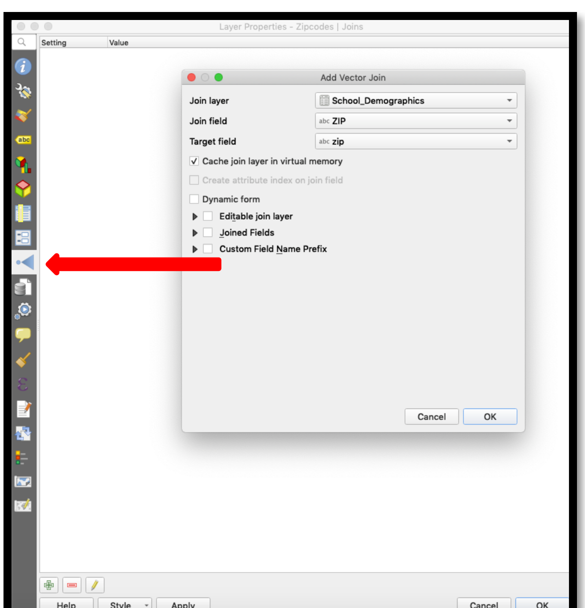
Zipcodes :: Features Tota

	objectid	po_name	shape_star	shape_stle	zip
1	15.00000000...	NASHVILLE	6579013.438...	21013.19233...	37219
2	55.0000000...	NASHVILLE	1071962039....	253501.2995...	37218
3	46.0000000...	GOODLETTS...	416047.4550...	2648.68502...	37072
4	23.0000000...	PEGRAM	1900364.756...	7047.826758...	37143
5	18.0000000...	FRANKLIN	46969608.0...	28995.8283...	37064
6	17.00000000...	NASHVILLE	1266395059....	241372.3112...	37221
7	42.0000000...	JOELTON	56522.61145...	2319.807423...	37080
8	3.00000000...	NASHVILLE	188884682....	75820.99782...	37216
9	1.00000000...	MADISON	596553400....	178783.0248...	37115
10	11.00000000...	BRENTWOOD	174978422.0...	159760.6942...	37027
11	9.00000000...	NASHVILLE	200664795....	93180.29225...	37204

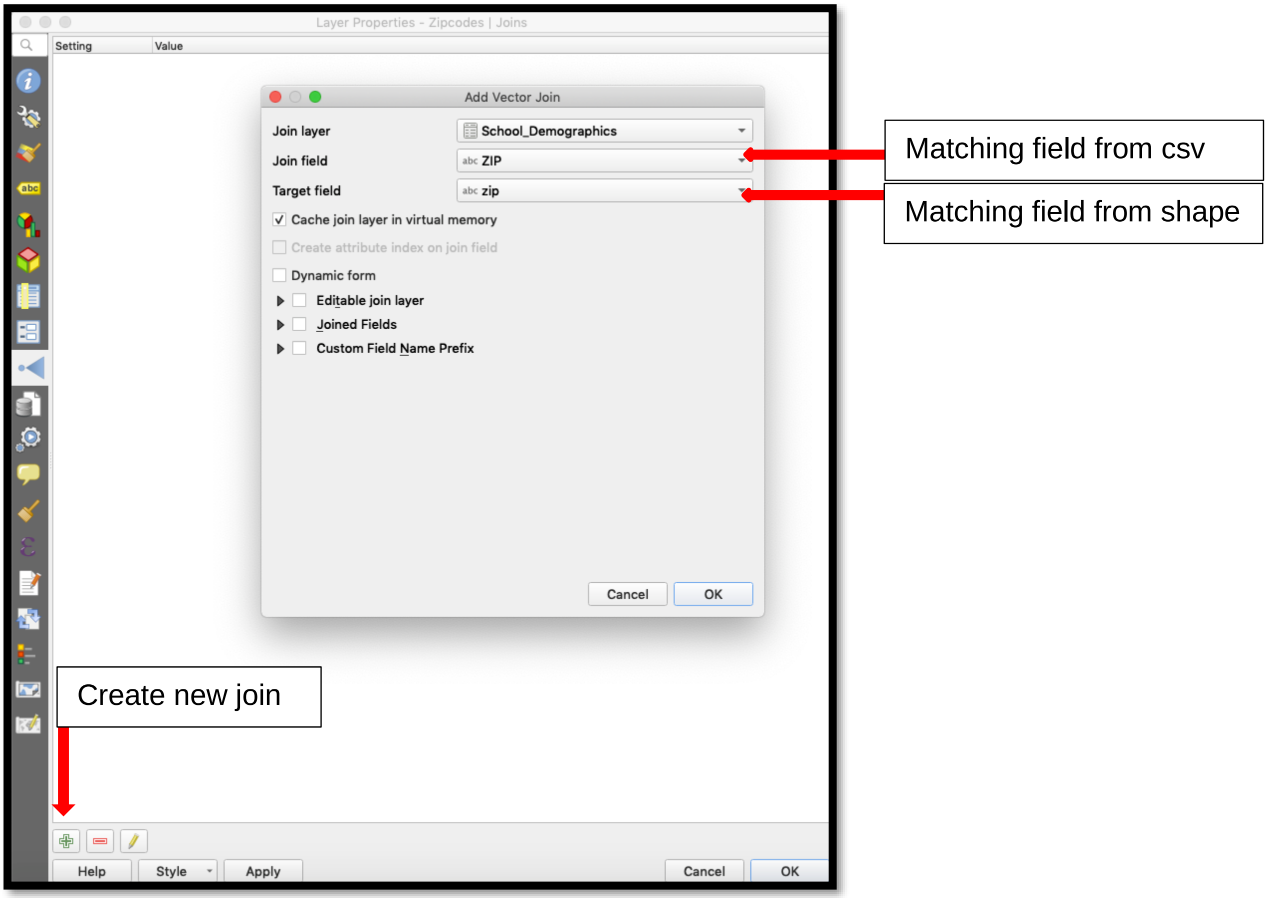
4. Note what field is the same in both datasets.

Creating a Join

1. Join the two tables based on their common field to view data from both tables simultaneously. Select **Zipcodes** and right click → Properties → Join

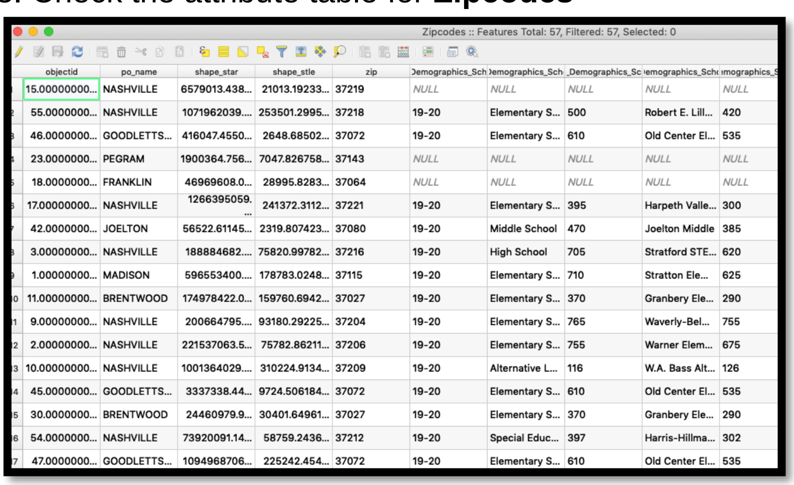


Click the green plus button to create a new join. The ‘Add Vector Join’ screen will appear. This screen will recognize that join is being performed between the shapefile and the **School_Demographics** table. Select the ZIP field as the Join Field and the and the zip field as the Target Field from the shapefile.



2. Click Apply to execute the join and then OK to close Layer Properties.

3. Check the attribute table for **Zipcodes**

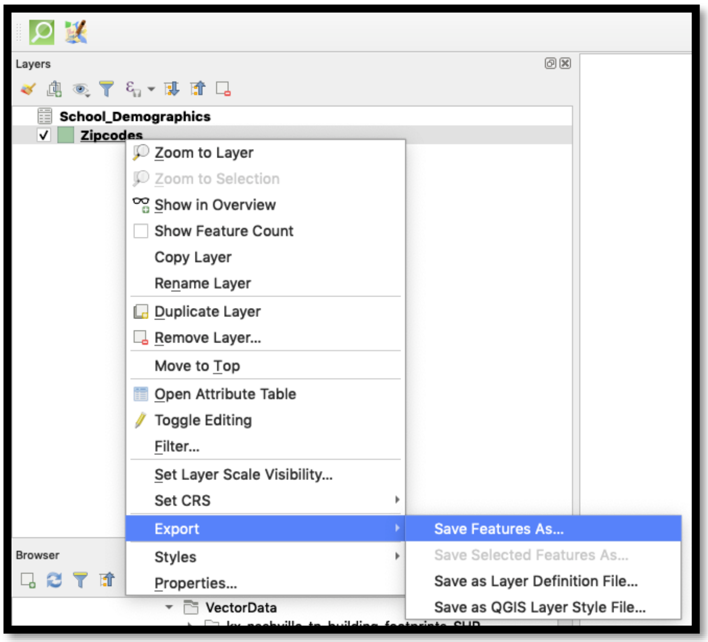

Zipcodes :: Features Total: 57, Filtered: 57, Selected: 0

	objectid	po_name	shape_star	shape_stle	zip	Demographics_Sch	Demographics_Sch	_Demographics_Sc	emographics_Sch	mographics_S
1	15.00000000...	NASHVILLE	6579013.438...	21013.19233...	37219	NULL	NULL	NULL	NULL	NULL
2	55.0000000...	NASHVILLE	1071962039....	253501.2995...	37218	19-20	Elementary S...	500	Robert E. Lill...	420
3	46.0000000...	GOODLETTS...	416047.4550...	2648.68502...	37072	19-20	Elementary S...	610	Old Center El...	535
4	23.0000000...	PEGRAM	1900364.756...	7047.826758...	37143	NULL	NULL	NULL	NULL	NULL
5	18.0000000...	FRANKLIN	46969608.0...	28995.8283...	37064	NULL	NULL	NULL	NULL	NULL
6	17.00000000...	NASHVILLE	1266395059....	241372.3112...	37221	19-20	Elementary S...	395	Harpeth Valle...	300
7	42.0000000...	JOELTON	56522.61145...	2319.807423...	37080	19-20	Middle School	470	Joelton Middle	385
8	3.00000000...	NASHVILLE	188884682....	75820.99782...	37216	19-20	High School	705	Stratford STE...	620
9	1.00000000...	MADISON	596553400....	178783.0248...	37115	19-20	Elementary S...	710	Stratton Ele...	625
10	11.00000000...	BRENTWOOD	174978422.0...	159760.6942...	37027	19-20	Elementary S...	370	Granbery Ele...	290
11	9.00000000...	NASHVILLE	200664795....	93180.29225...	37204	19-20	Elementary S...	765	Waverly-Bel...	755
12	2.00000000...	NASHVILLE	221537063.5...	75782.86211...	37206	19-20	Elementary S...	755	Warner Elem...	675
13	10.00000000...	NASHVILLE	1001364029....	310224.9134...	37209	19-20	Alternative L...	116	W.A. Bass Alt...	126
14	45.0000000...	GOODLETTS...	3337338.44...	9724.506184...	37072	19-20	Elementary S...	610	Old Center El...	535
15	30.0000000...	BRENTWOOD	24460979.9...	30401.64961...	37027	19-20	Elementary S...	370	Granbery Ele...	290
16	54.0000000...	NASHVILLE	73920091.14...	58759.2436...	37212	19-20	Special Educ...	397	Harris-Hillma...	302
17	47.0000000...	GOODLETTS...	1094968706...	225242.454...	37072	19-20	Elementary S...	610	Old Center El...	535

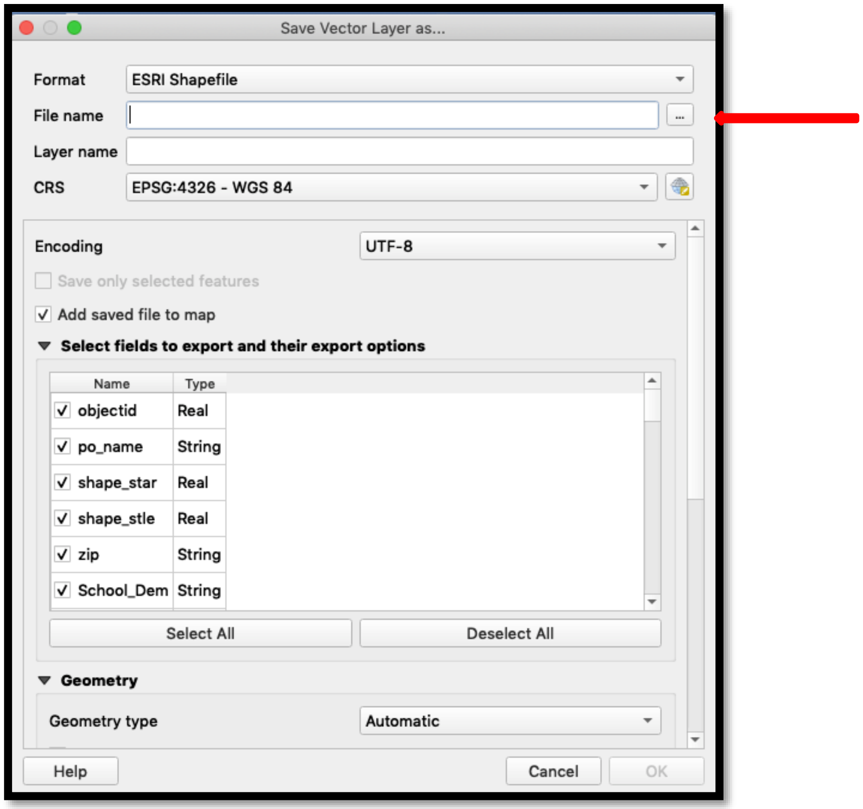
4. What do you notice? Scroll across to see more data.

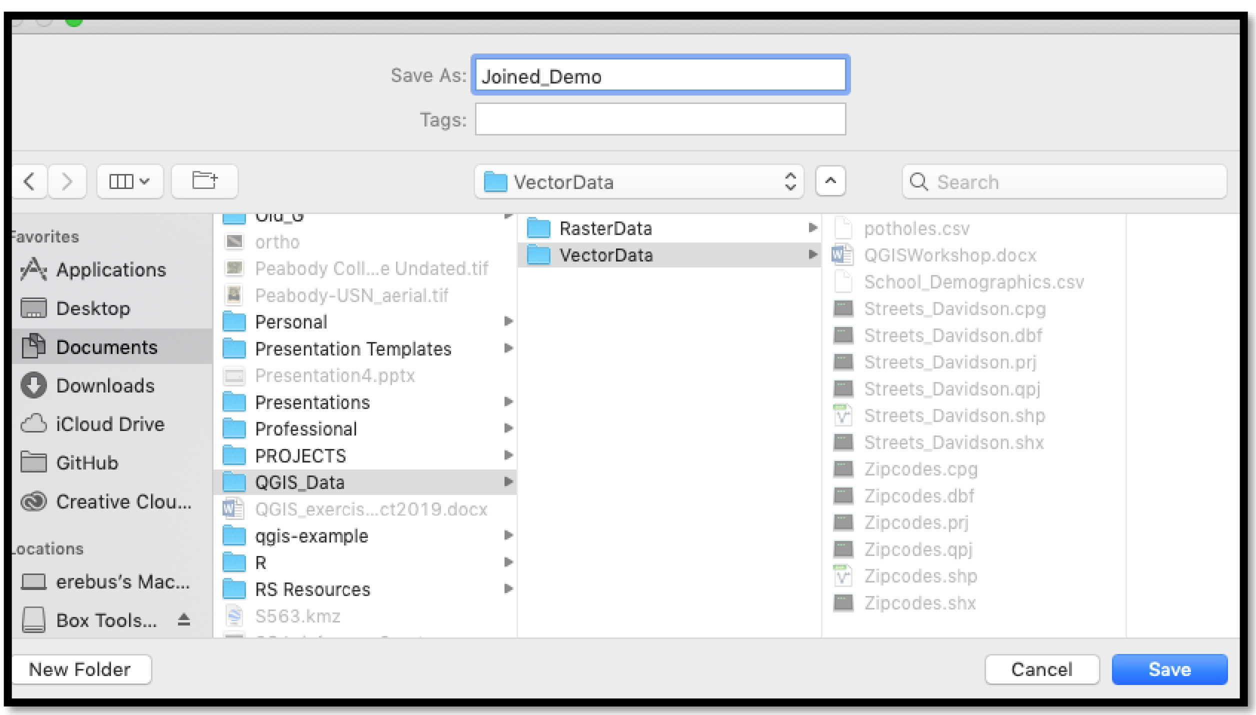
Export to New File

1. Right click **Zipcodes** layer →Save Features As

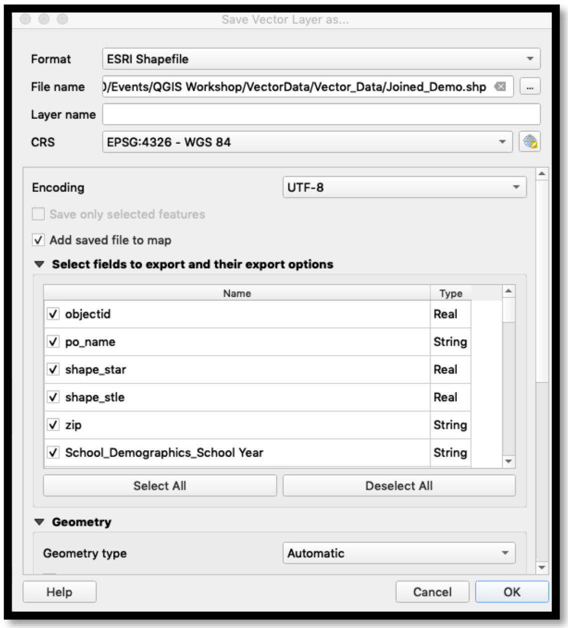


2. Make sure you click the … to locate the data file folder for this exercise and save to that folder.


Save Vector Layer as...
Format
ESRI Shapefile
File name
Layer name
CRS
EPSG:4326 - WGS 84
Encoding
UTF-8
Save only selected features
Add saved file to map
Select fields to export and their export options
Name
Type
objectid
Real
po_name
String
shape_star
Real
shape_stle
Real
zip
String
School_Dem
String
Select All
Deselect All
Geometry
Geometry type
Automatic
Help
Cancel
OK


