Exercise 2. Building a Base Dataset of the San Marcos Basin

GIS in Water Resources
Fall 2015

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Goals of the Exercise

This exercise is intended for you to build a base data set of geographic information for a watershed using the San Marcos Basin in South Texas as an example. The base dataset comprises watershed boundaries and streams from the National Hydrography Dataset Plus (NHDPlus). In addition, you will create a point Feature Class of stream gage sites by inputting latitude and longitude values for the gages in an Excel table that is added to ArcMap and the geodatabase. You will show how these locations can be connected to the NHDPlus flowlines using Linear Referencing and get some flow data for the Blanco River using the CUAHSI data downloader.

Computer and Data Requirements

To complete this exercise, you'll need to run ArcGIS 10.3 from a PC. You will download map packages of hydrologic information to do this exercise from HydroShare and other online data sources.

Procedure for the Assignment

Getting Started

We'll begin by getting the input data for Water Resource Region 12, and creating a new, empty geodatabase into which you'll put data for the San Marcos basin, which is a small drainage area within this region.

Open the ArcGIS Online map at: http://arcg.is/1JW0DBm This map is publicly shared so you don't need to login to ArcGIS Online to use it. Click on the **Texas Gulf** region. If there is no response, try another browser.

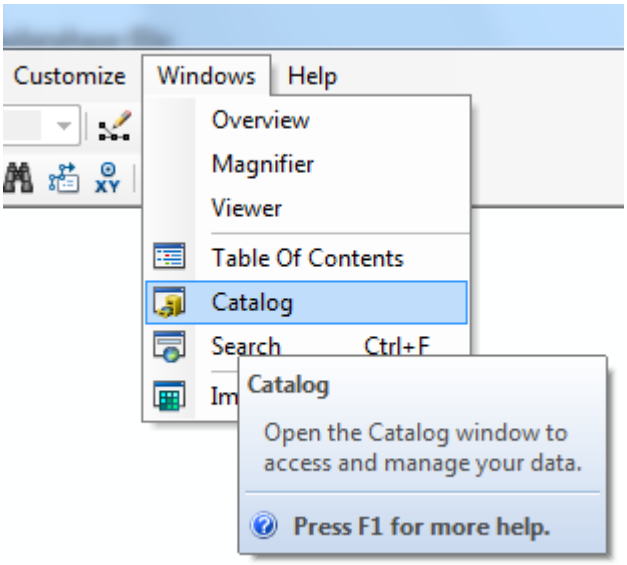
Then click on **More info**

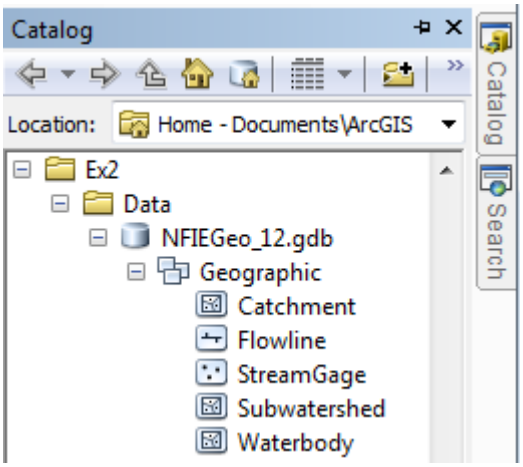
And scroll down to **Content**

Download the file **NFIEGeo_12.gdb.zip** (127.1MB). If you have trouble locating this file, you can get it directly at:
https://www.hydroshare.org/resource/1d78964652034876b1c190647b21a77d/

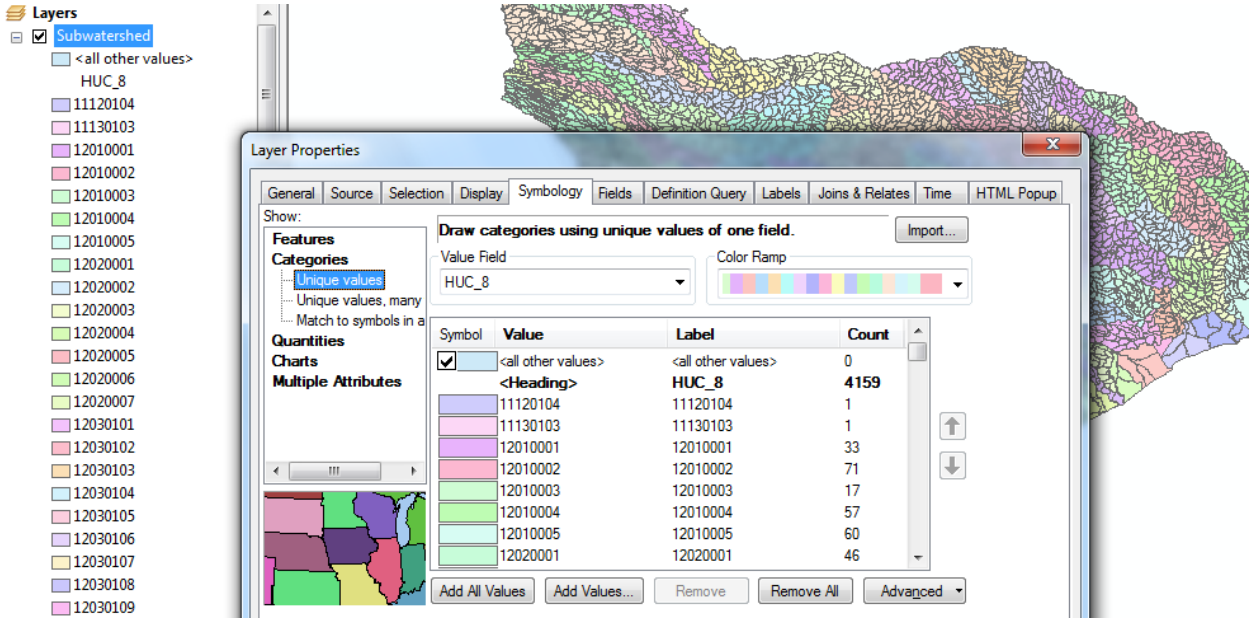
Unzip this geodatabase file.

Open ArcMap and use the Catalog tab in the top right hand corner to navigate to and open the NFIEGeo_12 geodatabase. If you don't see the Catalog tab in the top right corner of your ArcMap screen, use Windows/Catalog to open it within ArcMap.

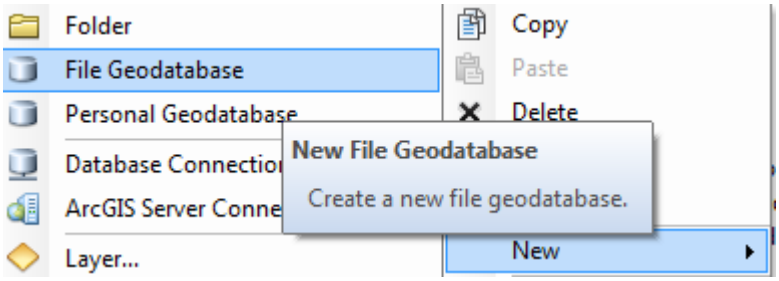




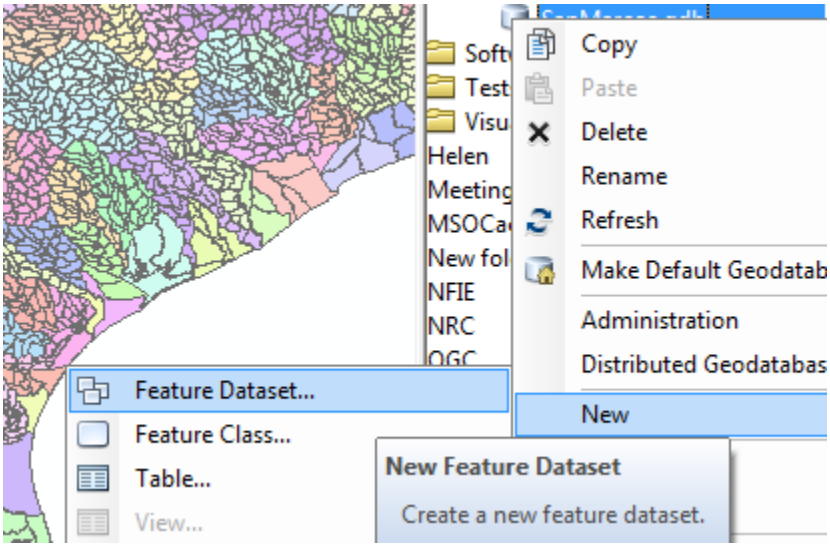
You'll see that there are five feature classes in this **Geographic** feature dataset. Choose the **Subwatershed** feature class and add that to ArcMap. Using **Properties/Symbology**, recolor the Subwatersheds using the HUC_8 attribute.



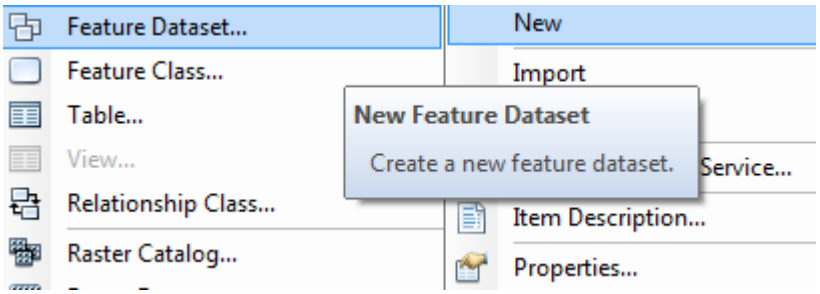
Let's create a new File Geodatabase in which we'll store the results of this exercise. Right click in a suitable folder area and create a new **File Geodatabase**:



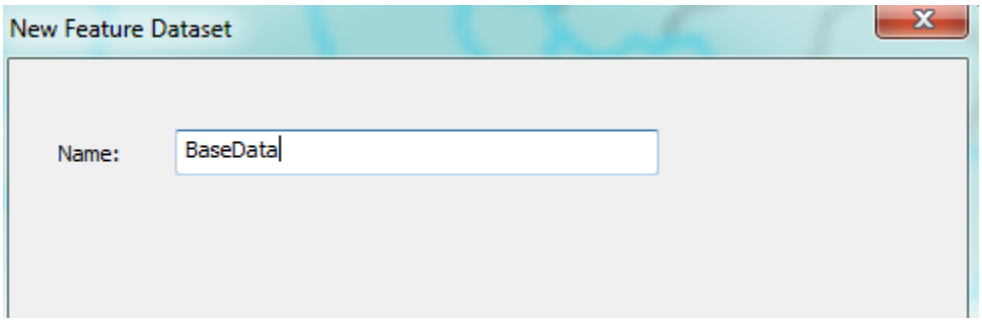
We'll call this **SanMarcos.gdb** Within that, right click and create a new **Feature Dataset** that we'll call **BaseData**.



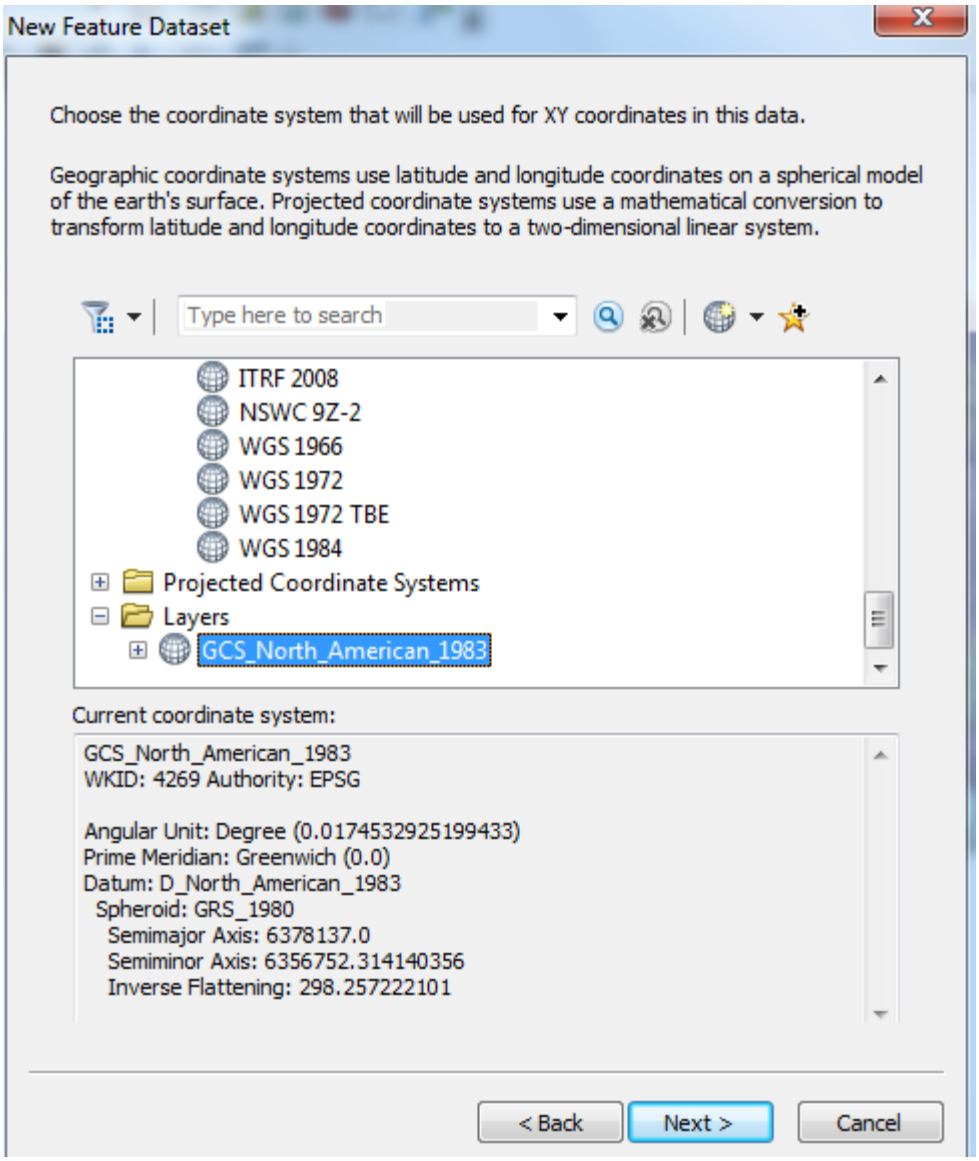
And call this **SanMarcos.**gdb. Within this, create a new **Feature Dataset**



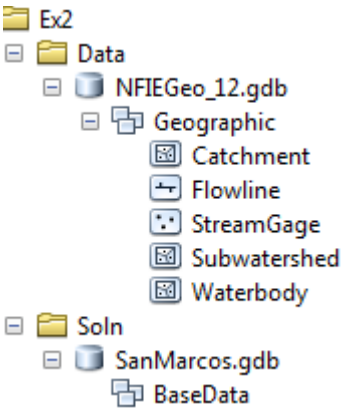
and call it **BaseData**



choose a coordinate system from the existing information indexed under Layers (this is the Subwatershed feature class that is already open in the display window). This is a geographic coordinate system defined on the NAD83 datum, or North American Datum of 1983.



Hit **Next**, and **Next** again to bypass having a Vertical Coordinate system, and then **Finish** to complete creating the Feature Dataset, leaving the tolerance information at the default values.



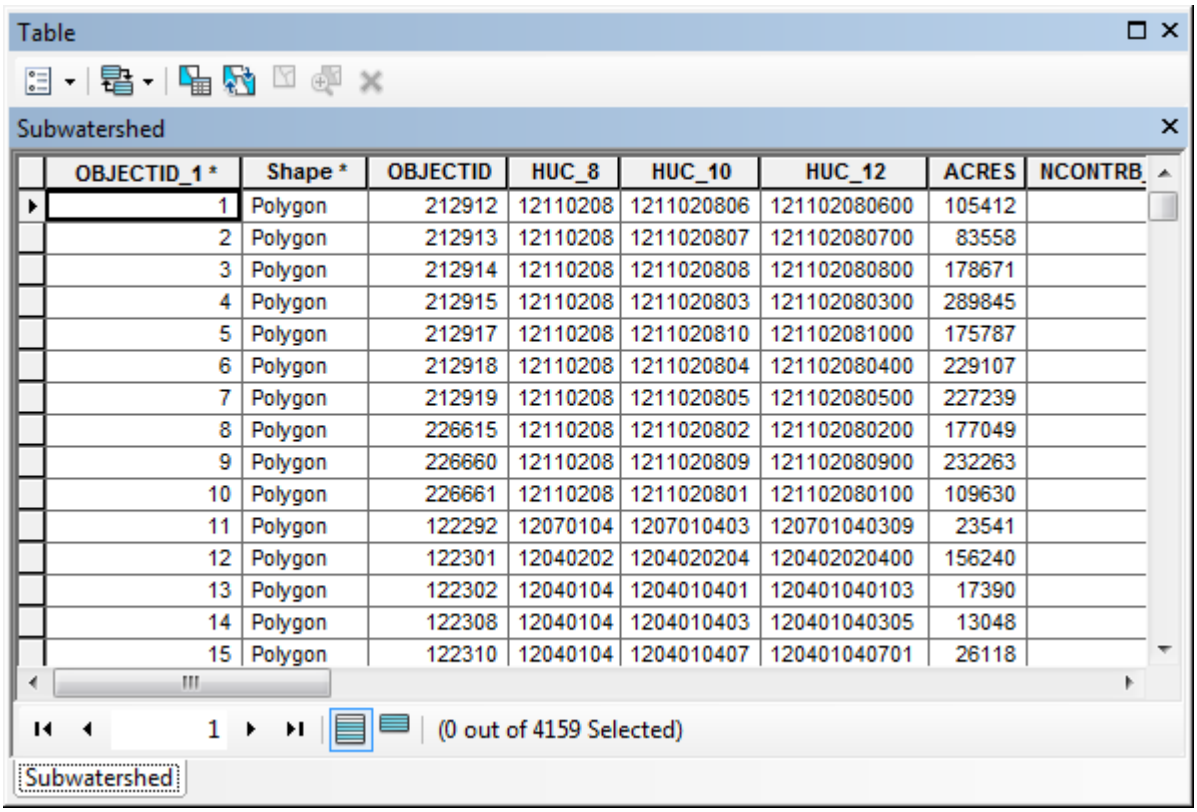
This **BaseData** feature dataset within the **SanMarcos** geodatabase will hold the data that you create for the San Marcos Basin.

Selecting the Watersheds in the San Marcos Basin

Let's zoom into the San Marcos basin.

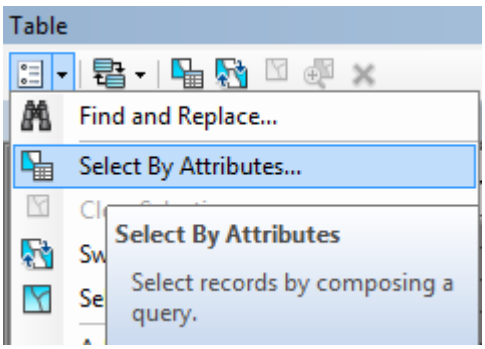
We want all the HUC12 subwatersheds that lie within the San Marcos subbasin, which has a HUC8 value of 12100203. These are the first 8 digits of the HUC12 identifier

In ArcMap, open the Attribute Table of the Subwatershed feature class

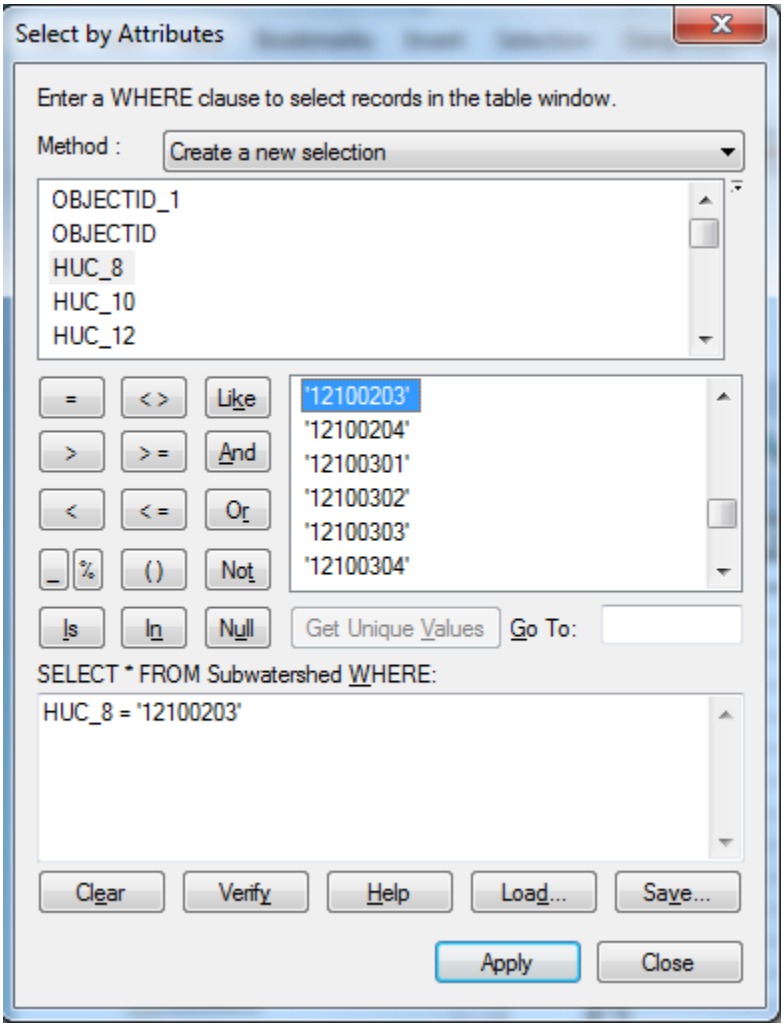


OBJECTID_1 *	Shape *	OBJECTID	HUC_8	HUC_10	HUC_12	ACRES	NCONTRB
1	Polygon	212912	12110208	1211020806	121102080600	105412	
2	Polygon	212913	12110208	1211020807	121102080700	83558	
3	Polygon	212914	12110208	1211020808	121102080800	178671	
4	Polygon	212915	12110208	1211020803	121102080300	289845	
5	Polygon	212917	12110208	1211020810	121102081000	175787	
6	Polygon	212918	12110208	1211020804	121102080400	229107	
7	Polygon	212919	12110208	1211020805	121102080500	227239	
8	Polygon	226615	12110208	1211020802	121102080200	177049	
9	Polygon	226660	12110208	1211020809	121102080900	232263	
10	Polygon	226661	12110208	1211020801	121102080100	109630	
11	Polygon	122292	12070104	1207010403	120701040309	23541	
12	Polygon	122301	12040202	1204020204	120402020400	156240	
13	Polygon	122302	12040104	1204010401	120401040103	17390	
14	Polygon	122308	12040104	1204010403	120401040305	13048	
15	Polygon	122310	12040104	1204010407	120401040701	26118	

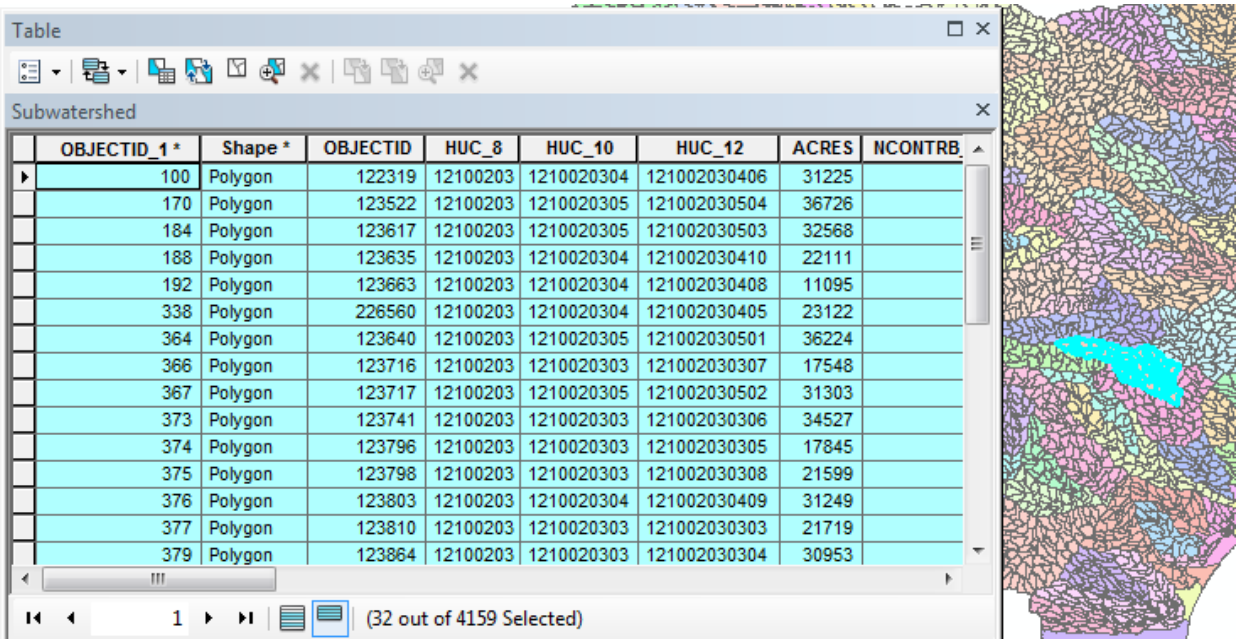
At the top left corner of the **Table**, click on the **Select by Attributes** tool



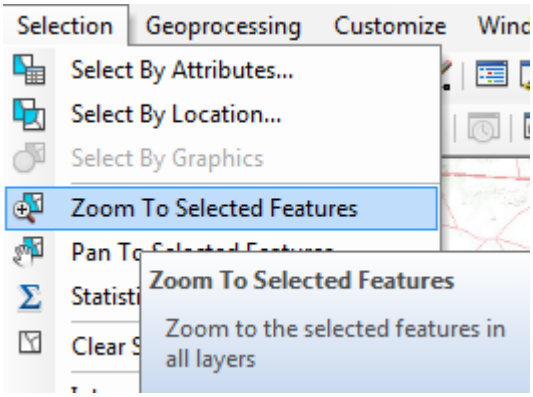
Click on "**HUC8**" and then "=" and then select "Get Unique Values" and from this select '**12100203**' click on the symbols to construct the entry



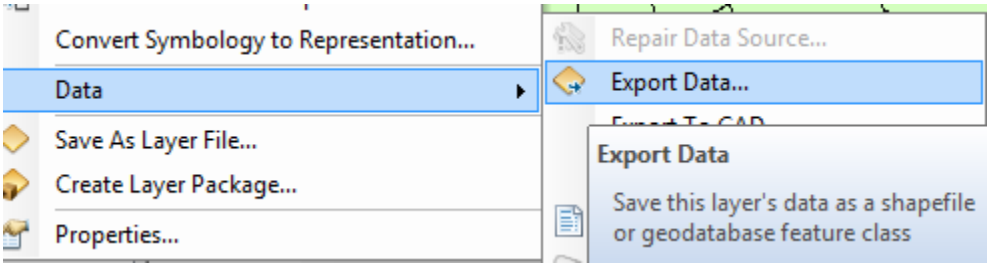
You'll see that this selects 32 of the HUC-12 Subwatersheds that lie within the San Marcos basin (one HUC-8 Subbasin). If you hit the **Selected** button at the bottom of the Table, you'll see the selected records, and also their highlighted images in the map.



