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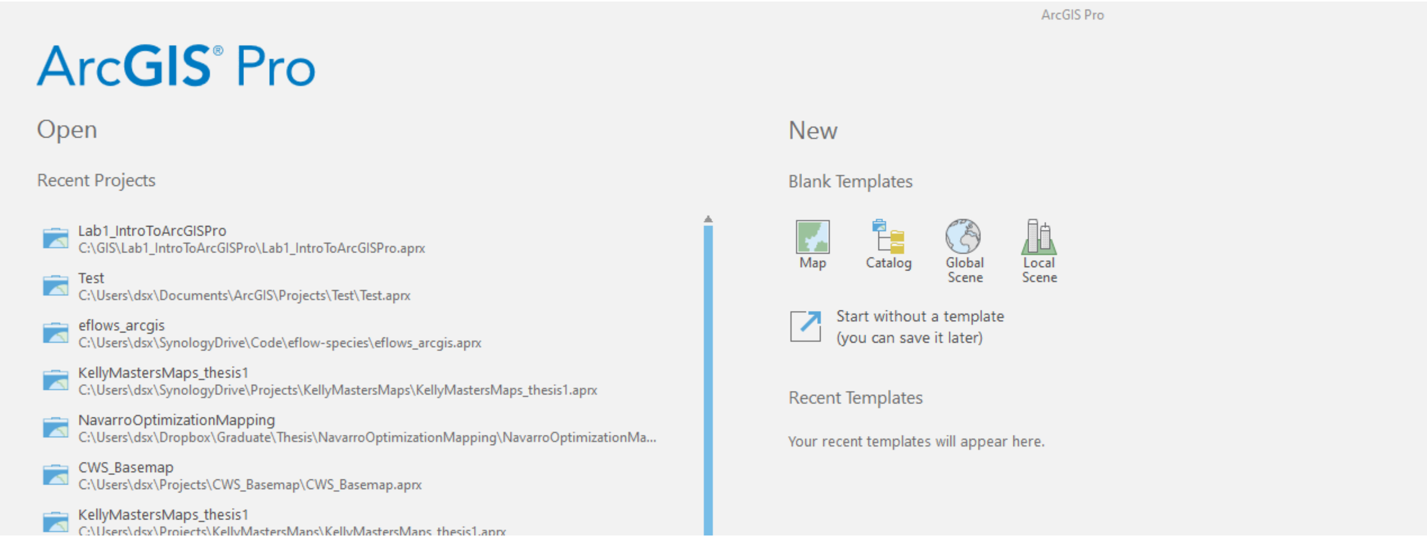
1. Getting Started Again

In the last lab, we went through how to open ArcGIS Pro, add data, navigate through layers, and use basic selection and symbology features to subset and display our data as we begin making our map of the Navarro River watershed. In this lab, you will build on that knowledge and learn about data exploration, attribute records, attaching additional data, and more symbology. You'll also learn about how to geoprocess your data - that is, how to analyze it in a geographic context.

Open up the ArcGIS Pro Project you used in the previous tutorial - we'll continue where we left off. If you don't remember where you saved it, ArcGIS Pro shows recent projects you have saved on its home screen when you open. Just open the application and look for your project on the lefthand side.