Save As:
Joined_Demo
Tags:
VectorData
Search
Favorites
Applications
Desktop
Documents
Downloads
iCloud Drive
GitHub
Creative Clou...
Locations
erebus's Mac...
Box Tools...
ortho
Peabody Coll...e Undated.tif
Peabody-USN_aerial.tif
Personal
Presentation Templates
Presentation4.pptx
Presentations
Professional
PROJECTS
QGIS_Data
QGIS_exercis...ct2019.docx
qgis-example
R
RS Resources
S563.kmz
RasterData
VectorData
potholes.csv
QGISWorkshop.docx
School_Demographics.csv
Streets_Davidson.cpg
Streets_Davidson.dbf
Streets_Davidson.prj
Streets_Davidson.qpj
Streets_Davidson.shp
Streets_Davidson.shx
Zipcodes.cpg
Zipcodes.dbf
Zipcodes.prj
Zipcodes.qpj
Zipcodes.shp
Zipcodes.shx
New Folder
Cancel
Save

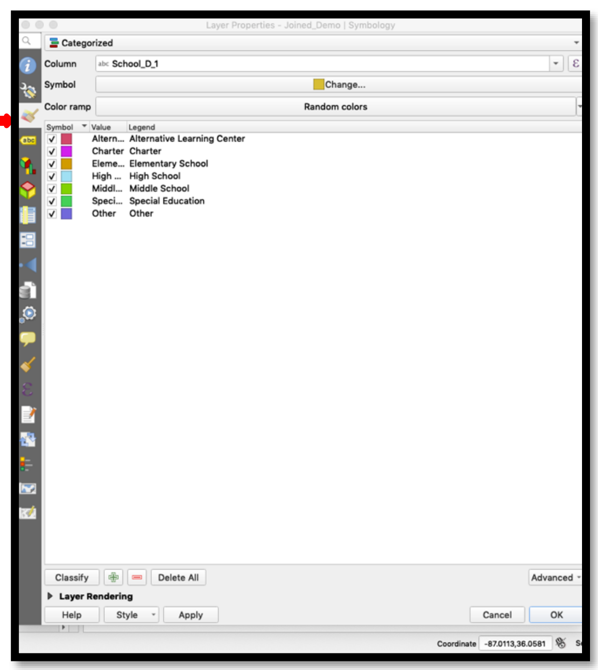
3. Call the new file **Joined_Demo**. Make sure the format is *ESRI Shapefile* and the CRS (Coordinate Reference System) remains at EPSG: 4326-WGS84.



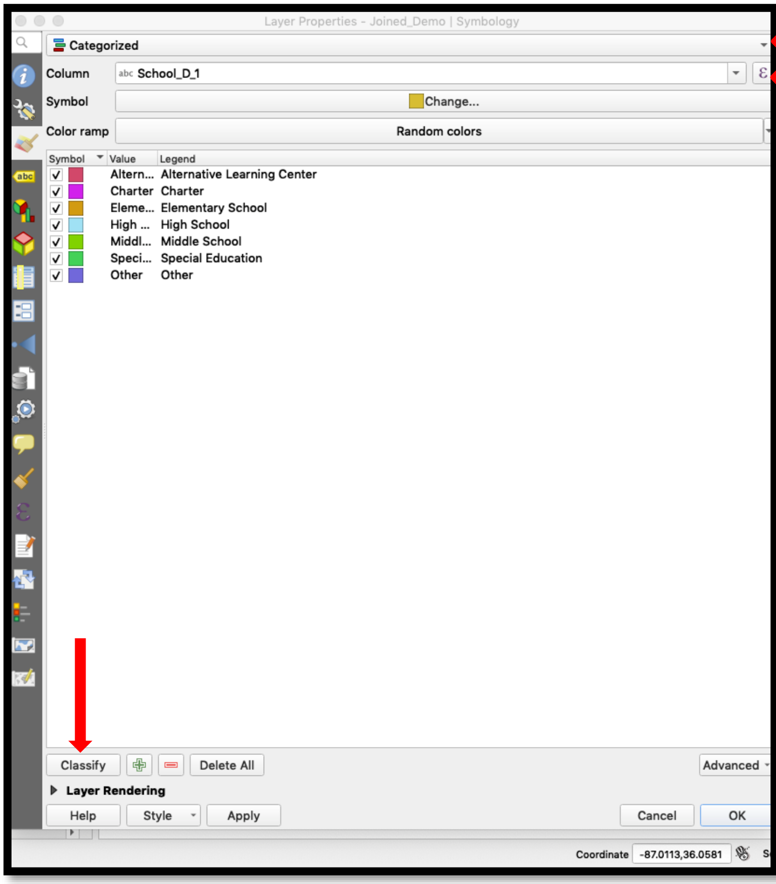
4. Turn off the original zipcodes layer by unchecking it's box in the layer pane or remove it by right clicking the layer and choosing 'Remove Layer'.

Symbolizing by Unique Values

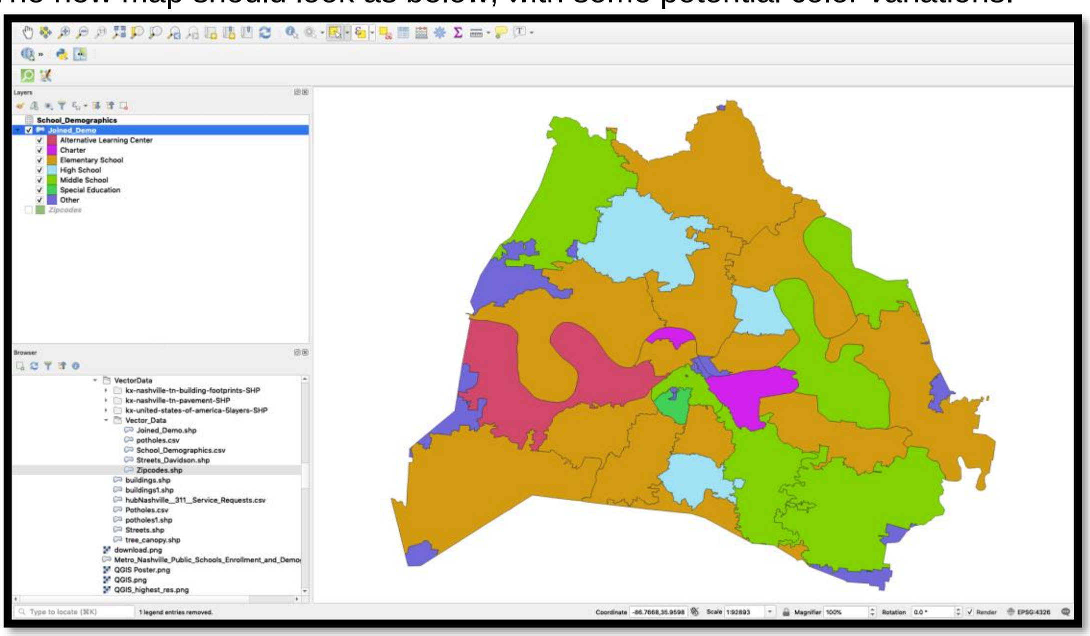
1. Make sure the original zipcodes layer is unchecked (not visible)→ right click **Join_Demo** layer → Properties → Symbology



2. Drop down the top menu and change the symbol type to Categorized. Set the Column drop down to School D_1 attribute, which corresponds to the type of school. Select the Classify button at the bottom left of the toolbox. Select Apply and OK.

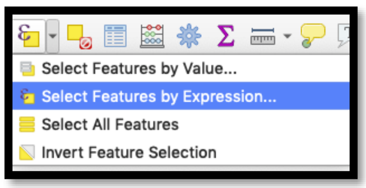


The new map should look as below, with some potential color variations.

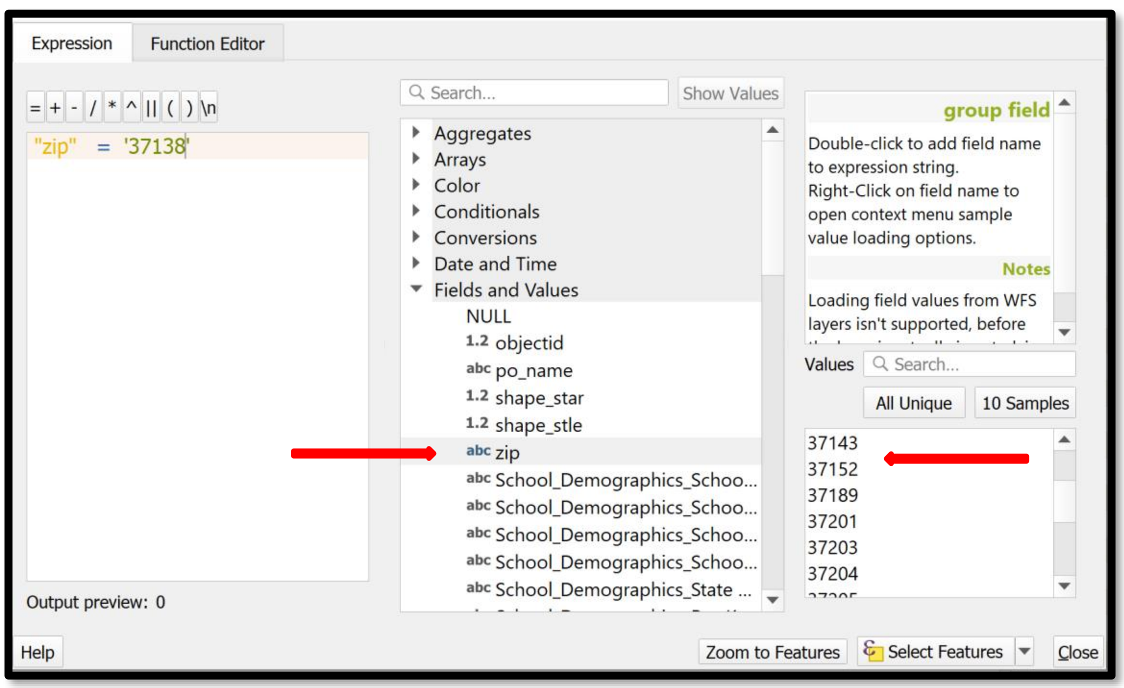


Select by Expression

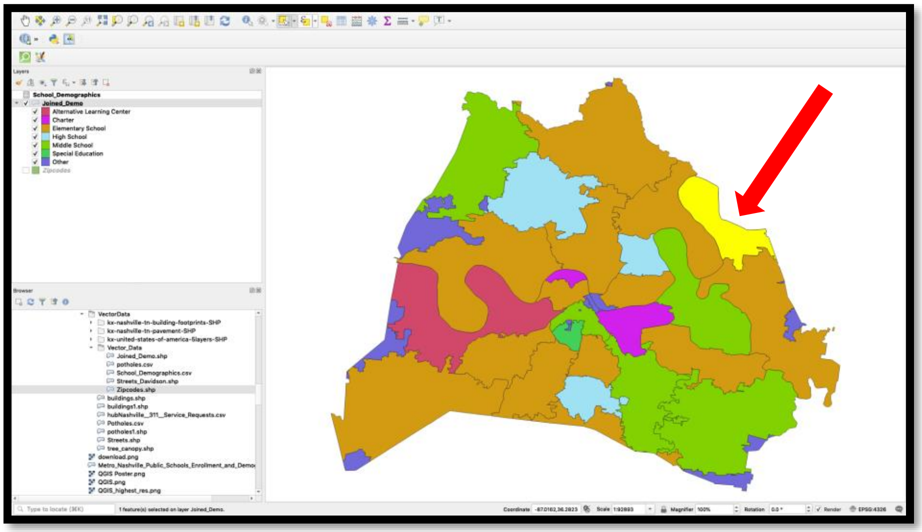
1. On the top menu bar find the Selection tool, drop down the selection box→Select by Expression



2. In the Expression box expand the Fields and Values sections to browse for the zip value. Click 'All Unique' to pull up a list of all the possible zip code options. Create an expression that is zip = pick a zipcode → click select features to make your selection.