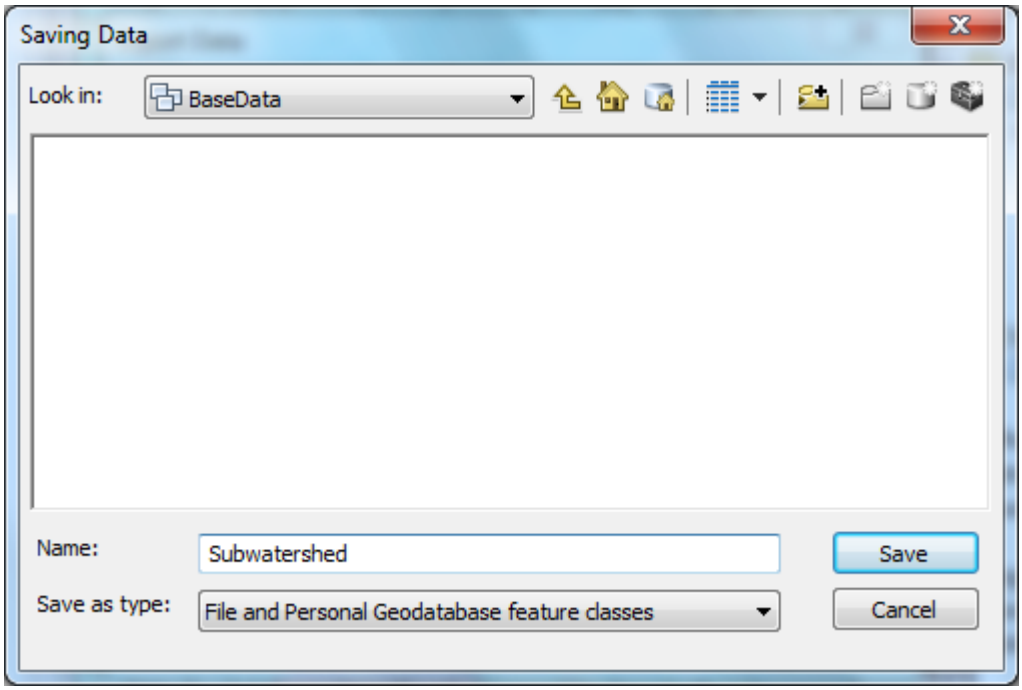
Use **Selection/Zoom to Selected Features**:



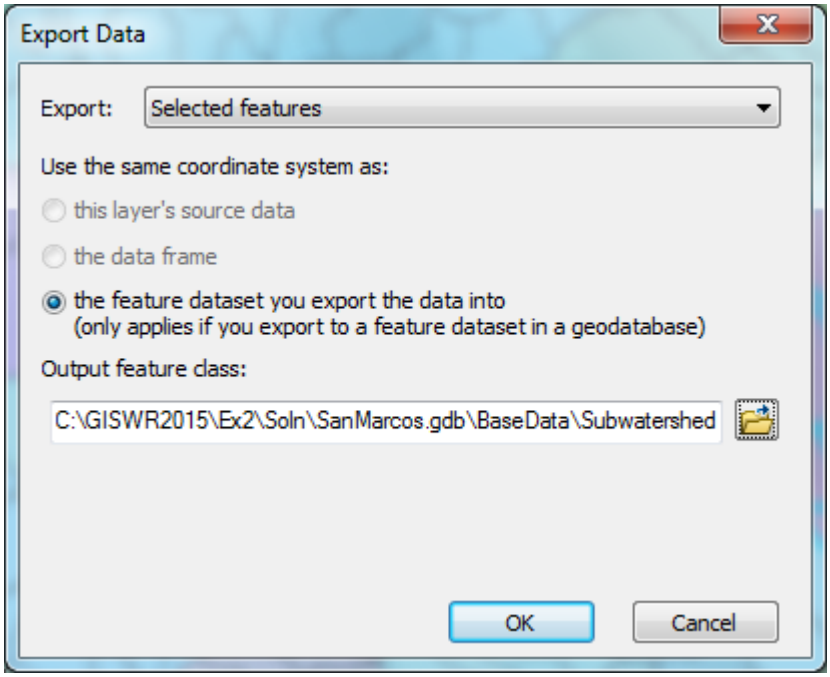
Close the **Subwatershed** attribute table to get it out of the way. Right Click on the **Subwatershed** layer and select **Data/Export Data** to produce a new Feature Class.



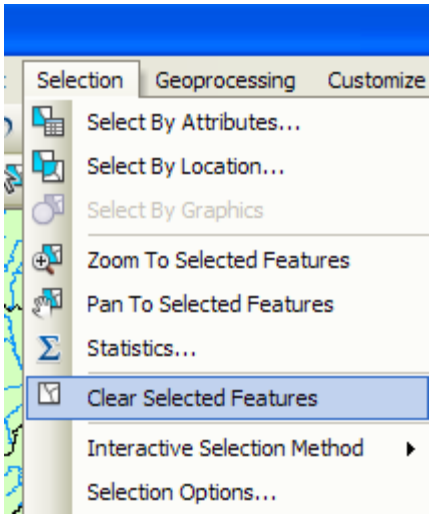
Be sure to navigate to where you established the SanMarcos geodatabase earlier and don't just accept the default geodatabase presented to you, which is somewhere deep in the file system that you may never find again! Browse inside the SanMarcos geodatabase you created to the **BaseData** Feature dataset and name this new feature class as **Subwatershed** and click **Save**. (Note that you may have to change the Save as Type to **File and Personal Geodatabase feature classes**).



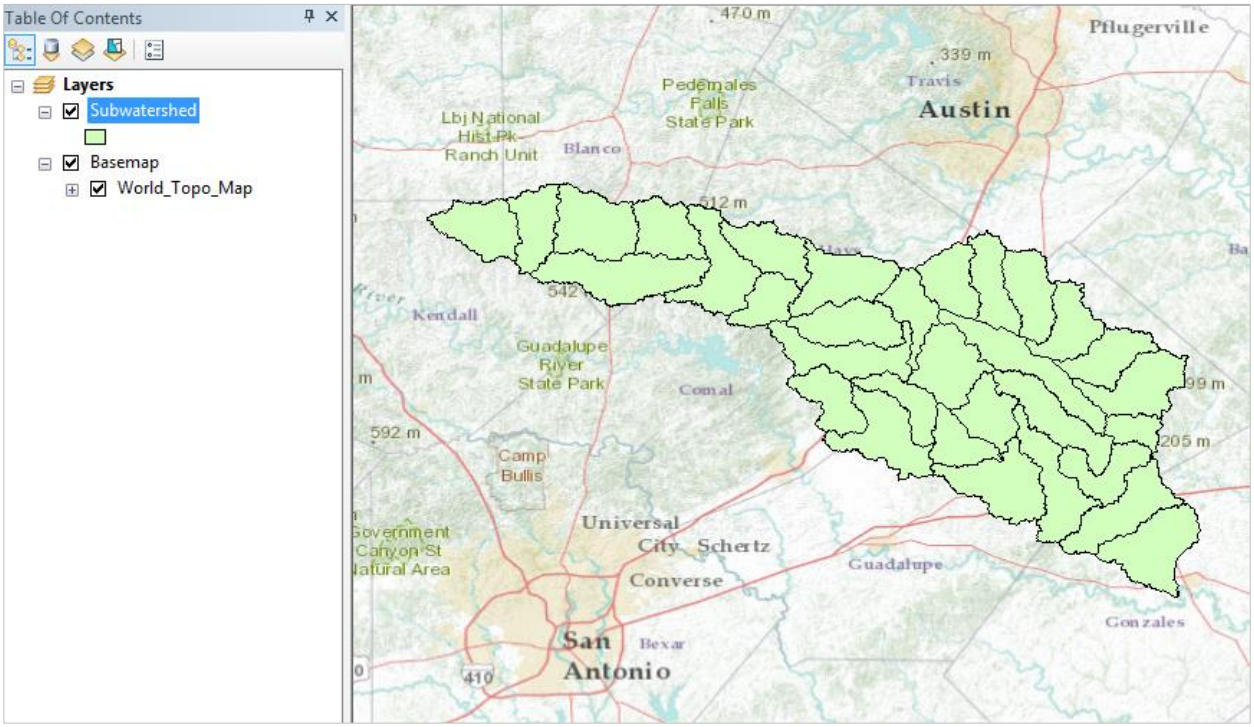
At the next screen click OK



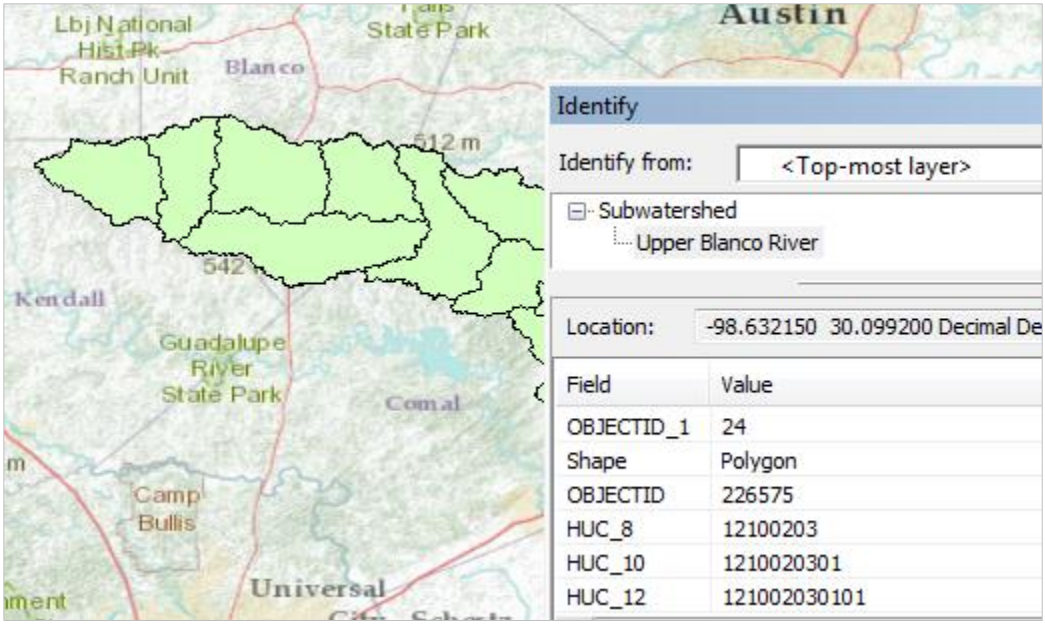
You will be prompted to whether add this theme to the Map, click **Yes**. In ArcMap, Use **Selection/Clear Selected Features** to clear the selection you just made.



And then Zoom to Layer to focus in on your selected Subwatersheds. Remove the original Subwatershed feature class from ArcMap so you can focus just on your selected ones. Change their symbology so that they are colored green if necessary. Watersheds are always green! Add a Topographic base map.



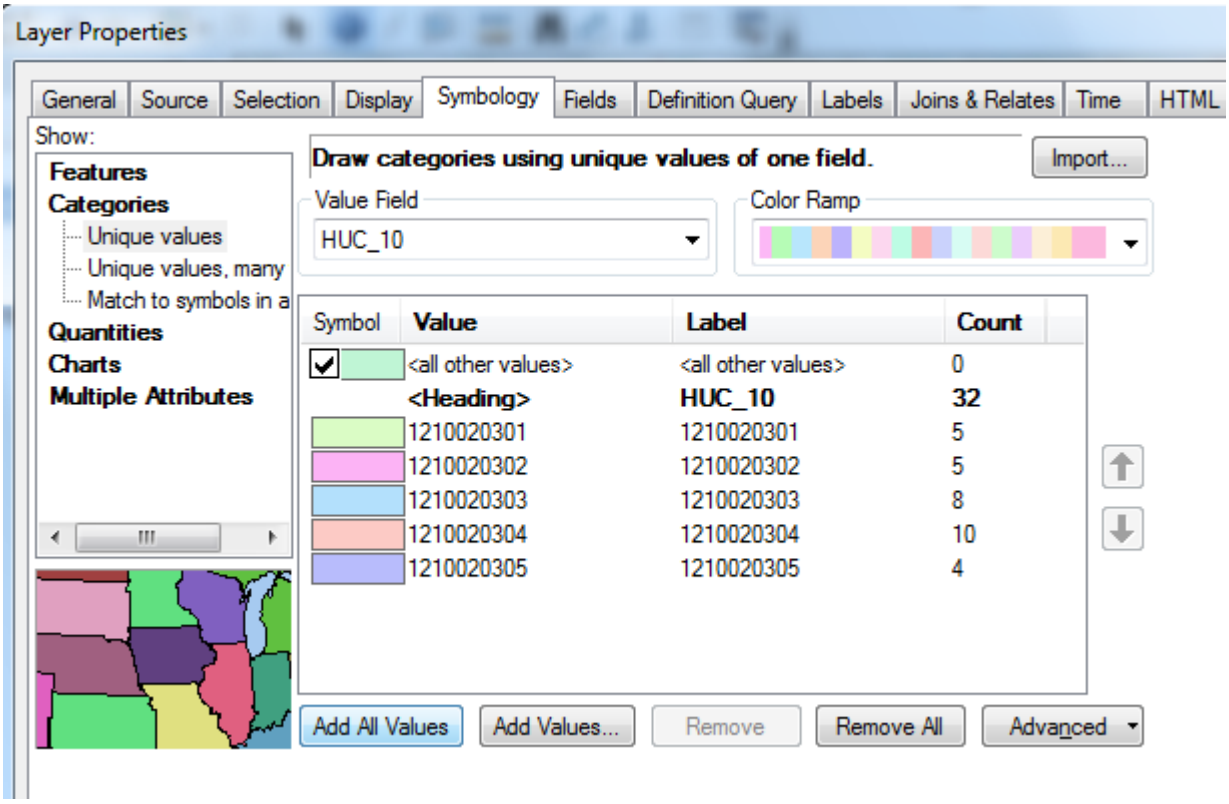
Use the Inquiry  button to query the uppermost subwatershed in the map



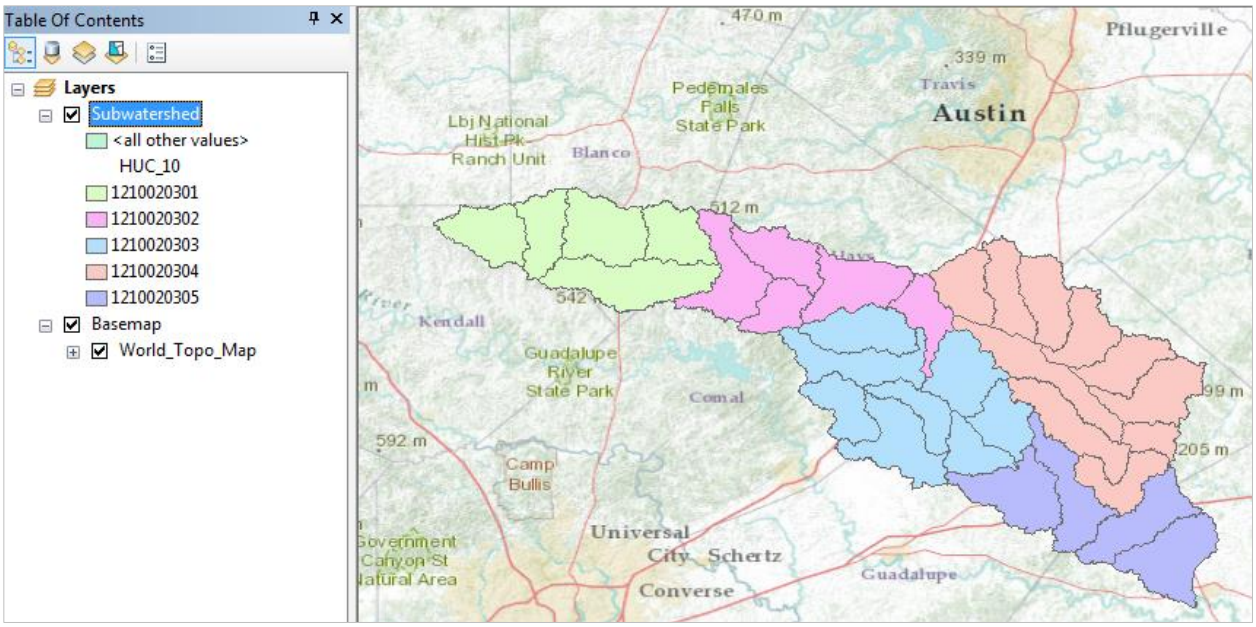
This is HUC_12 number **121002030101**. The position of this in the USGS drainage hierarchy is:

Region 12, **Subregion** 10, **Basin** 02, **Subbasin** 03, **Watershed** 01, **Subwatershed** 01, thus making the HUC_8 number **12100203** as we used earlier, and the additional subdivision to the HUC_12 level yielding the 32 Subwatersheds in this Subbasin.

Right click on the **Subwatershed** feature class, and select **Properties/Symbology**. Select **Categories Unique** values and use **HUC_10** as the Value Field, hit **Add All Values** to give each HUC10 watershed a different color. Hit **Apply** and **OK** to get this color scheme applied to the map.

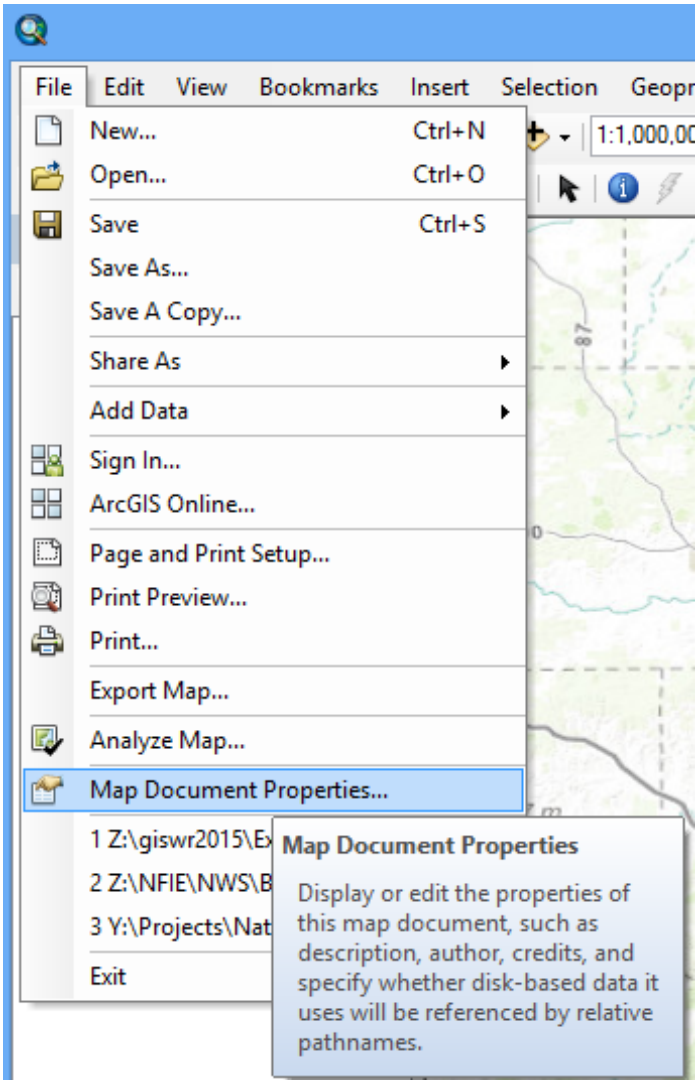


You should get this nicely colored map of the watersheds and subwatersheds of the San Marcos basin.

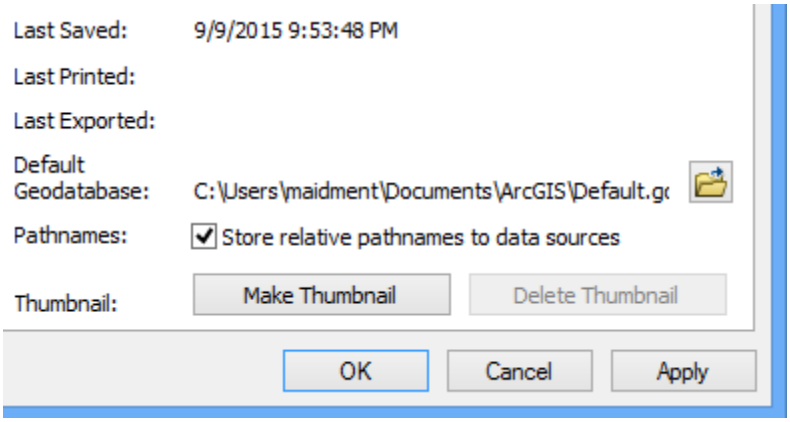


Notice that the 32 HUC-12 *subwatersheds* have been grouped into five *watersheds* within the San Marcos *subbasin* (I am here using the Watershed Boundary Dataset nomenclature to refer to the drainage area hierarchy in its formal sense).

