Intro to ArcGIS
PM 569 – Spatial Statistics

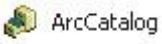
1. **Installing ArcGIS** (only on MS Windows machines or partitions)
   You can obtain a student copy of ArcGIS through the Spatial Sciences Institute. Please look here: http://spatial.usc.edu/index.php/software/proprietary-software-free/

2. **Introduction to the ArcGIS interface**

   The ArcGIS 10.2 interface is comprised of two main components:

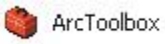
   ArcMap: 

   is the central application in the ArcGIS Desktop. It is the GIS application used for all map-based tasks including cartography, map analysis, and editing.

   ArcCatalog: 

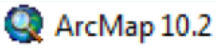
   is an application that will help you organize and manage all of your GIS data.

   The main spatial tools are in ArcToolbox, which is available through ArcMap and ArcCatalog. We primarily access it through ArcMap.

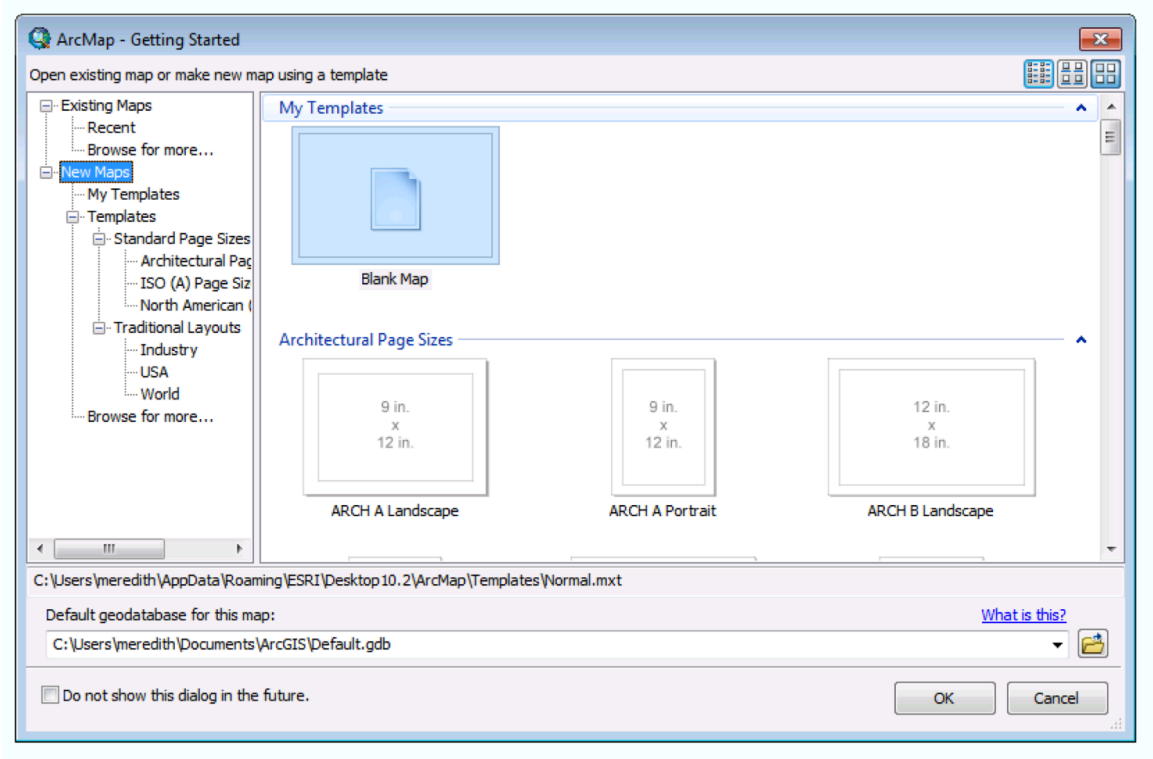
   ArcToolbox: 

   is a simple application containing many GIS tools used for geoprocessing. There are two version of the toolbox: the complete ArcToolbox version that comes with ArcInfo and a lighter version that comes with ArcGIS and ArcEditor software. GIS functions available in ArcGIS can be accessed through ArcMap, ArcCatalog or ArcToolbox.

   2.1 Getting Started in ArcGIS: ArcMap

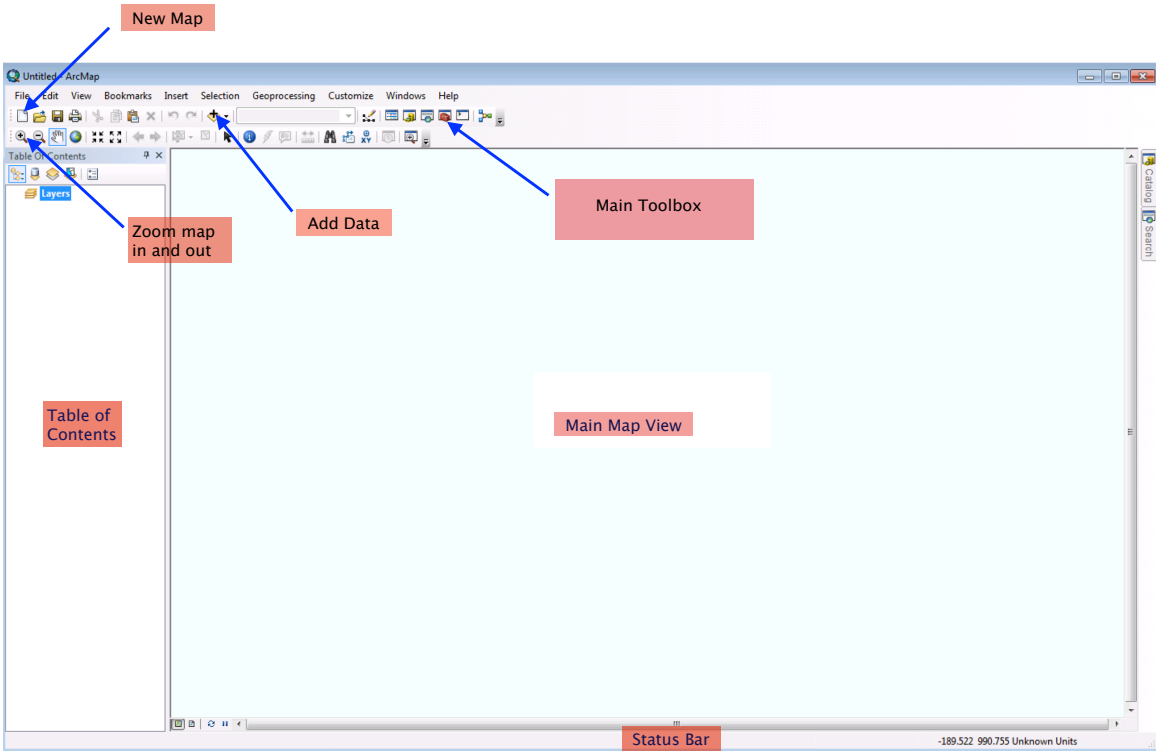
   Since ArcMap is the primary mapping component of the ArcGIS system, it is the most logical initial entrance point. From a windows based machine start ArcMap by navigating to your programs and selecting 

   Once loaded (and this may take time the first time you start it up), an ArcMap dialog box appears and offers several options for starting your ArcMap session. When the Getting Started window pops up, click on New Maps under the "Open existing map or make new map using a template" heading on the left. Under My Templates, select Blank Map. Click OK at the bottom of the window to open a blank map in ArcMap.