3. The selection will be highlighted in yellow

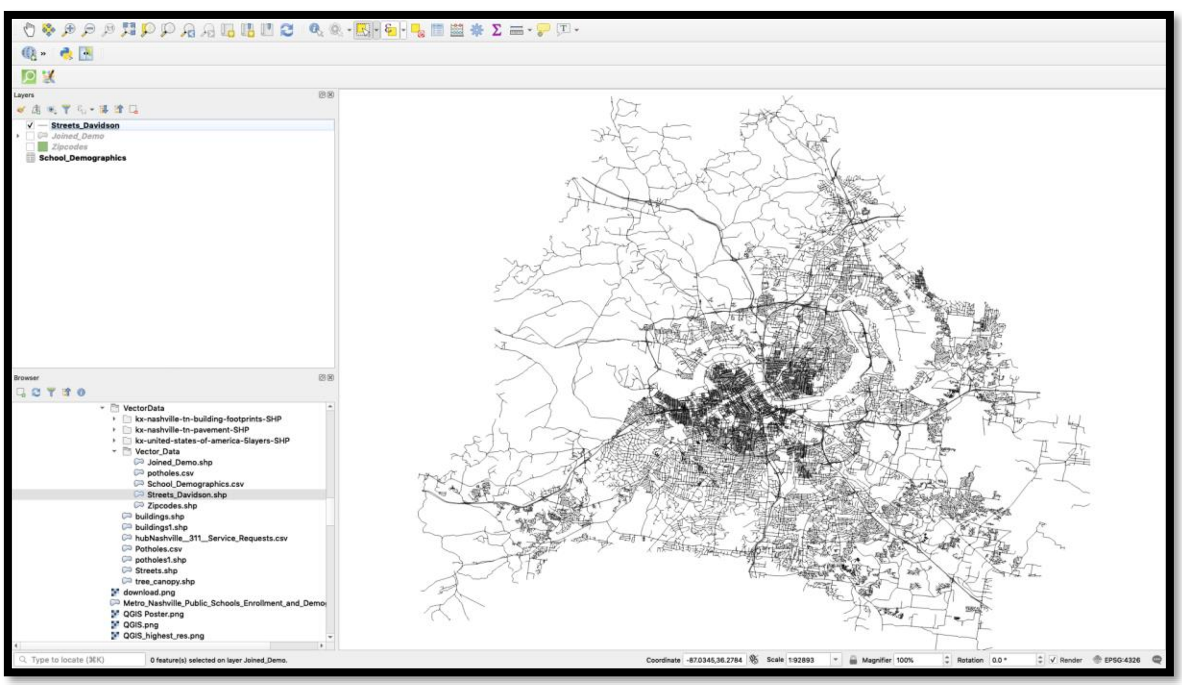


Start a new project

1. Project → New

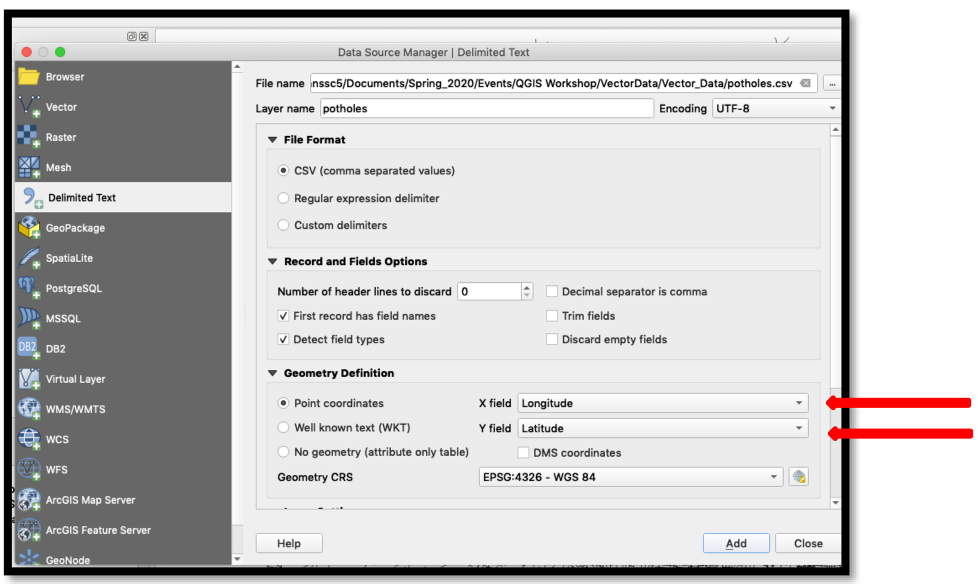
Clipping

1. Add **Streets_Davidson.shp** (drag file) to map view.

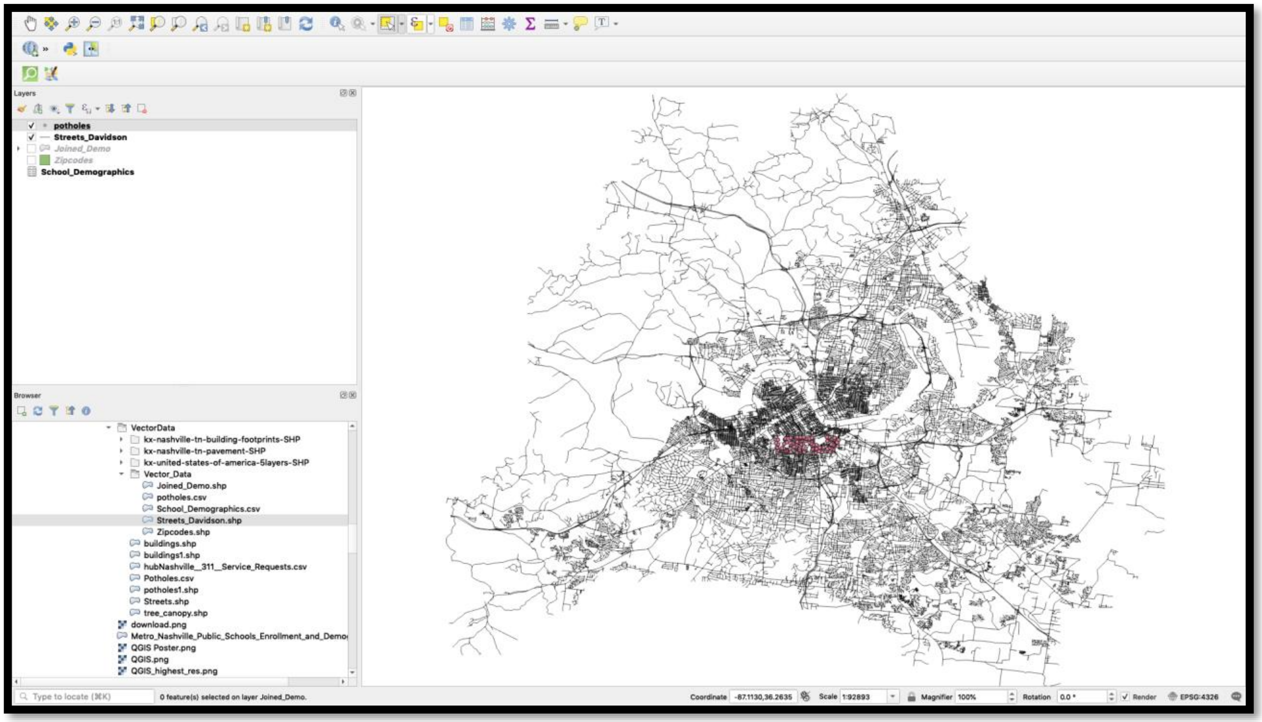


2. Add the **Potholes.csv** as a delimited text layer by choosing Layer → Add Layer → Add Delimited Text Layer.

3. This will open the 'Data Source Manger' window. Browse to your file and choose CSV as the format. Make sure to set the x and y fields with Longitude and Latitude accordingly and then click Add.



The data should add to the map as a point layer, as displayed below.

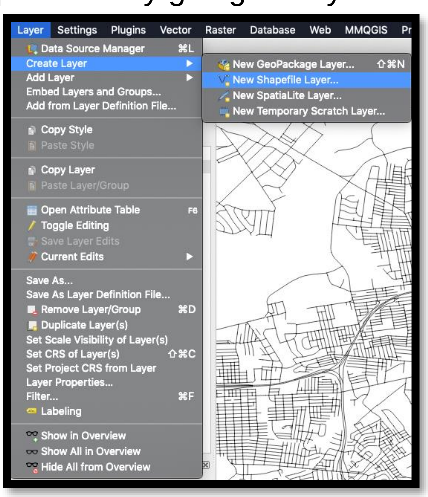


3. Right click the new potholes layer → zoom to layer

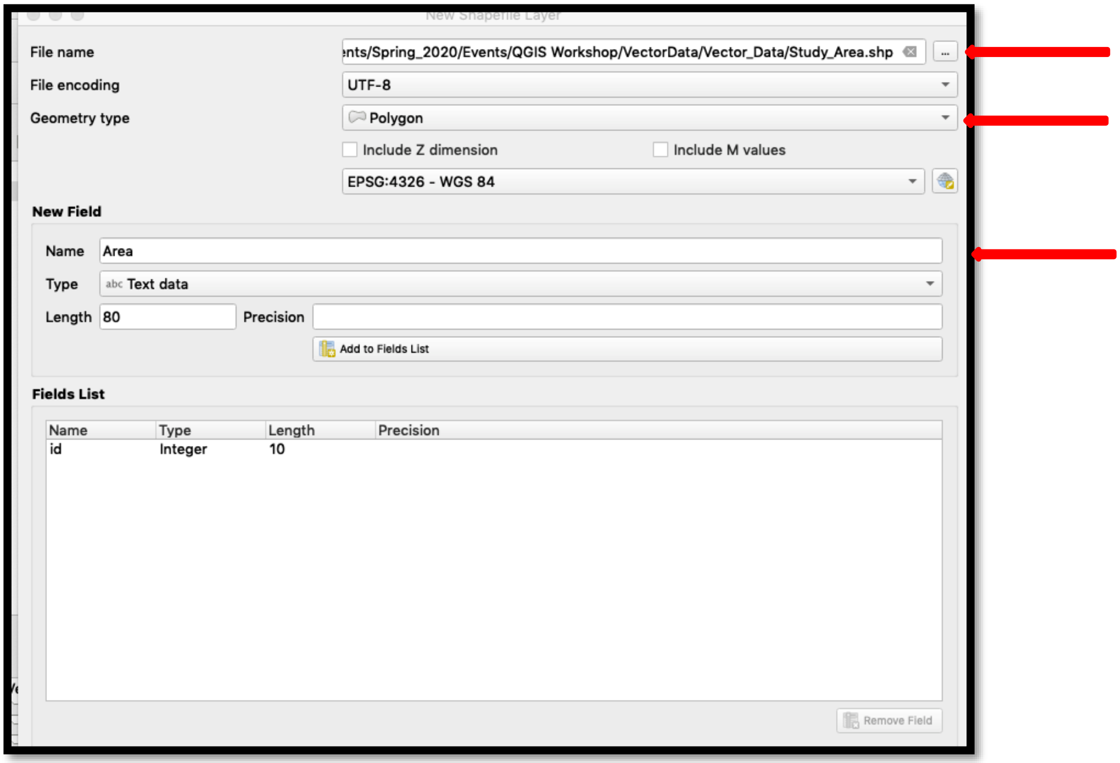
Clipping

Let's clip Davidson county street layer (**Streets_Davidson**)
There are several ways to clip, but we are going to clip by selection.

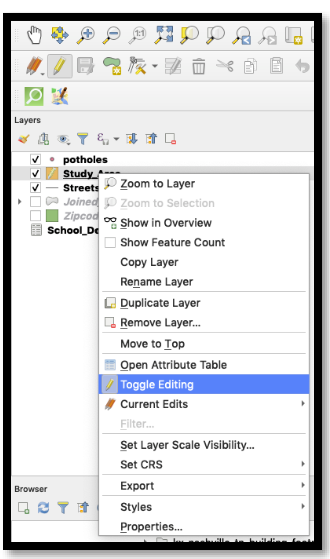
1. Create a new polygon layer to represent the area of interest (AOI) for our study of potholes by going to Layer → Create Layer → New Shapefile Layer



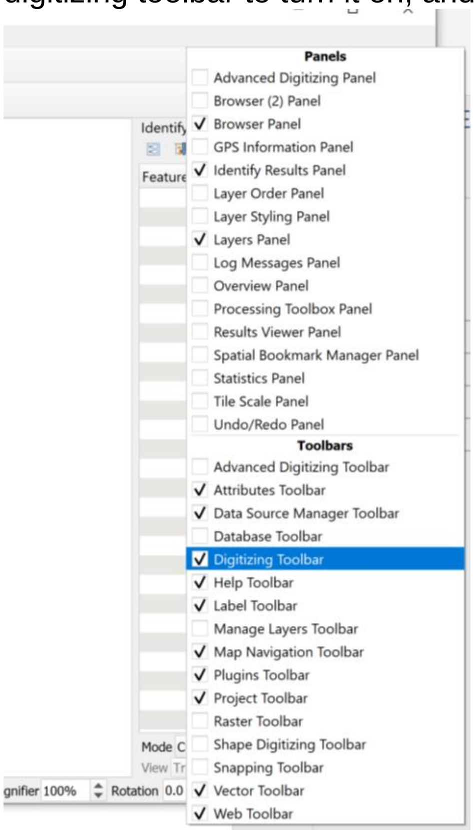
3. In the ‘New Shapefile Layer’ window, navigate to the vector data folder and name the new shapefile **Study_Area**. Change Geometry type to polygon. Name new field as Area.



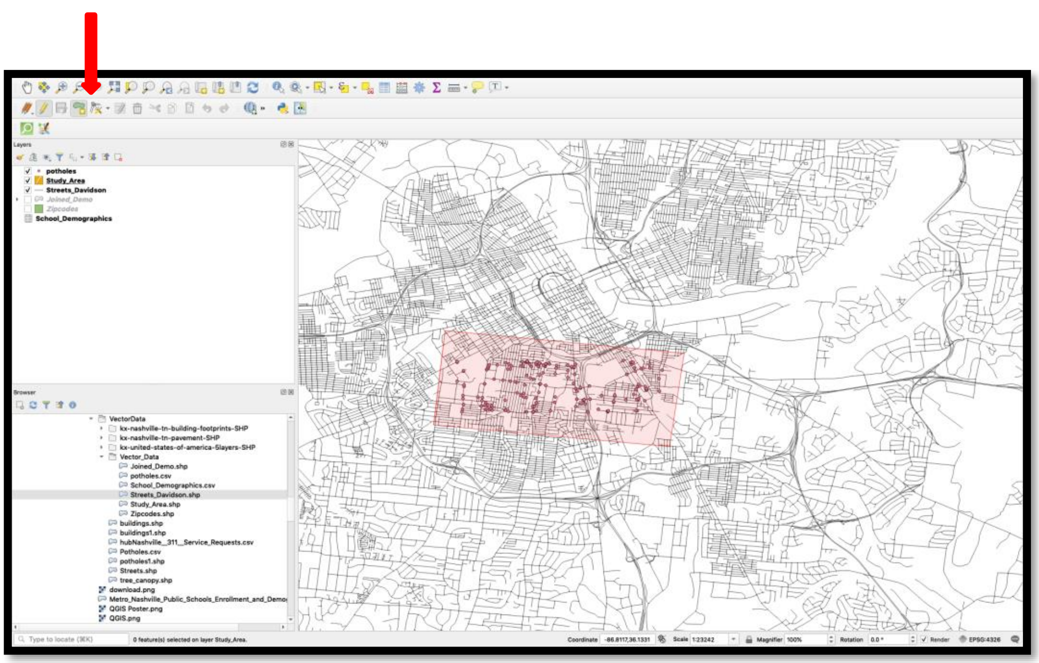
6. Draw your AOI around where the potholes are. Right click **Study_Area** →Toggle editing



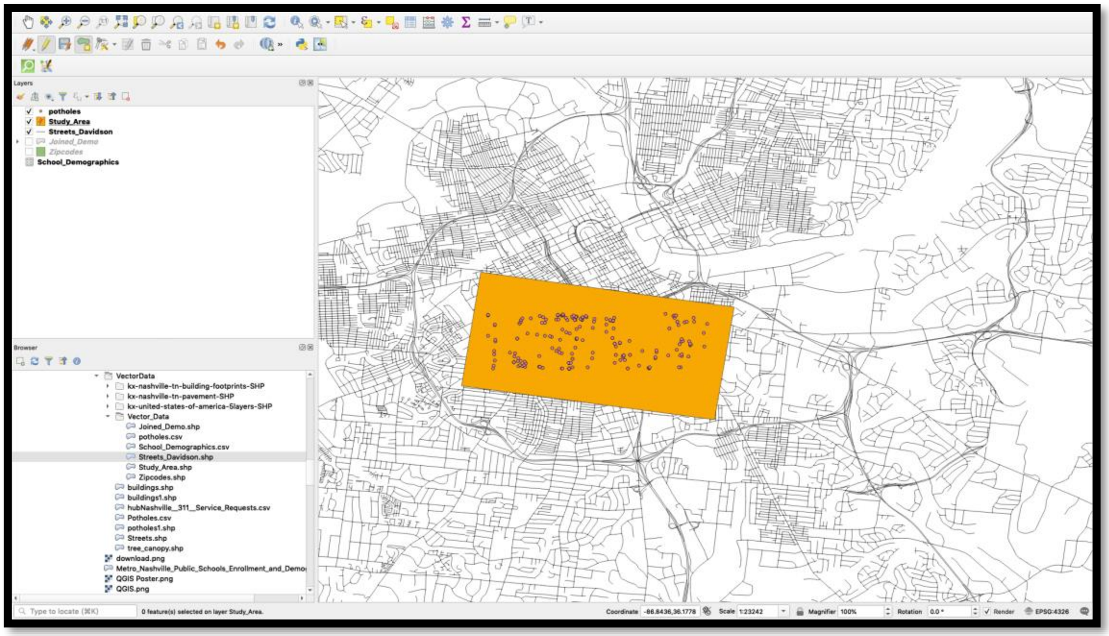
7. Right click in the tool bar area to open the toolbar and panel options. Check the digitizing toolbar to turn it on, and it will appear alongside the other toolbars.



8. Now select the Add polygon feature tool and draw a rectangle around the area where the potholes are.



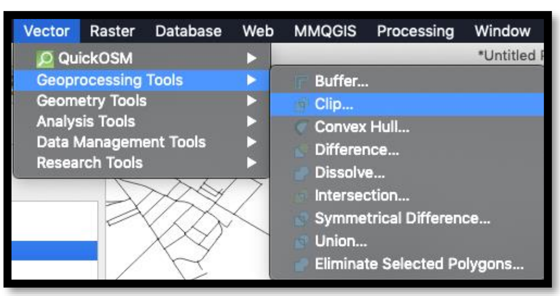
9. Once you draw your box right click and select ok to complete your drawing.