Use **File/Save As** to save your map file as **Ex2.mxd** with the new information that you've created. Its good to ensure that your map document is in the same place as your data and that only local file references are made – this makes it easier to reconnect your map document with your data if you move them to another folder location. To do this, Select **Map Document Properties**

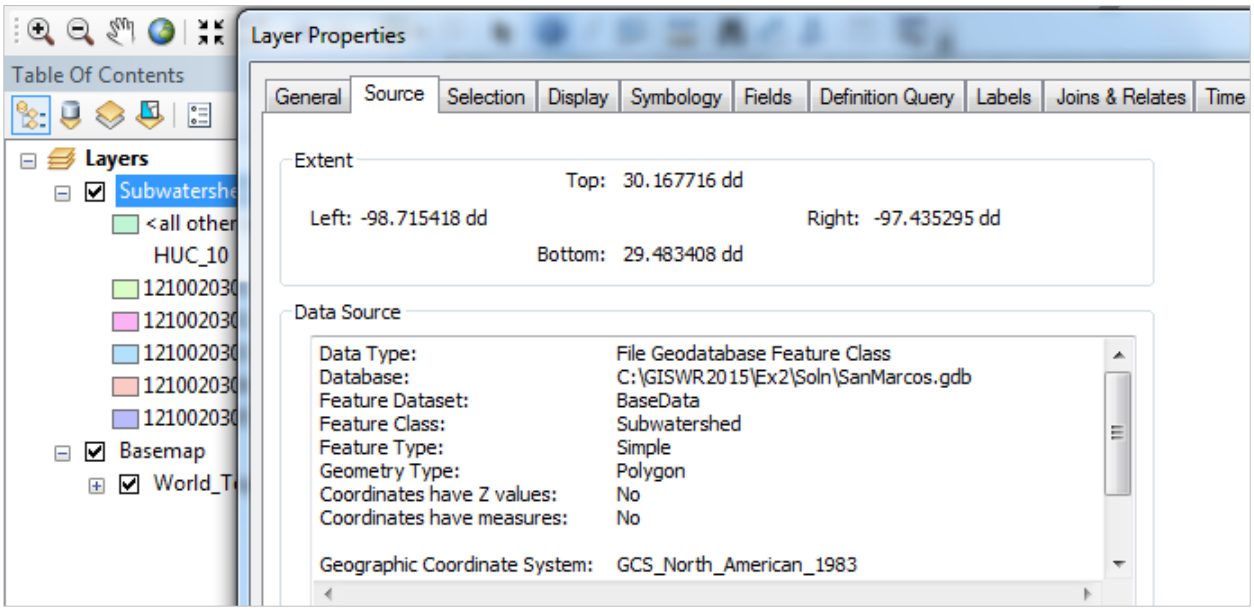


And at the bottom of the form that appears, Check the box next to **Store relative pathnames to data sources.**



Where is My Stuff?

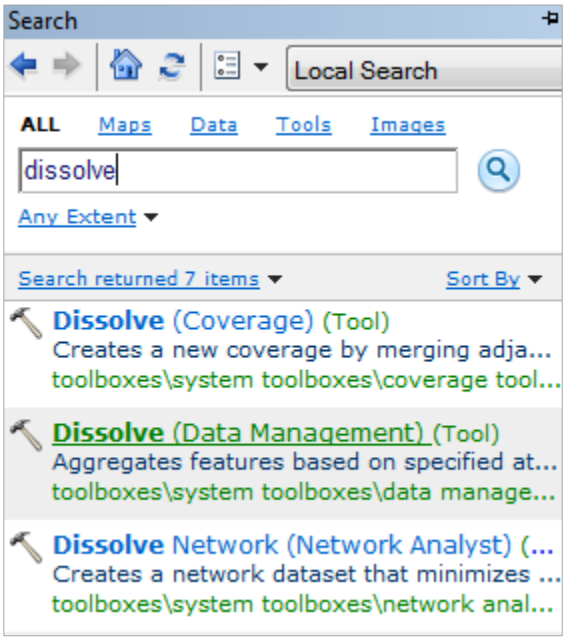
Right click on **Subwatershed** and select **Properties** and select the **Source** tab. Notice that this Feature Class you created is in the **BaseData** Feature Dataset in the **SanMarcos.gdb** Geodatabase in the location where you created it. It comprises Simple Features (no topology), that are Polygons (have X, Y values) but have no Z values or M values which deal with elevation and measure, respectively, that we'll encounter in a later exercises. It has a **Geographic Coordinate System** using the **North American 1983** datum. You'll learn more about these shortly also.



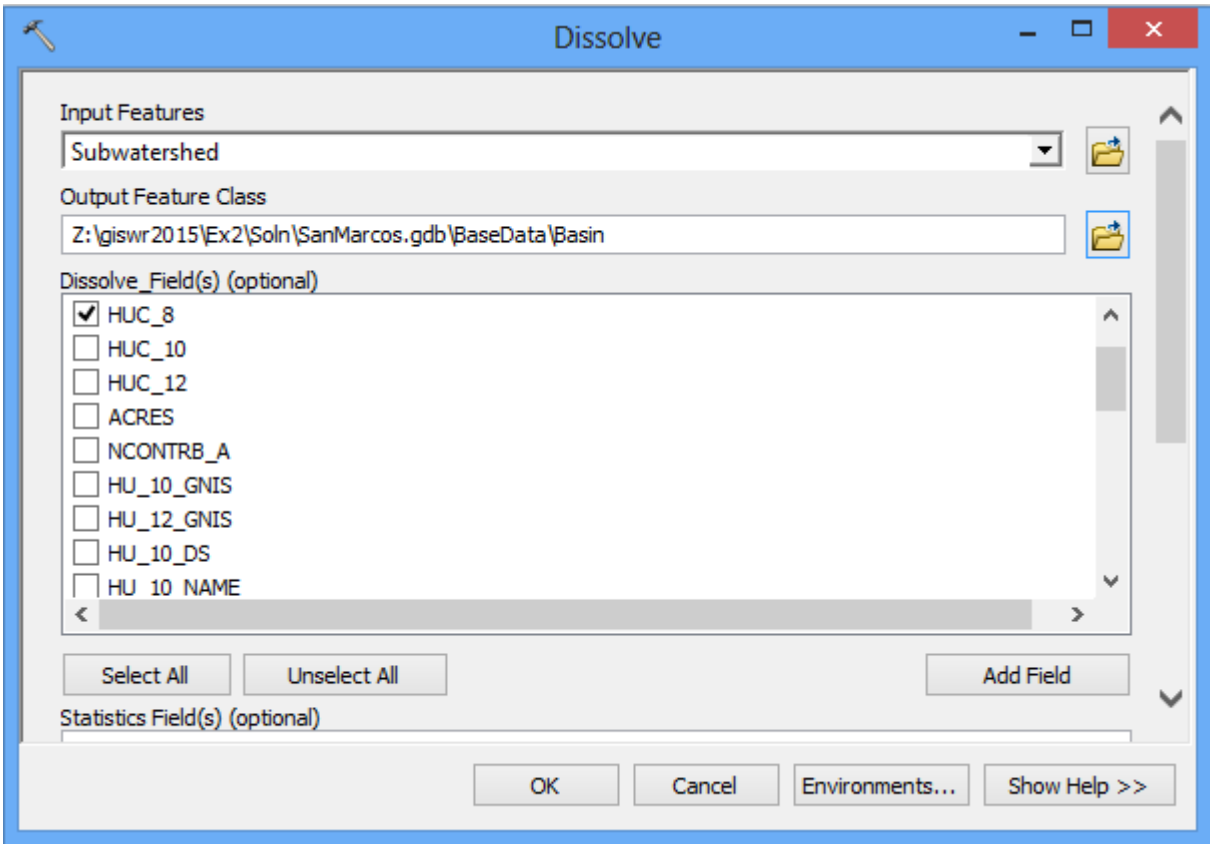
You should be aware of this to manage the space on your computer or move to another computer and have access to the same data.

Creating a San Marcos Basin Boundary

It is useful to have a single polygon that is the outline of the San Marcos Basin. Click on the **Search** button in ArcMap and within the Search box that opens up on the right hand side of the ArcMap display, click on **Tools** and then type **Dissolve**. You will see the system gives you several options. Select **Dissolve (Data Management)**

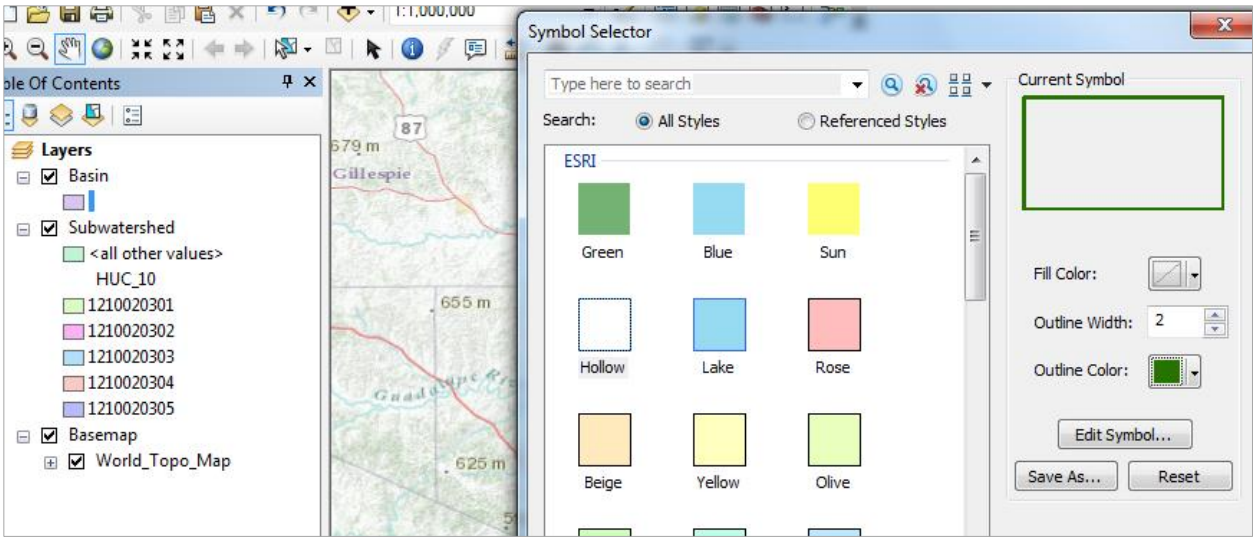


You'll see a **Dissolve** tool window appear. You can drag and drop the **Subwatershed** feature class from the Table of Contents into the **Input Features** area of this window. Click on **HUC_8** as your **Dissolve_Field**. This means that all Subwatersheds with the same HUC_8 number (12100203) will be merged together. Set the output Feature class to be called **Basin** in your **SanMarcos** geodatabase. If you don't do this, the result will be called Subwatershed_Dissolve and will be stored in a default geodatabase location. That is ok, and you can subsequently export it to your San Marcos geodatabase as the feature class Basin. Hit Ok to execute the function.

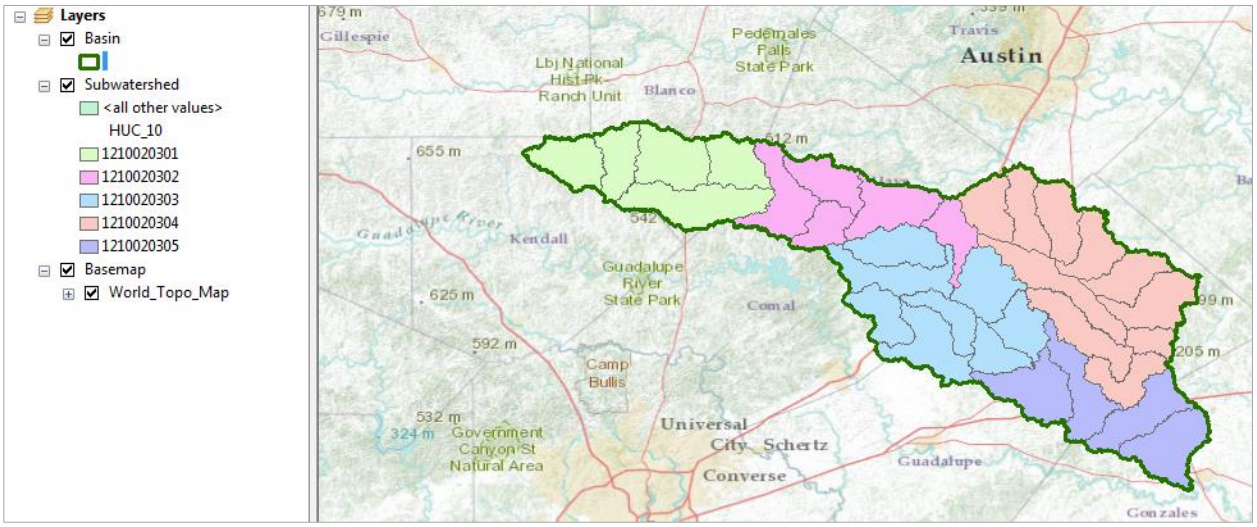


There'll be no apparent activity for a while and then you'll see some blue scrolling text at the bottom right and a pop up indicating completion and the **Basin** will appear.

Lets alter the map display to make the **Basin** layer just an outline. Click on the Symbol for the Basin layer and select **Hollow** for the shape, Green for the **Outline Color** and 2 for the **Outline Width**.

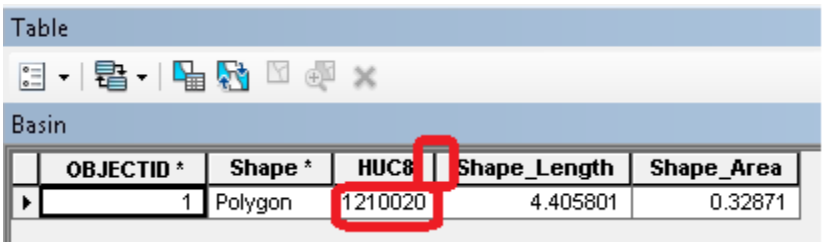


And you'll get a very nice looking map of the San Marcos Basin with its constituent subdrainage areas. Let's also remove the **Watershed_Dissolve** and **Subwatershed** feature classes since we don't need that any more in our map display. Right click on that feature class and select **Remove**

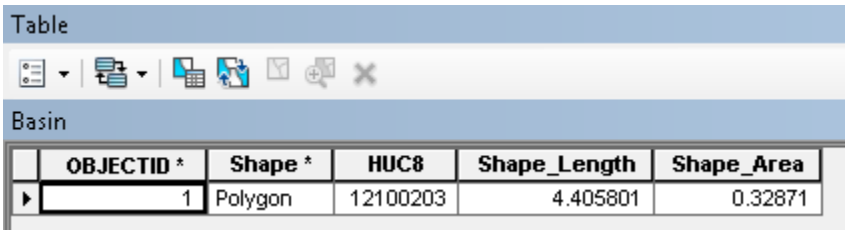


Right click on the Basin feature class and open its Attribute Table. Notice that the Basin feature class has only one Polygon and it is identified with the HUC_8 = 12100203, which is the 8-digit number all the HUC_12 subwatersheds had in common.

When this table first opens you might see fewer than 8 digits in the HUC8 Field.

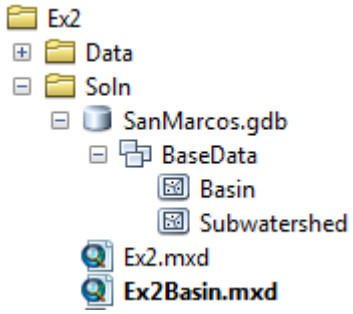


This occurs if the column display is too narrow. You can click between the headers to make it wider. **This is an effect to be alert to because it is not obvious that the number you are seeing is wrong.**



Save your ArcMap document to the file **Ex2Basin.mxd.** Note that this is a different name than used earlier, so you can retrieve the former configuration or this one separately.

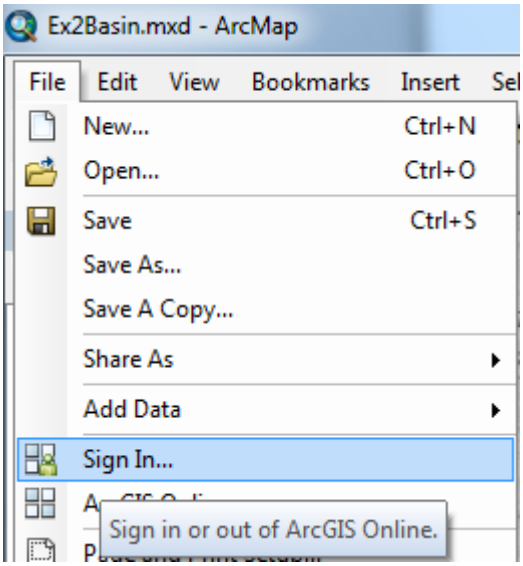
Click on the **Catalog** window in ArcMap and navigate to your **BaseData** feature dataset. Notice how you've now got the **Watershed** and **Basin** feature classes that you've just created stored inside it.

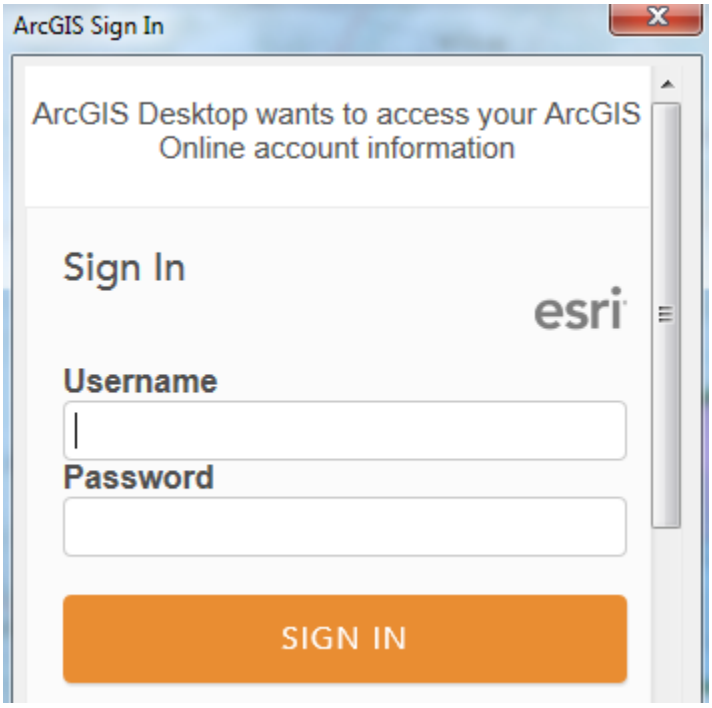


To be turned in: Make a map of the San Marcos basin with its HUC10 and HUC12 watersheds and subwatersheds. How many HUC10 and HUC12 units exist in the San Marcos Basin?

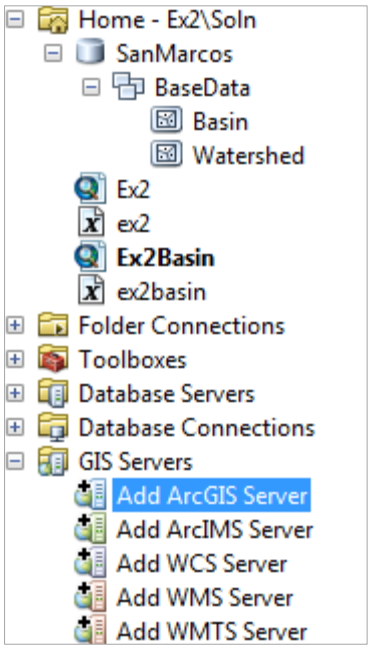
Land Cover Information for the San Marcos Basin

Now, we are going to use some of the new data services to find some land cover properties of the San Marcos basin. In ArcMap, sign in to ArcGIS Online

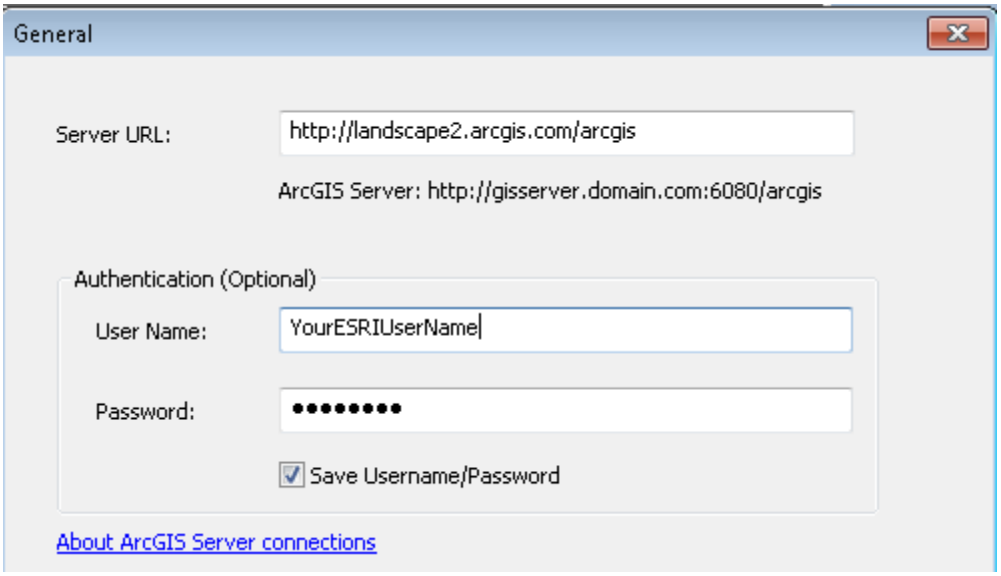




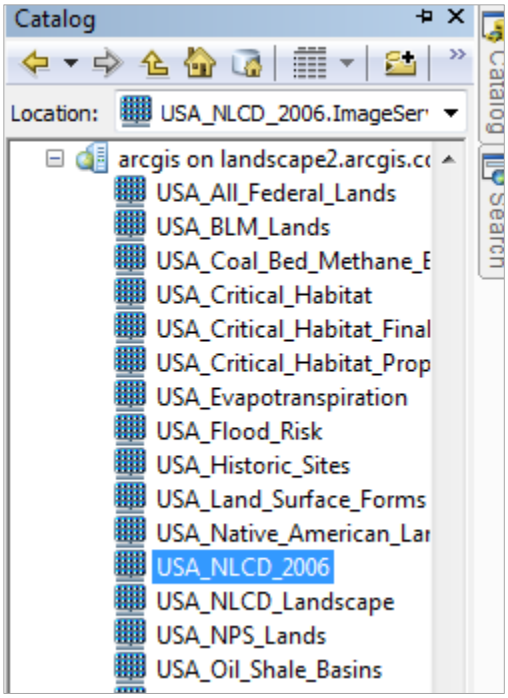
In ArcCatalog, select **Add GIS Server** and accept **Use GIS Services**



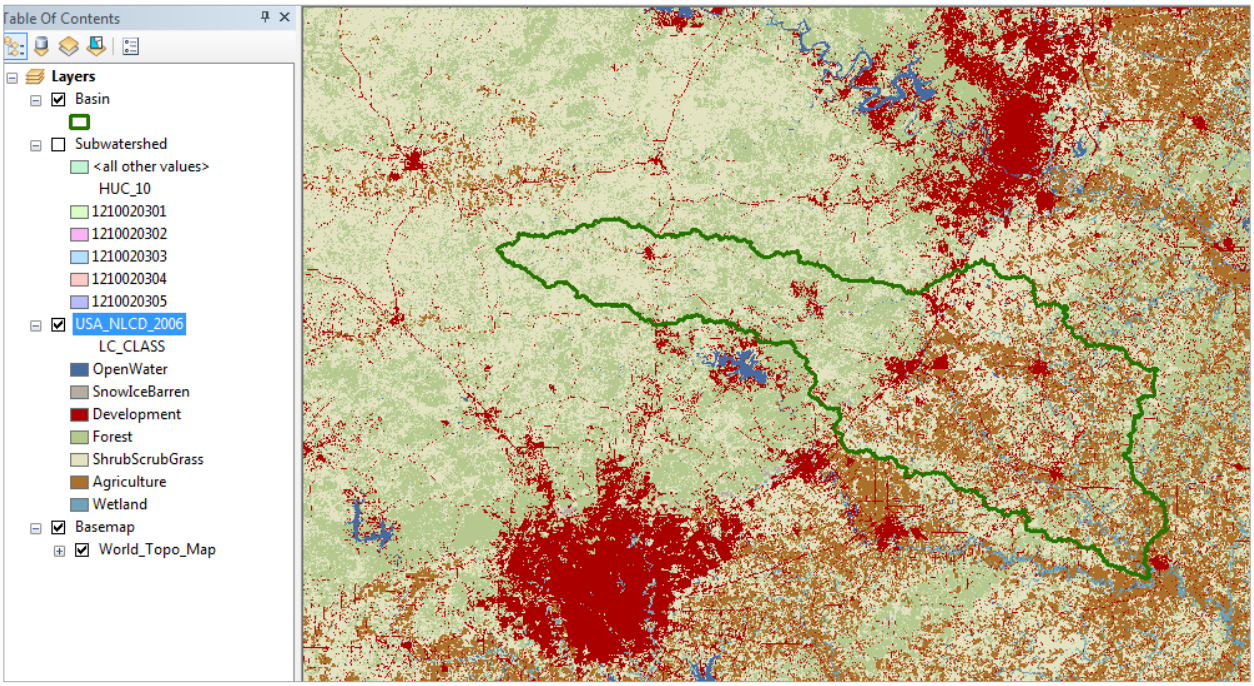
For the server URL use http://landscape2.arcgis.com/arcgis/ Enter your ArcGIS Online **User Name** and **Password** and hit Finish. (Note that on earlier versions of ArcGIS you may need to include the word **services** in the URL http://landscape2.arcgis.com/arcgis/services.)