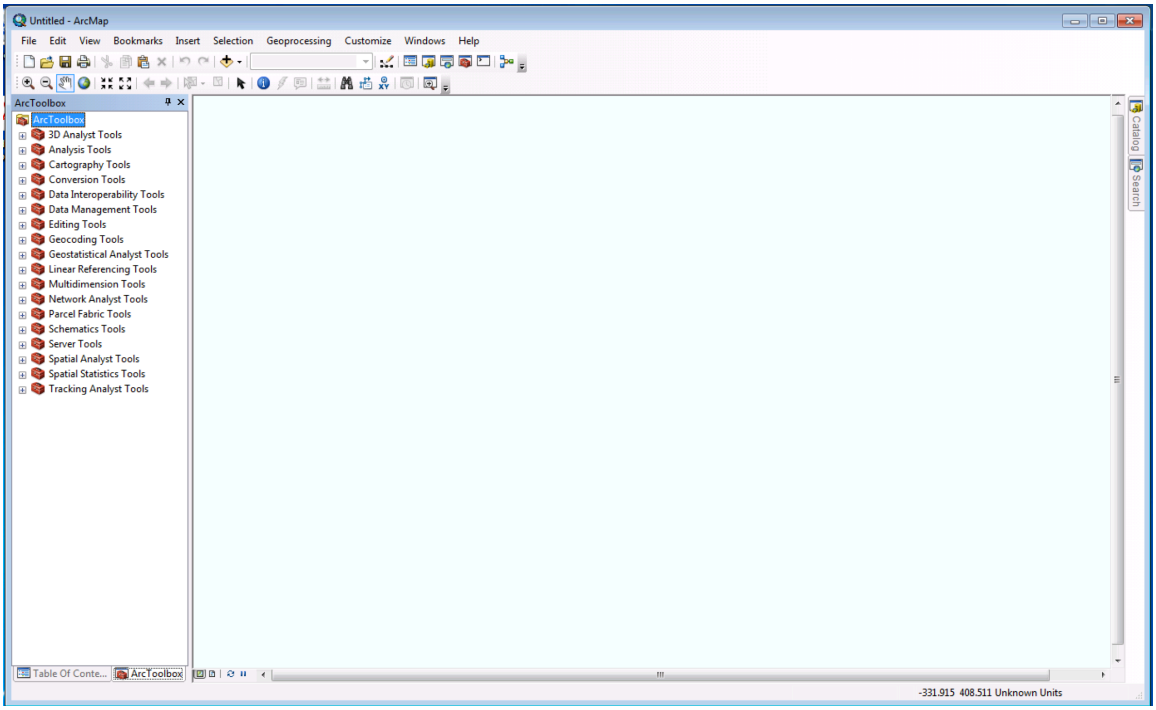


When you open it in the future, you will have options to select previously saved maps.

When a blank map has been selected, the main ArcMap window will automatically open. Now you can see ArcMap Window in the Geographic Data View.



ArcToolbox is routinely used, so it is handy to dock it in the ArcGIS window. Click on the main toolbox icon and when the toolbox opens, drag it to the left. Once placed on the left, when you double click it will dock as a tab with the Table of Contents.

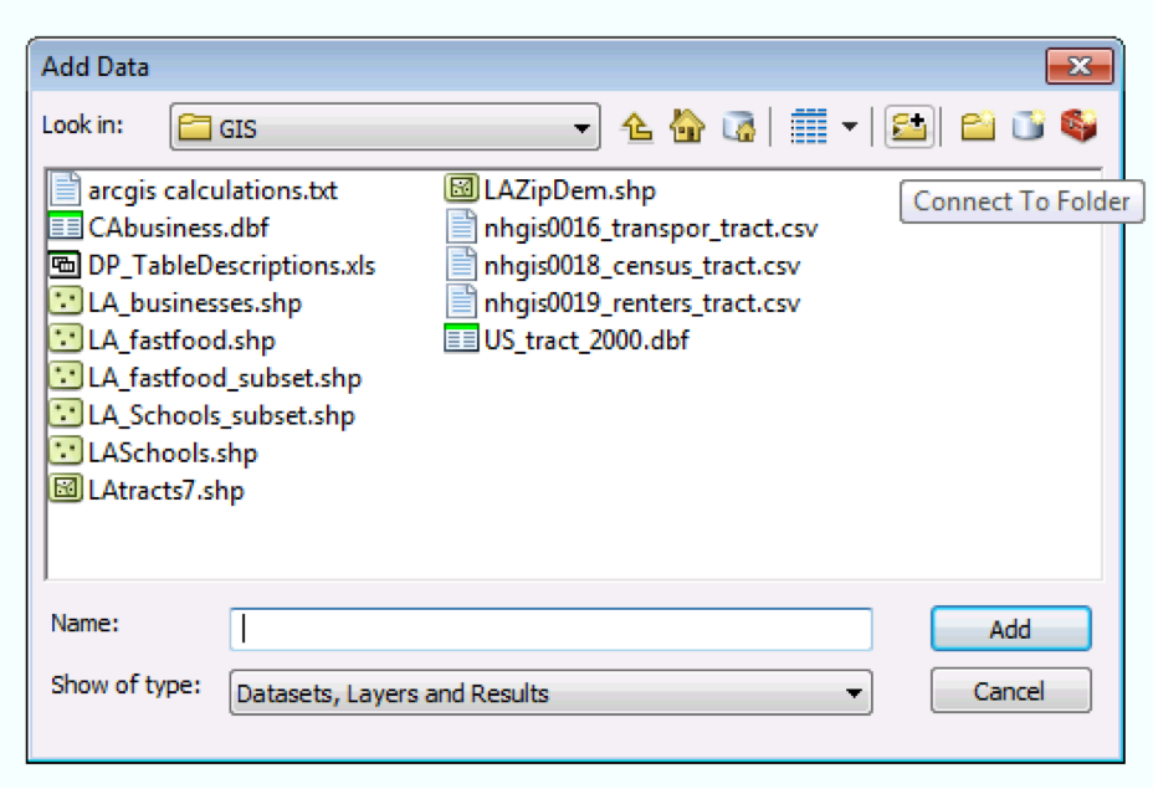


2.2 Adding Data

In this step, you will add data to your ArcMap document. An ArcMap document does not contain the data itself, but rather includes layers that point to data sources. We will use the LA Zip code data set, the CA weather station data, and a schools data set.

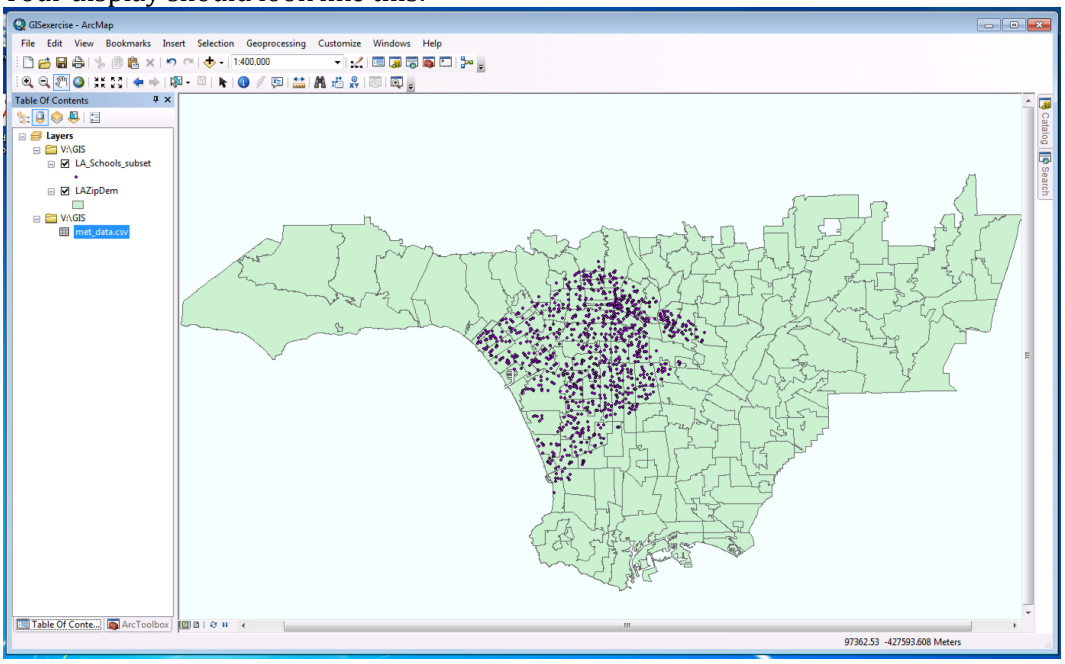
a) In ArcMap, click on the ADD DATA button. 

b) Navigate to the folder where you have saved LAZipDem.shp. Note, you may have to add a folder connection



Click ADD.
c) Click the ADD DATA button again, and then navigate to LA_Schools_subset.shp
d) Click the ADD DATA button again, and then navigate to met_data.csv
d) Click the SAVE button and navigate to your preferred folder. Save the map as GISexercise.mxd.