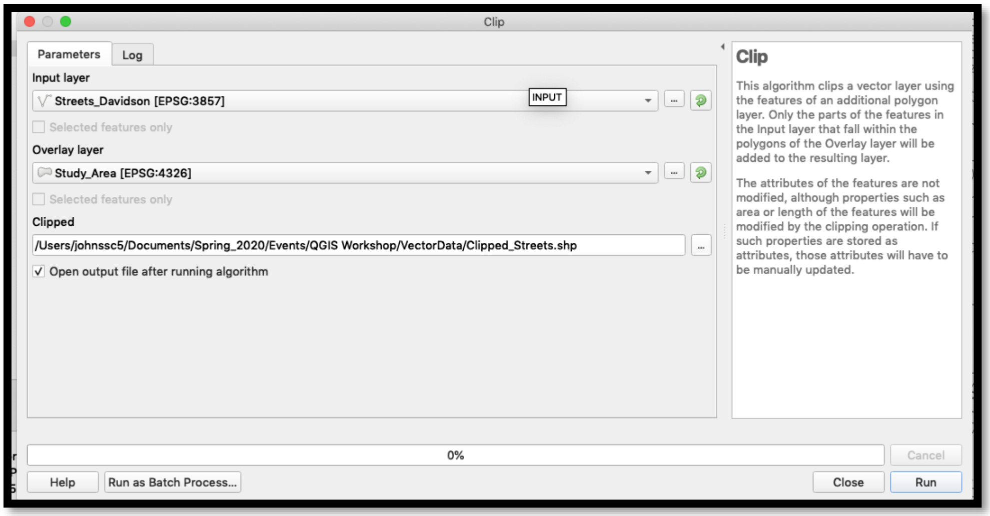
10. Turn off editing. → right click **Study_Area** → turn off editing → Save changes to layer

Clip Streets to Area of Interest

1. Select **Streets_Davidson** layer → Vector → Geoprocessing tools → Clip



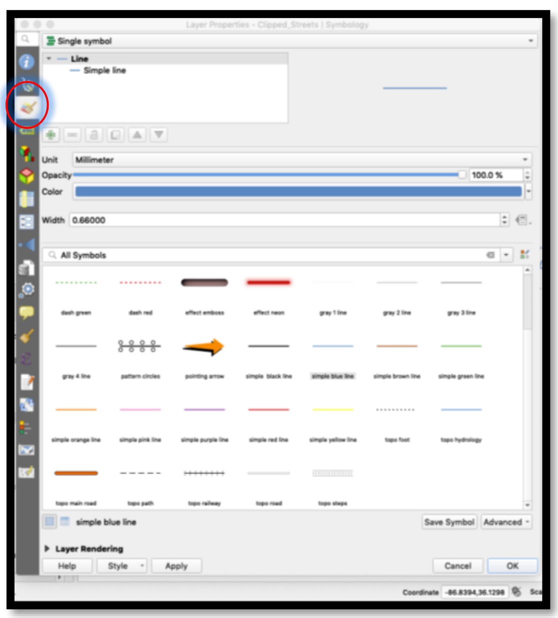
Call the new clipped layer **Clipped_Streets**



2. Turn off all layers except **Clipped_Streets** and **Potholes.**

Change basic symbology

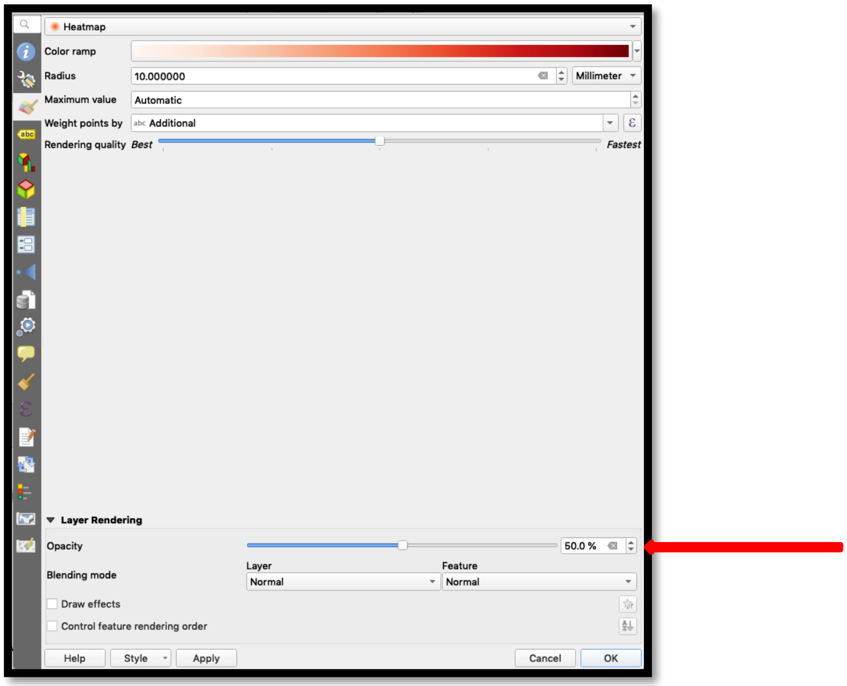
1. Right click clipped streets → Properties → Symbology. Select a color that is a good representative of a street



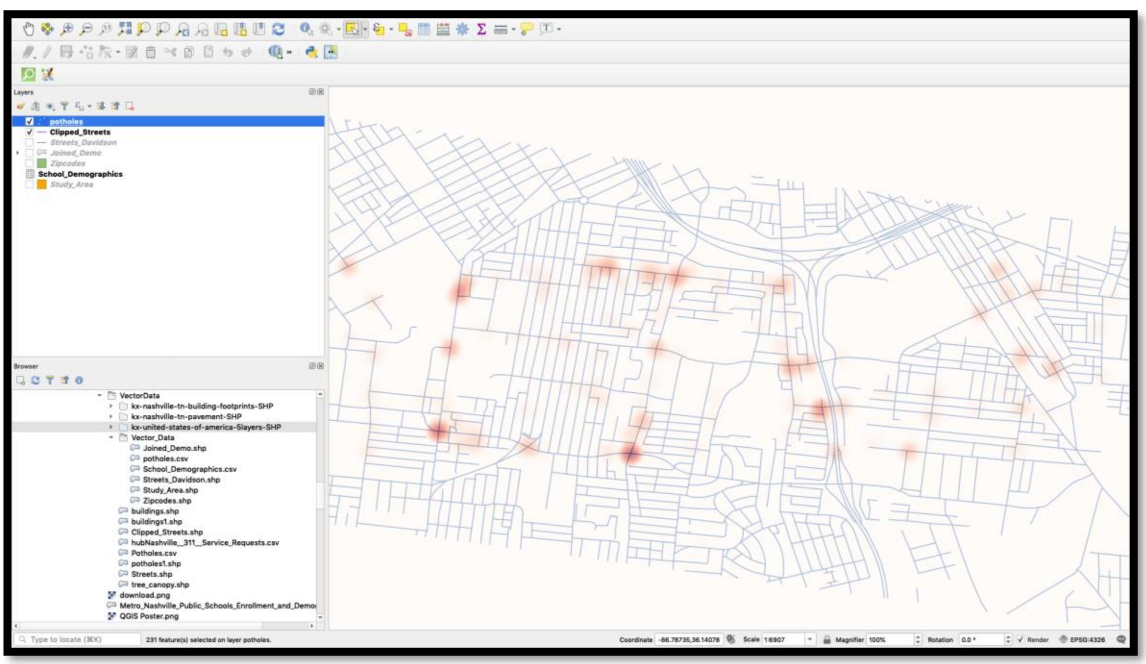
Note: You may to need to reorder layers

Creating a Heat Map

1. Right click **Potholes.shp**→ Layer Properties → Symbology. Drop down to Heatmap symbology type. Change the color ramp to a red ramp and change the opacity (transparency) to 50%.

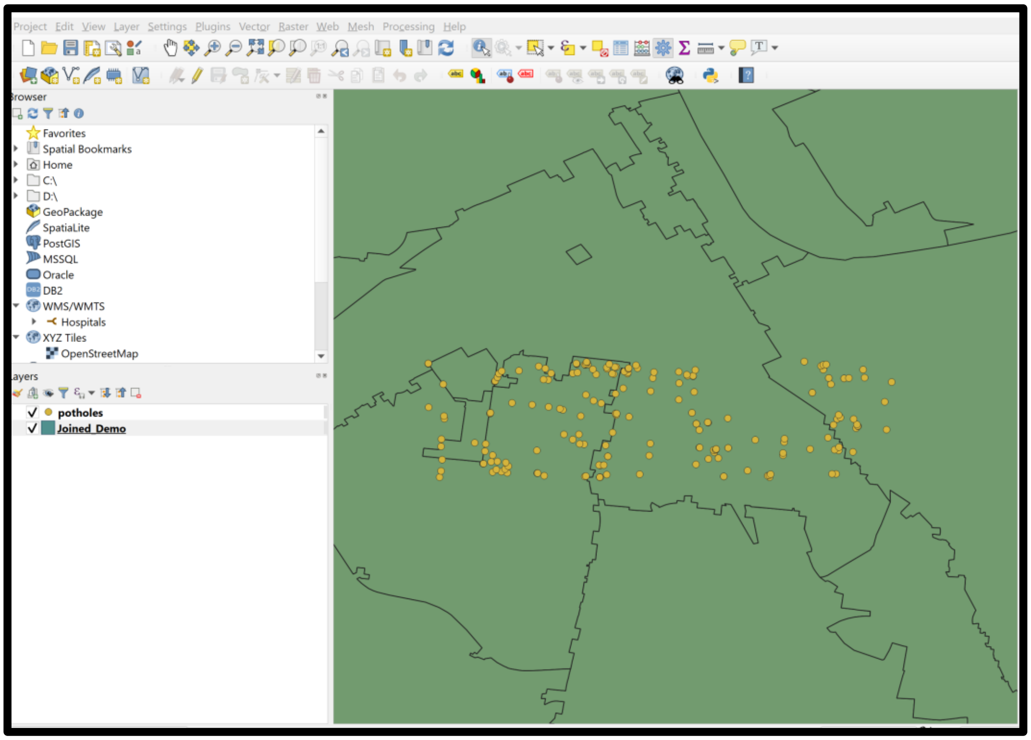


The heat map should display as below.

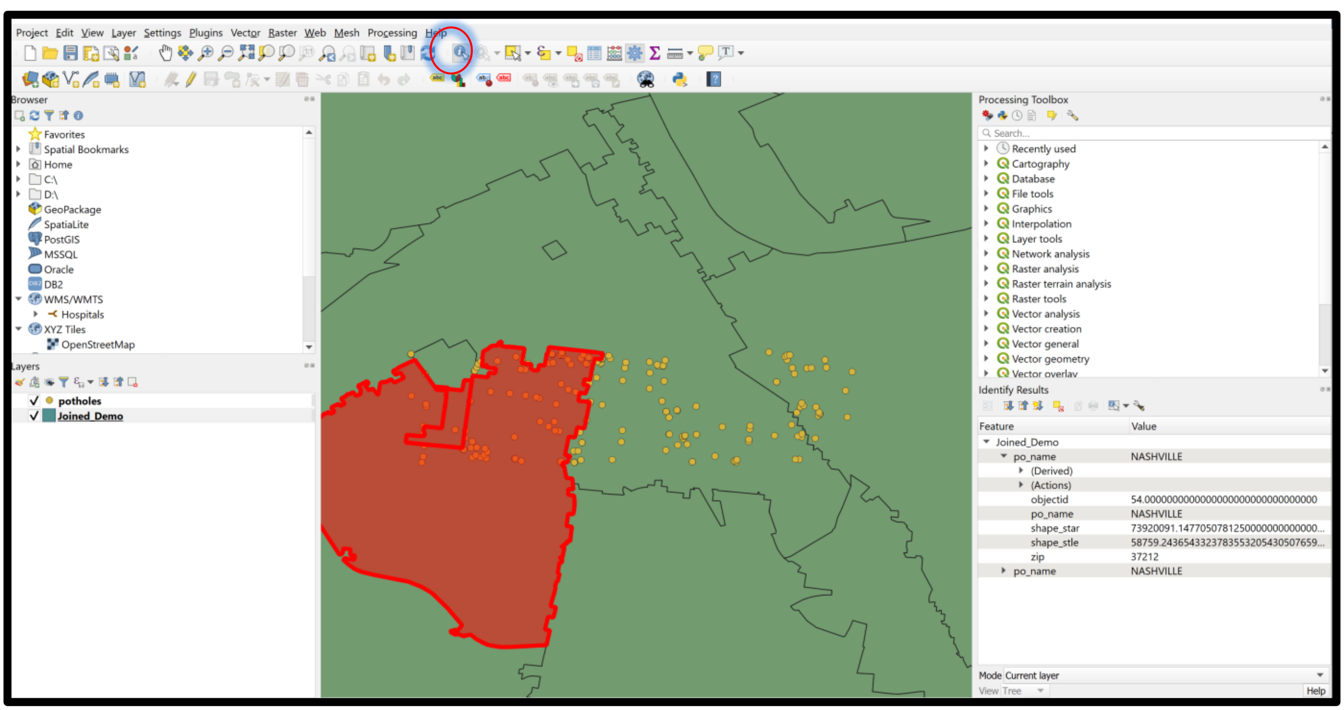


Select by Location

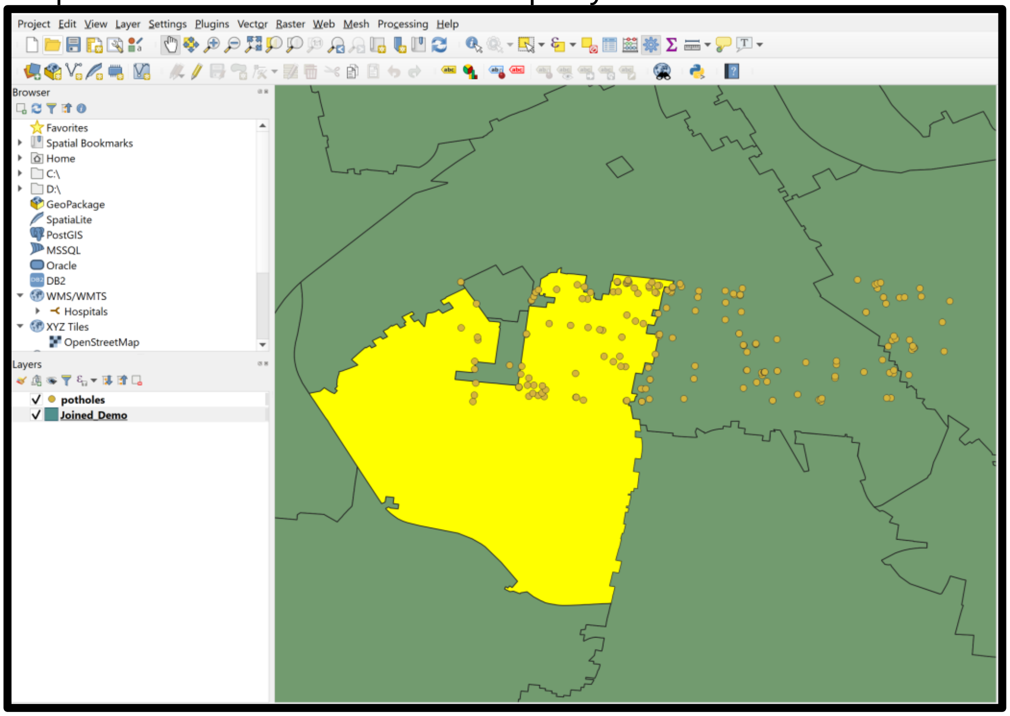
Add the **Joined_Demo** layer back into the map using the 'Add Data' button. Change the symbology of the **Potholes** layer back to a single symbol. Examine the distribution of potholes within the various zip code boundaries.



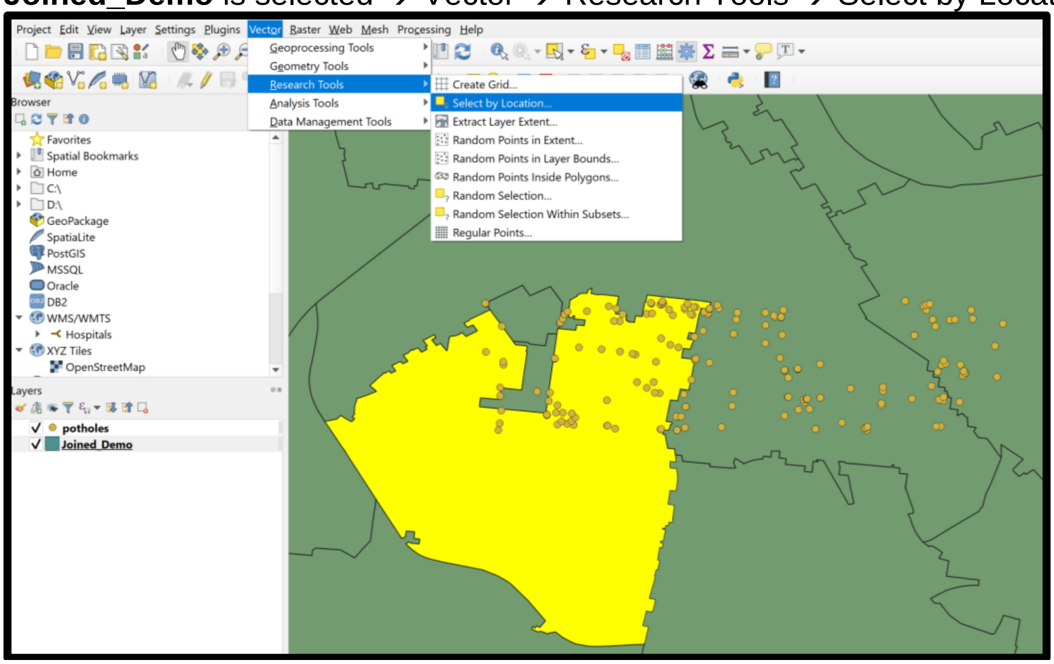
1. Click on the **Joined_Demo Layer** in the layers pane to set it as the active layer for selections. Click the Identify tool in the main toolbar and use it to identify each of the zipcodes in which a pothole falls.