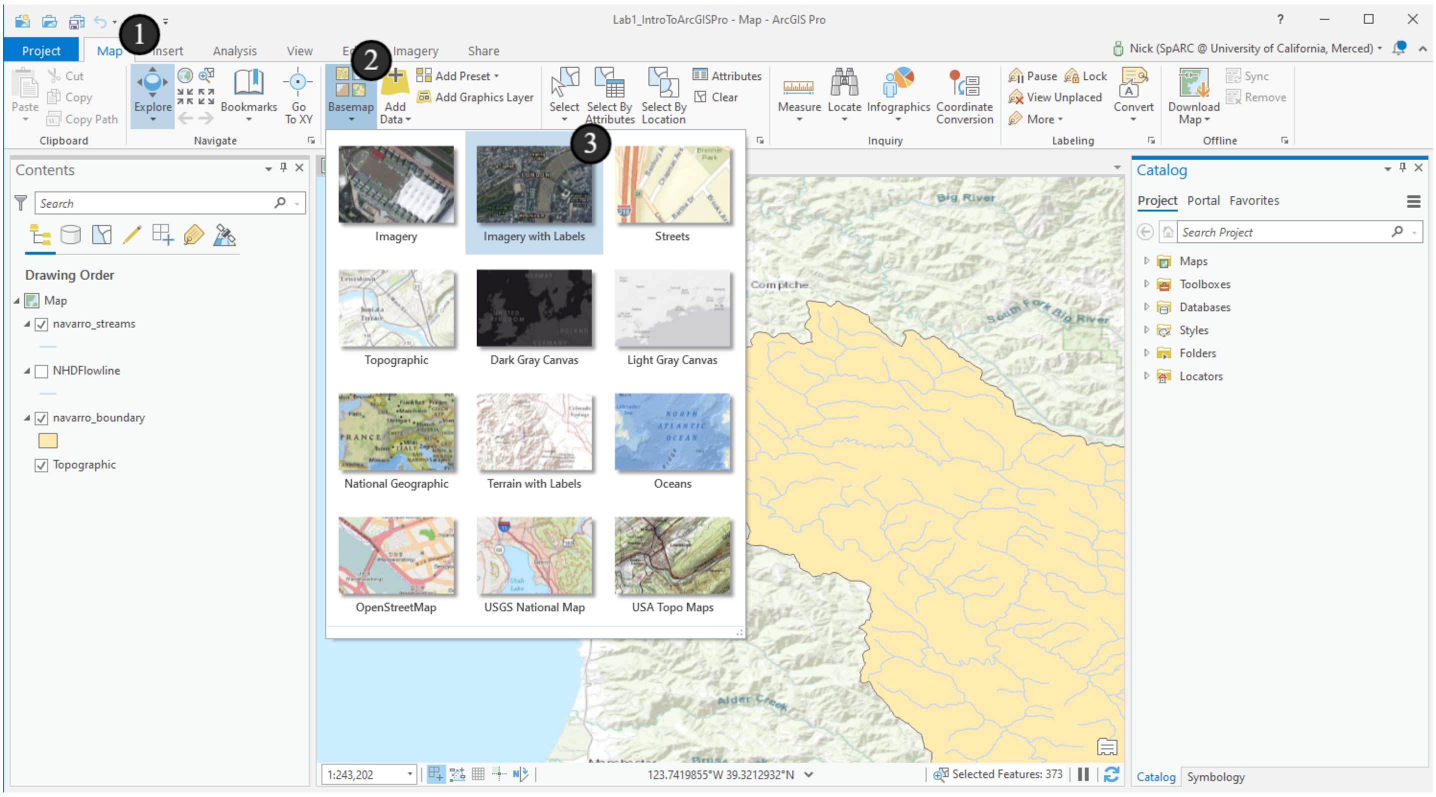
2. Getting to know Basemaps

When we opened up ArcGIS the first time, did you wonder how it started up with a map of the world already? Or are you so used to services like Google Maps that it felt familiar and like what you would expect from a mapping application? What is it using for that map of the world?

The background map that shows up automatically when we load a map in ArcGIS is called a Basemap. Basemaps can be comprised of a few different technologies depending on the GIS software you are using, but you may sometimes here them called tile maps or tile layers because they are frequently loaded as a grid of images so that your software can only load the part it needs.

Basemaps can provide context to our data immediately, helping us make maps more quickly, or helping us feel more comfortable in the software since data doesn't sit alone in space. ArcGIS Pro loads maps with a default basemap showing topography and some basic natural features like rivers and lakes, as well as some human context like cities, towns, and highways. But you can change the Basemap if you want to see something different. Let's try a satellite basemap. To make the switch,

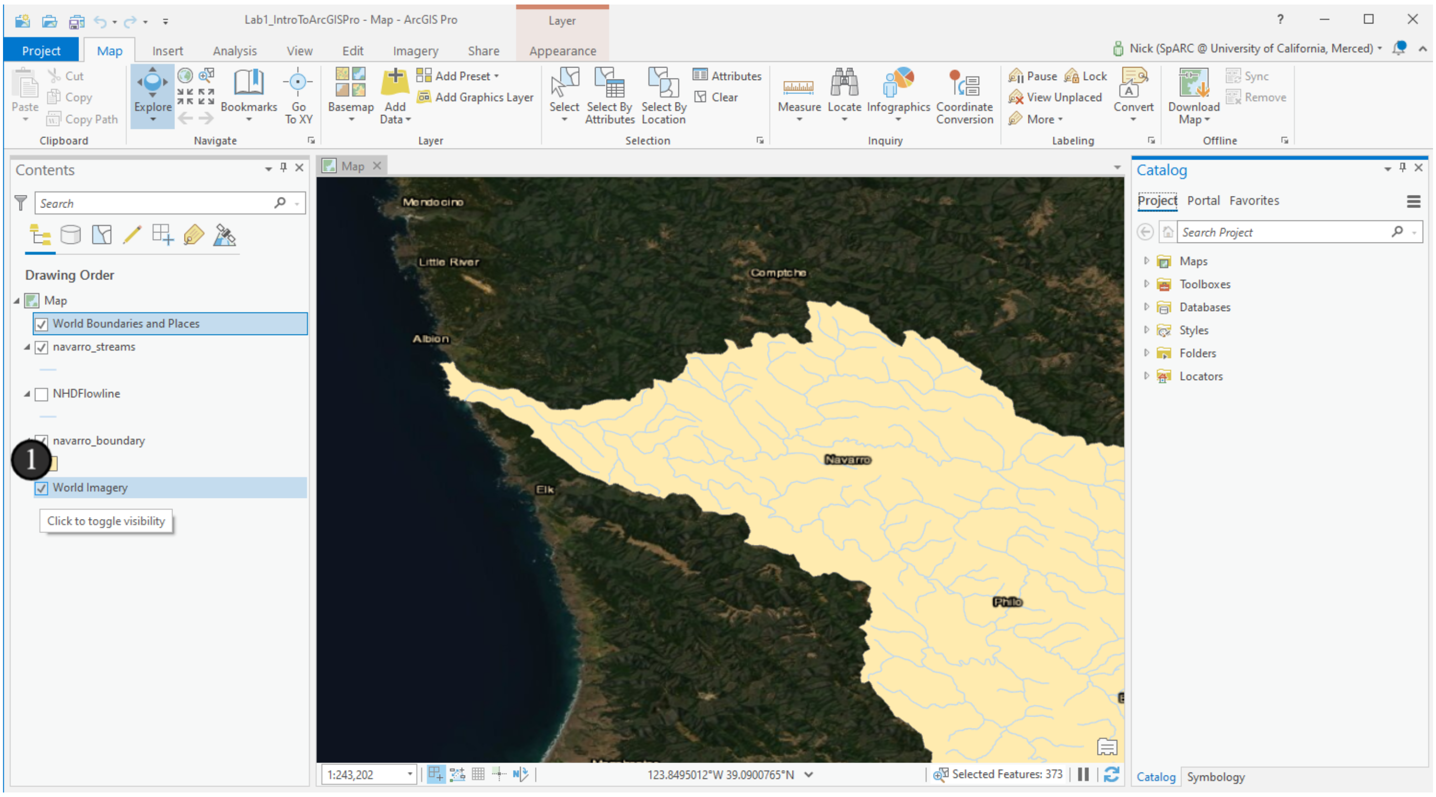
1. Make sure you're on the *Map* tab. If you aren't, then click over to it
2. Click the *Basemap* button next to the *Add Data* button we used previously.
3. Choose a new basemap - in this case, click on *Imagery with Labels*.



2.1 Toggling basemap visibility

Great! We see a satellite image show up in place of the topographic map that was here before, with our data drawn on top of it. We could explore seamless satellite imagery of the world now. Feel free to look around a bit or try other basemaps, but switch back to this one when you're ready to proceed.