Your display should look like this:



2.3 Using the Table of Contents

The Table of Contents is the pane at the far left of your screen that lists the data layers that you have added to your map document – in this case LAZipDem, LA_Schools_subset, and met_data.csv. You will work within the TABLE OF CONTENTS anytime you are in ArcMap– it is the place to go to access layer properties, attribute tables, and more. Right now you will just get used to the way ArcMap draws data layers.

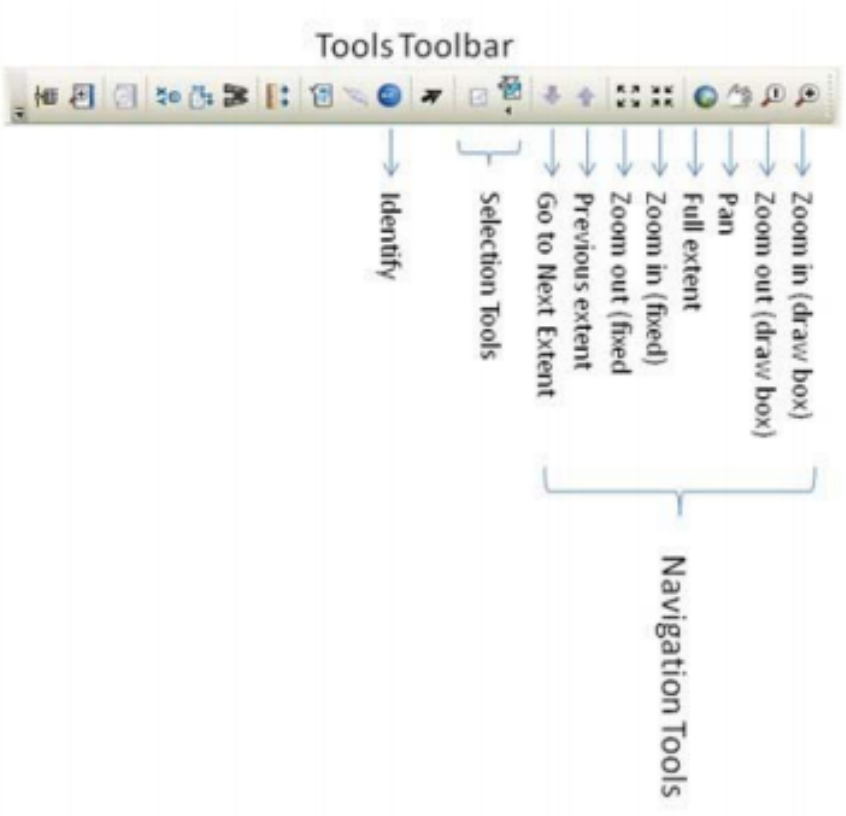
a) Note that LA_Schools_subset is at the top of the TABLE OF CONTENTS, and LAZipDem is below it. ArcMap always draws layers from the bottom of the TABLE OF CONTENTS up, so in this case towns are drawn first, and roads are drawn on top of them. Click on the layer name LAZipDem and drag it to the top of the Table of Contents. What happens? (You should see that the zip codes now cover up the schools, because they are drawn on top of the schools layer.)

b) Return LA_Schools_subset to its original position below LAZipDem.shp.

c) Click the check box next to LAZipDem.shp on and off. Notice the effect this has.

2.4 Using the Navigation Toolbar

Let's start exploring some GIS data. The Tools Toolbar, usually located horizontally at the top of the screen, has eight tools to help navigate. It also has several other tools to help you with basic functions like selecting and identifying features, measuring distance and area, and finding XY coordinates on your map. The most common tools are briefly described below.



We will go through each in class.

- The **identify tool** provides attribute information about selected features. Click on a geographic feature to get its attributes. The features in all visible layers under the pointer will be identified. The Identify Results window will appear automatically when you use this tool. The Identify Results window contains a dropdown list that lets you control precisely which layer(s) you want to identify features from with the Identify tool. You can either choose a particular layer or one of four generic settings: top most layer, visible layers, selectable layers, and all layers. 
- **Selection Tool** highlights features for a user-defined area. The data may be subset or identified based on this selection. 
- The **extent arrows** cycle through extents that you have previously viewed.
- The **fixed zoom** in and out will keep the map centered at it's current location and will zoom in or out. 
- **Full extent zooms** out to the full extent of all data in your map. 
- **Pan** moves the map around. 
- **Zoom** in and out with the magnifying class allows you to draw a box around an area and the extent will zoom in or out on that specific area. 
- The measure tool will help you measure distances on your map. As you draw a line with this tool, the length of the line is shown in the status bar. You can draw a line with multiple segments. Click once to start a new segment. Double-click or hit ESC to finish. The distance is shown in the Distance Units specified in the Properties dialog (Right click on the layer in the TOC to get the dialog box titled Data Frame Properties, then the General Tab shows Units for the Map (meters) as well as the Display. You can change the Display to Kilometers or Miles if you prefer). You cannot change the Map Units. 

2.5 Attribute Tables

Attribute tables are the data behind the map. Each layer will have an attribute table associated with it. In ArcGIS the attribute tables are used to perform queries, examine or edit the data. To open the attribute table, right click on the desired layer or spatial data file and select Open Attribute Table or from the menu. Try doing this for any of the layers you have open. Once the Attribute Table is open, arrange it on the screen so that you can see both the Map screen and the attribute table. You may have to minimize the ArcMap session.

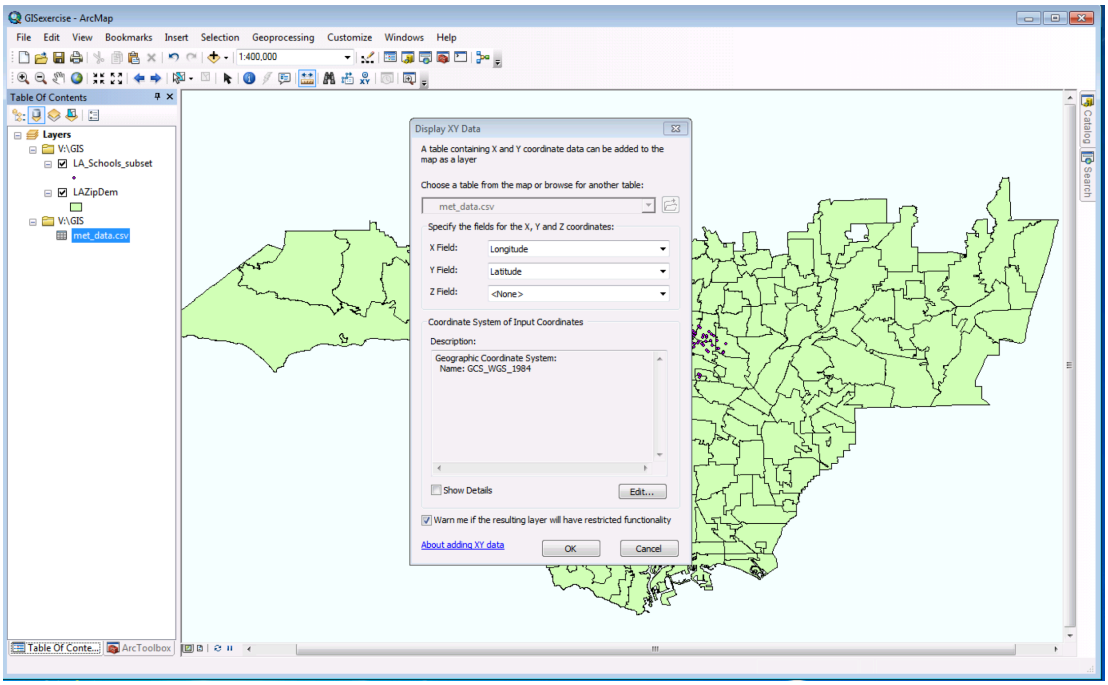
You will notice now that the two screens are dynamically linked. If you select an object on the ArcMap session, its attribute value is highlighted in the attribute table. Conversely, a selection made in the table is highlighted on the map. Experiment with making selections in both the attribute table and in ArcMap.