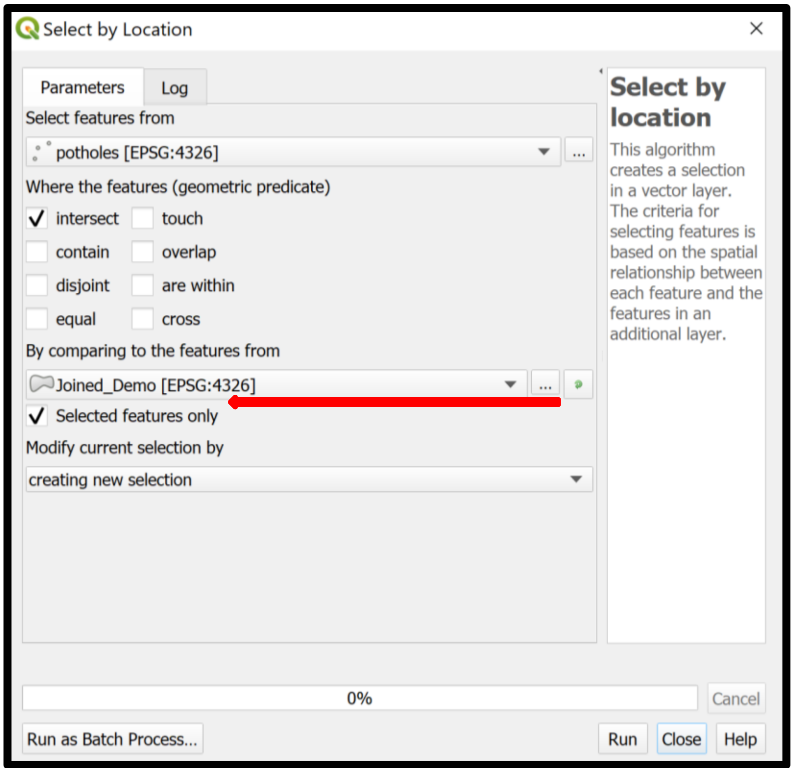
2. Use the Select Features by single click or area tool to select the 37212 zipcode shape. The selected area will show up in yellow.



3. We are going to select all the potholes that are within the 37212 zip code. Confirm **Joined_Demo** is selected → Vector → Research Tools → Select by Location.



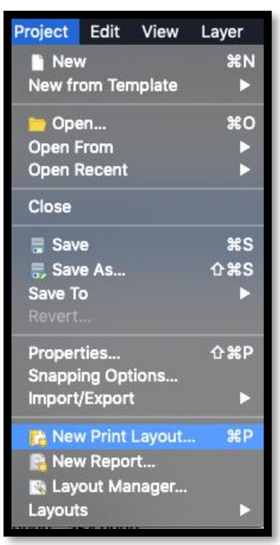
Select **potholes** as the layer to select features from, choose intersect as the geometric predicate, selected **Joined_Demo** as the comparing feature, and be sure to check the box that says 'Selected Features Only' under the comparing feature. This ensures we only select potholes in the 37212 zipcode.



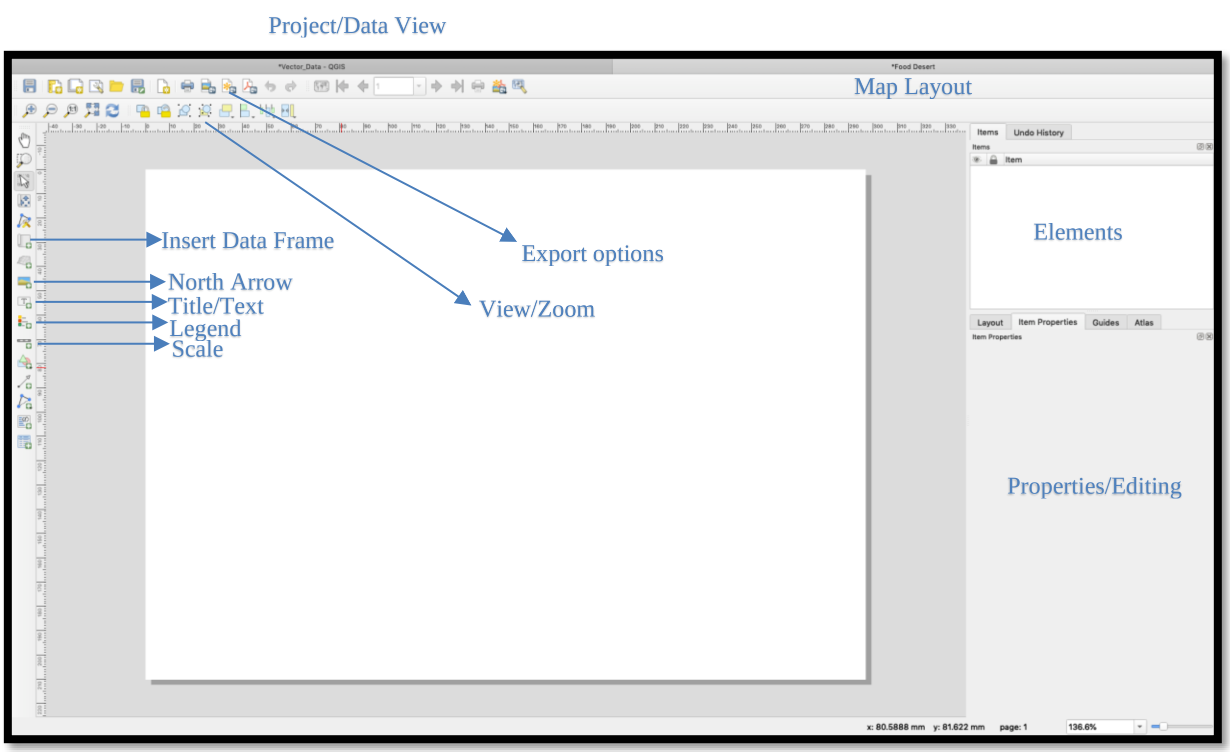
Creating a Map Layout

The map is complete and now to add the cartography and export it.

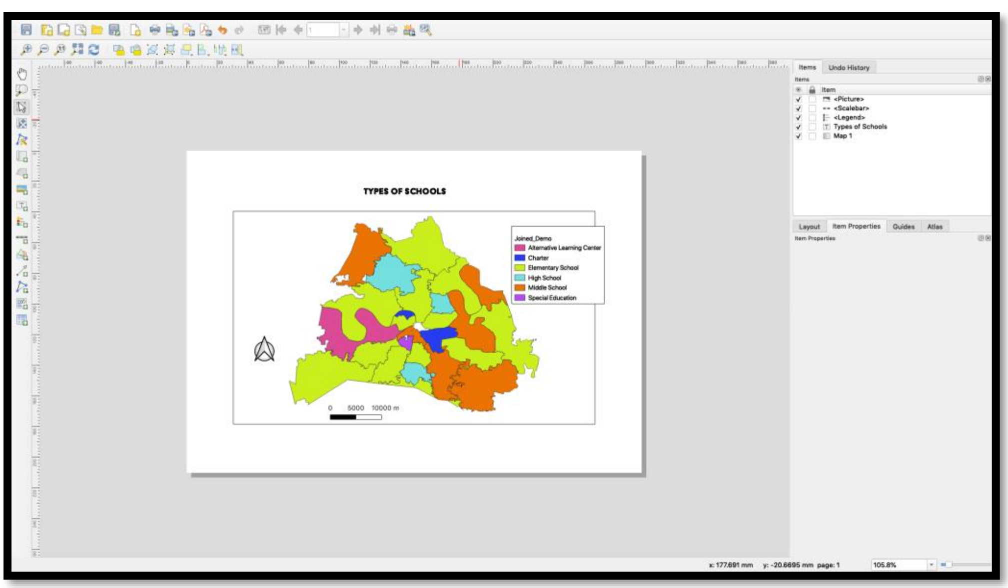
1. Create a new layout by navigating to Main menu → Project → New Project Layout



2. Name the map **Layout1** and the screen will open to a new layout with the following elements.



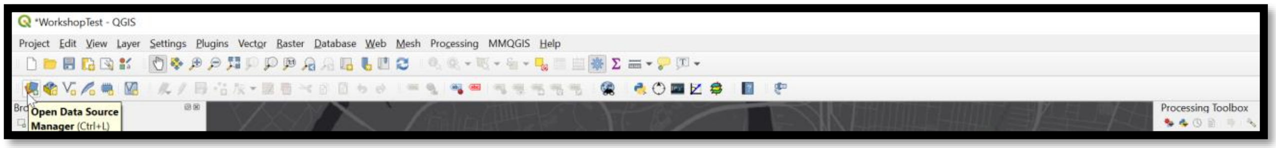
3. Draw a new Data Frame in the middle of the layout and add Title, Scale Bar, Neatline and North Arrow



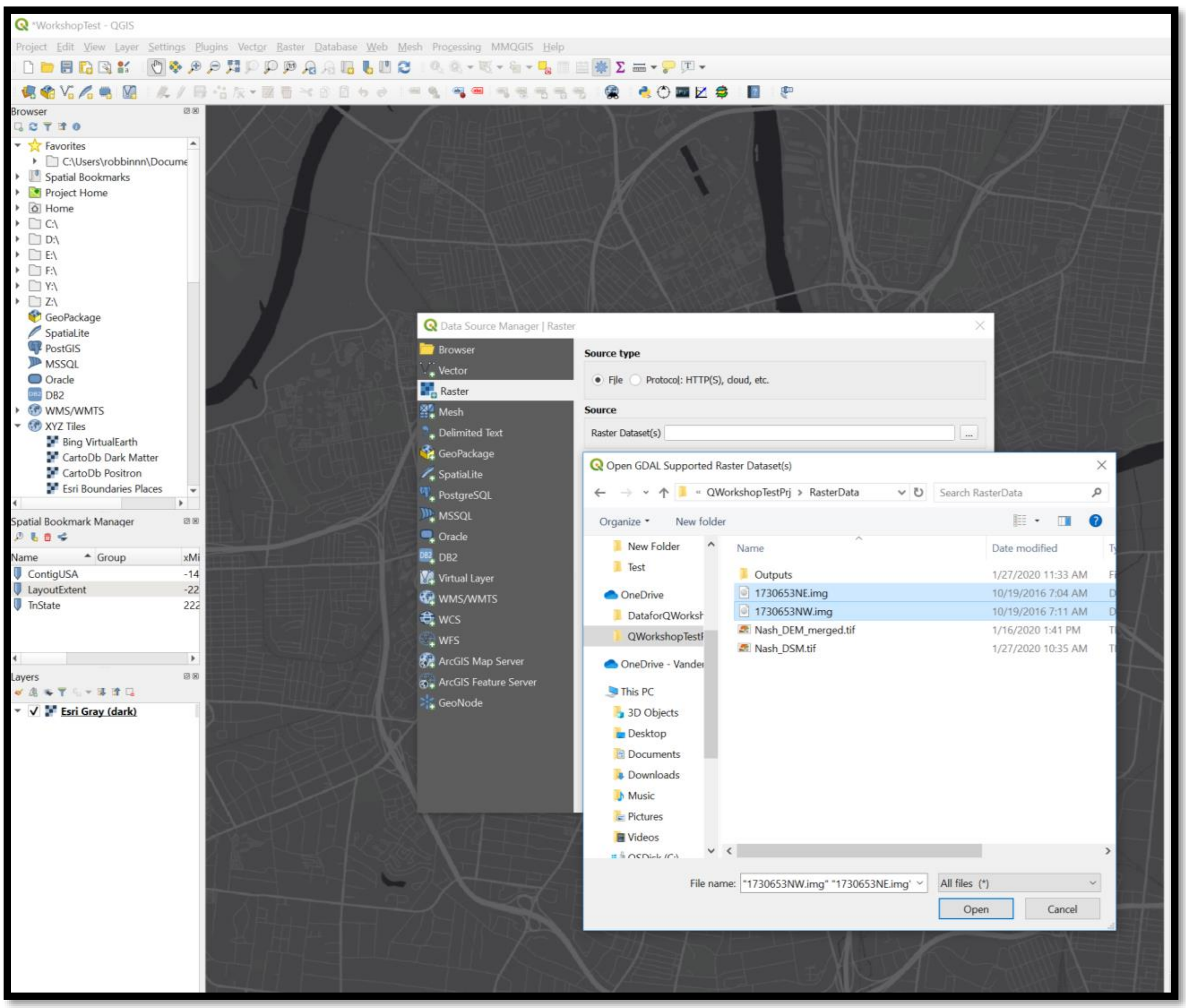
Raster Data

Adding and Merging Raster Data using Digital Elevation Models (DEM)

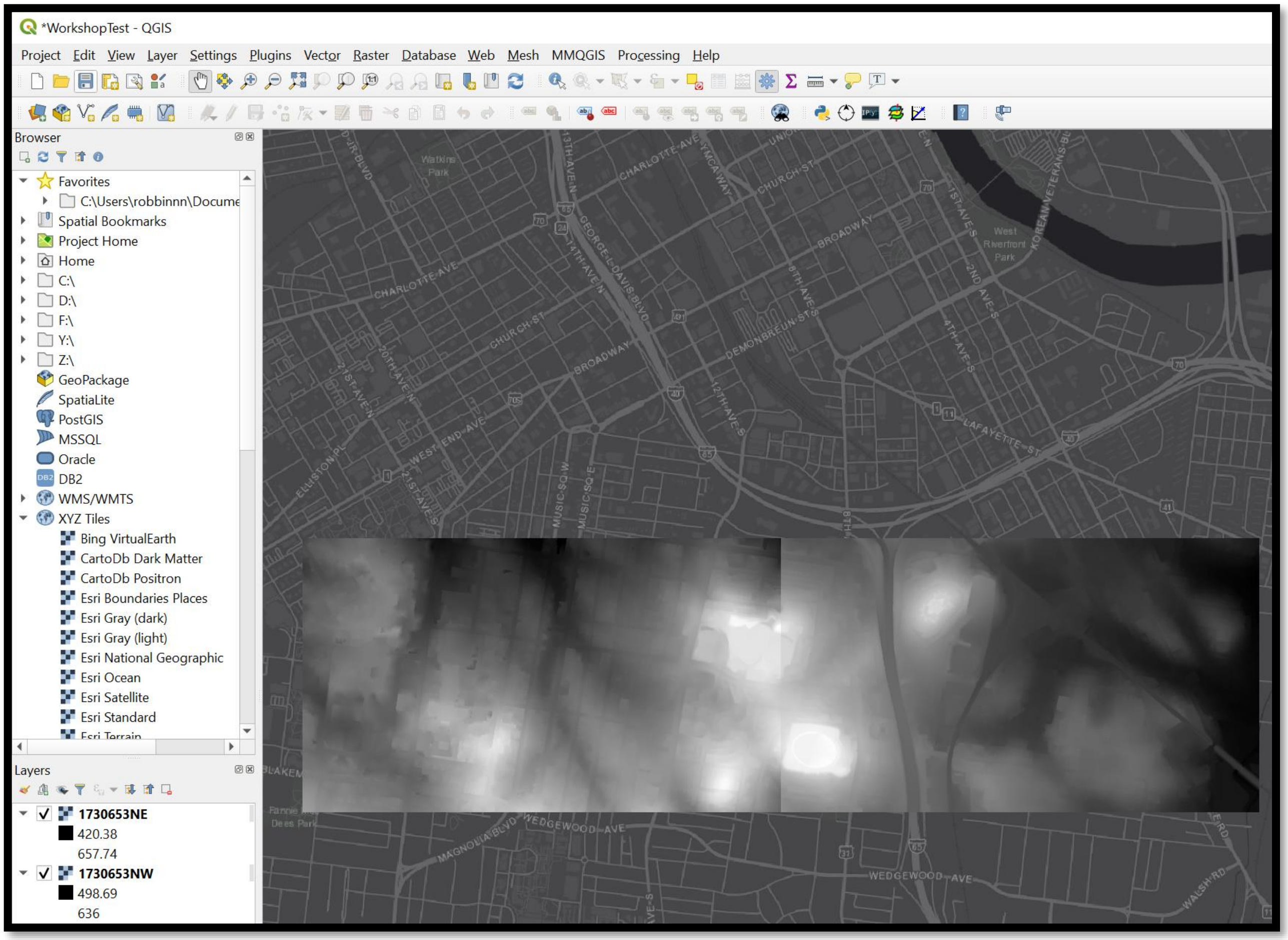
Step 1: Add the DEMs to the map.
Add the 2 DEM raster files to the QGIS project using the ‘Open Data Source Manager’



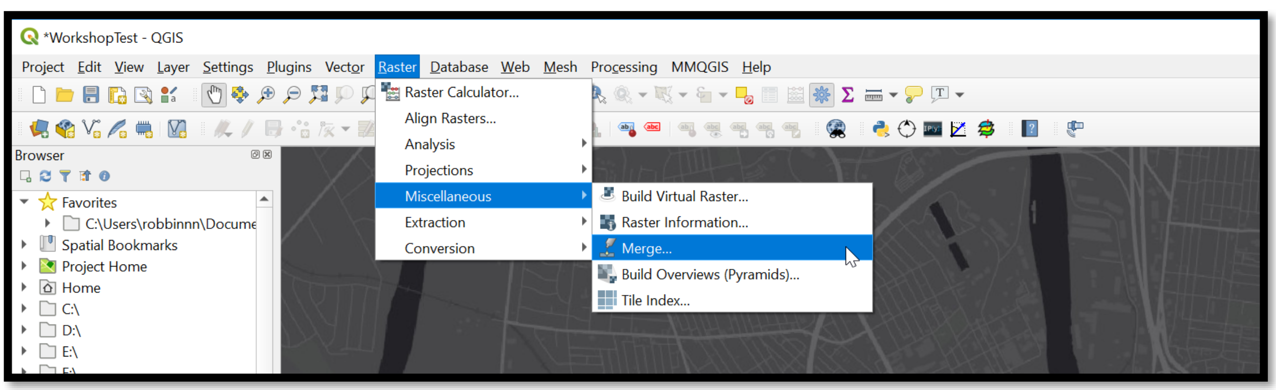
Choose Raster, and browse the directory to the file path ____ and select the two .img files, 1730653NE.img & 1730653NW.img. Select Open and then Add.