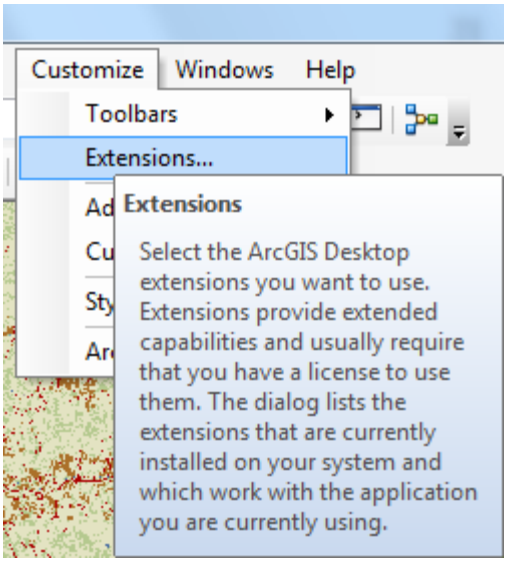
If you click on the + sign on the service that appears, you'll see an entry for **USA_NLCD_2006.** This is the USGS Land Cover raster map of the United States.

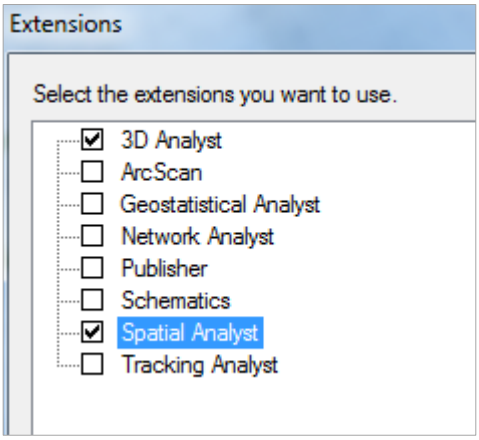


Drag the **USA_NLCD_2006** layer into your map and you'll see it shows up with predetermined color scheme that highlights urban areas in red. In the Table of Contents click off the **Subwatershed** layer, so that you only have the **Basin** displayed over the land cover data. San Antonio is to the bottom of the map, Austin to the top and San Marcos lies within the basin. Notice also the profusion of brown for Agriculture on the right hand side of the map, to the east of the Balcones escarpment.

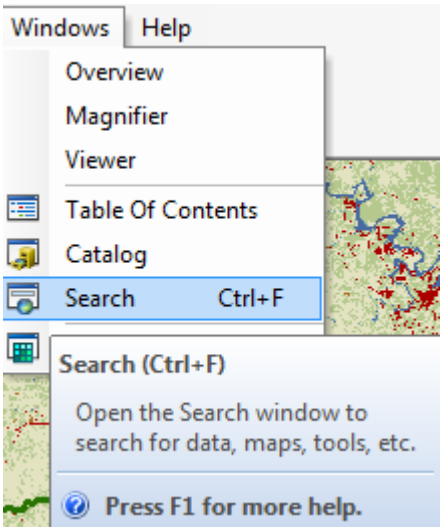


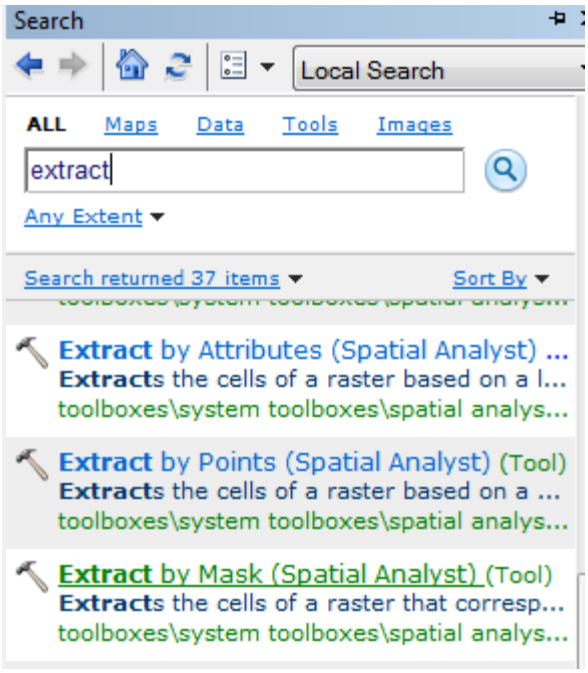
In order to do the next computation, you must have the Spatial Analyst extension of ArcGIS active. Click on **Customize/Extensions** and make sure that **Spatial Analyst** is checked on



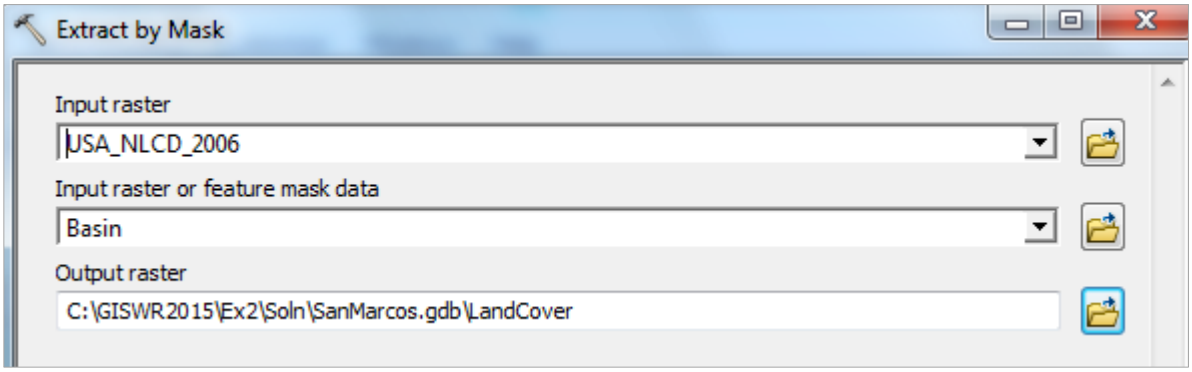


Use the **Search** tool in the top right of the ArcMap screen, and search for **Extract**, selecting the **Extract by Mask** tool. If you don't see this tool in ArcMap use **Windows/Search** in ArcMap to add it:

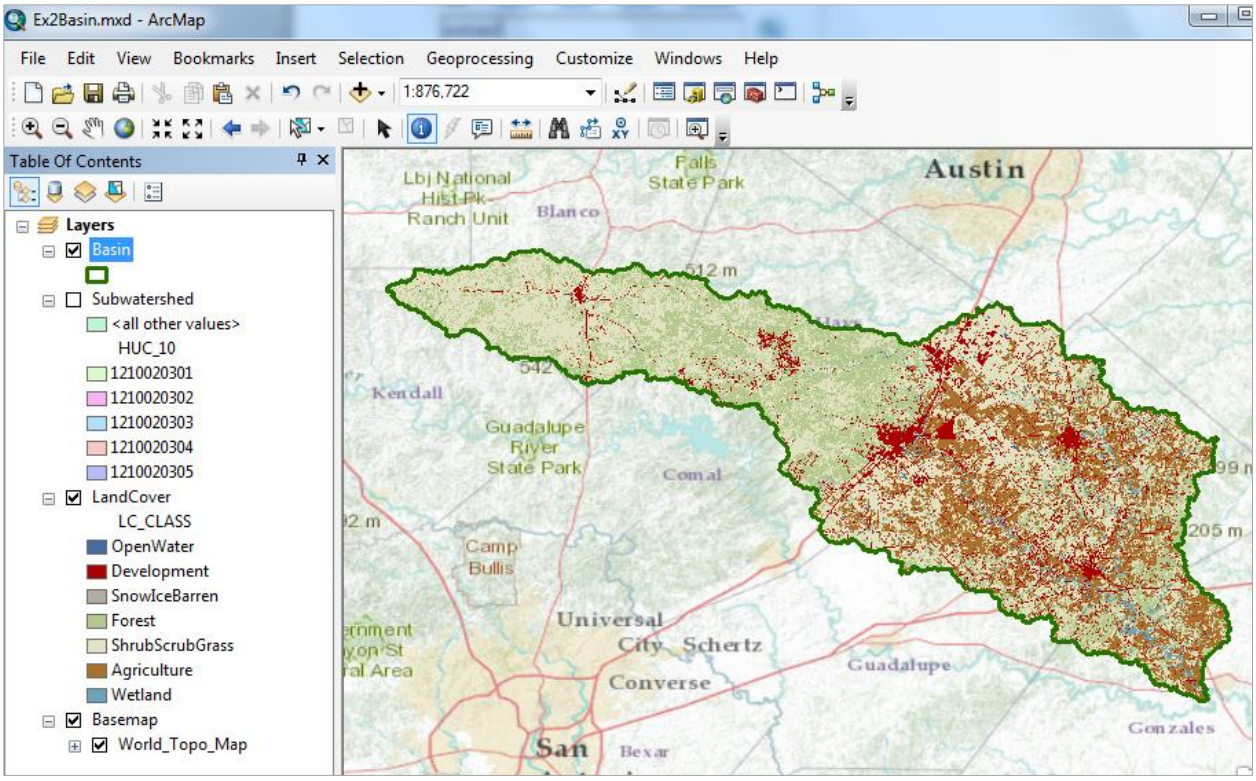




Click on the **Extract by Mask** tool, and use USA_NLCD_2006 as the Input Raster, Basin as the mask data and put the result in the SanMarcos geodatabase with the name LandCover. This is being stored as a raster in the geodatabase so it does not go inside the Feature Dataset (which only holds vector feature classes).

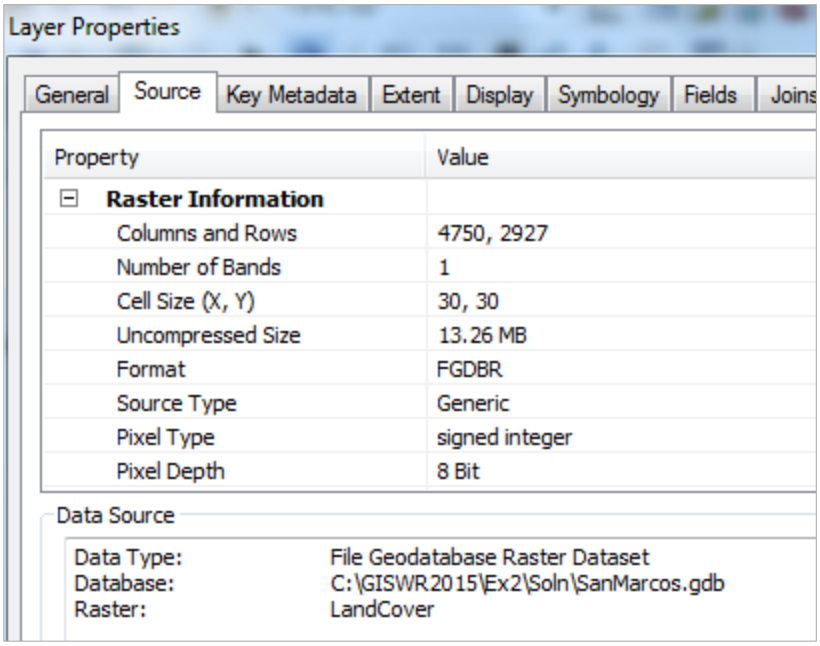


You'll see the blue text cycling along at the bottom of the screen as the data extraction continues and then the result appears in ArcMap using the same symbology as the original service. Very cool! Turn off the original NLCD service to highlight your new dataset.

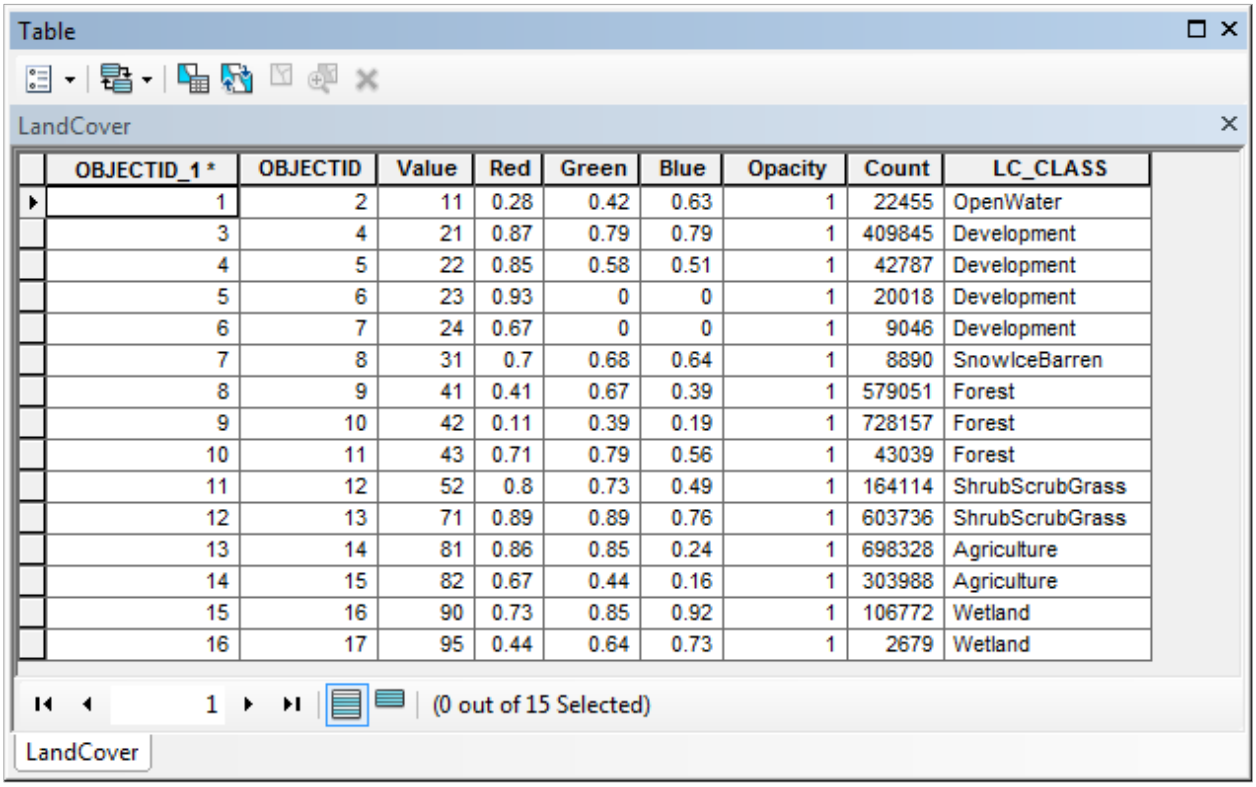


The contrast between the forest to the west of the Balcones fault zone and agriculture to the east is now particularly clear, as are the urban areas lying along the IH-35 corridor between Austin and San Antonio.

If you right click on the LandCover raster and open its Properties, you'll see it is a raster with 30m x 30m cells (these are derived from 30m Landsat imagery).

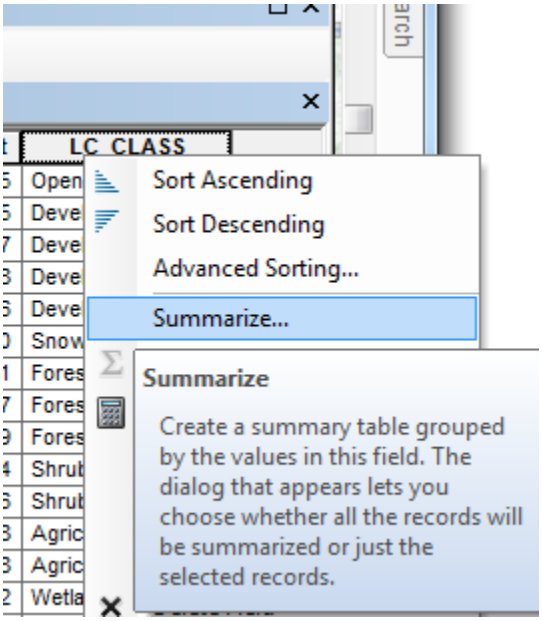


Because this is an integer grid, it has a Value Attribute Table (grids with real numbers do not have a VAT). Open the **Attribute Table** and you'll see the land cover classes indicated by **Value**. The **Count** indicates the number of cells having that Value

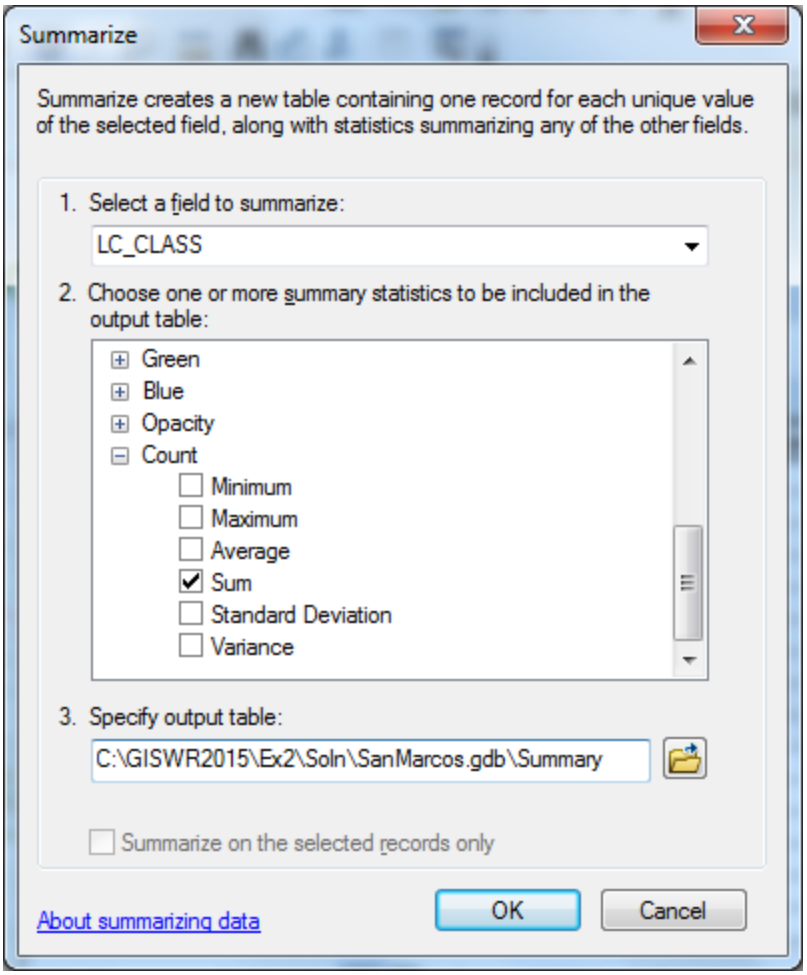


OBJECTID_1 *	OBJECTID	Value	Red	Green	Blue	Opacity	Count	LC_CLASS
1	2	11	0.28	0.42	0.63	1	22455	OpenWater
3	4	21	0.87	0.79	0.79	1	409845	Development
4	5	22	0.85	0.58	0.51	1	42787	Development
5	6	23	0.93	0	0	1	20018	Development
6	7	24	0.67	0	0	1	9046	Development
7	8	31	0.7	0.68	0.64	1	8890	SnowIceBarren
8	9	41	0.41	0.67	0.39	1	579051	Forest
9	10	42	0.11	0.39	0.19	1	728157	Forest
10	11	43	0.71	0.79	0.56	1	43039	Forest
11	12	52	0.8	0.73	0.49	1	164114	ShrubScrubGrass
12	13	71	0.89	0.89	0.76	1	603736	ShrubScrubGrass
13	14	81	0.86	0.85	0.24	1	698328	Agriculture
14	15	82	0.67	0.44	0.16	1	303988	Agriculture
15	16	90	0.73	0.85	0.92	1	106772	Wetland
16	17	95	0.44	0.64	0.73	1	2679	Wetland

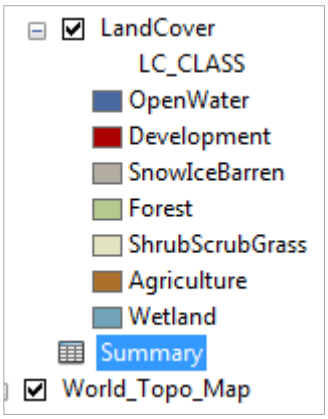
Right click on **LC_Class** and select **Summarize**

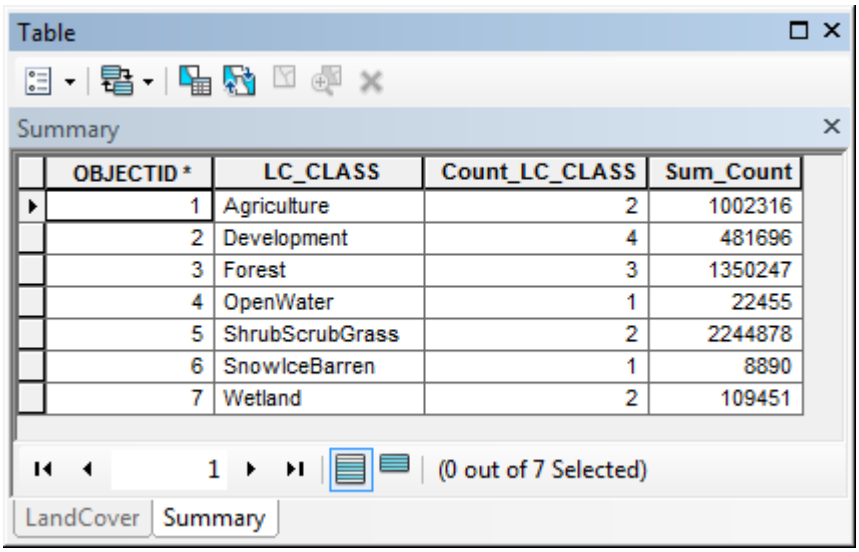


Expand the **Count** field and check **Sum**, save the result as a table called **Summary**



The computation will proceed and add the Summary table to your ArcMap document. Open it and you'll see a Summary of the land cover distribution of the San Marcos basin, as given by the count of the number of cells having each land cover type.



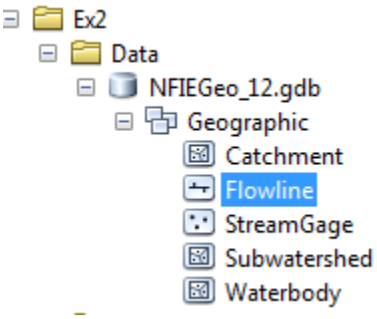


Save your map as Ex2LandCover.mxd.

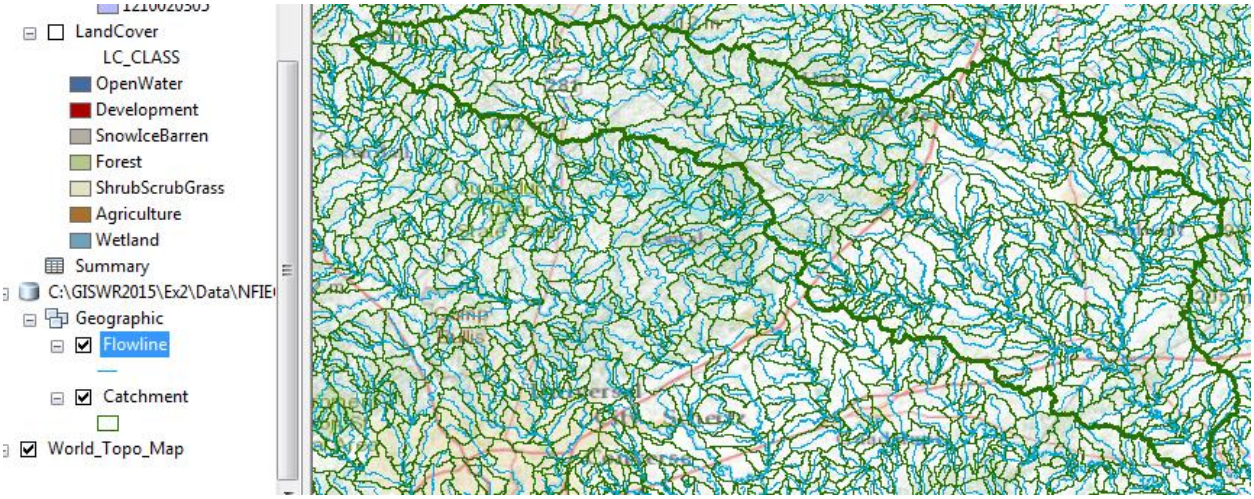
To be turned in: Make a map of the land cover variation over the San Marcos Basin. Prepare a table that shows the area (km^2) of each of the seven main land cover classes and the % of the total basin area that each represents.