2.6 Adding a Spatial Reference

While met_data.csv is in your Table of Contents, we don't see it on the map. You must indicate the latitude and longitude in ArcGIS so that it knows what to display. An added complication is defining the projection. The projection can be tricky because it depends on whether the other layers in your map already come with a projection or your map has a predefined projection. Please refer to http://isites.harvard.edu/fs/docs/icb.topic923260.files/Lab2_11.pdf for additional examples and details on projections.

To display xy data:

- Right click on the data file in the TOC
- Select Display XY Data…
- In the X field put Longitude and in the Y field put Latitude
- Select Edit… to define the coordinate system of the input coordinates. In this case, we will use a very general coordinate system WGS_1984. Navigate to Geographic Coordinate Systems, then select World. Scroll down to WGS 1984. Select OK.
- In the Main Display XY data window, select OK. If you get a warning message that the layer doesn't have an ObjectID, that's ok, just click OK again.



Now you will see that we have a new points layer called met_data.csv Events. This is still a temporary points file, so we need another step to make it a permanent shapefile.

- Right click on met_data.sv Events and select Data -> Export Data…
- In this case we want to export all features using the same coordinate system as the layer's source data.
- Name the feature class something that you will remember, and place it in a directory with the other shapefiles for this exercise.

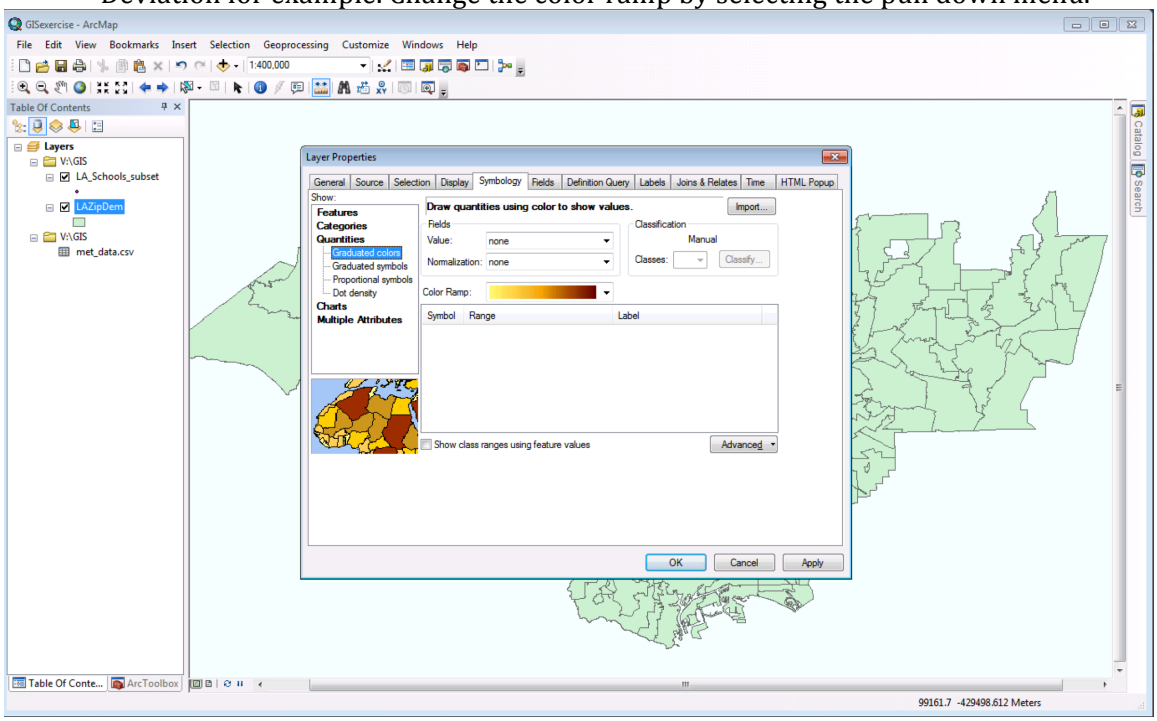
- You will be asked if you want to add the new shapefile to the map as a layer. Click Yes.
- You can now remove the temporary met_data.csv Events file by right clicking on it, and selecting Remove.

2.7 Editing the Symbology of a Layer

In ArcGIS, there are a wide range of options for displaying and classifying data. This section provides a brief introduction to the topic of editing the display of a layer. Currently, each layer of the map is displayed as a single color. However, we might want to observe variations within a layer. To do this, edit the display characteristics to show features from the accompanying non- spatial data. This display editing is carried out through the layer properties window.

Select the layer you want to edit (in this case let's use LAZipDem) in the Table of Contents (TOC):

- Right click on it and in the accompanying menu, select Properties.
- In the Properties window, select Symbology.
- In the Symbology window, click Quantities and select graduated colors. Then change Value to POP2010b (because we want to create the ranges based on the population living in each zip code). You may experiment with the classification by clicking on the Classify button. Try any method that appeal to you: Standard Deviation for example. Change the color ramp by selecting the pull down menu.



2.8 Exporting Maps

You can export a view or a layout to a graphics file in a number of supported output formats. This is an alternative to using screenshots. You can open the graphic file in other programs to enhance or edit the graphic. For example, the JPEG, EMF or PDF file format is often used when one wants to embed an ArcGIS graphic. When you export a

view, neither its table of attribute values (data table) nor its legend is exported only the map graphic is exported.
To export a view:

- From the File menu, select Export Map When the Export dialog appears, choose the file format you want to export to from the dropdown list of file types. Go to "options" and set the optimum resolution value you need (more resolution means larger files). (The Options button appears after you have chosen a file type, select it to set specific options for this file type).

It is best to switch to the Layout View before exporting a map. In this view you can see the map layout in a document. We can also add various items to enhance the map.
If you wish to have a map in landscape mode, from the Layout View, select File-> Page and Print Setup and select Landscape.

2.8.1 Adding a Legend to a Map in the Layout View

While preparing the data layers, you have already created descriptive layer titles for the legend. Now we are going to add the legend to the layout. To do so:

- Click on the Insert pull down menu and scroll down to Legend. This will invoke the Legend Wizard.
- In step one of the Legend Wizard, ensure that all of the layers that you desire to display have been included in the legend. You can also shift the order that they are displayed by clicking on the up and down arrow. Remove the files that you do not want from the legend. When done, click next.
- In the second part of the Legend Wizard, you can add a title and justify your legend. When done, click next.
- In part three of the Legend Wizard, you select the format for your legend. Experiment with different border, background and drop shadow options.
- At this or any other point in the creation of your legend, you can select preview and thus avoid the remaining steps of the Legend Wizard.
- The remaining two screens in the Legend Wizard provide advanced formatting options. Experiment with these at your own pace. For now, click Preview and then Finish.
- A legend will now appear on your screen. Click on it and drag it to the bottom of your layout where you have some open space. You can resize it by clicking on the legend corners to ensure that it fits properly in the space available. You can also resize the map by clicking on the green outline and dragging it in the direction that you desire.
- Often the numbers of your graudated symbol will have many digits after the decimal. To round, you must go back to the symbology of the layer. In the TOC right click on the layer, go to Properties -> Symbology. Press Tab and right click on any of the symbol levels. A popup window will appear, from there go to Format Labels… your desired number of digits after the decimal can be selected here. For the LAZipDem layer, choose 0.

2.8.2 Adding a Title and other text to a Map in the Layout View

All text is added to the layout view using Insert menu at the top of the window.
To add a title:

- From the Insert menu select Title.

- Write your desired title.
- When it appear on the layout, you can move it to the desired location on your map
- To change the font, double click on the title and a font dialog window will appear.

To add text:

- From the Insert menu select Text.
- A small text box with the word "Text" will automatically appear on your map.
- Select it to drag it to the desired location, and double click to edit the font and the text.