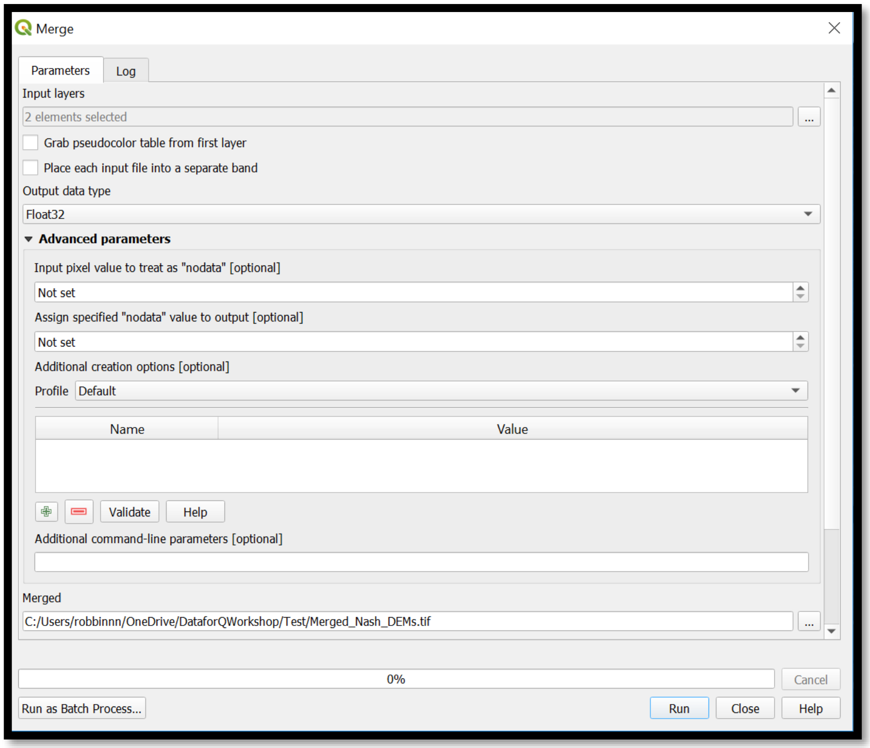
Your map should have two rasters over the Fort Negley area and Peabody College.



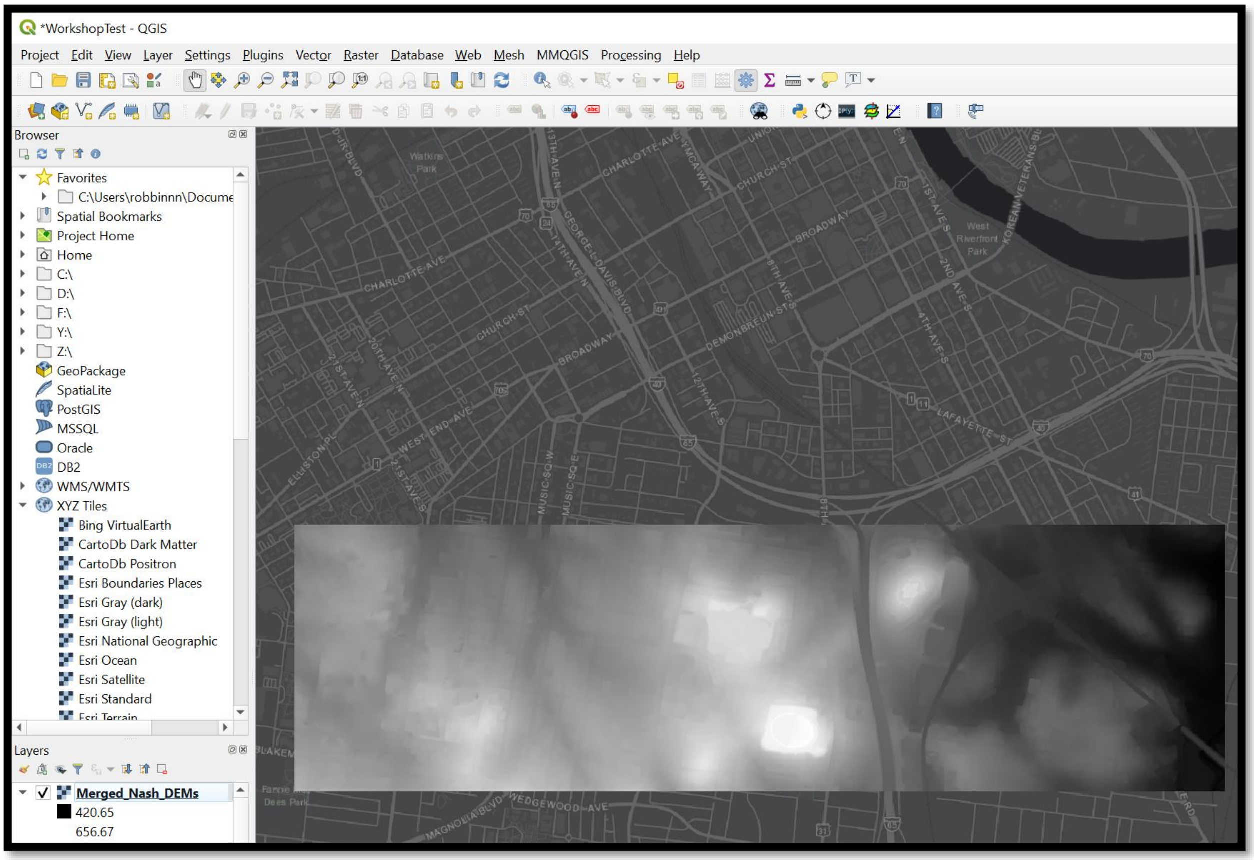
Step 2: Merge the two images into one continuous raster DEM.
Open the 'Merge' (GDAL) tool by browsing the Raster tab-> Miscellaneous-> Merge or by searching for 'Merge' in the Processing Toolbox pane.



In the 'Merge' tool window, select the two .img files you added to the project as your input layers, keep output data type as Float32 (same as the input .img files) and set an output location to your local C drive and call this Merged_Nash_DEMs. Run the tool.



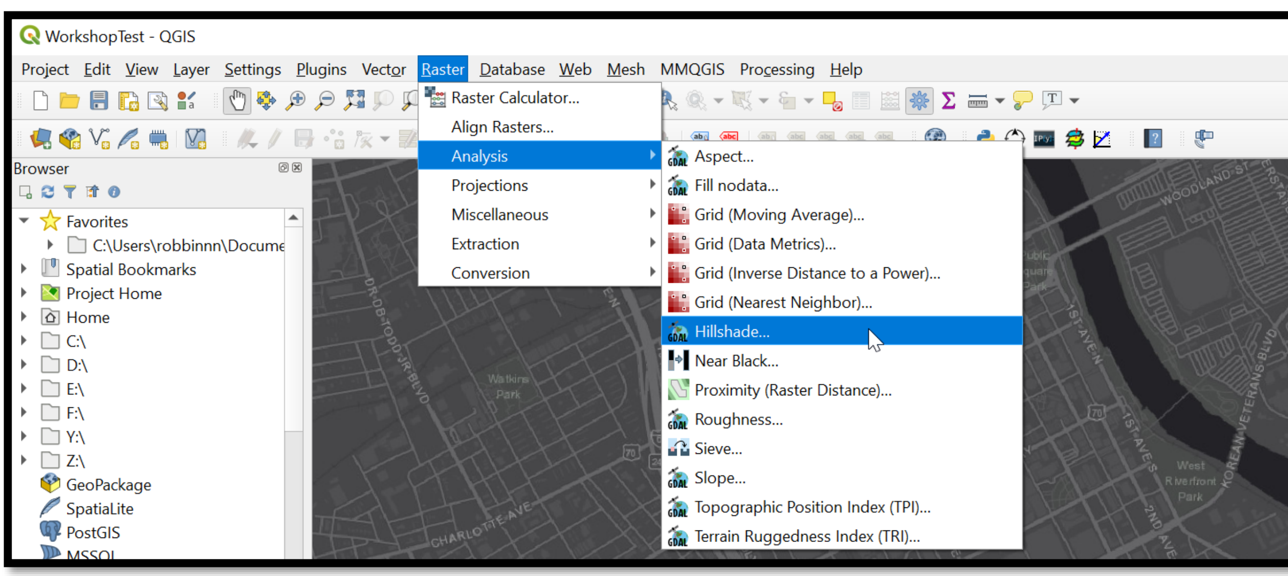
The output will be automatically added to the map and should looks as follows:



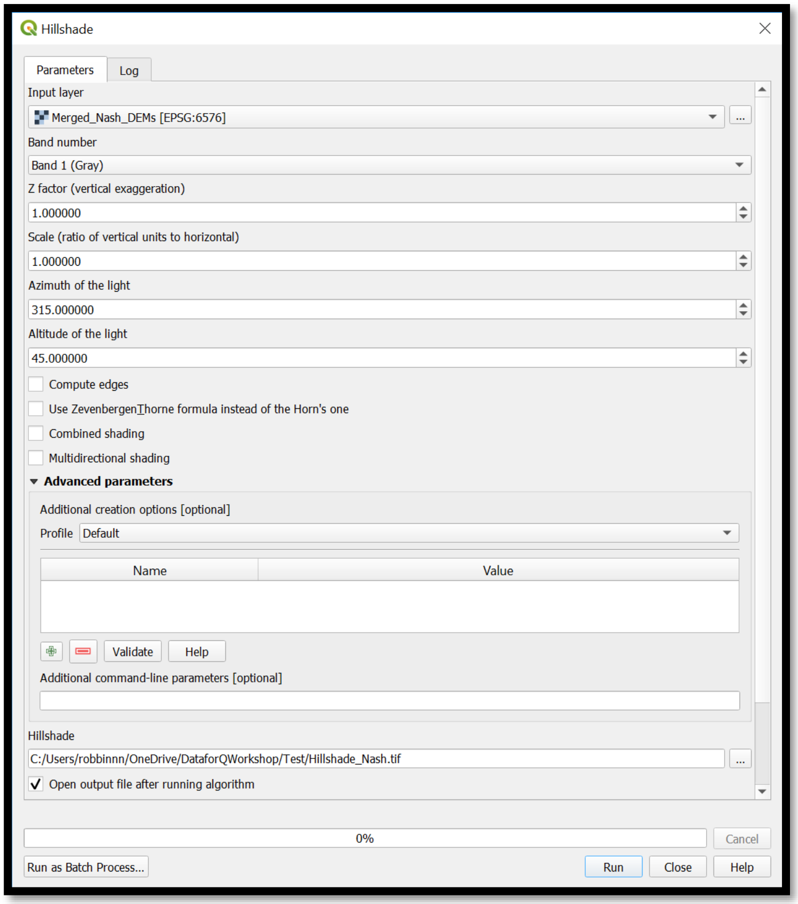
Creating a Hillshade

Step 1: Create a hillshade from the DEM.

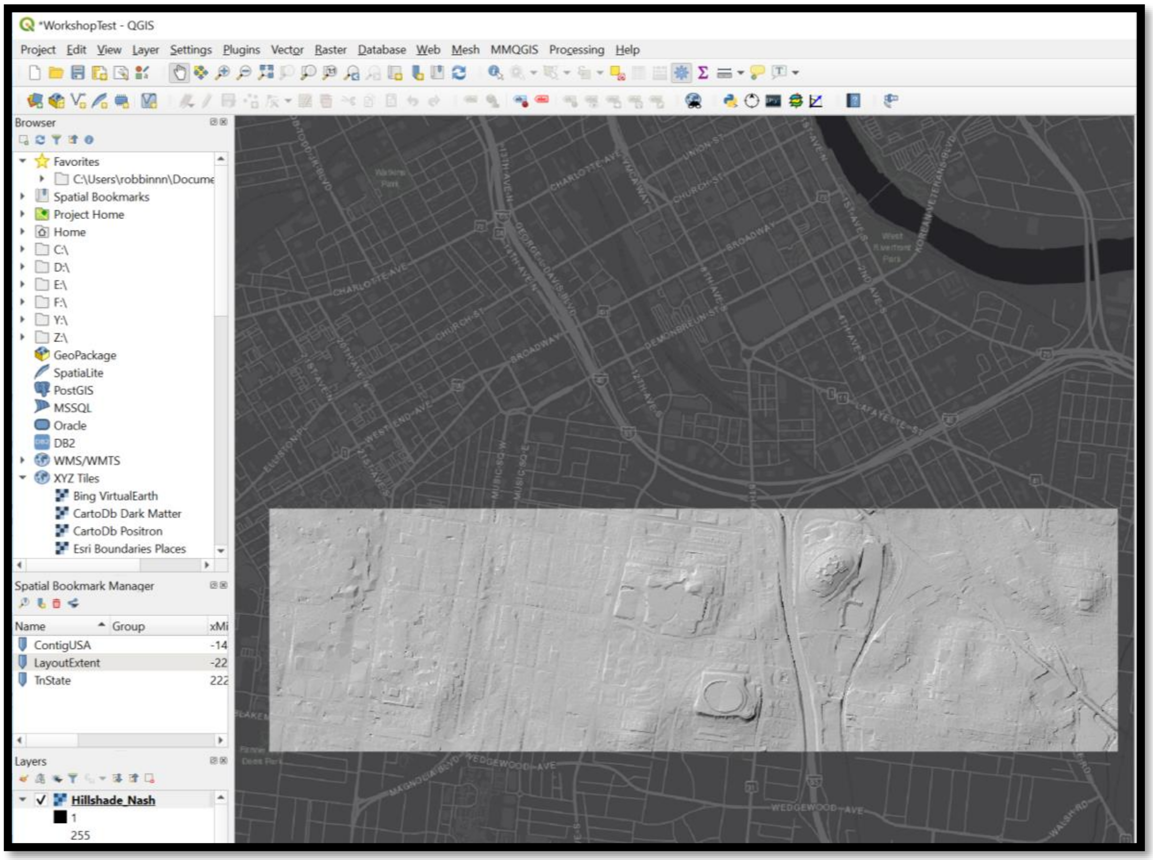
Find the ‘Hillshade’ (GDAL) tool by opening the Raster tab -> Analysis -> Hillshade or search for ‘Hillshade’ in the Processing Toolbox pane.



Set the input layer as the Merged_Nash_DEMs. Set the output location to your local C drive and name the new raster Hillshade_Nash. Leave the other presets and run the tool.