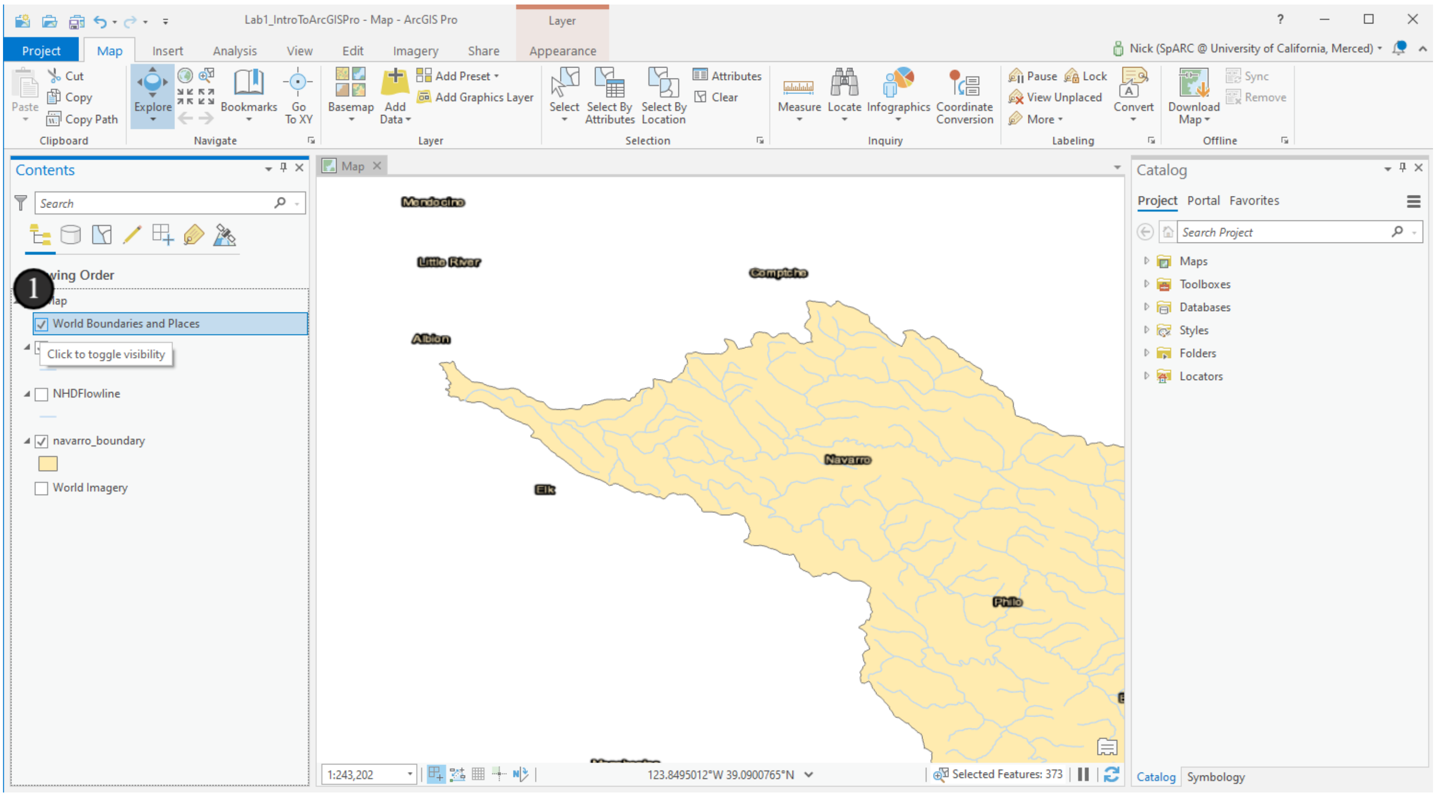
Sometimes we might not want to use a basemap though, so it can be useful to be able to disable it temporarily or remove it. If you want to turn off the basemap, just click the checkbox next to its layer in the Contents pane.



2.2 The labels are still there!

OK, so our satellite data turned off, but what's this? There are still labels floating around! Is this a bug? Nope! This is expected. Some basemaps are a single layer, with any labels included along with the map data as a single image. Others, like the satellite layer we are using, consist of two layers: the imagery at the bottom of our list of layers, and the labels at the top of the list of layers. If we want to turn them off, we can do that separately.