2.8.3 Adding a North Arrow and Scale Bar in the Layout View

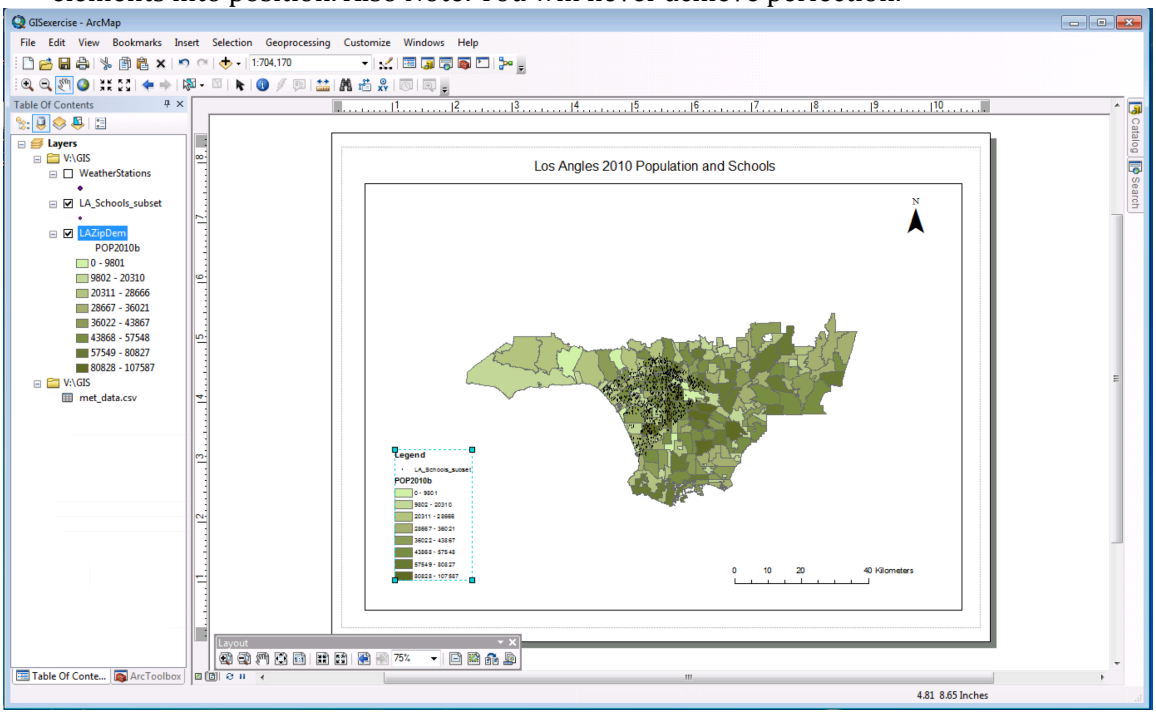
The North Arrow and Scale are important components of a map.

To add a north arrow click Insert on the main menu. Scroll down and select "North Arrow." Select the north arrow you desire from the menu and click OK. The north arrow will be added to the map. When it is highlighted in blue, you can move it around and adjust the size of the arrow.

To add a scale bar to your layout:

- Click Insert along the main menu. Scroll down and select Scale Bar.
- In the Scale Bar Selector, select the style of scale bar that suits your map layout. Then
- add the units of the scale bar. To do this, click on Properties and in the dialog that emerges, set the Division Units to meters or kilometers (as meters is the unit of the layers in this map). Click OK.
- A scale bar will be added to the layout. When it is highlighted in blue, you can adjust its size and adjust its location.

Note: Test out the options in the Layout view (under the main Menu click View and then click to make sure Grid, Rulers and Guide are visible). This will help you move your map elements into position. Also Note: You will never achieve perfection.



3. Commonly Used Spatial Analyst Tools

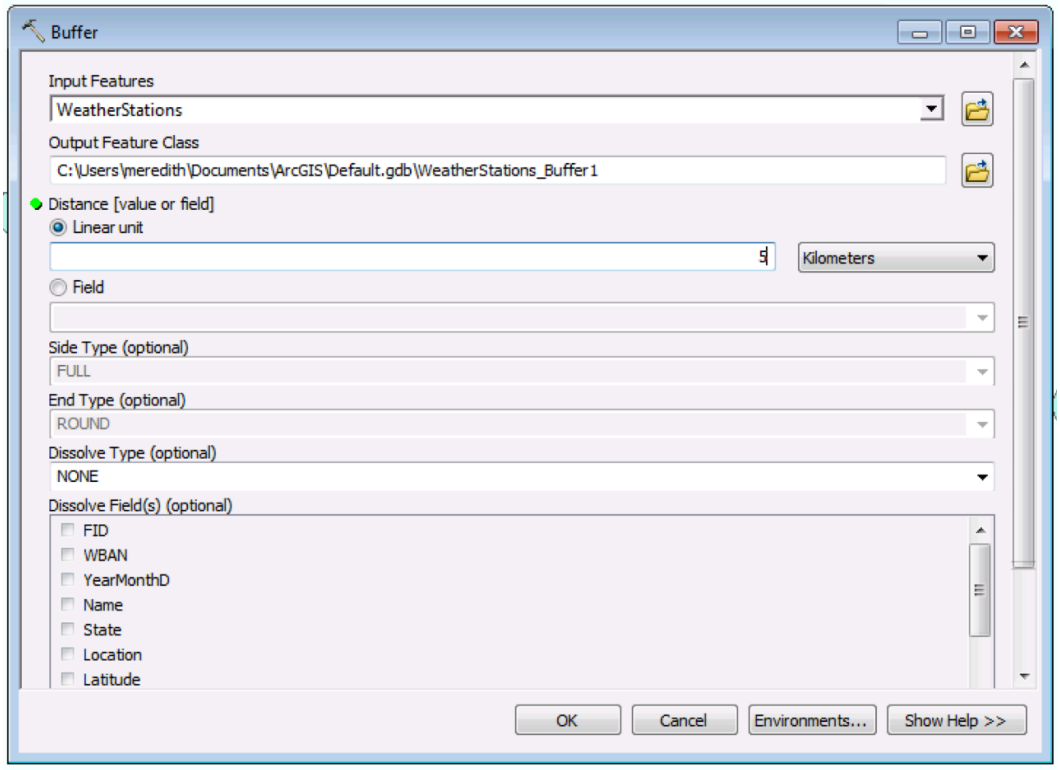
In ArcToolbox there are a wide variety of tools. Many useful spatial tools are in the Analysis and Spatial Analyst Toolboxes. With these tools we can perform a variety of geoprocessing tasks such as creation of buffers, clipping layers, intersecting layers, and spatially joining layers.

3.1 Buffers

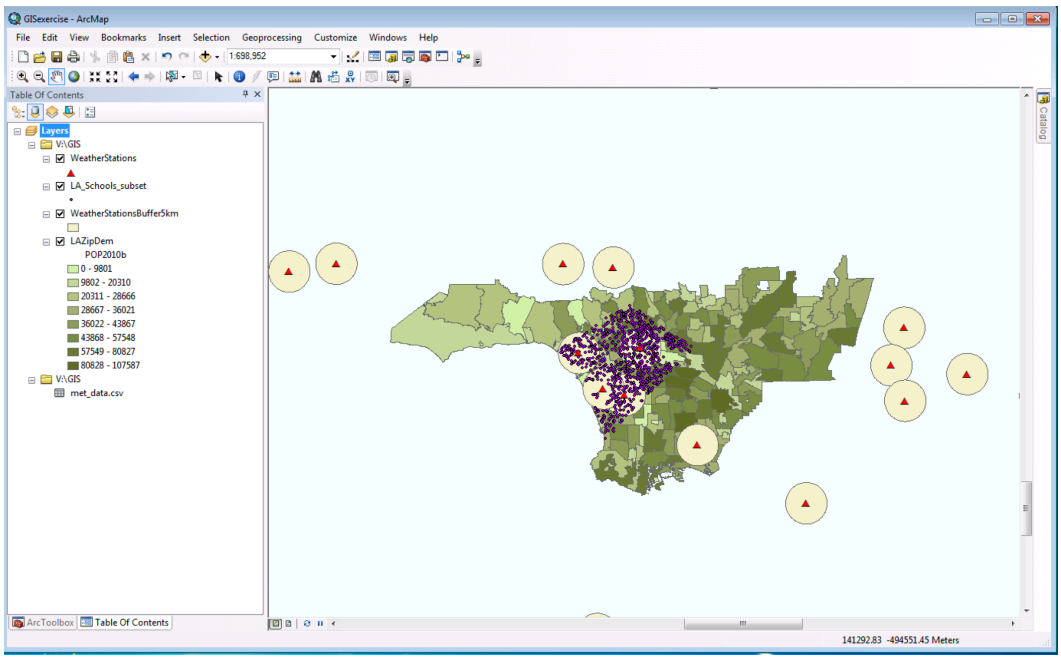
Our first geoprocessing task will be creating a new area around an already existing layer. This is called a buffer. Buffers can be created around any of the vector file types—points, lines, and/or polygons. We will be using the WeatherStations point file to create buffers.