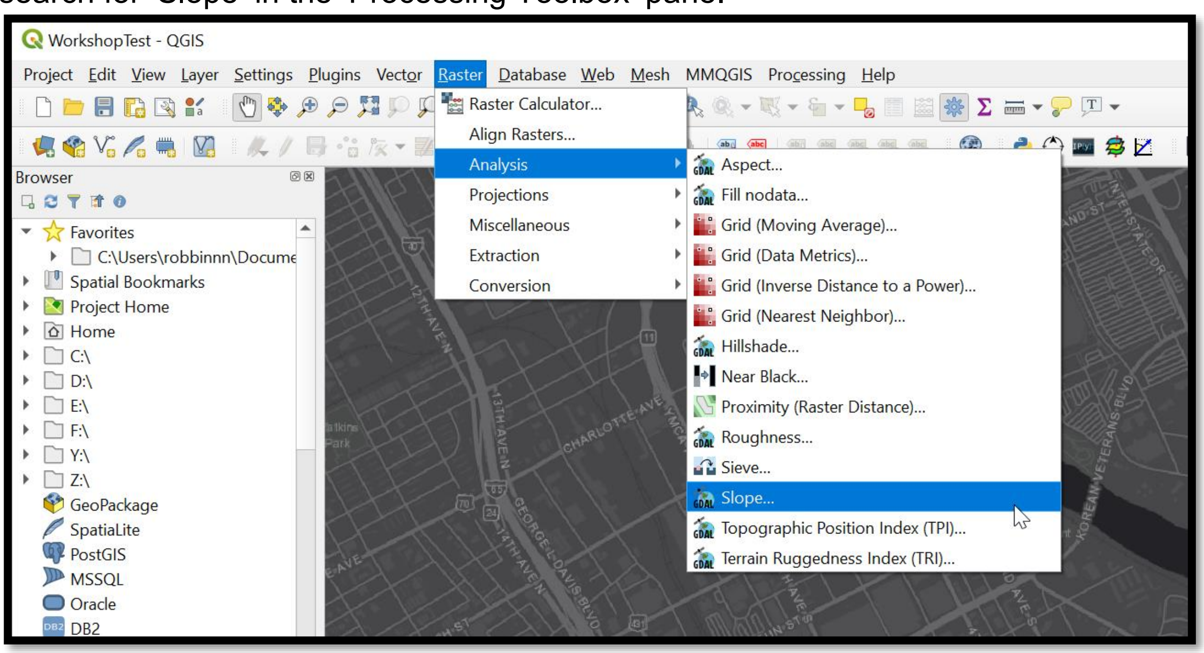


The output will be directly added to the map and should looks like below:

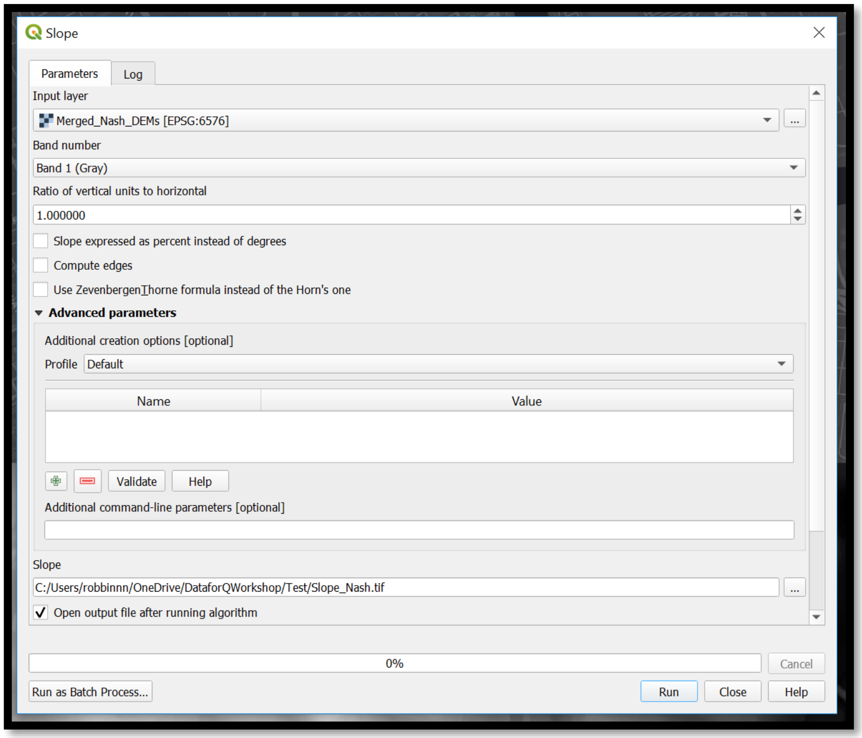


Analyzing the DEM

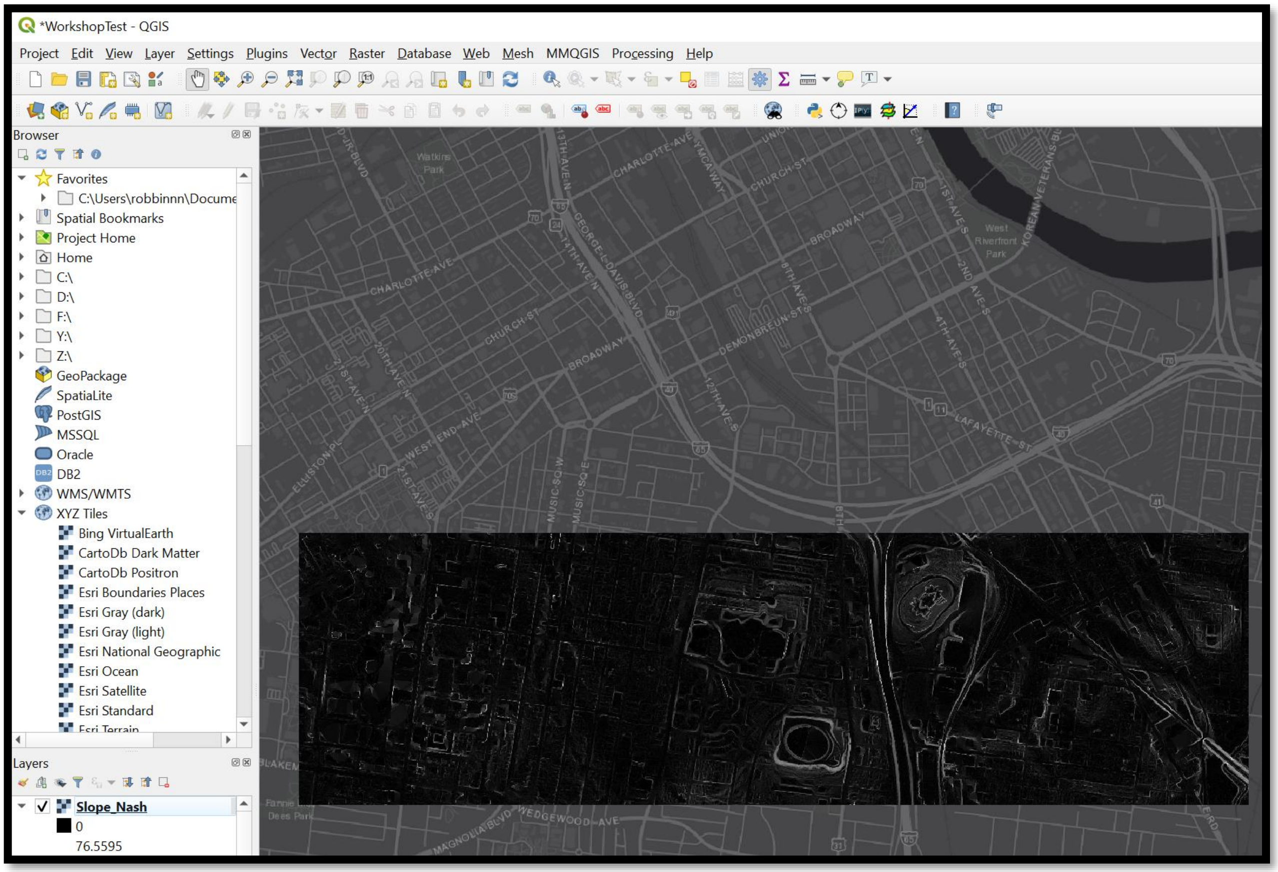
Step 1: Derive a slope raster from the DEM.
Find the ‘Slope’ (GDAL) tool by browsing to the Raster tab -> Analysis -> Slope, or search for ‘Slope’ in the ‘Processing Toolbox’ pane.



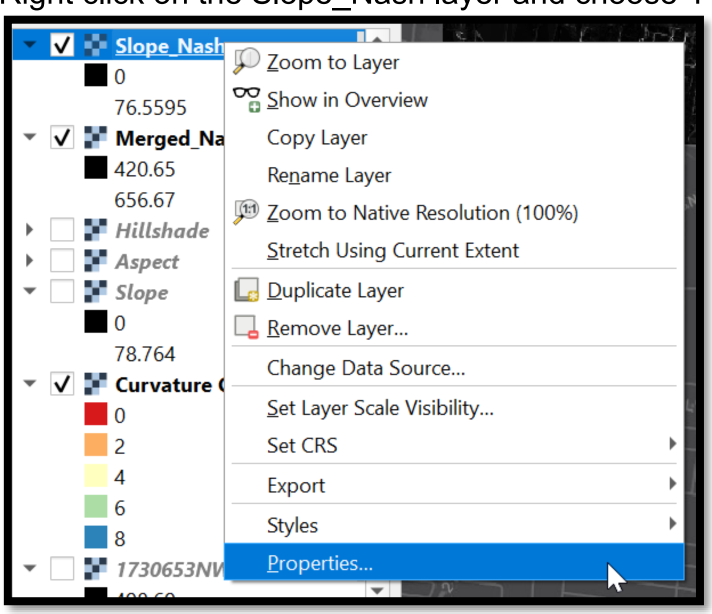
Set the Merged_Nash_DEMs as the input raster and set an output location to the Raster folder. Call the new raster **Slope_Nash**. Leave all other tool parameters the same and run.



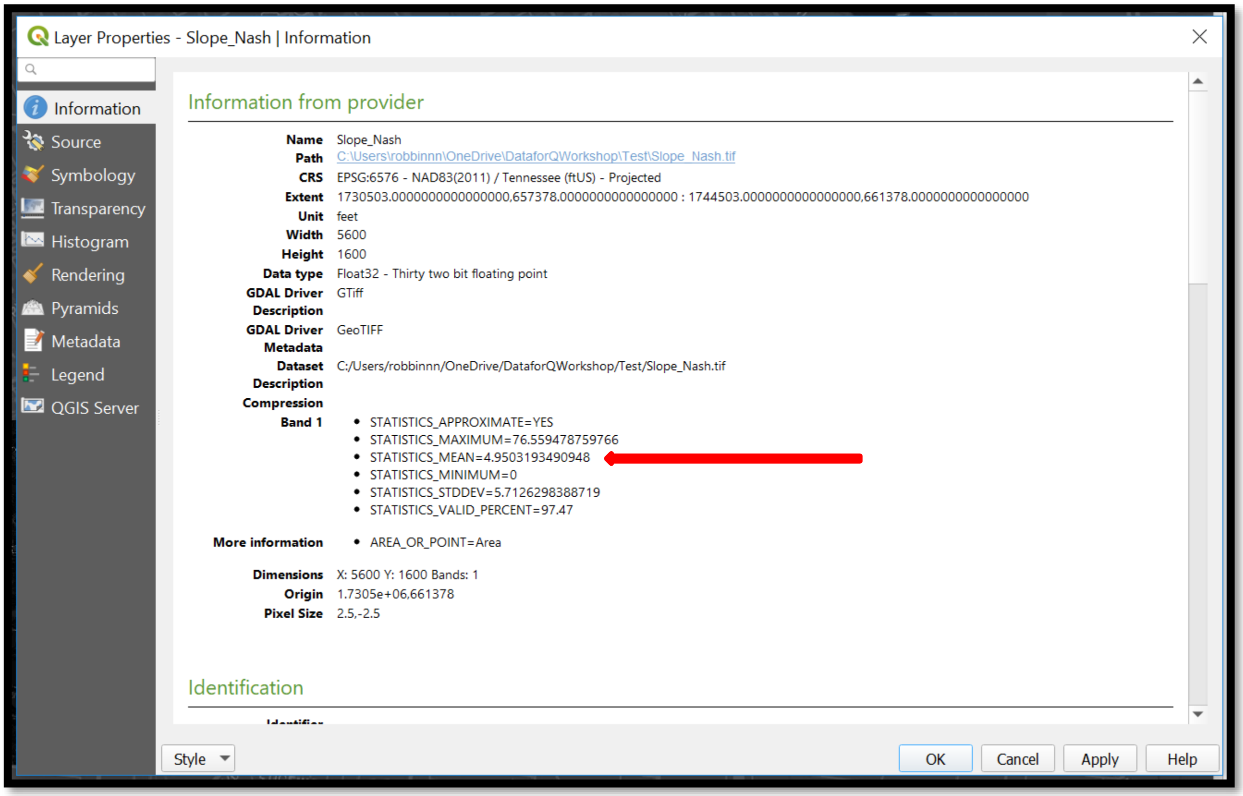
The slope raster will be added to the display and should look like below:



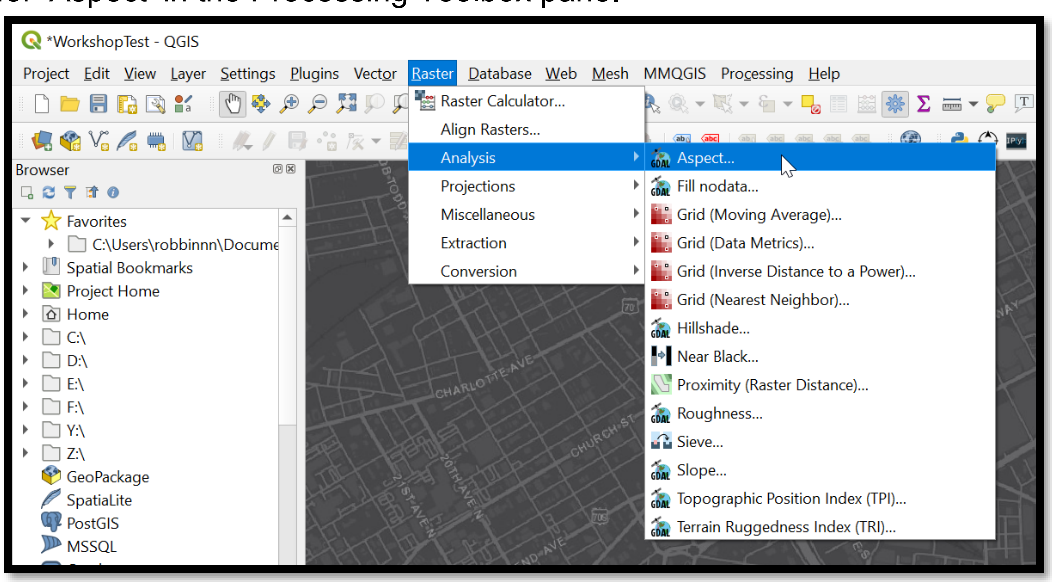
Step 2: Find the average slope of the area.
Right click on the Slope_Nash layer and choose 'Properties.'



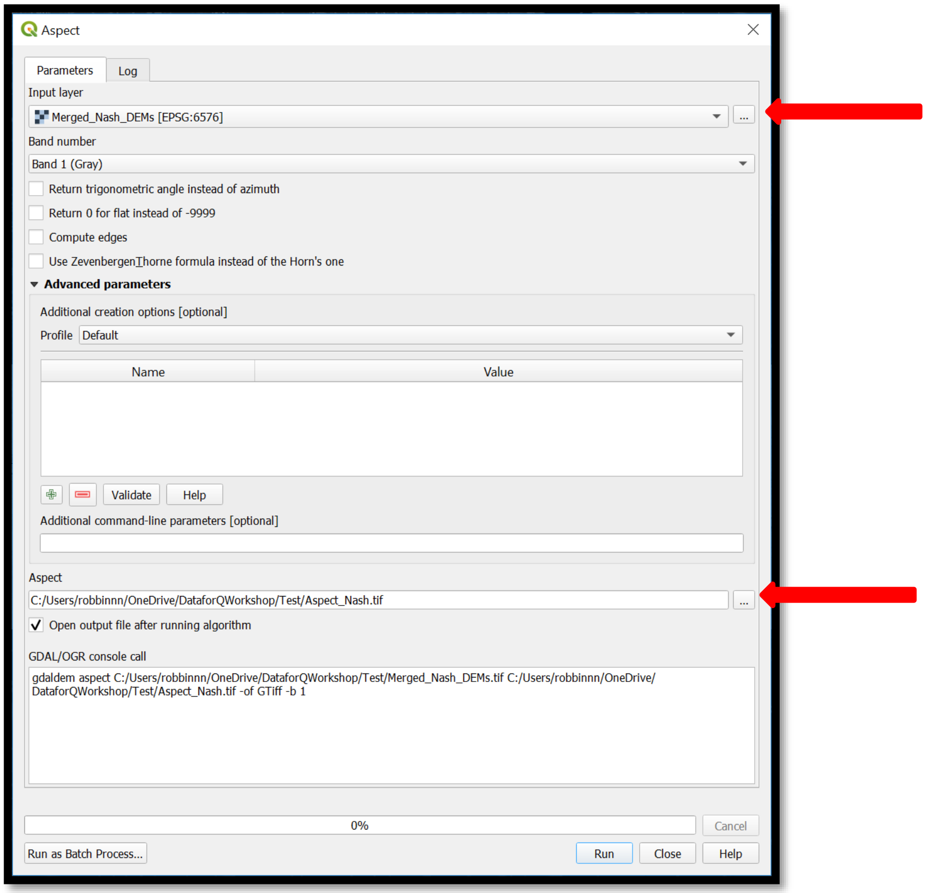
In the Information section of the Properties, look at the statistics to determine the average slope.