1. Click the visibility checkbox next to the *World Boundaries and Places* layer now to turn it off.

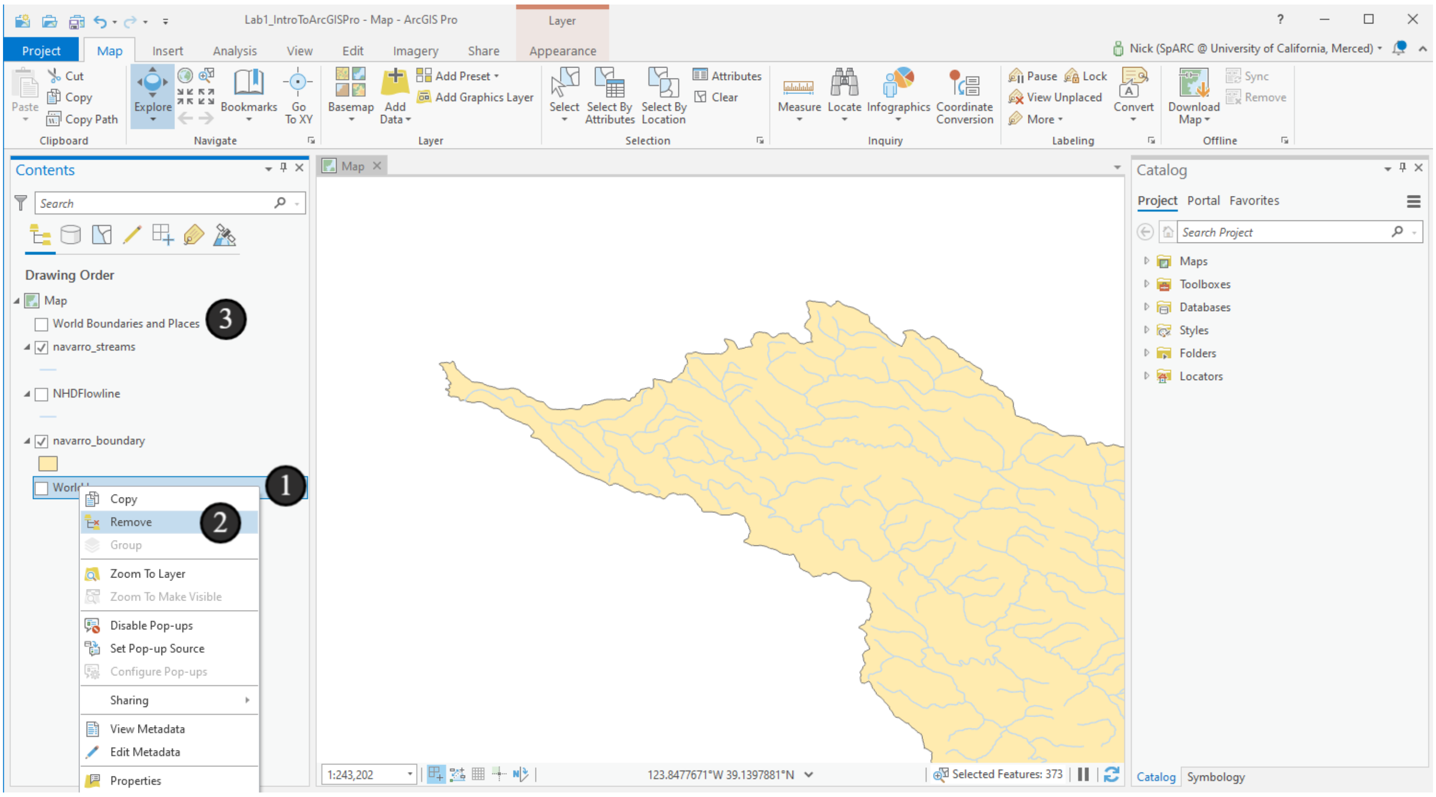


2.3 Removing basemaps

Now we see no basemaps, but we can always turn them back on if we want them.

We can also remove basemaps entirely if we want. Let's remove this basemap now. To remove the basemap:

1. Right click on its name in the Contents pane. In this case, the *World Imagery* layer.
2. Then click *Remove*
3. Repeat the same steps for the *World Boundaries and Places* label layer at the top of the Contents pane.

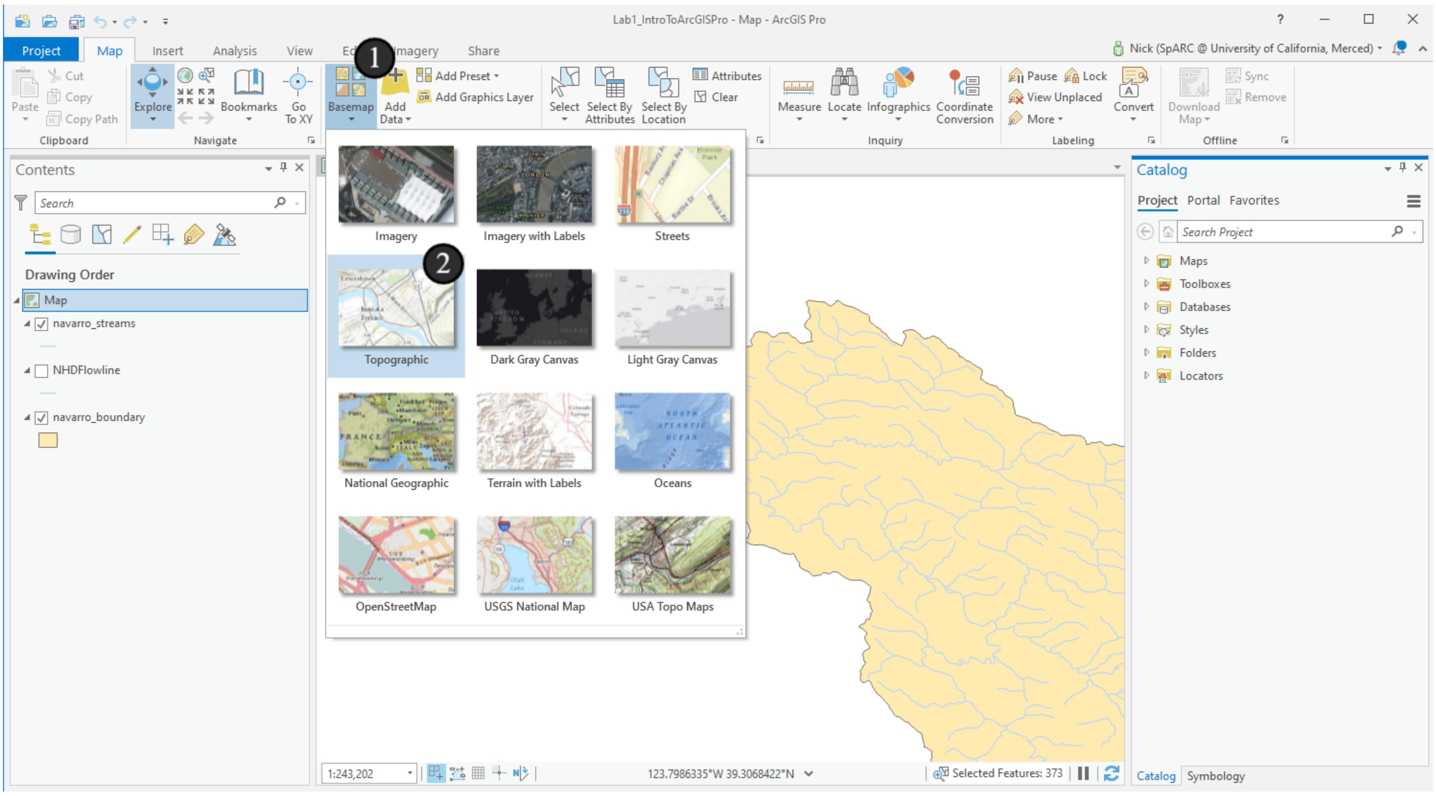


2.4 Add the topographic basemap back in

Now, let's go back and add in the Topographic basemap again so we can use it in our map:

1. Click the *Basemap* button on the ribbon
2. Click the *Topographic* basemap

A few notes before going further - I noticed at this step that I still had the NHDFlowline layer in the document, even though the end of the previous tutorial removed it - I'd forgotten to do that step here, but am removing it now before the next step. It's OK if you still have it in the document - we won't be using it again for this project. Other parts of the tutorial may also change zoom and extent at times - you can move your zoom and extent around freely as well, and remember that if you want to get back to an overview, you can right click on one of the layers and zoom to it. OK, let's keep going!