Let's pretend we want to examine the temperature in a neighborhood, and assume that residents within a 5 km radius of weather stations experience the temperature measured at the point of the weather station. Buffers are new areas of a certain distance around a point (or line or polygon). In this case we will create a circular area with a 5 km radius around each weather station.

- In Analysis Tools Choose Proximity -> Buffer
- In Input Features, put the vector layer of your choice in here. In this case, choose WeatherStations.
- In Output Feature Class, name the file as you would like it saved, and make sure you have the correct path (e.g. WeatherStationsBuffer5km).
- Under Distance, choose the linear unit you wish to be the radius of your buffer. In this case, choose 5 and make sure the units are Kilometers.
- Click OK. It may take a few seconds to process.



The buffer layer will automatically be added to your table of contents.

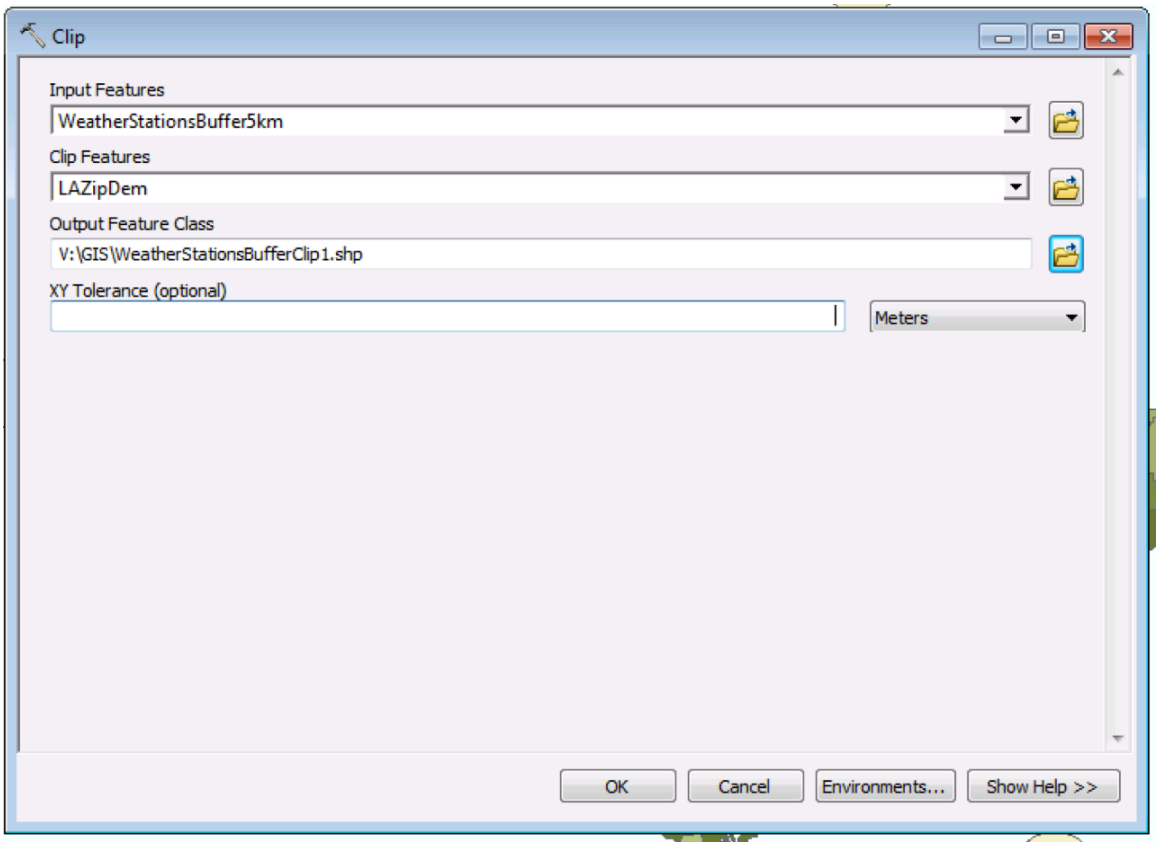


If you look at the attribute table for the buffer layer, you will see a new column added which indicates BUFF_DIST. It should be 5 for each row.

3.2 Clip

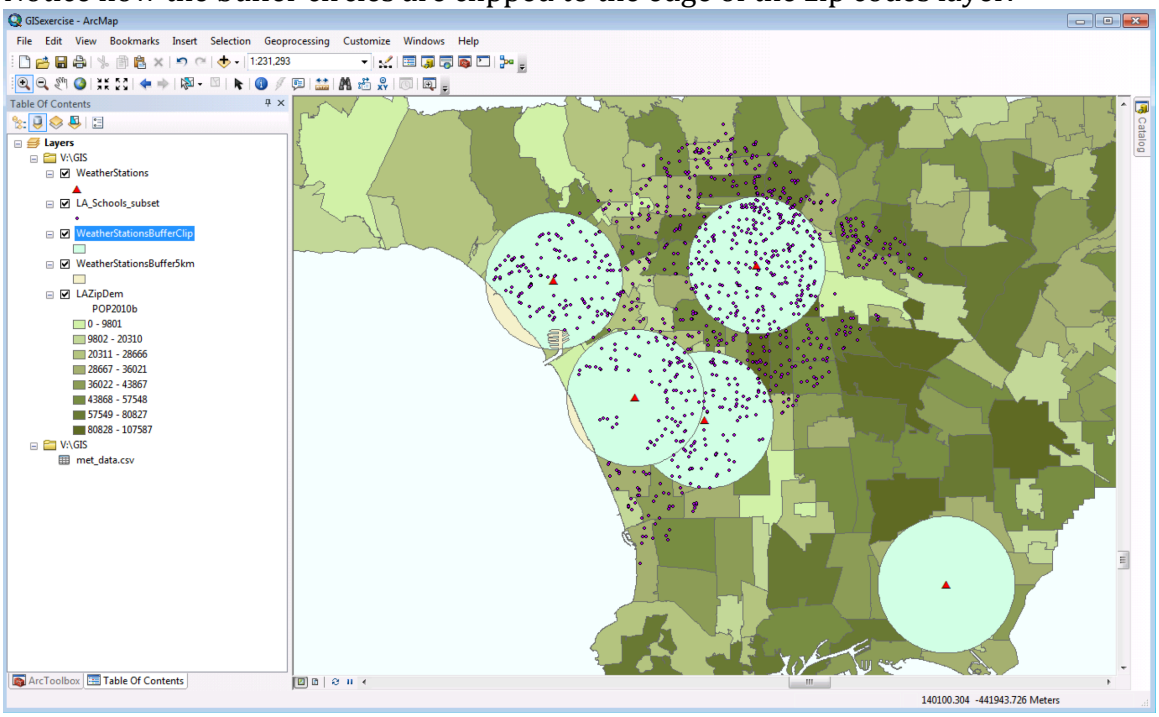
Now that we have a 5 km buffer of the areas that have a temperature measured at the weather station, let's look at the zip codes that are 'affected'. We will use the zip codes layer as a way to identify areas. We only want to keep weather stations that are within the LA zip code area. Usually associated with the "within" condition, the clip function works like a cookie cutter. In our case we will be using the weather stations as the input layerand cutting it with LA county (the zip codes).

- Under Analysis Tools select Extract -> Clip.
- For Input Features, select the WeatherStationBuffers5km.
- For Clip Features select LAZipDem.
- Under Output Feature Class select the path and a file name for the new clipped shapefile (e.g. WeatherStationsBufferClip.shp)
- You do not need to add anything to XY Tolerance.
- Click OK.



The result will add another layer called WeatherStationsBufferClip, which will be the weather stations and the 5km buffers around them clipped to the region of the LA zip codes.