Obtaining the San Marcos Flowlines and Catchments

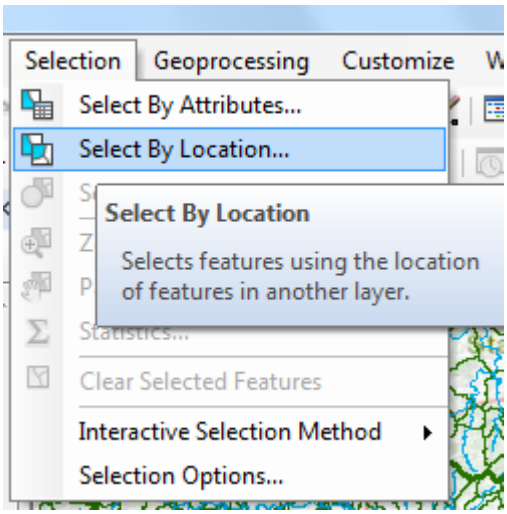
Go back to the NFIEGeo_12.gdb and add the Flowlines and Catchments to your ArcMap display. Turn off the LandCover distribution.



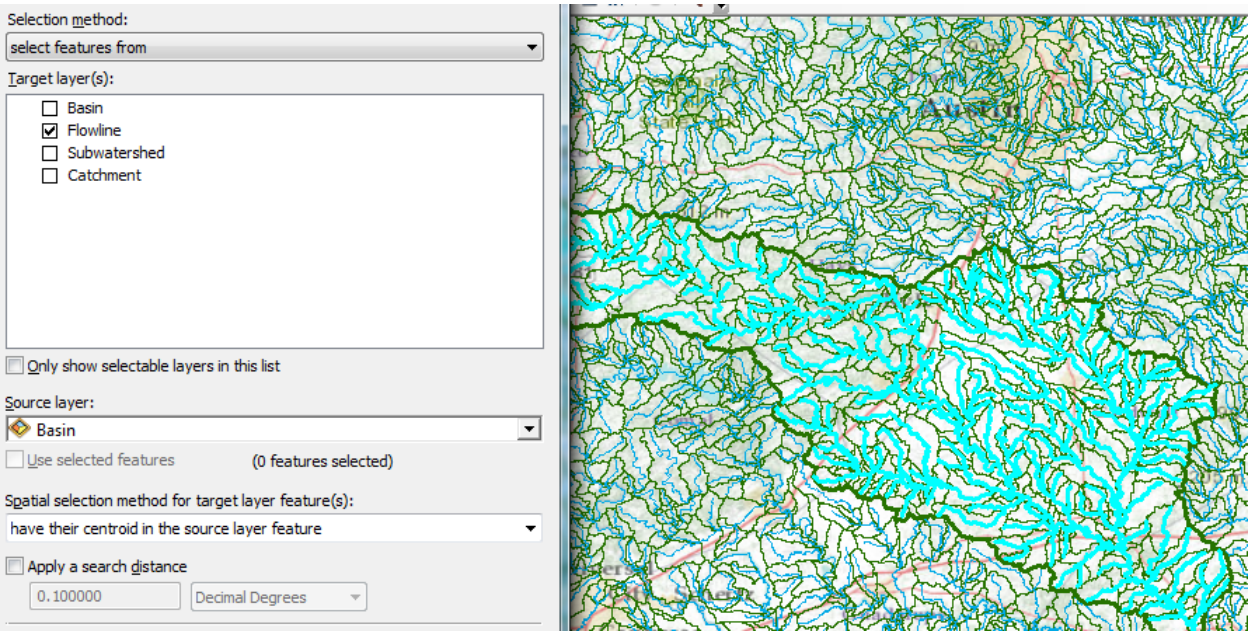
Color your Catchments as hollow with a green outline and your Flowlines as nice blue streams.



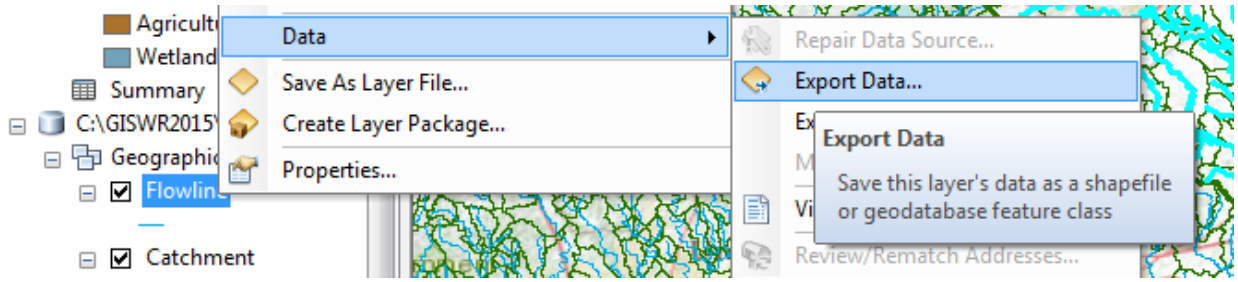
Now, let's select the features from our large dataset that lie within our Basin. In ArcMap, use **Selection/Selection by Location**

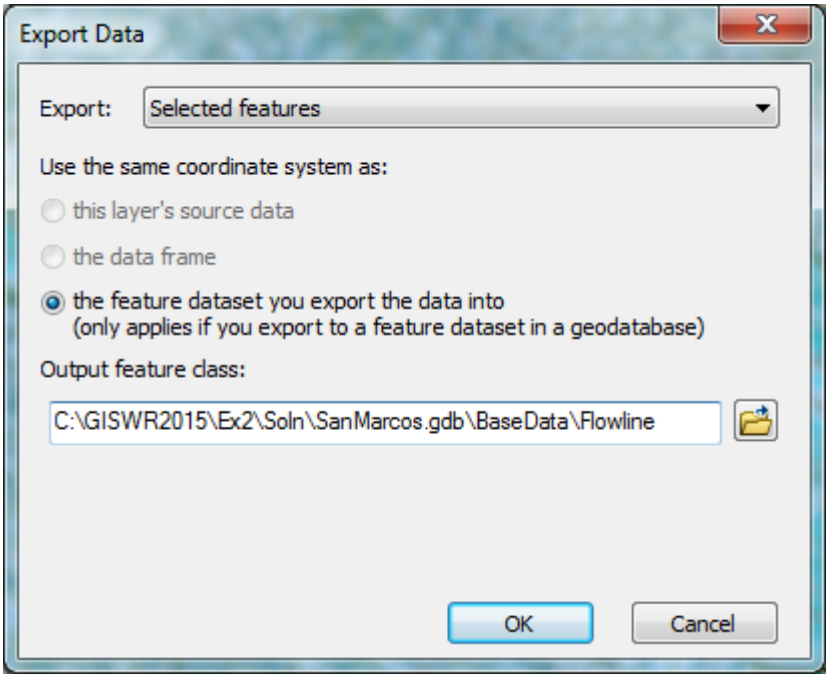


Select the features from the **Flowline** feature class that **Have their Centroid in the Source Layer Feature** for **Basin** and you'll see these flowlines selected as shown below.

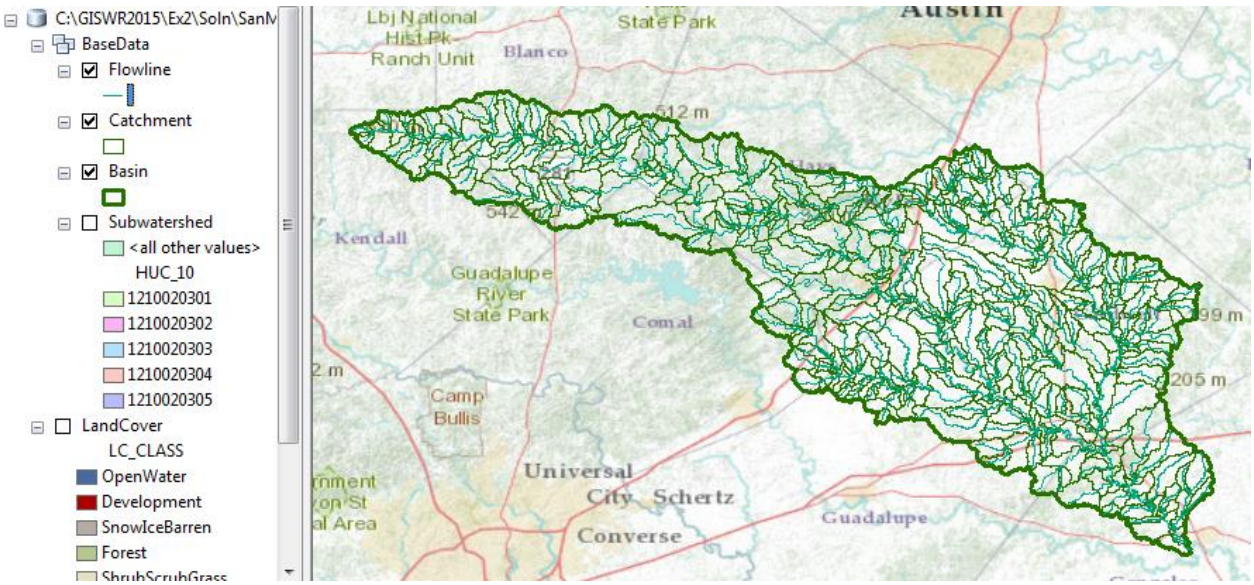


Export these selected Flowlines to a feature class called **Flowline** in the SanMarcos geodatabase, and add it to your ArcMap display

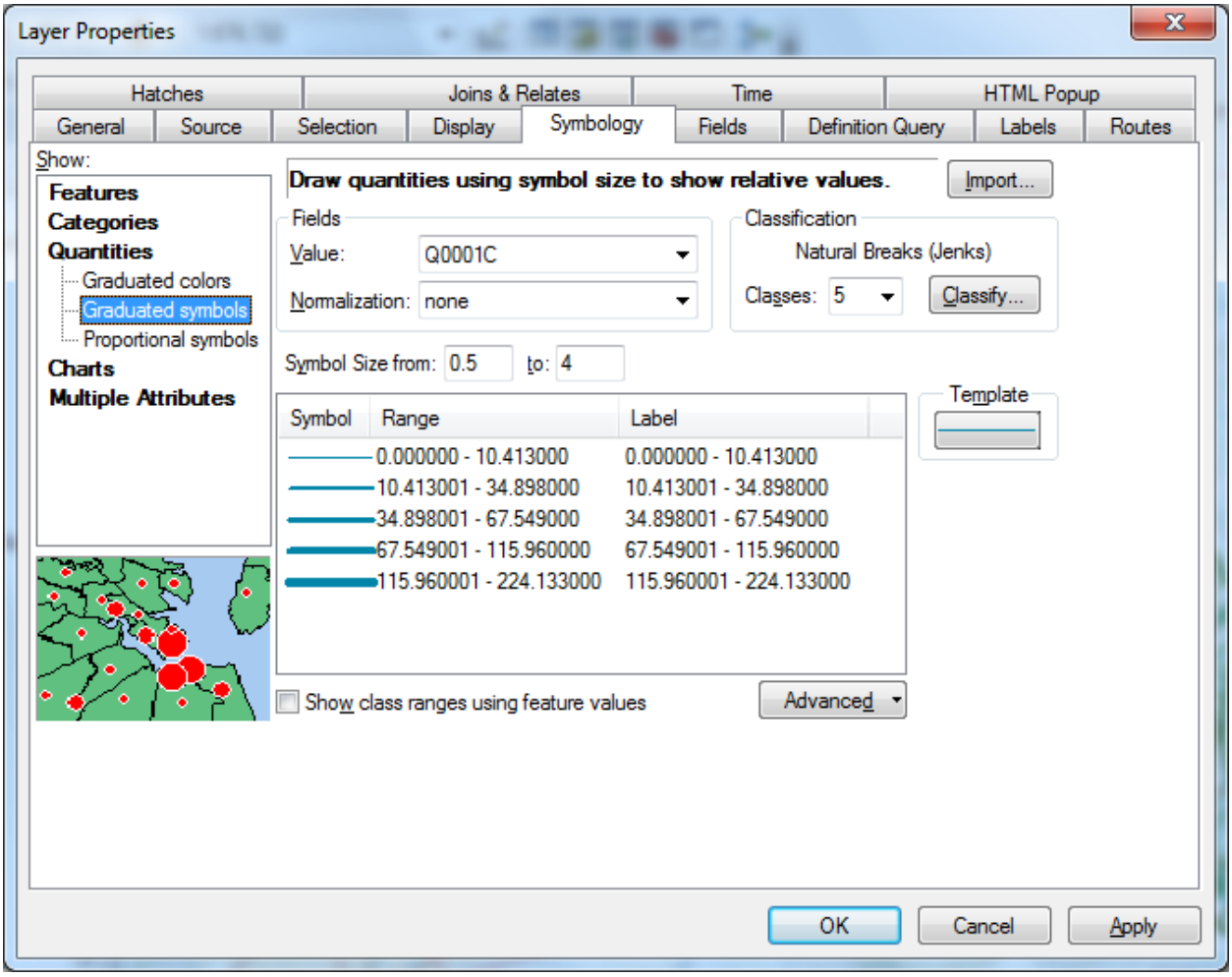




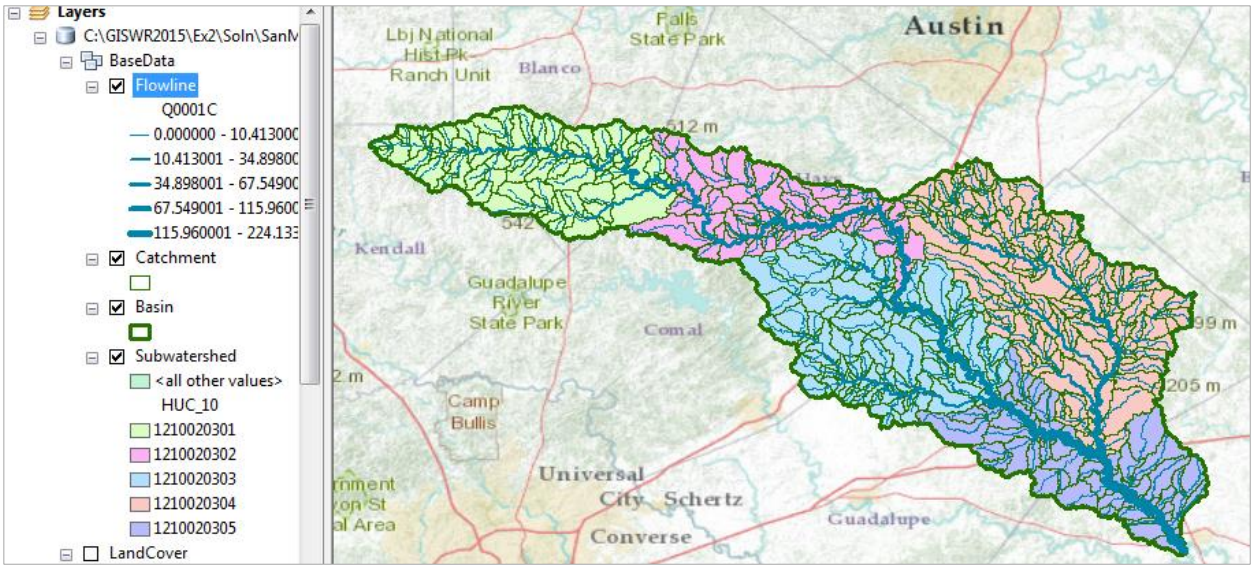
Clear the Selected Features, then repeat this procedure for selecting the **Catchment** features that lie within the San Marcos basin. Remove the large coverages of Flowline and Catchment that you started with and display only the Flowlines and Catchments within the San Marcos Basin.



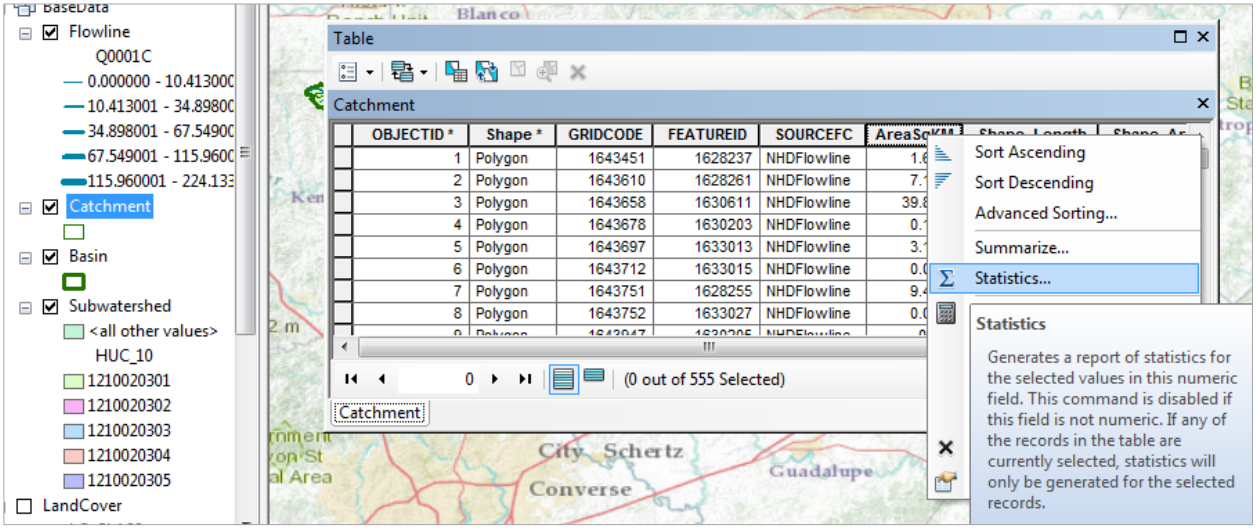
This process isn't quite so clever as for the land cover distribution – you have to recolor the newly added Flowlines and Catchments to make them blue and green respectively. This map looks a little bit like spaghetti, so let's recolor the Flowlines according to the Mean Annual Flow (Q0001C attribute). Right click on the **Flowline** feature class and select **Properties/Symbology**. Use **Graduated Symbols** with **Value Q0001C** and click on **Template** to change the base color to blue.



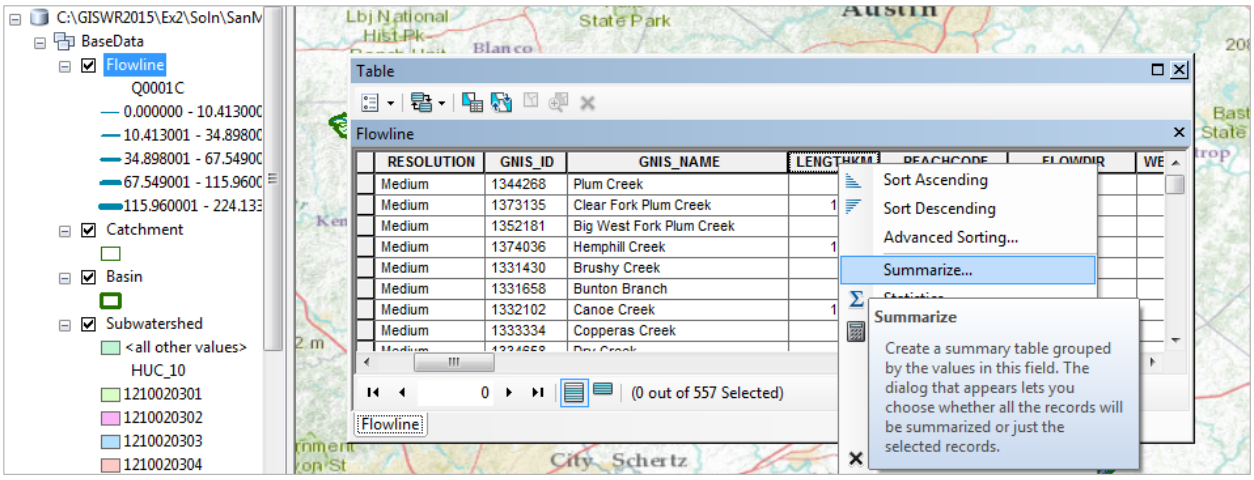
Turn on the display for the Subwatershed feature class. Now you've got a much more interesting map with the main river, called upstream the Blanco River and then downstream the San Marcos River. The tributary on the east side of the basin is Plum Creek. This is all laid out over a subdivision of the San Marcos basin by the HUC10 Watersheds.



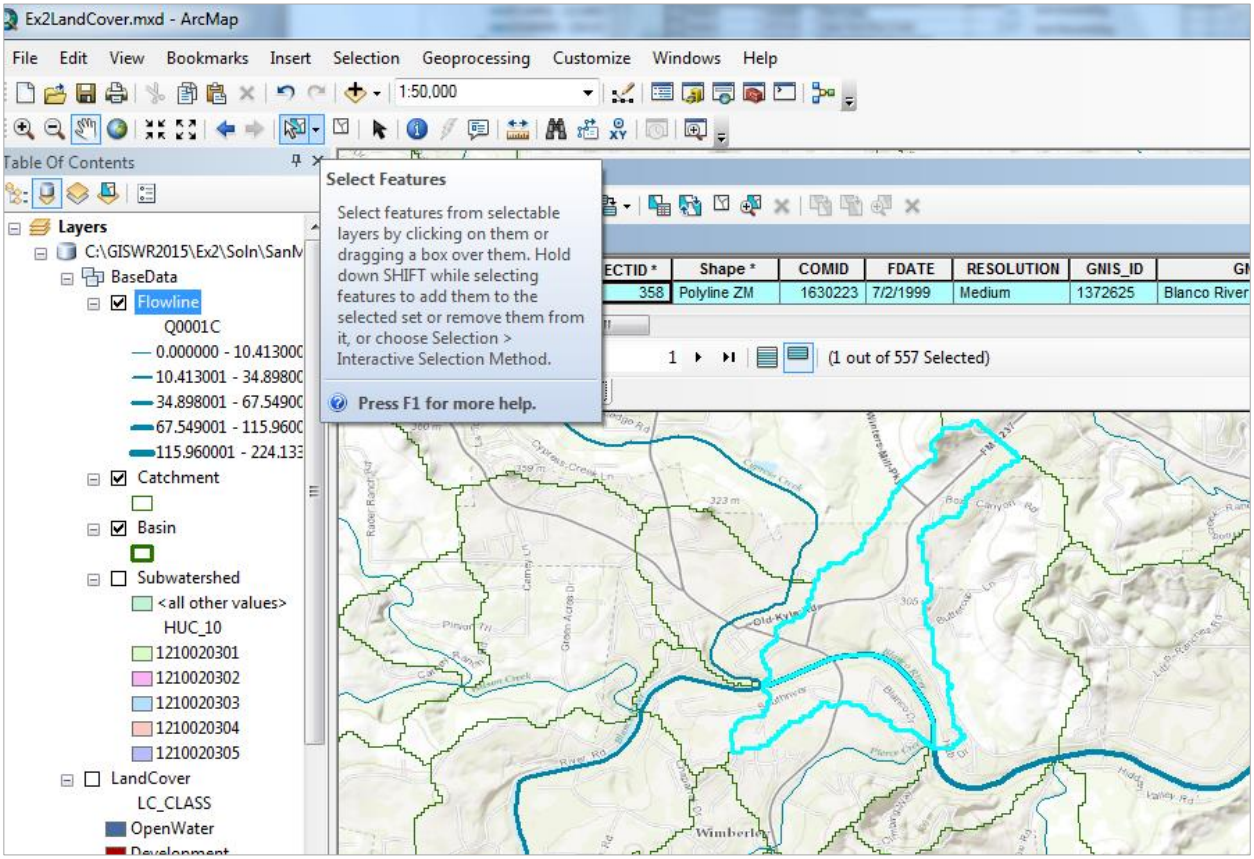
If you open up the **Catchment Attribute Table** and right click on the **AreaSqKm** attribute, you can determine the statistics of the Catchment areas.