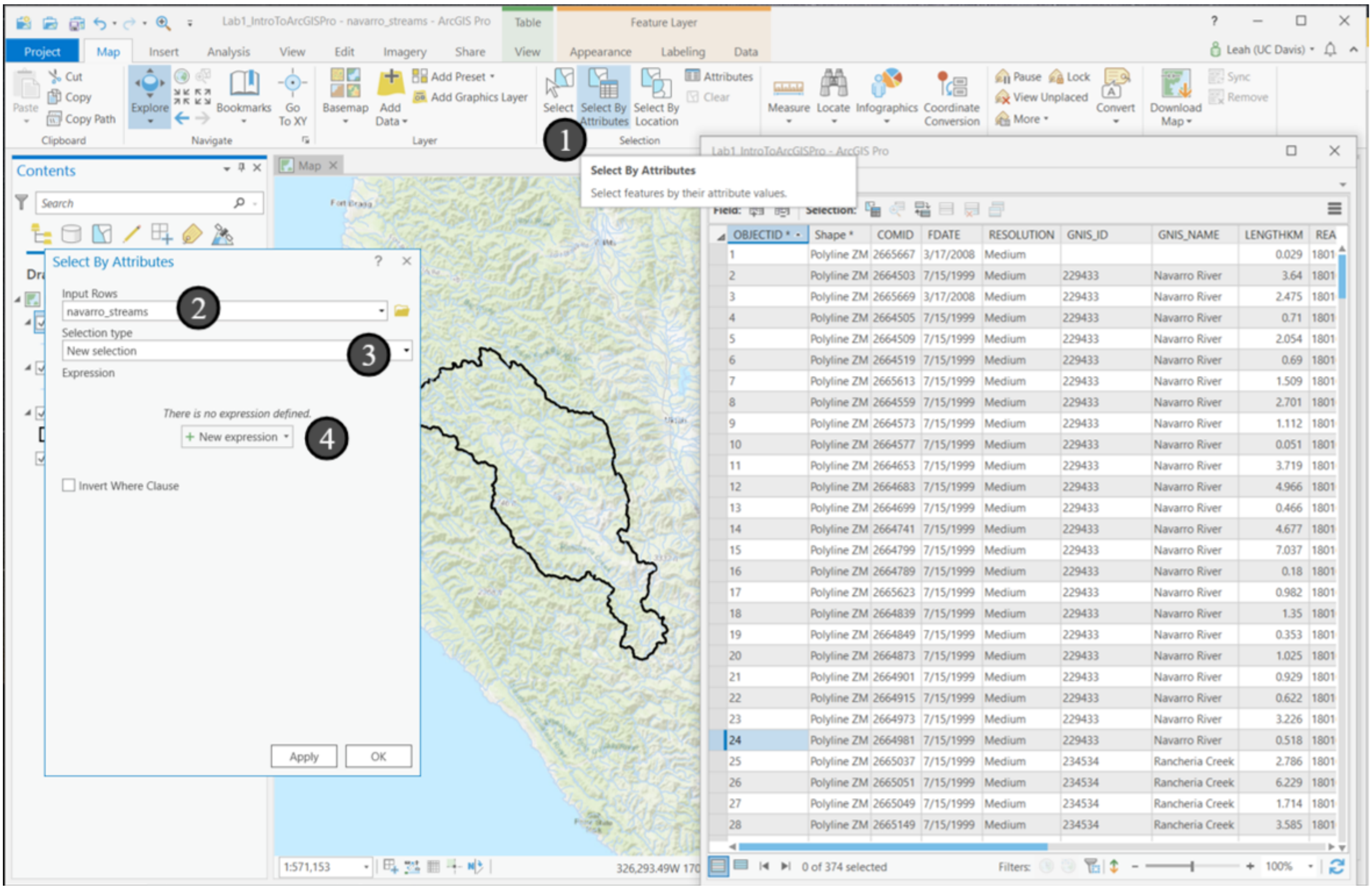
3. A different way: the Select By Attributes tool

Let's create that same selection a different way, and one that's very common, especially if you need to do something more complex than selecting sequential records. We're going to use the *Select By Attributes* tool. Similar to the *Select By Location* tool, which creates a selection based on spatial relationships, *Select By Attributes* gives us a selection based on the attribute information of a feature class. Both are core tools for interactive GIS and have important placement in the interface as a result.

Click the *Select by Attributes* button (1) in the Selection section in the main ribbon. This will open the Select By Attributes floating window (in versions 2.5 and below, it was a docked pane).

Select By Attributes gives us a set of controls to create a *query* or *expression* to use to select our attributes. Queries are ways to subset tabular data, including spatial data. These queries are similar to ones you would have used if you have worked with other database applications (such as Microsoft Access, SQL Server, MySQL, etc). You can manually type a query once you are comfortable and familiar with ArcGIS, or you can use the controls that ArcGIS gives us to create the query - recommended while you get used to the syntax.

Make sure that navarro_streams is listed in the Input Rows dropdown (2). If the Selection type (3) is not already *New selection*, select that option in the dropdown menu. Finally, click the *New Expression* button (4) to open up a query box.