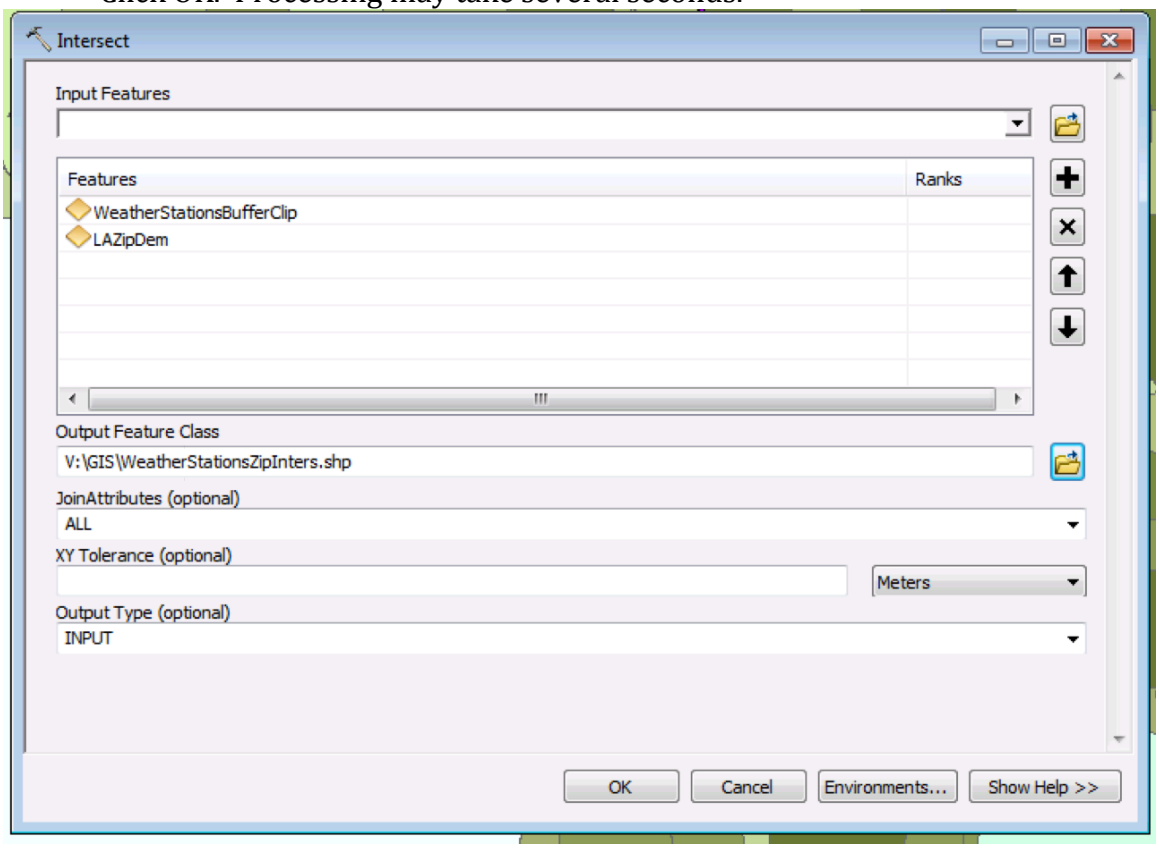
Notice how the buffer circles are clipped to the edge of the zip codes layer.



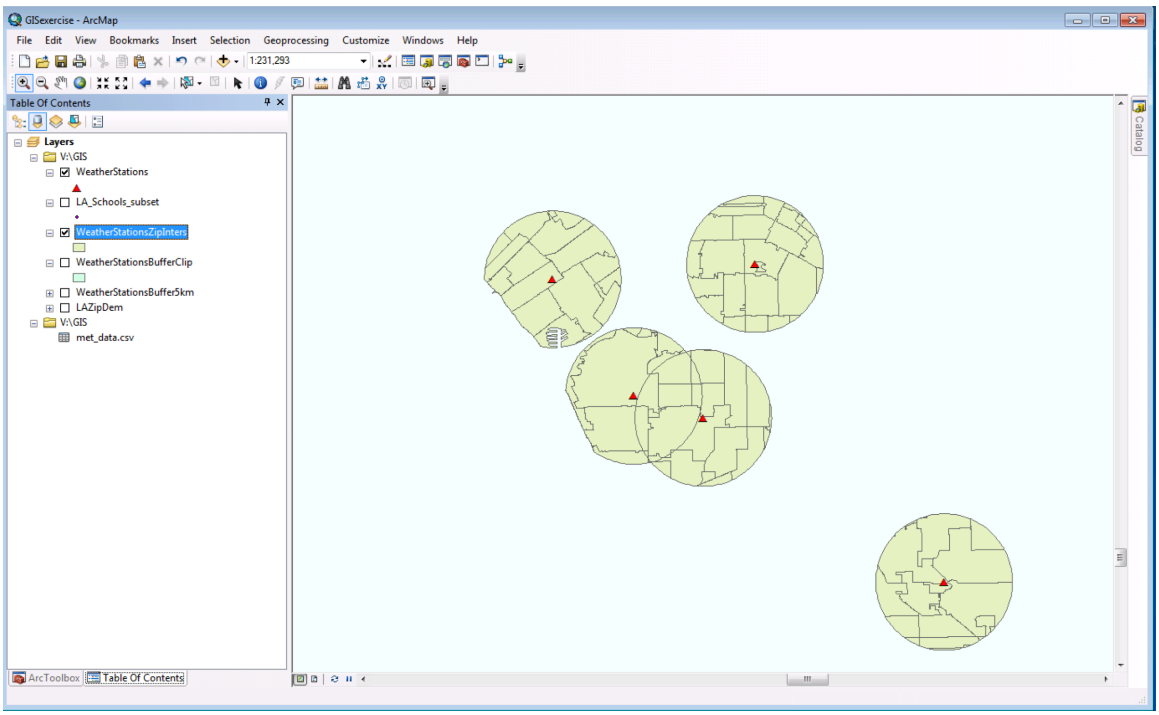
3.3 Intersect

The intersect tool allows us to generate the zip codes that fall within the buffers.

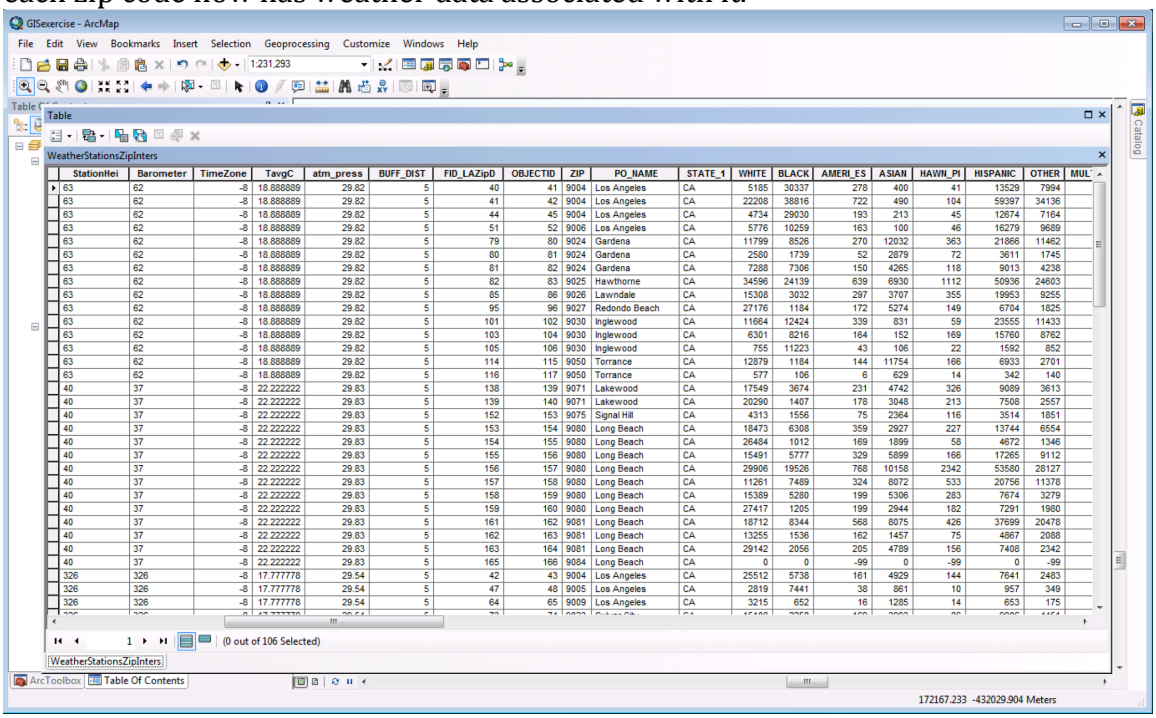
- In the Analyst Toolbox select Overlay -> Intersect
- In Input Features select WeatherStationsBufferClip and add it
- In Input Features also select LAZipDem. It should appear in the list with the buffer layer.
- In Output Feature Class select the path and call the new intersection file WeatherStationsZipInters
- Click OK. Processing may take several seconds.