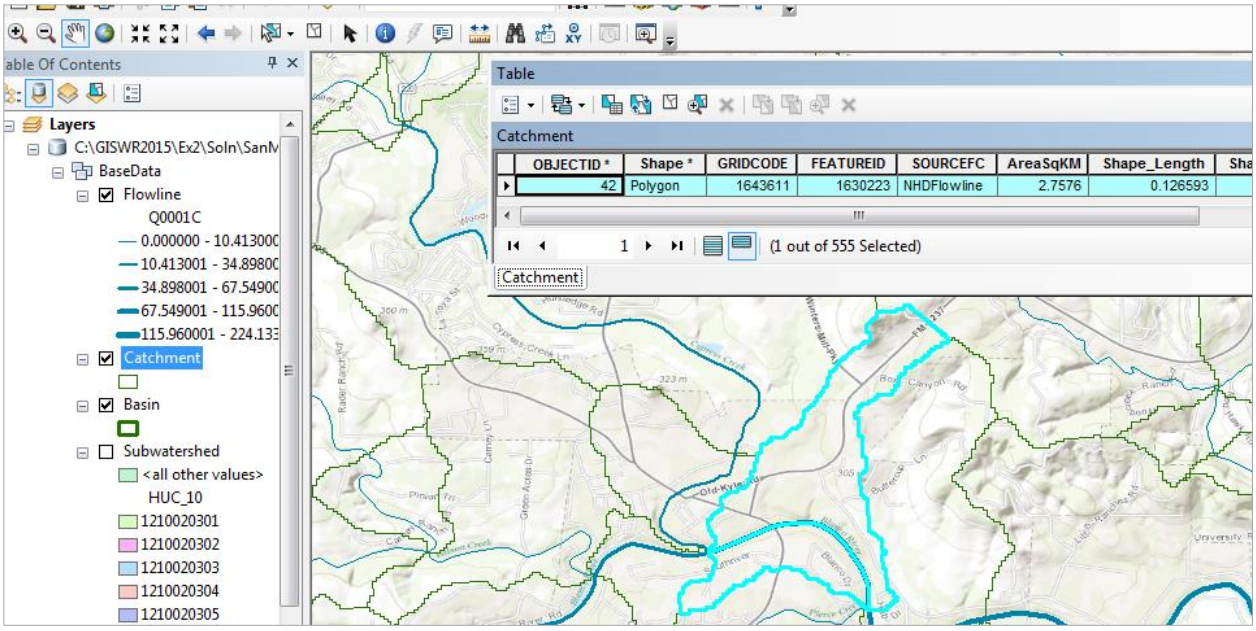
You can similarly summarize the attributes of **Flowline** feature class, such as the **LengthKm** attribute.



Use the Basemap to find the town of Wimberley near the upper end of the basin

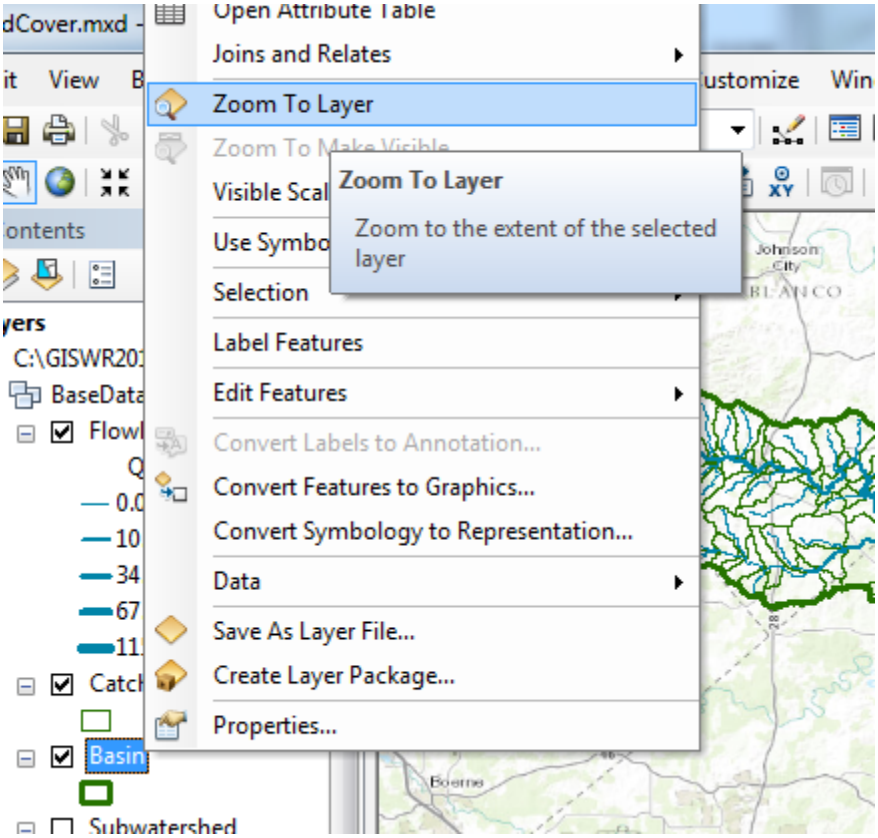


You can use the **Select** tool to select a flowline, such as the one labelled with **COMID = 1630223** (be sure to expand the field so you can see all the numbers in it) as shown in the diagram. If you similarly select the Catchment in this area, you'll see

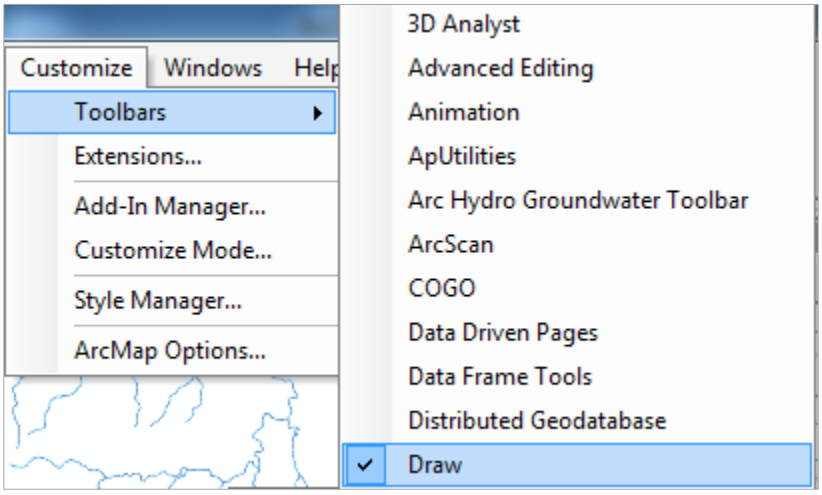


That the Catchment has FeatureID = 1630223. It is this COMID-FEATUREID association that makes the NHDPlus such a powerful dataset --- each stream feature has a unique area associated with it, and that is true over the whole United States. This is the basic association that we've used for the National Flood Interoperability Experiment.

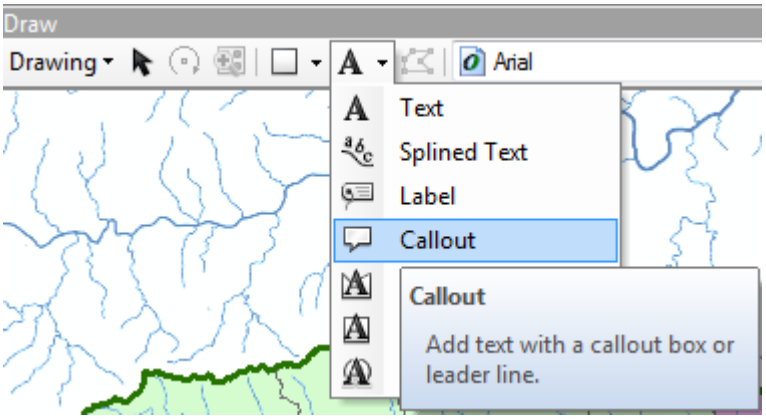
Clear the Selected Features, and **Zoom to Layer** for the **Basin** feature class to get back the original extent of our map.



Now let's create a map and do some summarization of watershed attributes. Right click in the grey area at the top of ArcMap to the right of the menu bars. Open the **Draw** Toolbar

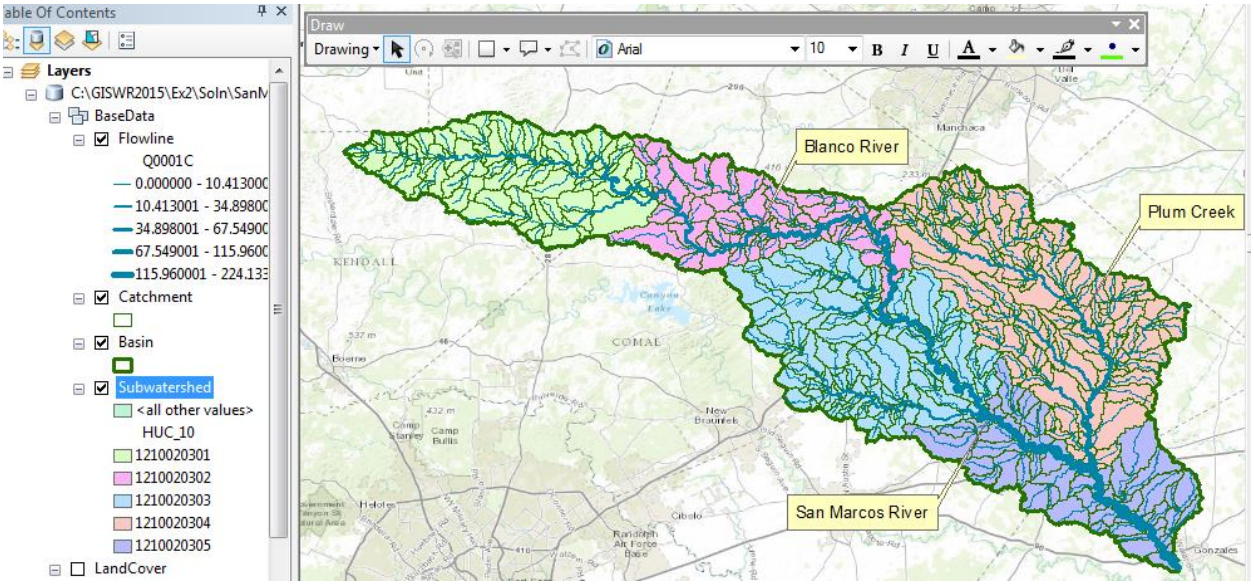


And select a **Callout** tool



Click somewhere on the Blanco River and drag the callout away to create a connection with that point. Type in **Blanco River** as the text. Do the same for the other two main rivers in the map, the San Marcos River and Plum Creek.

Save your map document as **Ex2Flow.mxd**



To be turned in: Make a map of the San Marcos basin with its labelled rivers. How many Catchments lie within this basin? What is their average area (Sq. Km)? How many Flowlines lie within this basin? What is their average length (Km)?

Creating a Point Feature Class of Stream Gages

Now you are going to build a new Feature Class yourself of stream gage locations in the San Marcos basin. I have extracted information from the USGS site information at http://waterdata.usgs.gov/tx/nwis/si

SiteID	SiteName	Latitude	Longitude	DASqMile	MAFlow
08171000	Blanco Rv at Wimberley, Tx	29º 59' 39"	98º 05' 19"	355	142

08171300	Blanco Rv nr Kyle, Tx	29º 58' 45"	97º 54' 35"	412	165
08172400	Plum Ck at Lockhart, Tx	29º 55' 22"	97º 40' 44"	112	49
08173000	Plum Ck nr Luling, Tx	29º 41' 58"	97º 36' 12"	309	114
08172000	San Marcos Rv at Luling, Tx	29º 39' 58"	97º 39' 02"	838	408
08170500	San Marcos Rv at San Marcos, Tx	29º 53' 20"	97º 56' 02"	48.9	176

(a) Define a table containing an ID and the long, lat coordinates of the gages

The coordinate data is in geographic degrees, minutes, & seconds. These values need to be converted to digital degrees, so go ahead and perform that computation for the 8 pairs of longitude and latitude values. This is something that has to be done carefully because any errors in conversions will result in the stations lying well away from the San Marcos basin. I suggest that you prepare an Excel table showing the gage longitude and latitude in degrees, minutes and seconds, convert it to long, lat in decimal degrees using the formula

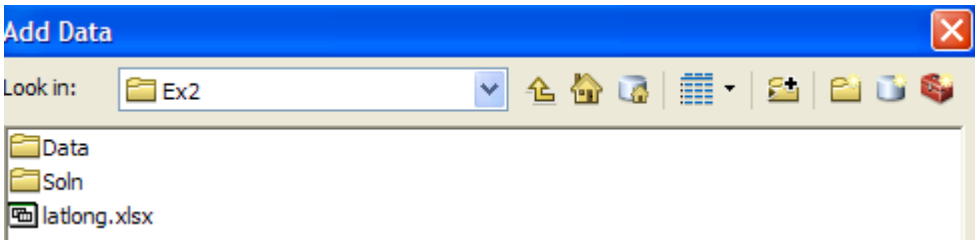
Decimal Degrees (DD) = Degrees + Min/60 + Seconds/3600

Remember that West Longitude is negative in decimal degrees. Shown below is a table that I created. **Be sure to format the columns containing the Longitude and Latitude data in decimal degrees (LongDD and LatDD) so that they explicitly have Number format with 4 decimal places using Excel format procedures. Format the column SITEID as Text or it will not retain the leading zero in the SiteID data**. Add the additional information about the USGS SiteID, SiteName and Mean Annual Flow (MAF). Note the name of the worksheet that you have stored the data in. I have called mine **latlong.xlsx**. Close Excel before you proceed to ArcMap.

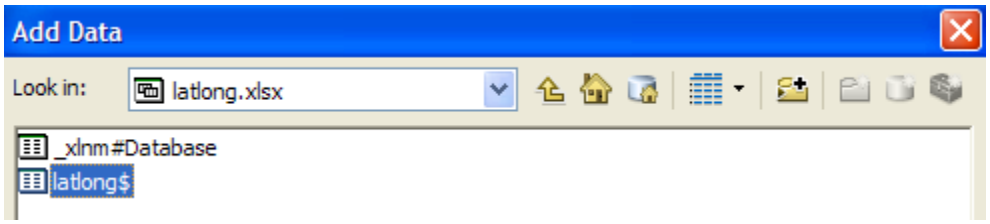
SiteID	SiteName	Latitude	Longitude	LatDeg	LatMin	LatSec	LongDeg	LongMin	LongSec	LatDD	LongDD	DASqMile	MAFlow
08171000	Blanco Rv at Wimberley, Tx	29º 59' 39"	98º 05' 19"	29	59	39	98	5	19	29.9942	-98.0886	355	142
08171300	Blanco Rv nr Kyle, Tx	29º 58' 45"	97º 54' 35"	29	58	45	97	54	35	29.9792	-97.9097	412	165
08172400	Plum Ck at Lockhart, Tx	29º 55' 22"	97º 40' 44"	29	55	22	97	40	44	29.9228	-97.6789	112	49
08173000	Plum Ck nr Luling, Tx	29º 41' 58"	97º 36' 12"	29	41	58	97	36	12	29.6994	-97.6033	309	114
08172000	San Marcos Rv at Luling, Tx	29º 39' 58"	97º 39' 02"	29	39	58	97	39	2	29.6661	-97.6506	838	408
08170500	San Marcos Rv at San Marcos, Tx	29º 53' 20"	97º 56' 02"	29	53	20	97	56	2	29.8889	-97.9339	48.9	176

(b) Creating and Projecting a Feature Class of the Gages

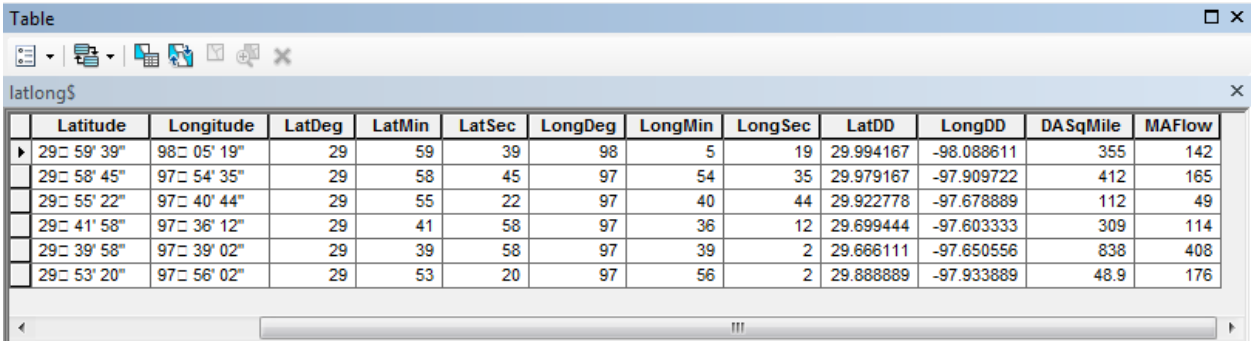
(1) Open **ArcMap** and the **Ex2Flow.mxd** file you created earlier in this exercise. Select the add data button  and navigate to your Excel spreadsheet



Double click on the spreadsheet to identify the individual worksheet within the spreadsheet that you want to add to ArcMap (it's a coincidence that they have the same name in this example and that is not necessary in general).



Hit **Add** and your spreadsheet will be added to ArcMap. Pretty cool!! Its always been a struggle to add data from spreadsheets before and it seems like at ArcGIS 10, they have gotten this right. If you have trouble with this step, save the Excel file as a .csv format and add it that way.



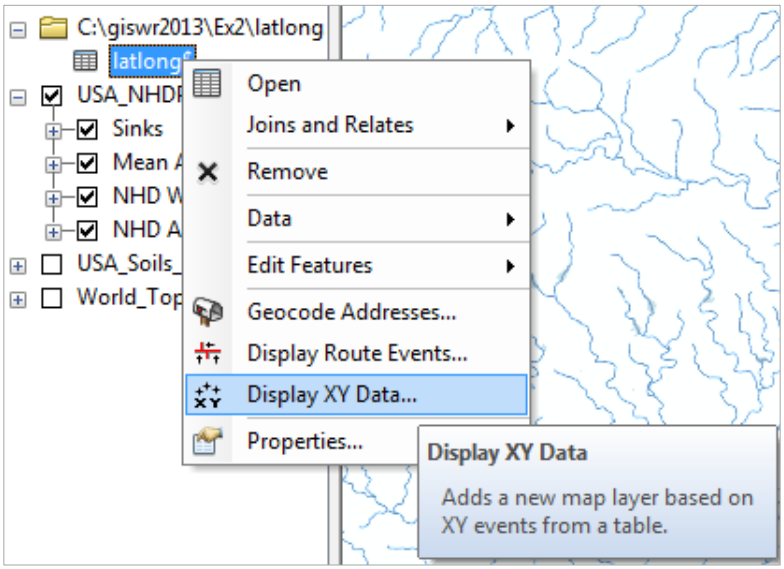
Table

latlong$

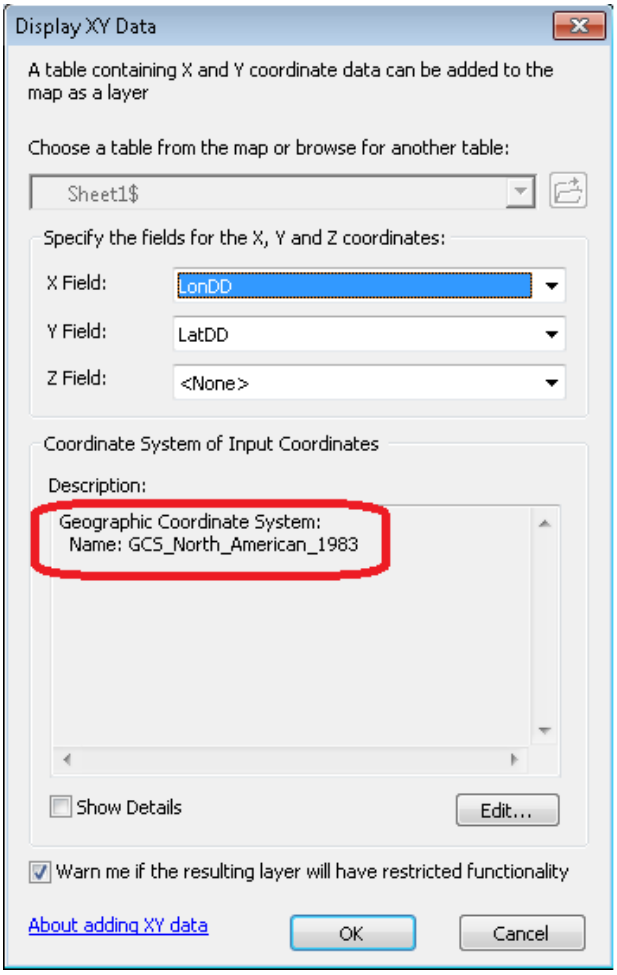
Latitude	Longitude	LatDeg	LatMin	LatSec	LongDeg	LongMin	LongSec	LatDD	LongDD	DASqMile	MAFlow
29□ 59' 39"	98□ 05' 19"	29	59	39	98	5	19	29.994167	-98.088611	355	142
29□ 58' 45"	97□ 54' 35"	29	58	45	97	54	35	29.979167	-97.909722	412	165
29□ 55' 22"	97□ 40' 44"	29	55	22	97	40	44	29.922778	-97.678889	112	49
29□ 41' 58"	97□ 36' 12"	29	41	58	97	36	12	29.699444	-97.603333	309	114
29□ 39' 58"	97□ 39' 02"	29	39	58	97	39	2	29.666111	-97.650556	838	408
29□ 53' 20"	97□ 56' 02"	29	53	20	97	56	2	29.888889	-97.933889	48.9	176

Now we are going to convert the tabular data in the spreadsheet to points in the ArcMap display.

(2) **Right click** on the new table, **latlong$**, and select **Display XY Data**

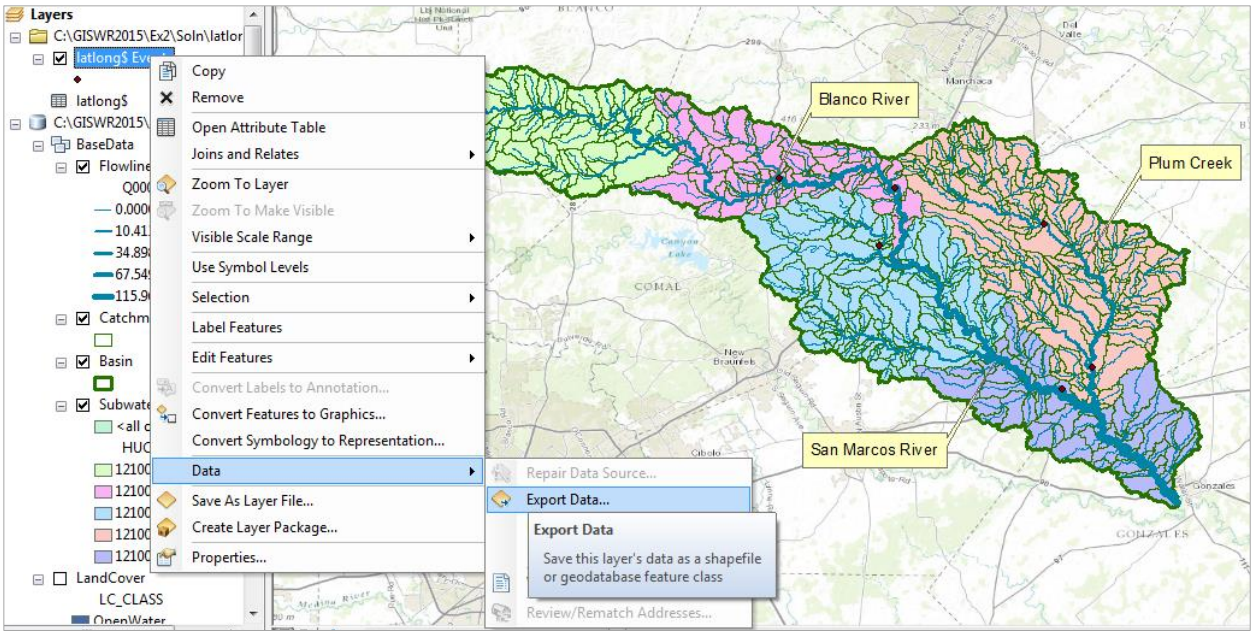


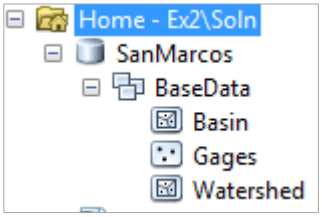
(3) Set the X Field to **LongDD**, the Y Field to **LatDD**, Note that by default a GCS_North_American_1983 coordinate system is chosen. This is correct for this dataset. You could use Edit to change it if the coordinate system of the input data was different.