3.1 Select by attribute using a query

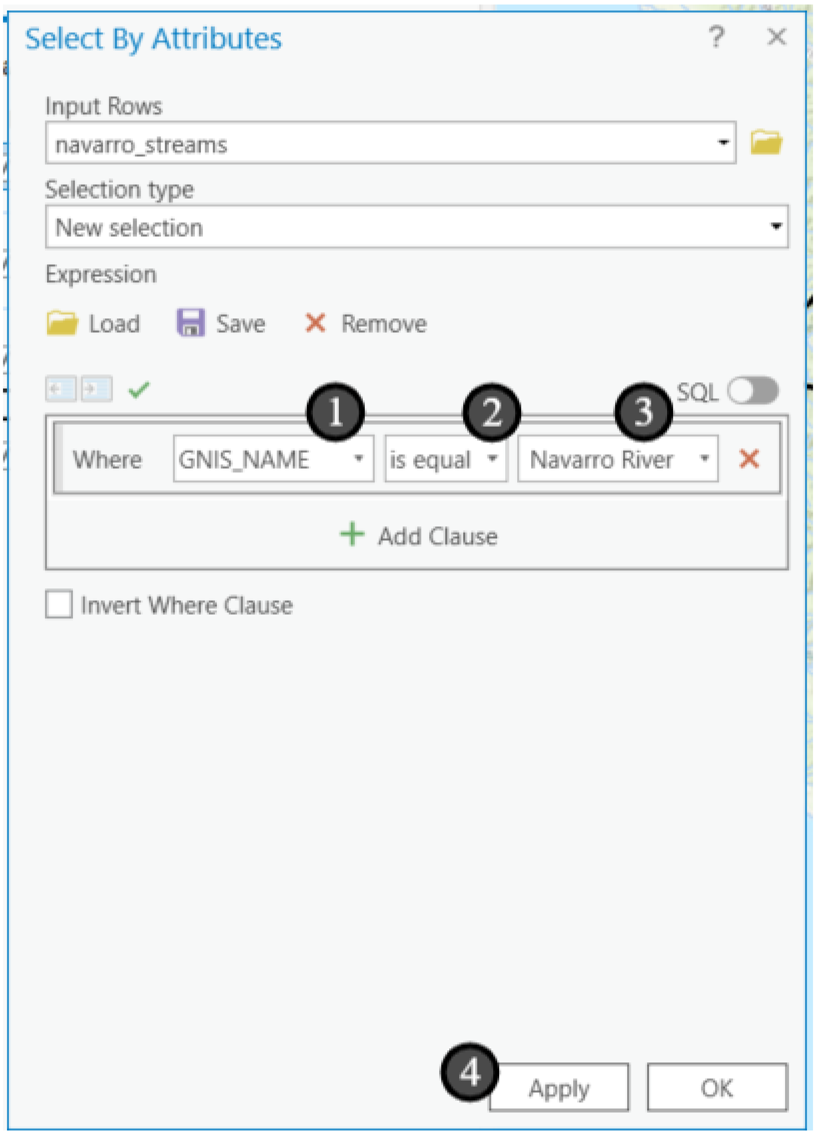
Since we want to select the same records we just manually selected (but cleared) in the attribute table, we'll want to find all stream records that are part of the mainstem Navarro River - aka, where the *GNIS_NAME* attribute is set to *Navarro River*. We'll use these controls to create a query ArcGIS can understand to do that.

1. In the first dropdown menu after "Where", select *GNIS_NAME*
2. Now we need to add a *relationship operator*. In this case, we want records where an attribute is the same as a particular value, so which one would we use? Select *is equal* in the next dropdown menu.
3. To assign the value that we're looking for, we can either type a value or use the dropdown menu. Notice that ArcGIS has automatically filled this dropdown menu with the unique values in the *GNIS_NAME* field so we ca select from the valid values in that field. Click into the third box and start typing *Navarro River* in the box to see what happens. *Navarro River* should auto-fill in the box. You can also select it from the dropdown list.

If you want to see what is happening under the hood, click on the SQL button next to reveal your SQL query string. Why do you think 'Navarro River' is surrounded by single quotes? If you are familiar with SQL, the query we have built using this window is equivalent to

```
SELECT * FROM navarro_streams WHERE GNIS_NAME = 'Navarro River'.
```

We can now edit this statement as we like. In this case, GNIS_NAME = 'Navarro River' is what we want, so we'll leave it alone. Click Apply (4) to see the results on the map.