If we de-select all of the other layers but the newly created intersect, we see that the buffers have been intersected with the zip codes.



Explore the attribute table for WeatherStationsBufferClip. You will see that each zip code now has weather data associated with it.

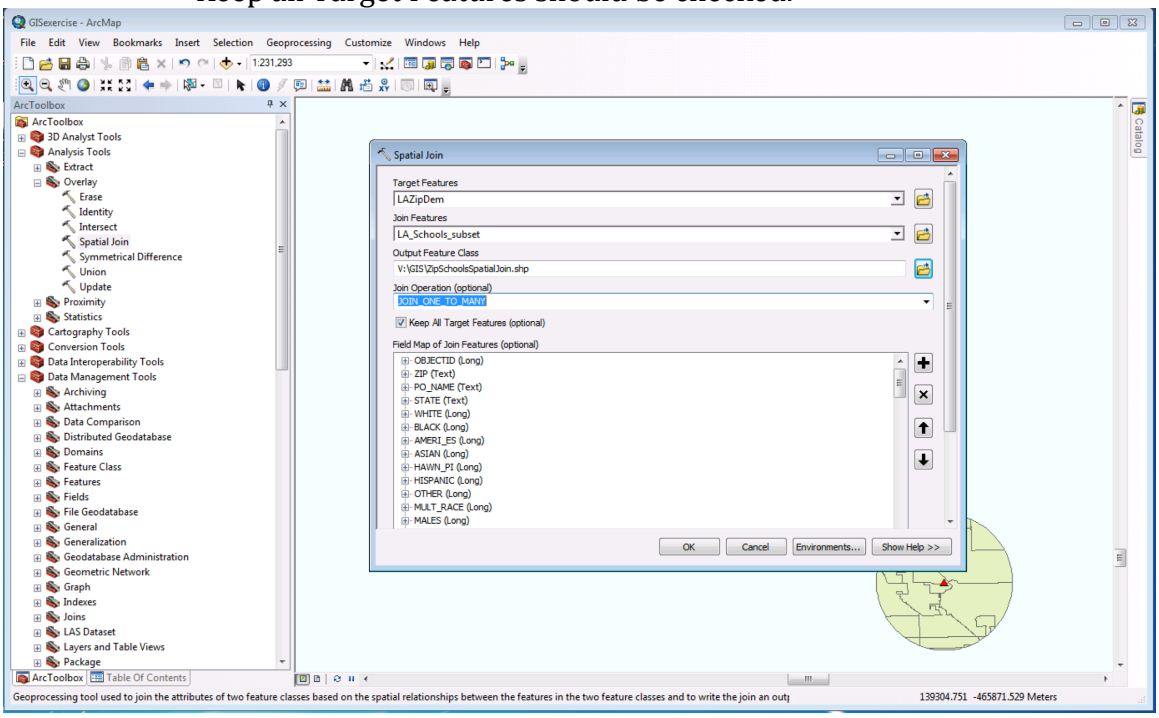


3.4 Spatial Join

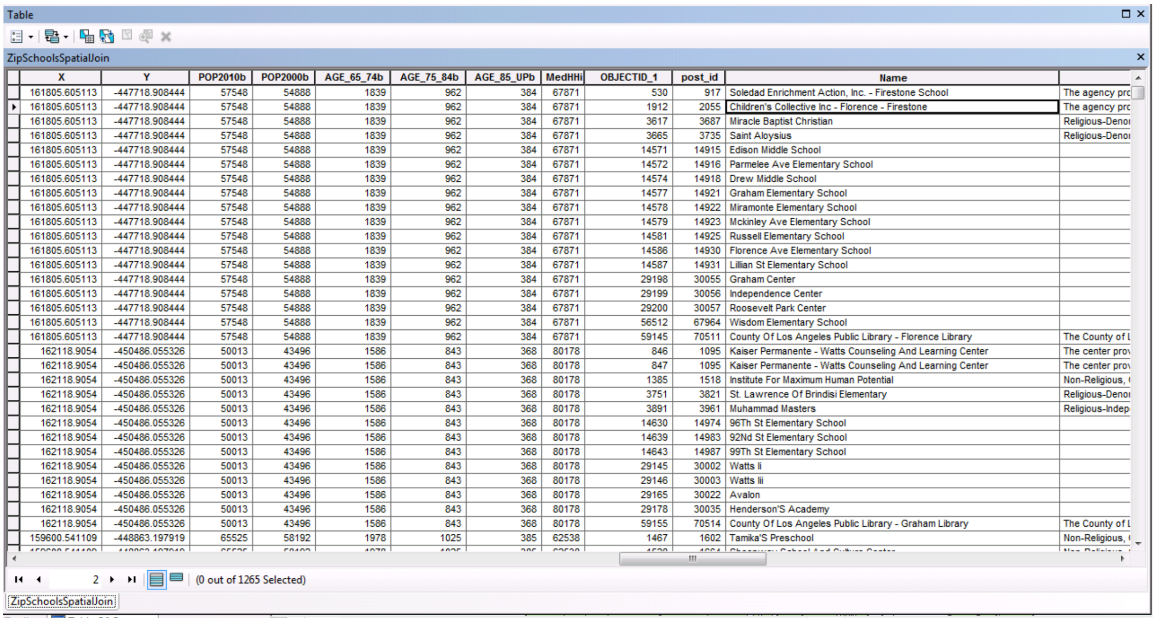
Let's explore another similar tool in Analysis Tools, the Spatial Join. Here, let's join the schools with the zip code data, based on whether the school falls in a zip code (spatially).

- In Analysis Tools select Overlay -> Spatial Join.

- For Target Features select LAZipDem. This is the larger area for which we want to select schools that fall within each zip code.
- For Join Features select LA_Schools_Subset.
- For Output Feature Class make sure you have the right path and name the new file ZipSchoolsSpatialJoin.
- Under join operation, we will use JOIN_ONE_TO_MANY because we have many schools that will fall within each zip code.
- Keep all Target Features should be checked.



In this case, the output layer will look just like LAZipDem because we did a join of the points to the zip codes. Where we will see the result of our spatial join is in the attribute table. Open it to explore what was processed. Essentially, now each school will be associated with the zip code data that it falls within. If we look at the school name for instance, we now see that each school name has been assigned the zip code demographic data from LAZipDem. This can be very useful if we wish to analyze zip code characteristics associated with each school.



4. **Spatial Statistics Tools in ArcGIS**
   Several of the methods we discussed in class are available through the **Spatial Statistics Tools** in ArcToolbox. Go to Arc Toolbox and you will see several options.
   - Analyzing Patterns:
     Cluster and Outlier Analysis (Local Moran's I)
     Hot Spot Analysis (Getis-Ord G*)
   - Modeling Spatial Relationships:
     Spatial weights matrix (areal data)
     Geographically Weighted Regression (GWR)
     Ordinary Least Squares (non-spatial)
   - Rendering:
     Cluster and Hotspot analyses from analyzing patterns can be made into density plots with these tools.
   - Utilities:
     Enables additional spatial weights and distance based calculations.

5. **Geostatistical Analyst Tools in ArcGIS**
   Tools for geostatistical analysis are in a separate toolbox. Currently, the HSC ArcGIS license does not include this toolbox. However, if you can gain access, several tools that perform analyses that we did in R are available.
   - Interpolation:
     Inverse Distance Weighted interpolation (IDW)
     Empirical Bayesian Kriging (Semivariogram is selected within module), Moving Window Kriging (Semivariogram is selected within module)
   - Utilities:
     Cross Validation, Neighborhood Selection, Semivariogram Sensitivity