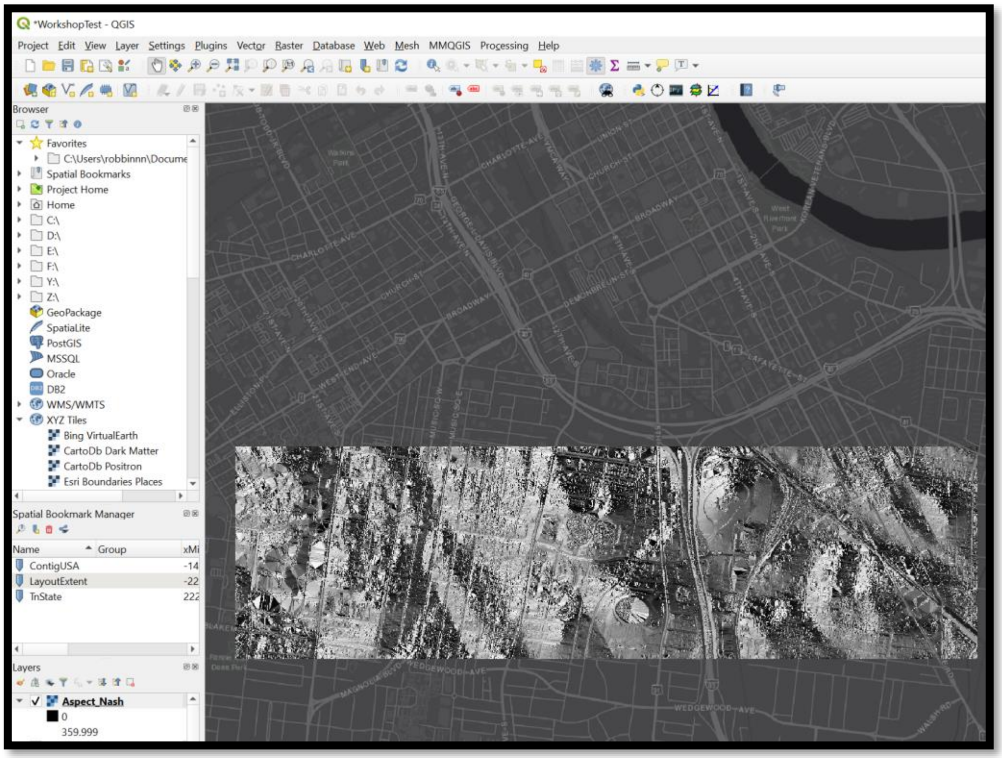
Step 3: Generate an aspect raster.
Find the ‘Aspect’ (GDAL) tool by opening the Raster tab -> Analysis -> Aspect or search for ‘Aspect’ in the Processing Toolbox pane.



Choose the Merged_Nash_DEMs as the input layer and set an output location to your local C drive. Name the new raster Aspect_Nash. Leave all other presents and run the tool.



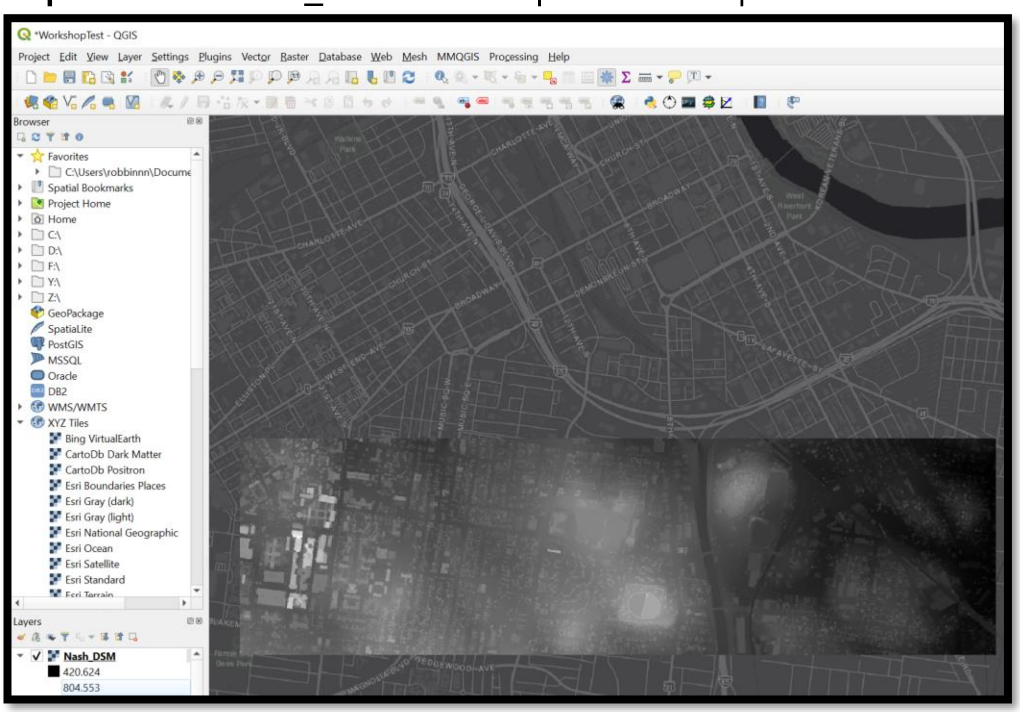
The output should be added to the map and should appear as below:



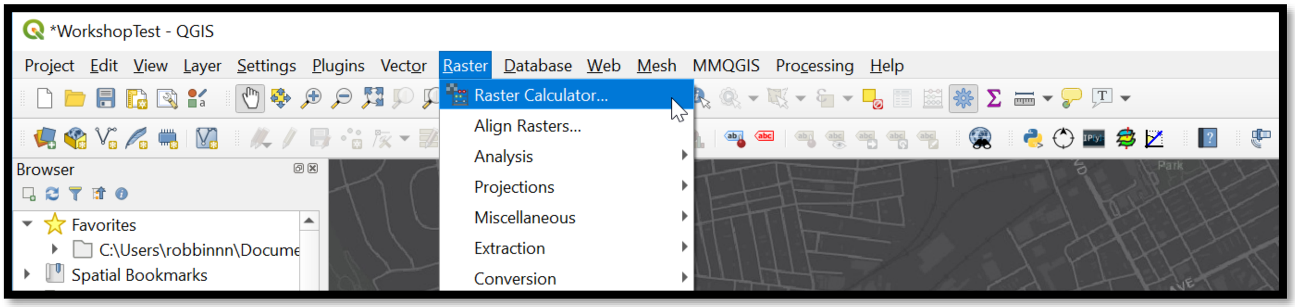
Working with Raster Calculator

Raster calculator is an essential tool for manipulating raster data to create new rasters or reclassify rasters. In this example we will use our Nashville DEM and a LiDAR derived digital surface model (DSM) to create a canopy height model (CHM).

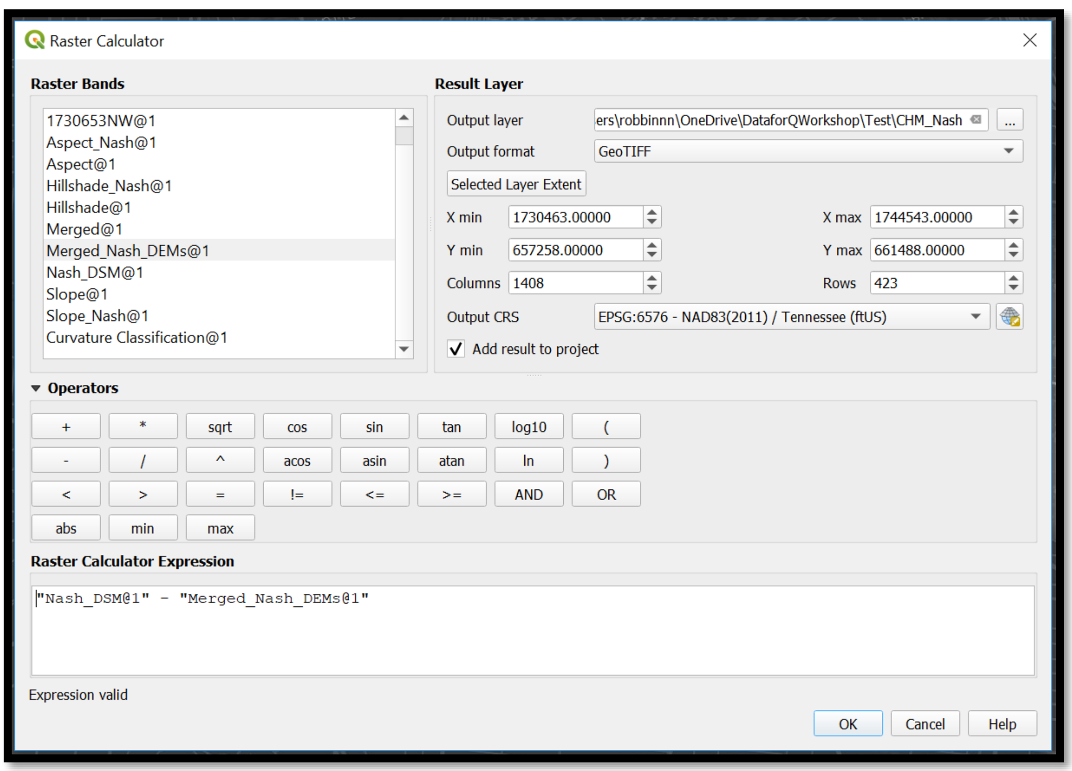
Step 1: Add the Nash_DSM to the map from the file path:



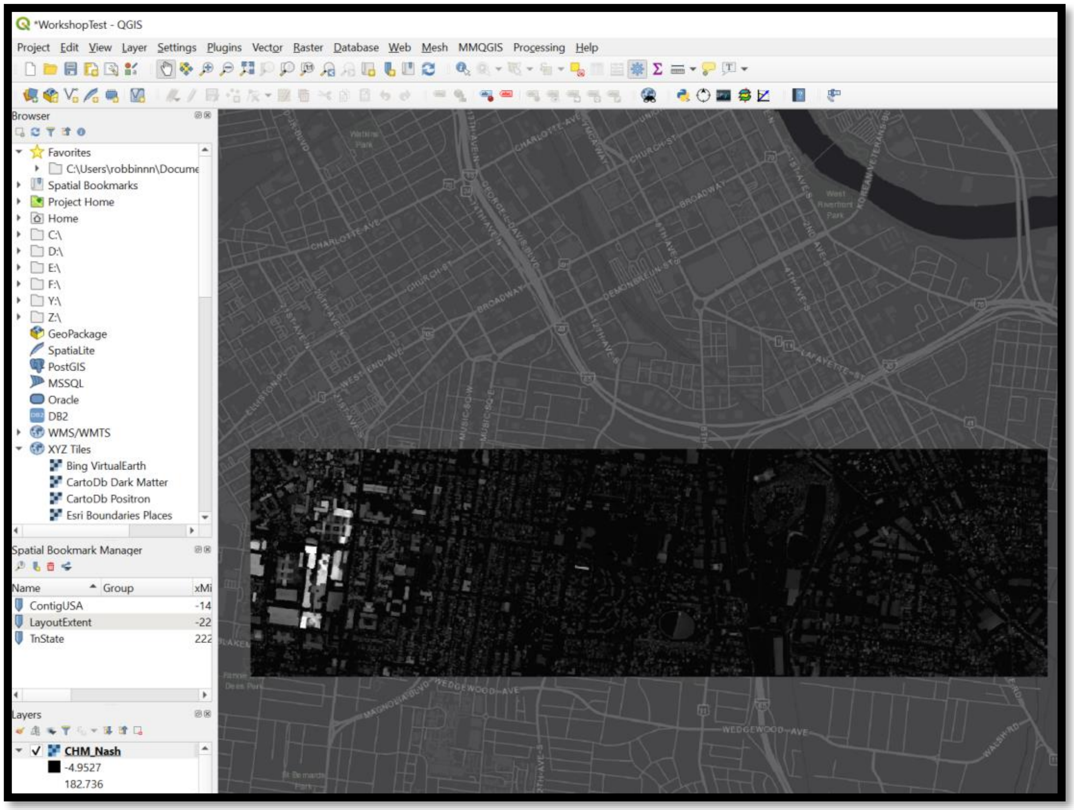
Step 2: Open the 'Raster Calculator' tool by going to the Raster tab -> Raster Calculator or search for 'Raster Calculator' in the Processing Toolbox pane.



Step 3: Using the 'Raster Calculator' we are going to create a new raster layer that represents the CHM. The CHM is calculated as follows CHM=DSM-DEM. In the tool window, specify an output location and choose GeoTiff as the Output format. In the expression window, write "Nash_DSM@1"- "Merged_Nash_DEMs@1". The raster names have a @1 after them because they all contain only one band. If you wrote the expression correctly you should see it say 'Expression valid' at the bottom of the tool window. Click OK.



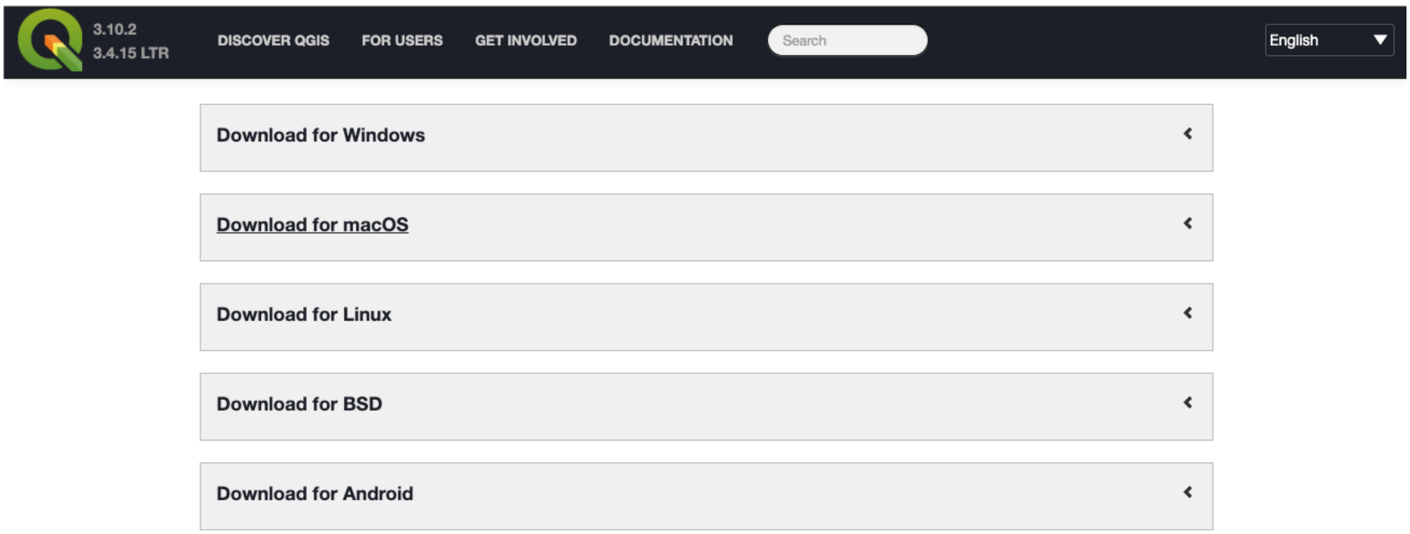
The new layer should be added to the map and should appear as below:



Additional Material

Installation

Recommended: Download the most recent version of QGIS available, with the most recent features, or the most recent Long-Term Release (Stable), which is designed to be maintained with bug-fixes and such for the next three release cycles. Long term releases might not have the newest features found in the most recent version, but focus is broader stability across time.



For Windows users:

Download and run the standalone installer, available here: https://qgis.org/en/site/forusers/download.html **(QGIS Standalone Installer Version 3.4)**. Choose 64 of 32 bit based on your computer.

For Mac OS users:

Download and run the standalone installer, available here: https://qgis.org/en/site/forusers/download.html **(QGIS Standalone Installer Version 3.4)**. Choose 64 of 32 bit based on your computer.

For Linux Users:

Follow instructions provided here: https://qgis.org/en/site/forusers/alldownloads.html#linux.

Add a Background Layer

When we import spatial data, we often like to visualize them over some sort of background layer, such as aerial imagery, or a simple map. This allows us to identify if layers are being displayed in approximately the right location, and it can help with some preliminary interpretation of data. For this exercise, we will utilize the QuickMapServices Plugin.

- Click on "Web" from the menu bar at top, navigate to "QuickMapServices Plugin" -> "Search QMS"; the search panel for this plugin will appear.
- By default, some Google layers will be available to load. If you click "Add" while selecting any specific layer, the newly added background layers will appear as the bottom-most layer.
    - You can also use the Search bar to find map services that are made available in this plug-in (e.g., search for Google, Bing, or Open Street Map).

Changing Projections (CRS)

For many operations it is necessary to have all layers in the same CRS; even if it is not necessary, it can help speed-up processing considerably. The DEM has elevation in meters, according the layer's metadata, and it is in a geographic projection (Lat/Long, NAD83). However, for computing some derivatives of elevation such as Slope, it is helpful to have the horizontal units the same as the units for elevation. Thus, we will work in a projection that is also defined in meters, the Albers Equal Area Projection. This projection may cause some distortion in shape, but maintains accurate area measurements. This is just a demonstration, and in doing your own work, it is important to consider how spatial distortions may manifest in different projections.
The steps for converting the CRS of raster and vector layers are somewhat different. Furthermore, when converting the CRS of raster layers, it is important to think about how resampling may cause distortion.