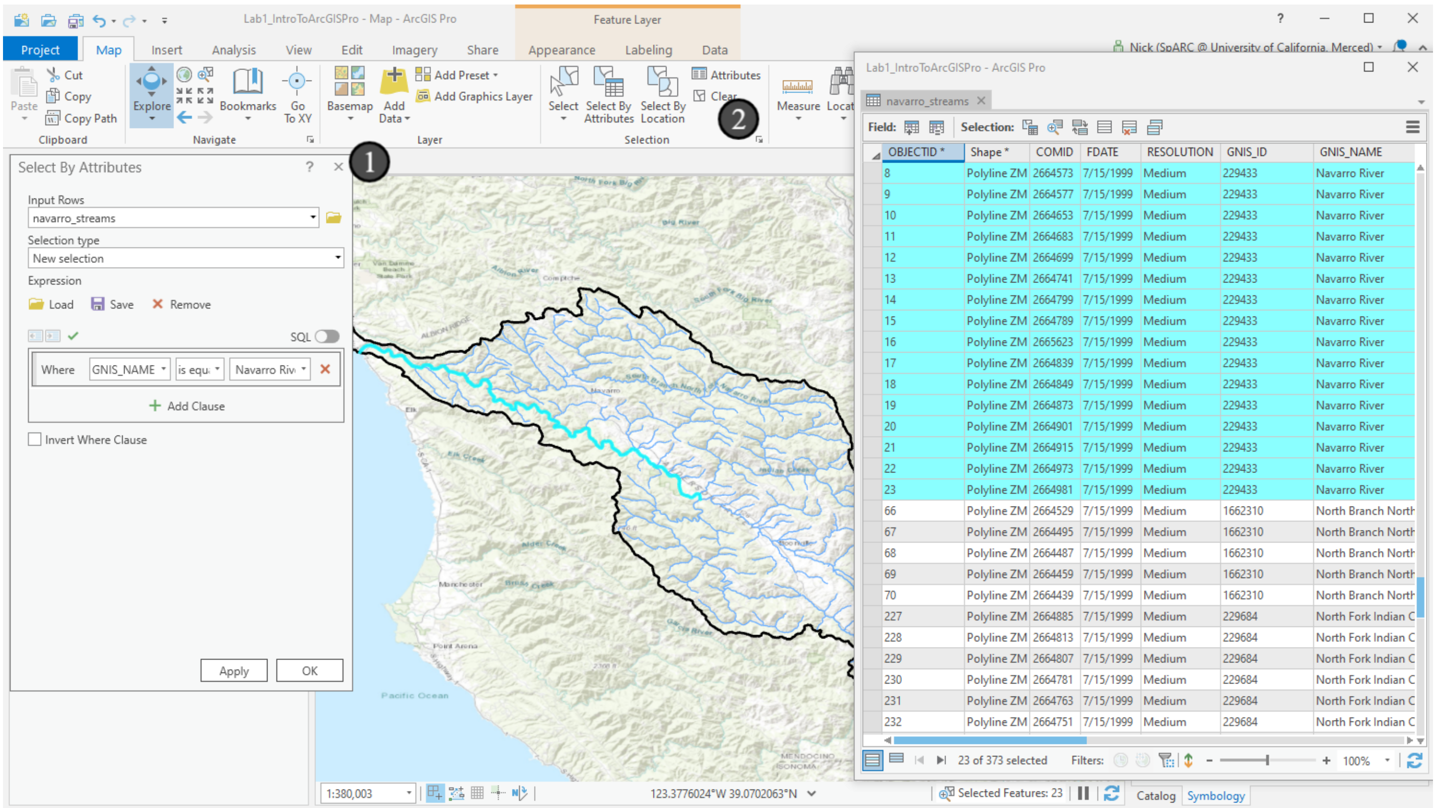

Select By Attributes
Input Rows
navarro_streams
Selection type
New selection
Expression
Load
Save
Remove
SQL
1
2
3
Where
GNIS_NAME
is equal
Navarro River
Add Clause
Invert Where Clause
4
Apply
OK

3.2 Explore the selection

Notice that the selection appears in the map window and in the attribute table when you run it. If the selection didn't select what we wanted, we could refine it and try again with the Apply button. It looks good though, so we'll leave it alone.

Click the x in the upper right hand corner of the Select By Attributes window (1) to close it. If you clicked OK instead, your selection query would be re-run. Either is fine. Clicking *Apply* instead of *OK* for the selection is useful when you want to see what the selection looks like and possibly make changes to your query. Clear your selection when you're done (2).

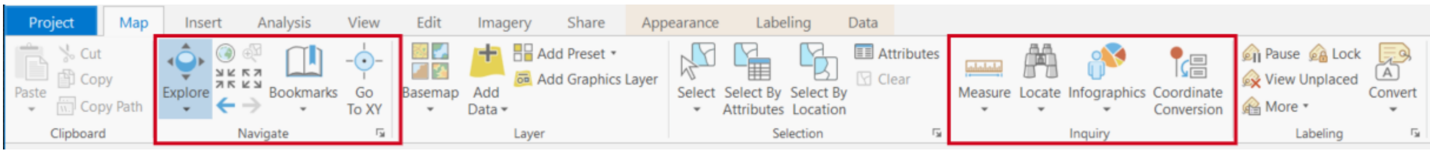
Feel free to explore your map, but when you are done, clear your selection (using a button that should now be familiar - check the *Selection* section of the Map ribbon). You can also close the attribute table window now if you haven't already - before you do, it's often a good idea to *dock* the window again - that is, to drag it onto one of the icons that attaches it to the left, bottom or right sides - floating windows have a tendency to go missing for anyone with multiple monitors and can create issues and confusion that are difficult to resolve.



3.3 Some other ways to browse data and find records by attributes

We've gone through numerous ways to locate and subset your data now. There are a few other ways to do this that I want you to play with a bit, but we won't walk you through - you'll figure them out on your own. The tools in question are in the boxed sections of the ribbon. Hover over tools to see their names and a bit about what they do. For this step, try using the *HTML Popup* and *Find* tools a bit. You will find each useful at some point in your GIS use.

If you have time, explore the other tools in this section as well - they are all great in various situations, but we won't go through them individually.