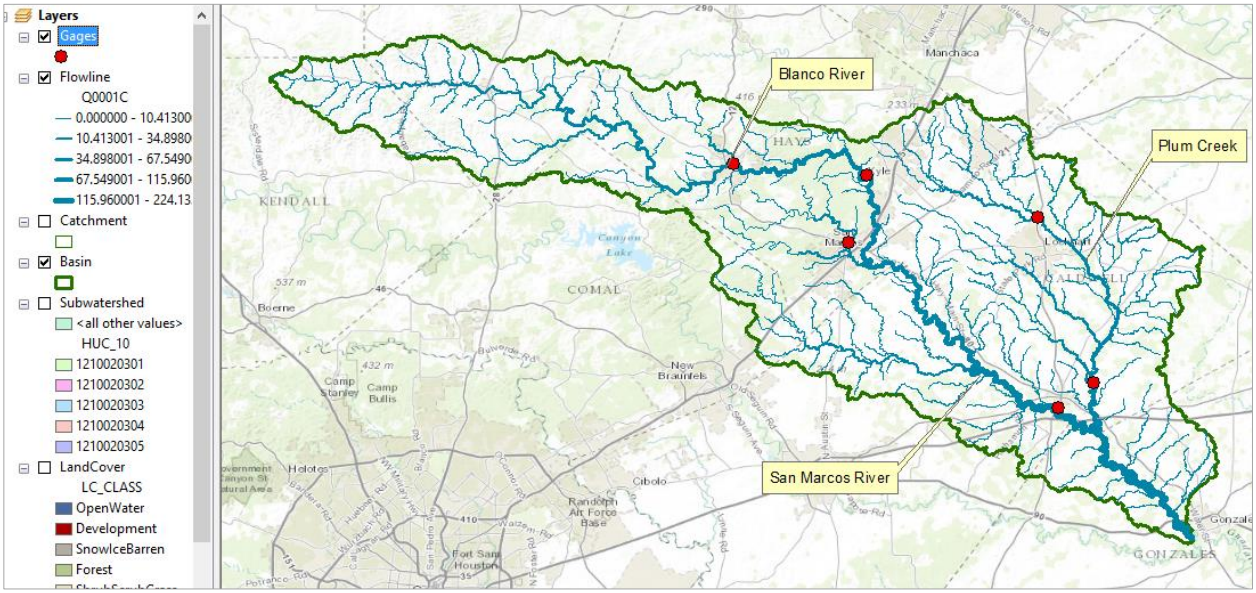
Hit **OK**, to complete it and you'll get a warning message about your table not having an ObjectID. Just hit Ok and and voila! Your gage points show up on the map right along the San Marcos River just like they should. Magic. I remember the first time I did this I was really thrilled. This stuff really works. I can create data points myself! If you don't see any points, don't be dismayed. Check back at your spreadsheet to make sure that the correct X field and Y field have been selected as the ones that have your data in decimal degrees.

Now let's store these points in our geodatabase as a real feature class, called **Gages**. Right click on **Latlong$Events** (or possibly Sheet1$events) and **Export Data** to convert the points into a **Gages** feature class in the San Marcos Geodatabase, as you did earlier with Basin and Watershed.



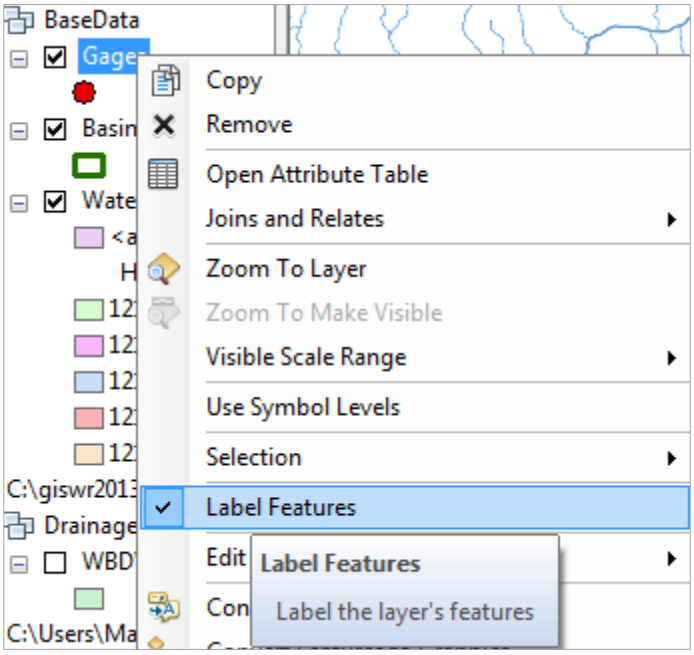


Add the resulting Gages to your map and recolor and resize them so you can see them clearly.

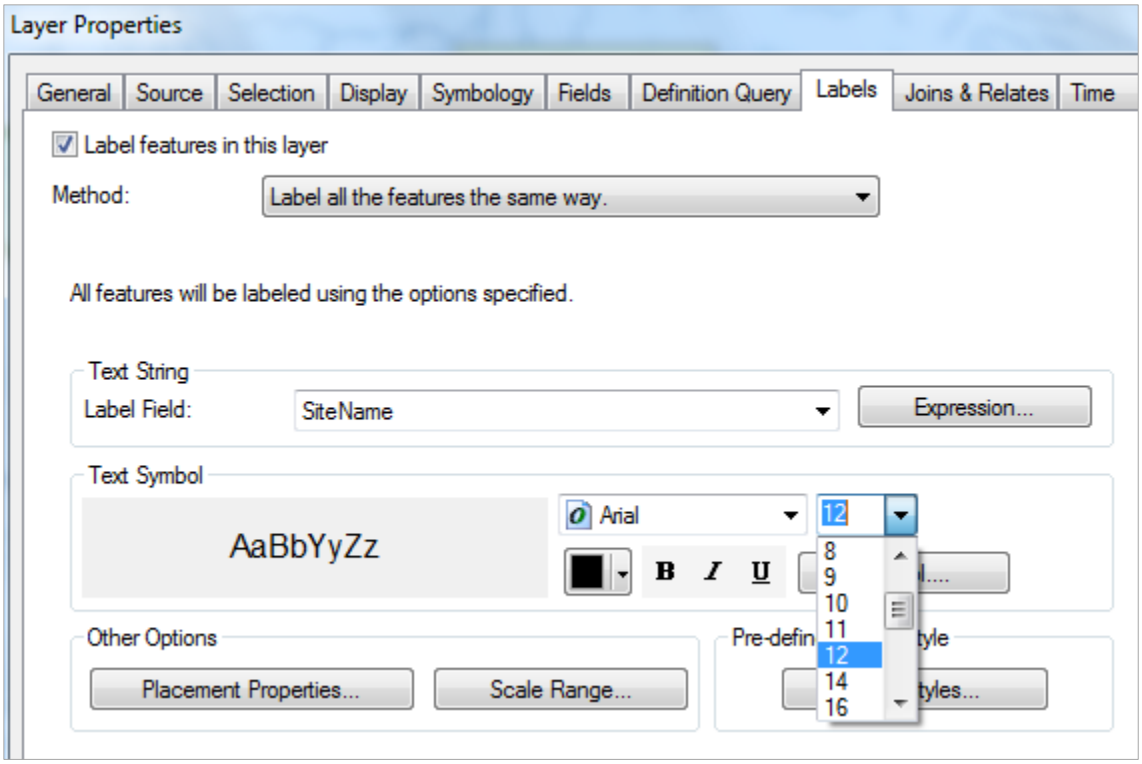


Now let's label the Gages with their Names. Right click on the **Gage** feature class and click on **Label Features**. You'll see some labels show up in small lettering. It can occur that some

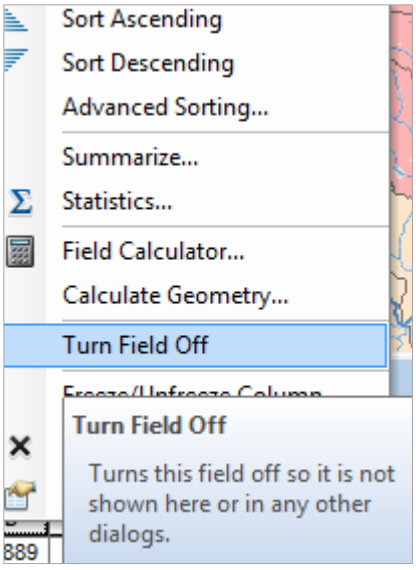
labels don't show up because they display where you've got your Watershed Callouts created earlier. Drag those Callout boxes to another location and the gage labels will appear.



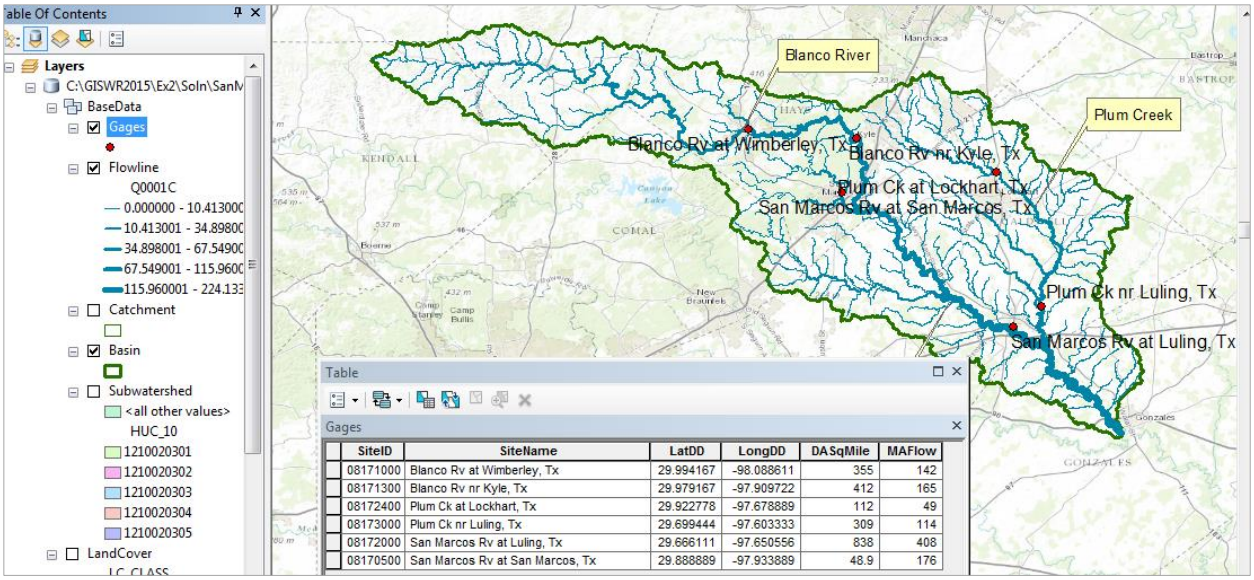
To resize the labels, right click on **Gage** and select **Properties/ Labels**, and then select 12 point type.



Open the **Attribute Table** of the **Gages,** and right click on the fields that you really don't need to see and hide them.



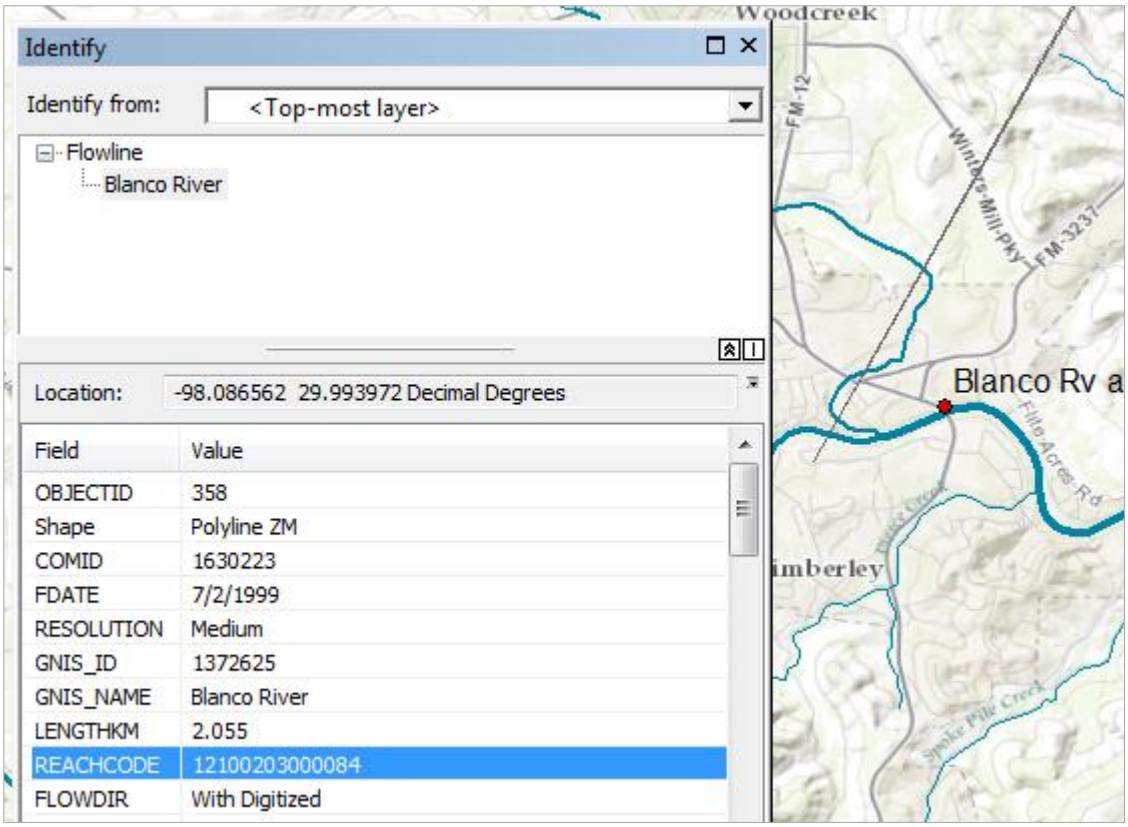
Make a display like that shown below.



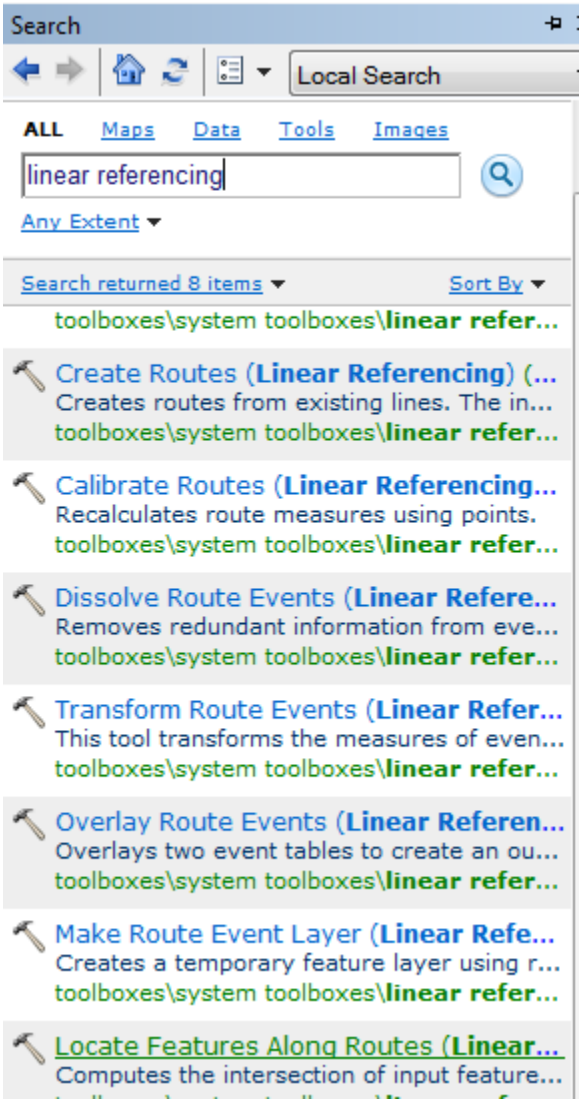
SiteID	SiteName	LatDD	LongDD	DASqMile	MAFlow
08171000	Blanco Rv at Wimberley, Tx	29.994167	-98.088611	355	142
08171300	Blanco Rv nr Kyle, Tx	29.979167	-97.909722	412	165
08172400	Plum Ck at Lockhart, Tx	29.922778	-97.678889	112	49
08173000	Plum Ck nr Luling, Tx	29.699444	-97.603333	309	114
08172000	San Marcos Rv at Luling, Tx	29.666111	-97.650556	838	408
08170500	San Marcos Rv at San Marcos, Tx	29.888889	-97.933889	48.9	176

Linear Referencing the Stream Gages

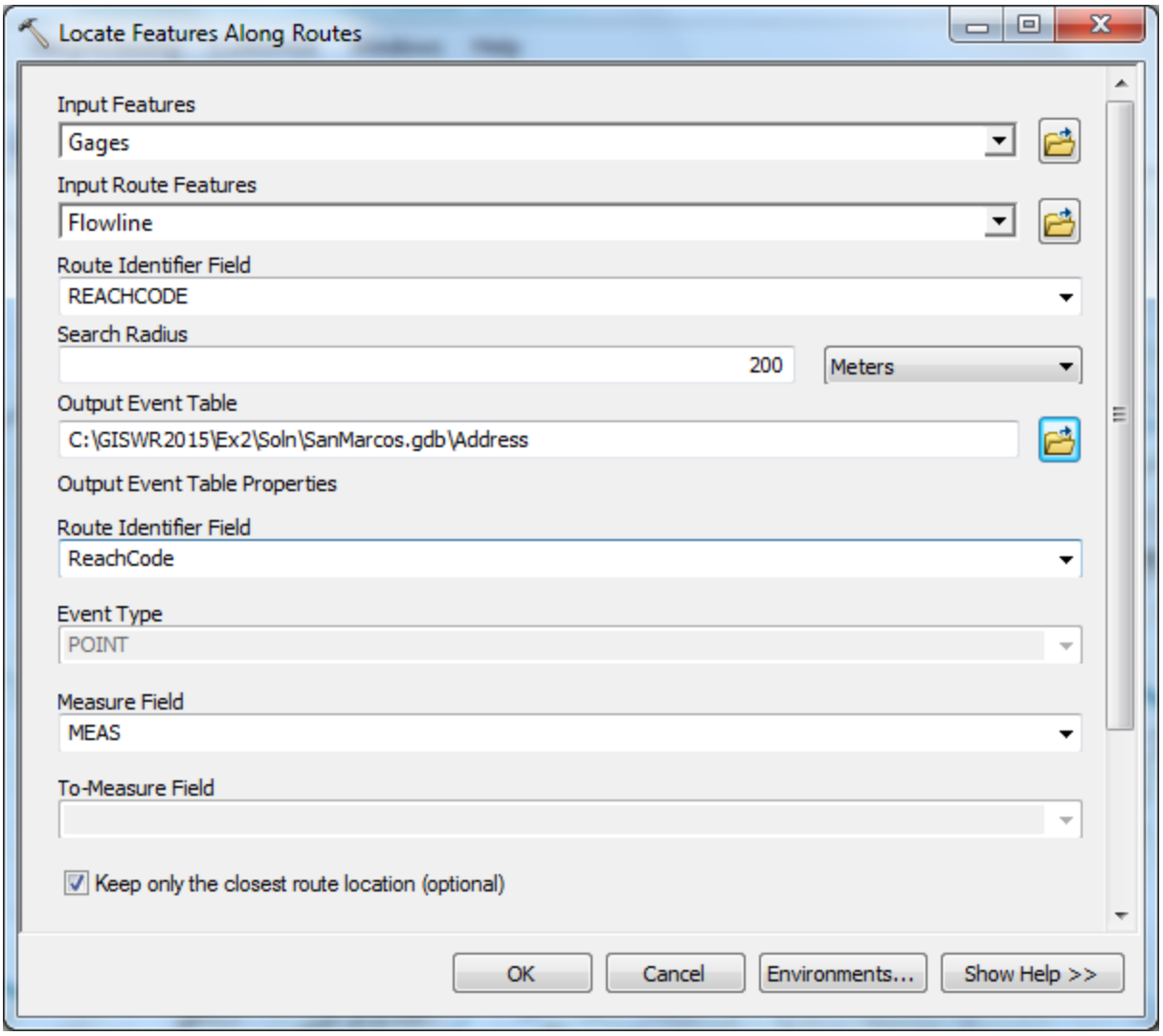
Now, let's locate the gages on the Flowlines. Zoom in to the location of the Blanco River at Wimberley and query the Flowline there. You'll see it has a **ReachCode** value of **12100203000084**. This means that it is river segment 84 in the HUC8 Subbasin 12100203. The EPA and USGS have similarly labelled all the river and stream reaches in the nation.



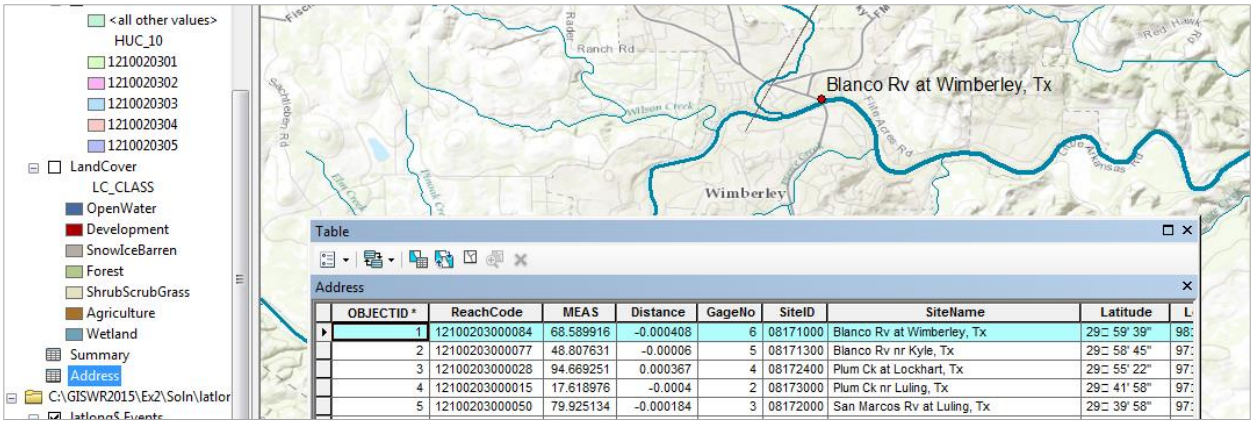
Use **Search** to locate **Linear Referencing** tools and select **Locate Features Along Routes**

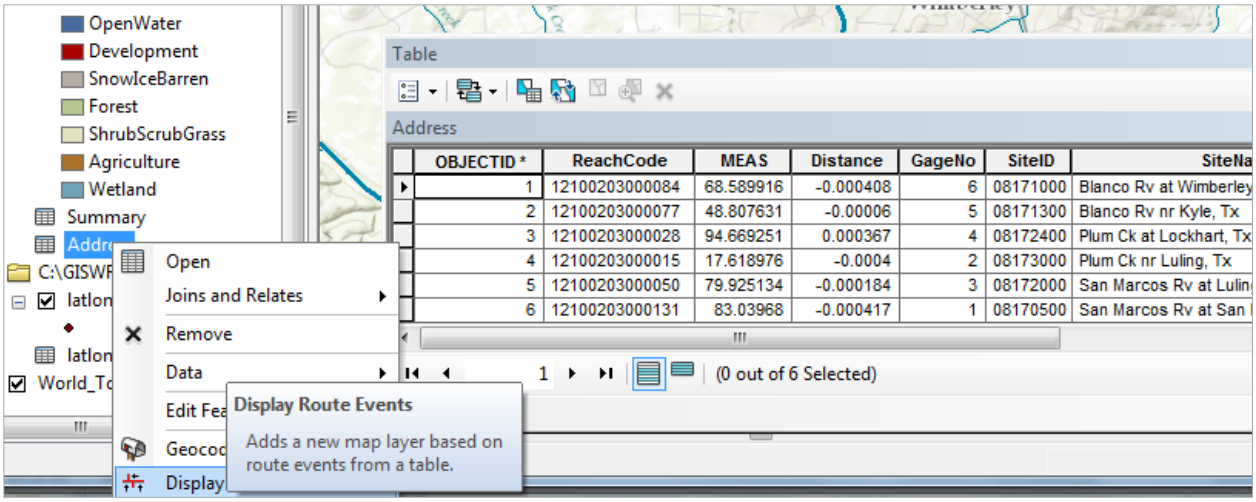


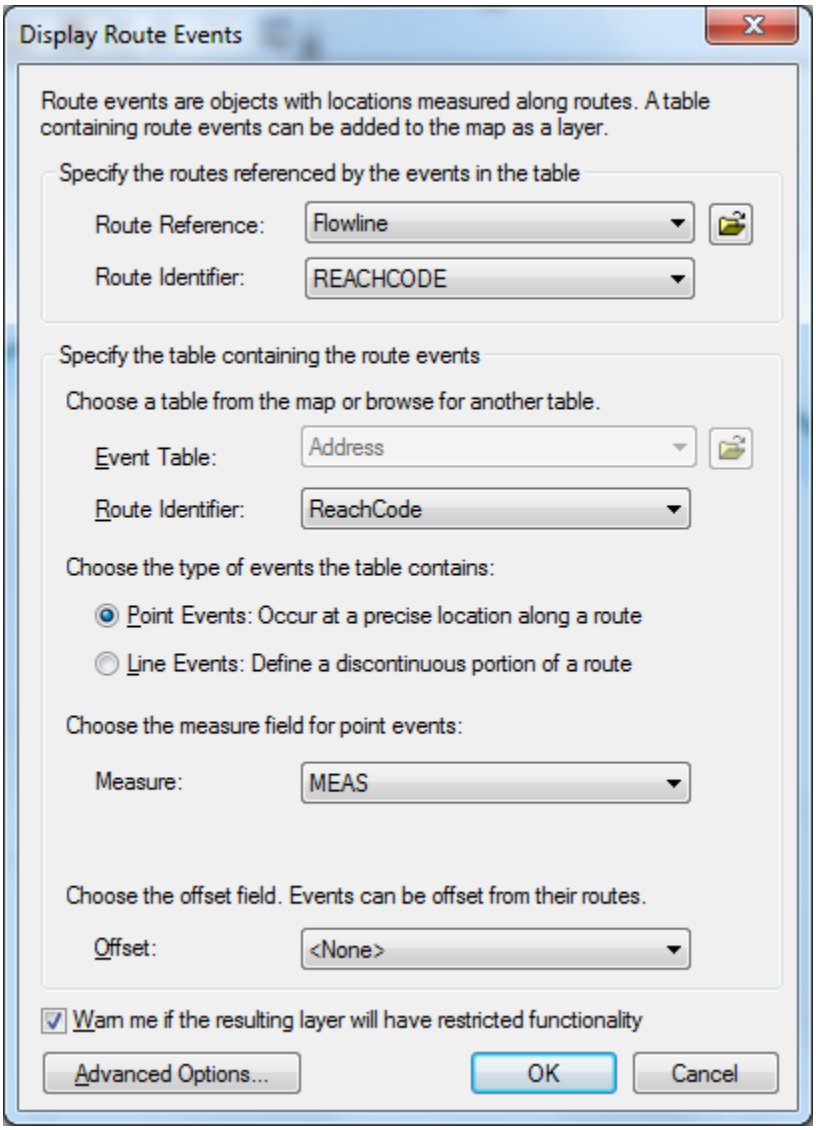
Fill out the resulting table as shown:



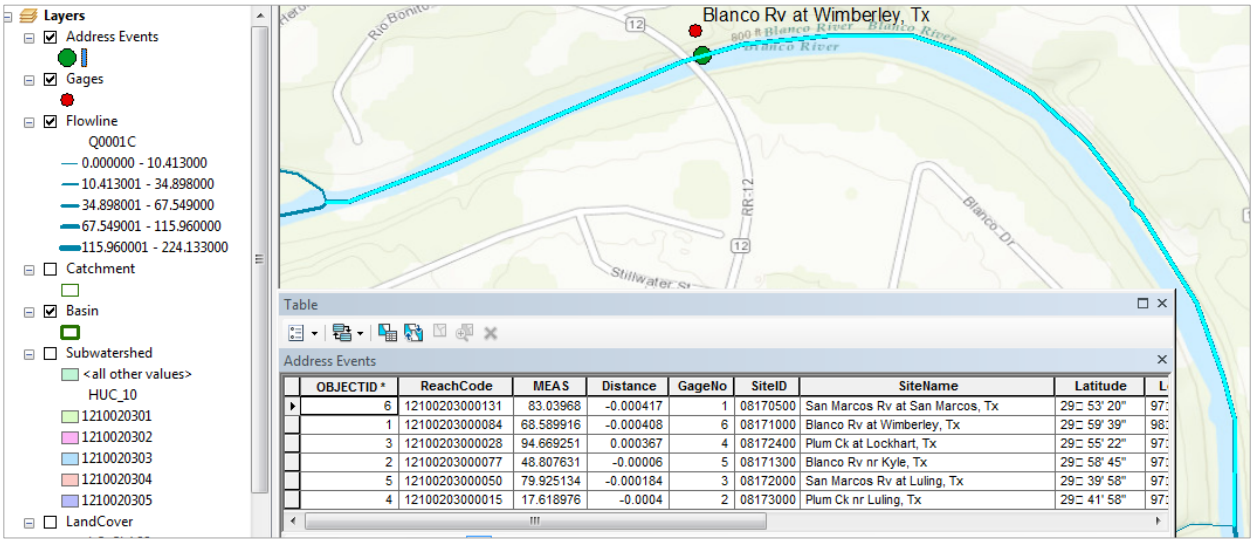
And you'll see a table called **Address** show up in your map display that has ReachCode and Measure locations for all your gages. This "addresses" them on the nation's stream network so that we know where they are.




OpenWater
Development
SnowIceBarren
Forest
ShrubScrubGrass
Agriculture
Wetland
Summary
Open
Joins and Relates
Remove
Data
Edit Fea
Geocod
Display
Display Route Events
Adds a new map layer based on route events from a table.
Table
Address
OBJECTID *
ReachCode
MEAS
Distance
GageNo
SiteID
SiteNa
1 12100203000084 68.589916 -0.000408 6 08171000 Blanco Rv at Wimberley
2 12100203000077 48.807631 -0.00006 5 08171300 Blanco Rv nr Kyle, Tx
3 12100203000028 94.669251 0.000367 4 08172400 Plum Ck at Lockhart, Tx
4 12100203000015 17.618976 -0.0004 2 08173000 Plum Ck nr Luling, Tx
5 12100203000050 79.925134 -0.000184 3 08172000 San Marcos Rv at Lulin
6 12100203000131 83.03968 -0.000417 1 08170500 San Marcos Rv at San
(0 out of 6 Selected)


Display Route Events
Route events are objects with locations measured along routes. A table containing route events can be added to the map as a layer.
Specify the routes referenced by the events in the table
Route Reference: Flowline
Route Identifier: REACHCODE
Specify the table containing the route events
Choose a table from the map or browse for another table.
Event Table: Address
Route Identifier: ReachCode
Choose the type of events the table contains:
Point Events: Occur at a precise location along a route
Line Events: Define a discontinuous portion of a route
Choose the measure field for point events:
Measure: MEAS
Choose the offset field. Events can be offset from their routes.
Offset: <None>
Warn me if the resulting layer will have restricted functionality
Advanced Options...
OK
Cancel

I have colored in the resulting Address Events in Green and used the Attribute Selection on Flowlines to select those with ReachCode = 12100203000084. The Measure value of 68.59 for this location means that the Green point is 68.59 % of the distance upstream from the downstream end of this flowline (the flow goes from left to right in this picture). As you can see, the Address Event is located right on the Flowline, not a little way off as the latitude and longitude of the gage would have indicated (and these values might be at the gage house which is a little way from the stream itself. In this manner, you can see how Linear Referencing provides precise location on the stream network of stream gages or other point features (you can also do Linear Referencing for line features that stretch from one point on a line to another).

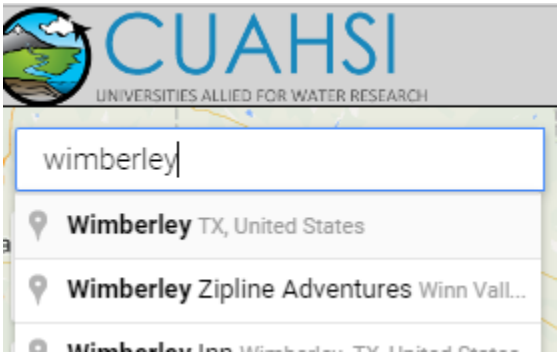


OBJECTID *	ReachCode	MEAS	Distance	GageNo	SiteID	SiteName	Latitude	L
6	12100203000131	83.03968	-0.000417	1	08170500	San Marcos Rv at San Marcos, Tx	29° 53' 20"	97:
1	12100203000084	68.589916	-0.000408	6	08171000	Blanco Rv at Wimberley, Tx	29° 59' 39"	98:
3	12100203000028	94.669251	0.000367	4	08172400	Plum Ck at Lockhart, Tx	29° 55' 22"	97:
2	12100203000077	48.807631	-0.00006	5	08171300	Blanco Rv nr Kyle, Tx	29° 58' 45"	97:
5	12100203000050	79.925134	-0.000184	3	08172000	San Marcos Rv at Luling, Tx	29° 39' 58"	97:
4	12100203000015	17.618976	-0.0004	2	08173000	Plum Ck nr Luling, Tx	29° 41' 58"	97:

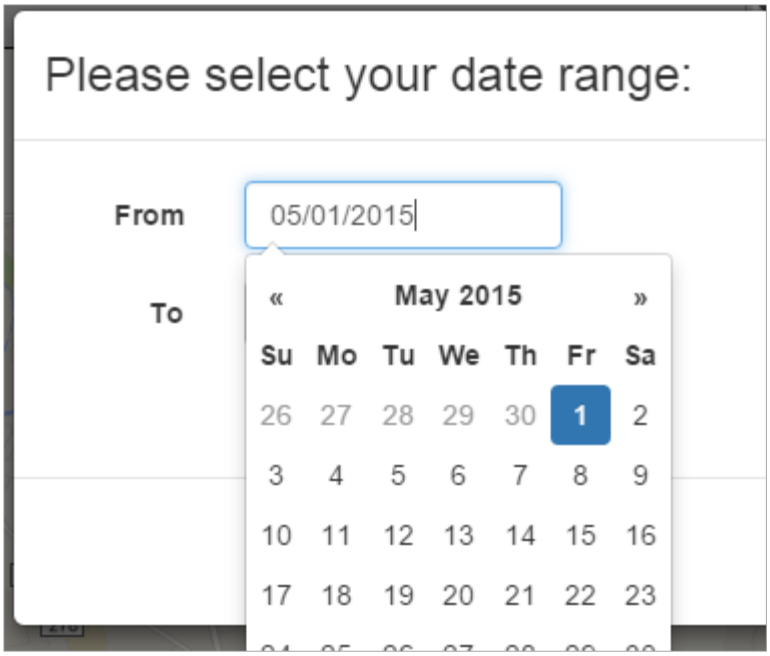
Save your map as **Ex2Gages.mxd**.

Flow Data for the Blanco River

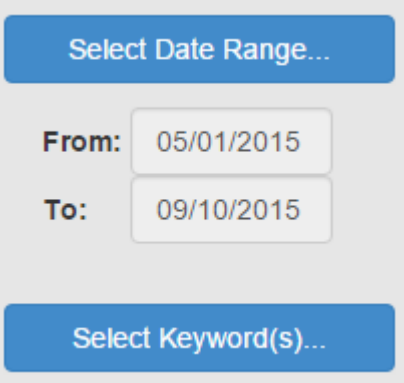
Open the CUAHSI data viewer http://data.cuahsi.org Enter the location Wimberley, Texas in the box in the upper left corner.



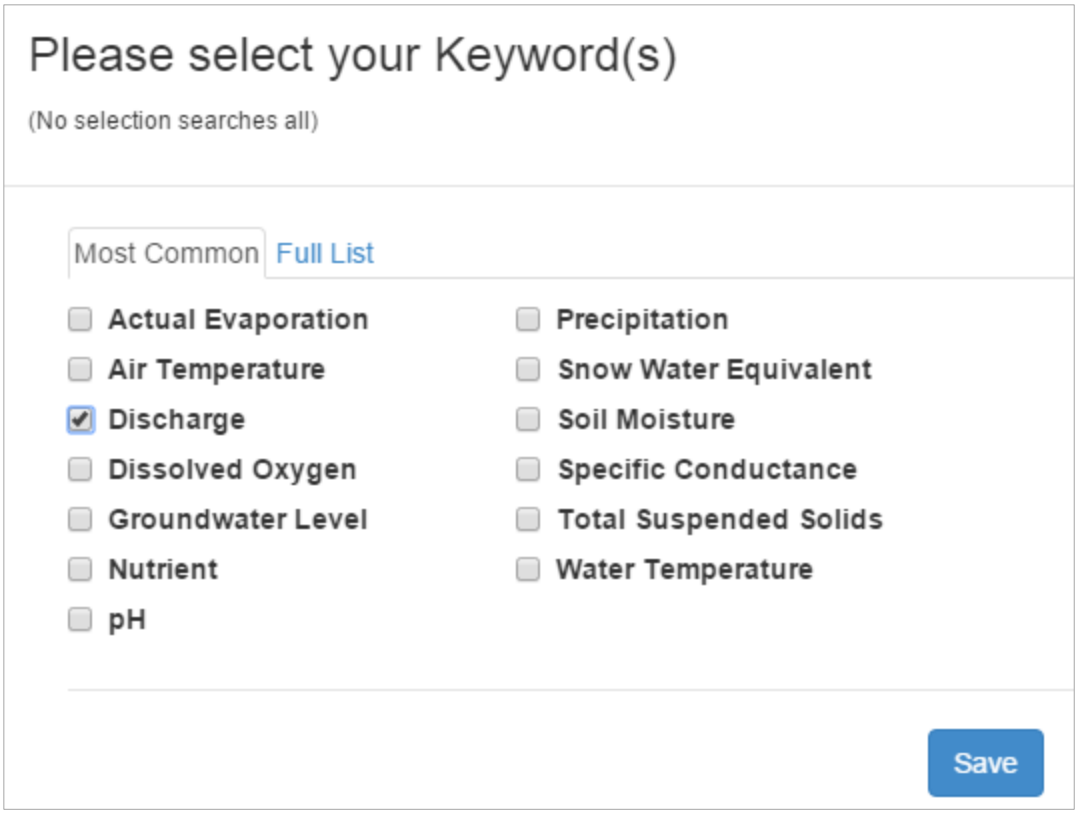
In the top right hand corner, select a Date Range of May 1, 2015 to present



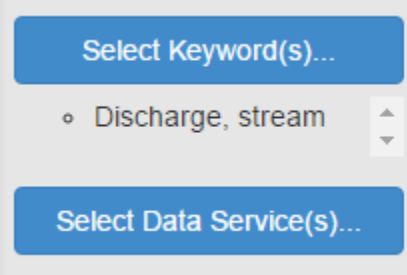
So the Date Range is set at:



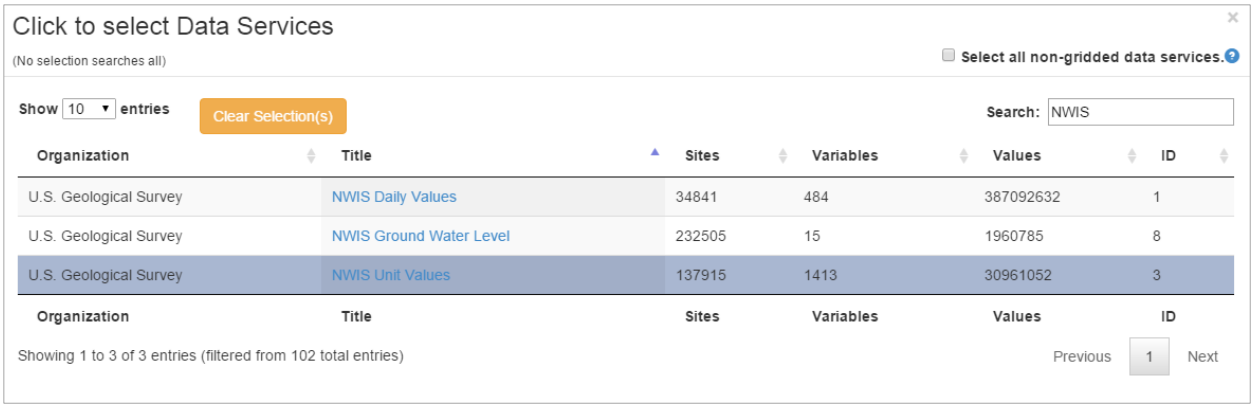
Select a Keyword for **Discharge**



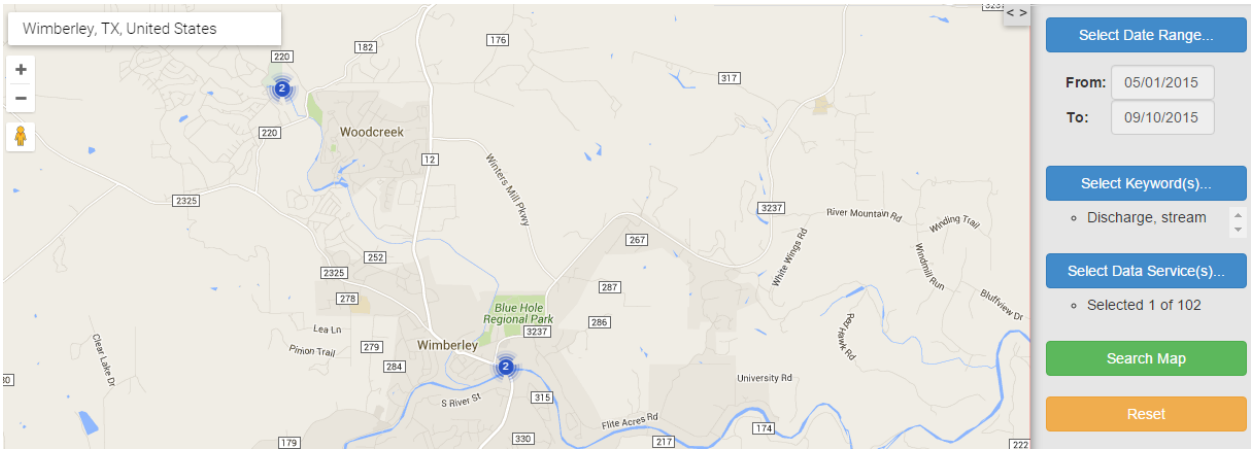
Select a Data Service



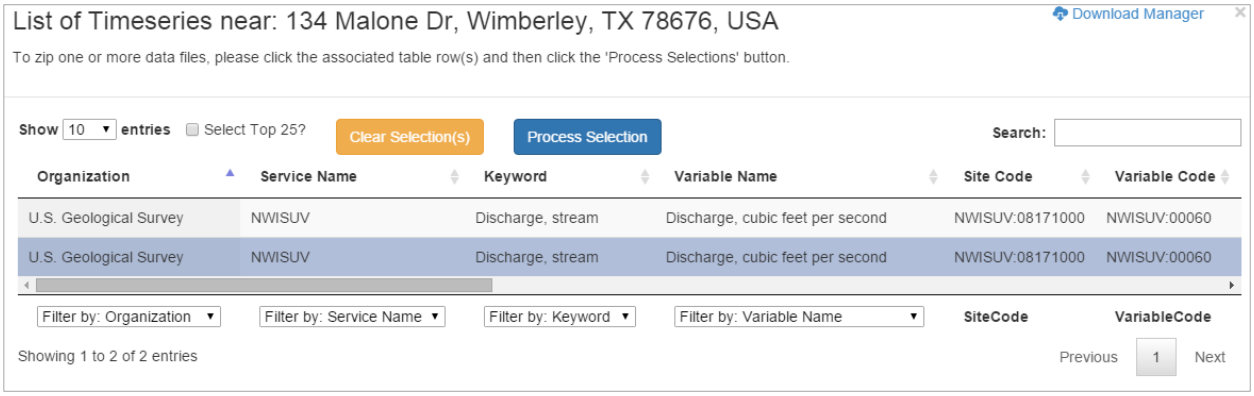
Put **NWIS** in the Search Box in the top right hand side and select **NWIS Unit Values** as your data service (real-time instantaneous data).



Search the map and you'll see the gage at Wimberley highlighted



Click on the gage and select one of the two series that are listed and hit **Process Selection**



You can see the progress of your download request in the **Download Manager**

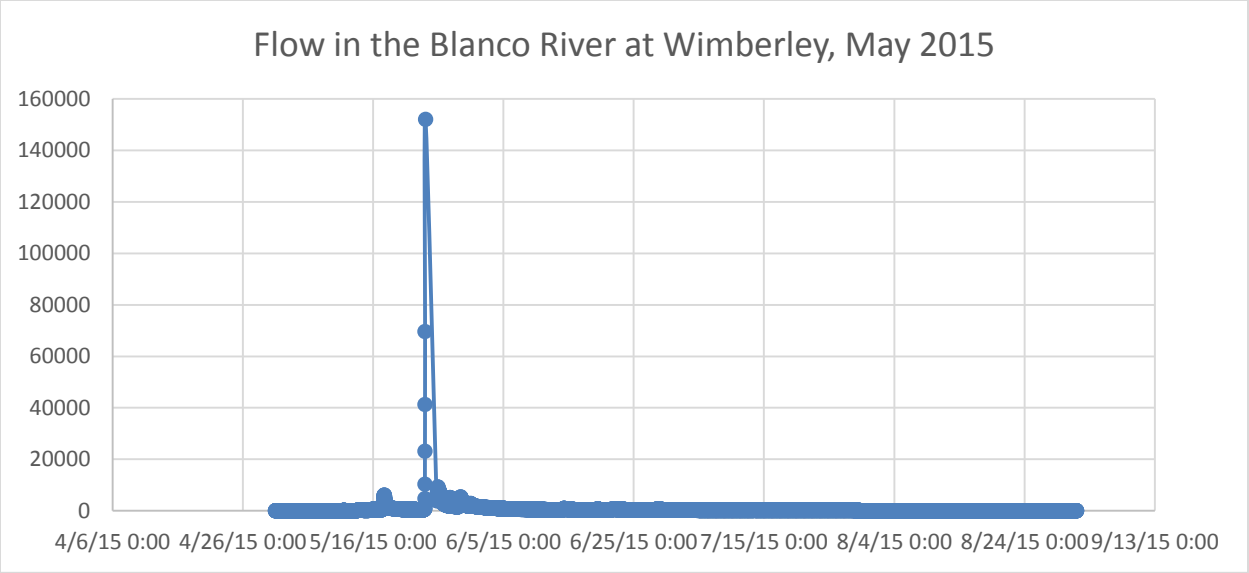
You'll get a local Excel file downloaded to your computer. Open this and select the **Local Time** and **Discharge** fields

	A	B	C	D	E
	Organization	SourceDescription	SourceLin	VariableN	VarU
	unknown	unknown	unknown	Discharge	unkn
	UTCTimeStamp	LocalTimestamp	UTCOffset	Value	Value
	5/1/2015 0:00	5/1/2015 0:00	0	67	
	5/1/2015 0:15	5/1/2015 0:15	0	67	
	5/1/2015 0:30	5/1/2015 0:30	0	67	
	5/1/2015 0:45	5/1/2015 0:45	0	67	
	5/1/2015 1:00	5/1/2015 1:00	0	67	
	5/1/2015 1:15	5/1/2015 1:15	0	67	
	5/1/2015 1:30	5/1/2015 1:30	0	67	
	5/1/2015 1:45	5/1/2015 1:45	0	67	
	5/1/2015 2:00	5/1/2015 2:00	0	67	
	5/1/2015 2:15	5/1/2015 2:15	0	67	
	5/1/2015 2:30	5/1/2015 2:30	0	67	

Format the cells in the first column to show Date/Time

	A	B	C	
	LocalTimestamp	Discharge, cubic fee		per
	5/1/15 12:00 AM	67		
	5/1/15 12:15 AM	67		
	5/1/15 12:30 AM	67		
	5/1/15 12:45 AM	67		
	5/1/15 1:00 AM	67		
	5/1/15 1:15 AM	67		
	5/1/15 1:30 AM	67		

And plot a chart of the flow of the Blanco River at Wimberley



To be turned in. Make a map showing the labeled gages and their attribute table. Zoom into each of your gages, and compare the Drainage Area and the Mean Annual Flow from between the gage values and those given as Q0001C and Q0001E on the NHDPlus Flowline feature class. Prepare a table for your six gages which shows these comparisons. Discuss your results. Groundwater flow plays a role in this basin as there is a big discharge from the Edwards aquifer in a spring at San Marcos. Determine the distance in Km that each gage is upstream of the most downstream point of the reach on which it is located. Show a chart of the flow of the Blanco River at Wimberley. Notice the huge flood that occurred on this river – a 40 ft wall of water passed through the town of Wimberley during Memorial Weekend, 2015

Ok, you're done!

Summary of Items to be Turned in:

1. *Make a map of the San Marcos basin with its HUC-10 and HUC-12 watersheds and subwatersheds. How many HUC-10 and HUC-12 units exist in the San Marcos Basin?*
2. *Make a map of the land cover variation over the San Marcos Basin. Prepare a table that shows the area (km^2) of each of the seven main land cover classes and the % of the total basin area that each represents.*
3. *Make a map of the San Marcos basin with its labelled rivers. How many Catchments lie within this basin? What is their average area (Sq. Km)? How many Flowlines lie within this basin? What is their average length (Km)?*
4. *Make a map showing the labeled gages and their attribute table. Zoom into each of your gages, and compare the Drainage Area and the Mean Annual Flow from between the gage values and those given as Q0001C and Q0001E on the NHDPlus Flowline feature*

class. Prepare a table for your six gages which shows these comparisons. Discuss your results. Groundwater flow plays a role in this basin as there is a big discharge from the Edwards aquifer in a spring at San Marcos. Determine the distance in Km that each gage is upstream of the most downstream point of the reach on which it is located. Show a chart of the flow of the Blanco River at Wimberley. Notice the huge flood that occurred on this river – a 40 ft wall of water passed through the town of Wimberley during Memorial Weekend, 2015