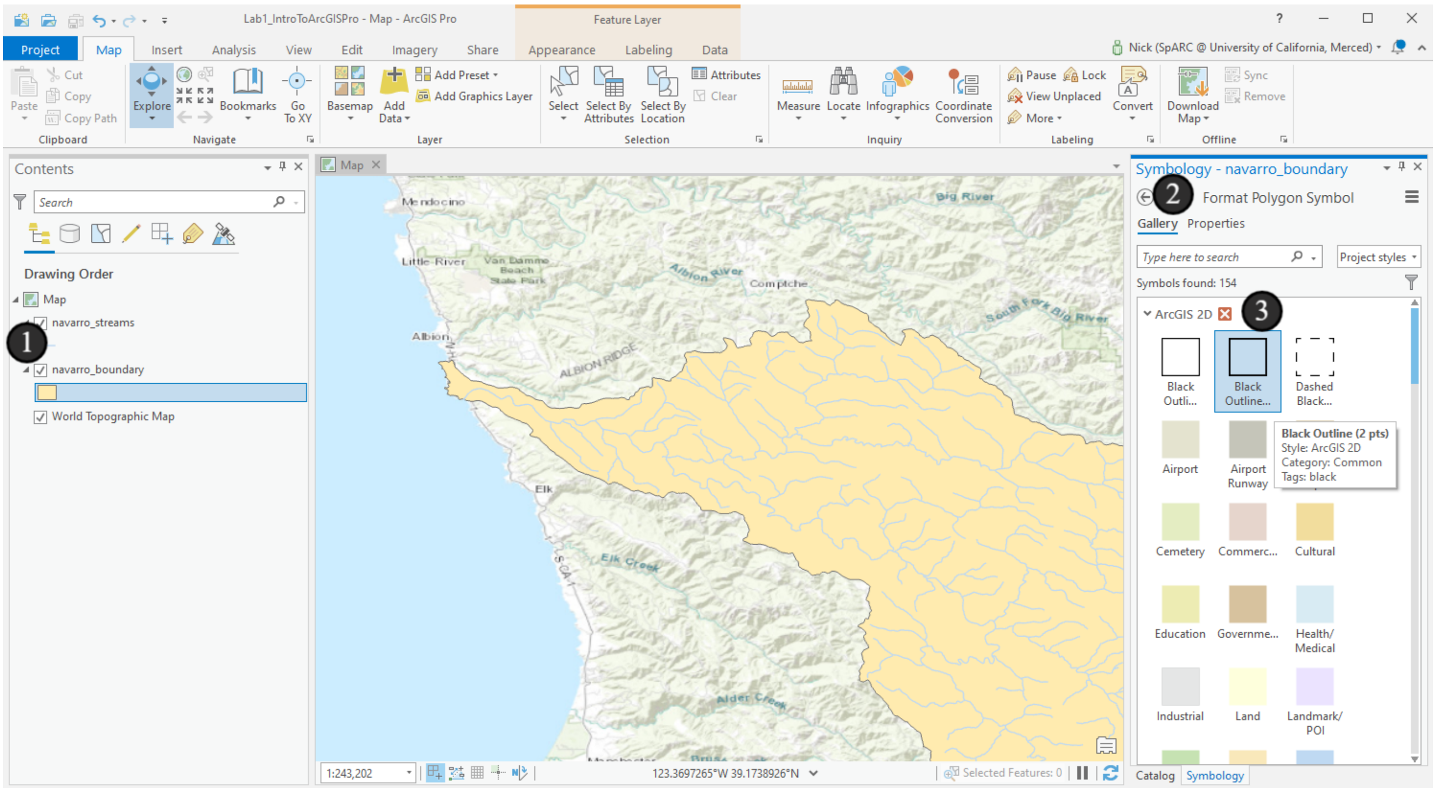
4. Changing symbology again

Let's make it easier to use the watershed boundary as context. *navarro_boundary* has been filled with a color, but since we have a basemap, we want to see what's under it (as shown in the layer stacking order in the table of contents - higher layers are drawn on top of lower layers and cover them up).

1. Click the colored box underneath *navarro_boundary* in the table of contents - your color may be different than shown here. This will open the *Symbology* tab in the pane to the right of your map.
2. Select the Gallery tab (this may already be selected).
3. Select *Black Outline (2 pts).* This option will make the polygon's *fill* completely transparent, and set the outline to a black line with a width of 2.

Note: To further adjust line width and color, as well as options to change the *fill* of the polygon, you can click on the *Properties* tab.

Feel free to play around with the symbology as you see fit! The lab is trying to guide you through many things and make sure you don't get lost, but I encourage you to take a longer look at anything you'd like to understand further and play with the options. If you're worried - just save your work first so you can go back to where you departed from the lab's instructions.

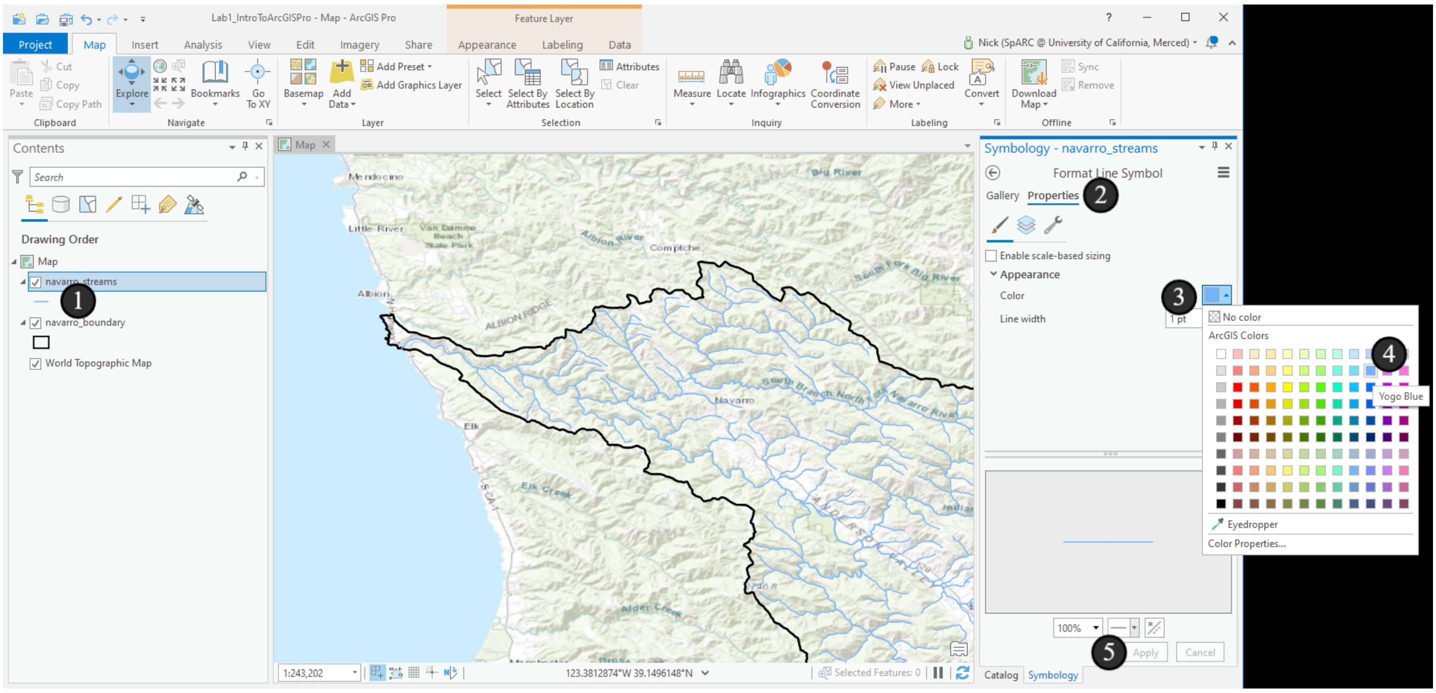


4.1 Changing the stream color (again)

Since we're now drawing the rivers on the basemap, our own data is a bit hard to distinguish from the basemap's rivers. Let's change the color to a darker blue so we can see it better. We'll do a little more customization than we did in the past.

1. Open the symbology pane the same way you did previously - you can click on the *patch* below the layer name, or right click on the layer itself and click *Symbology*. If you still had the symbology pane open, simply clicking on the layer in the *Contents* pane will activate the *Symbology* pane for that layer.
2. Instead of using a premade option in the gallery, let's select another color ourselves. Click the *Properties* tab in the *Symbology* pane.
3. In the *Appearance* section, click the box of color in order to select a new color.
4. Choose a new blue color. In this case, I chose "Yogo Blue", two rows down and three columns from the right side.
5. Click *Apply* at the bottom in order to make the symbology changes you made active in your map (note that we don't need to do this when selecting items from the gallery, so it's sometimes easy to forget here.

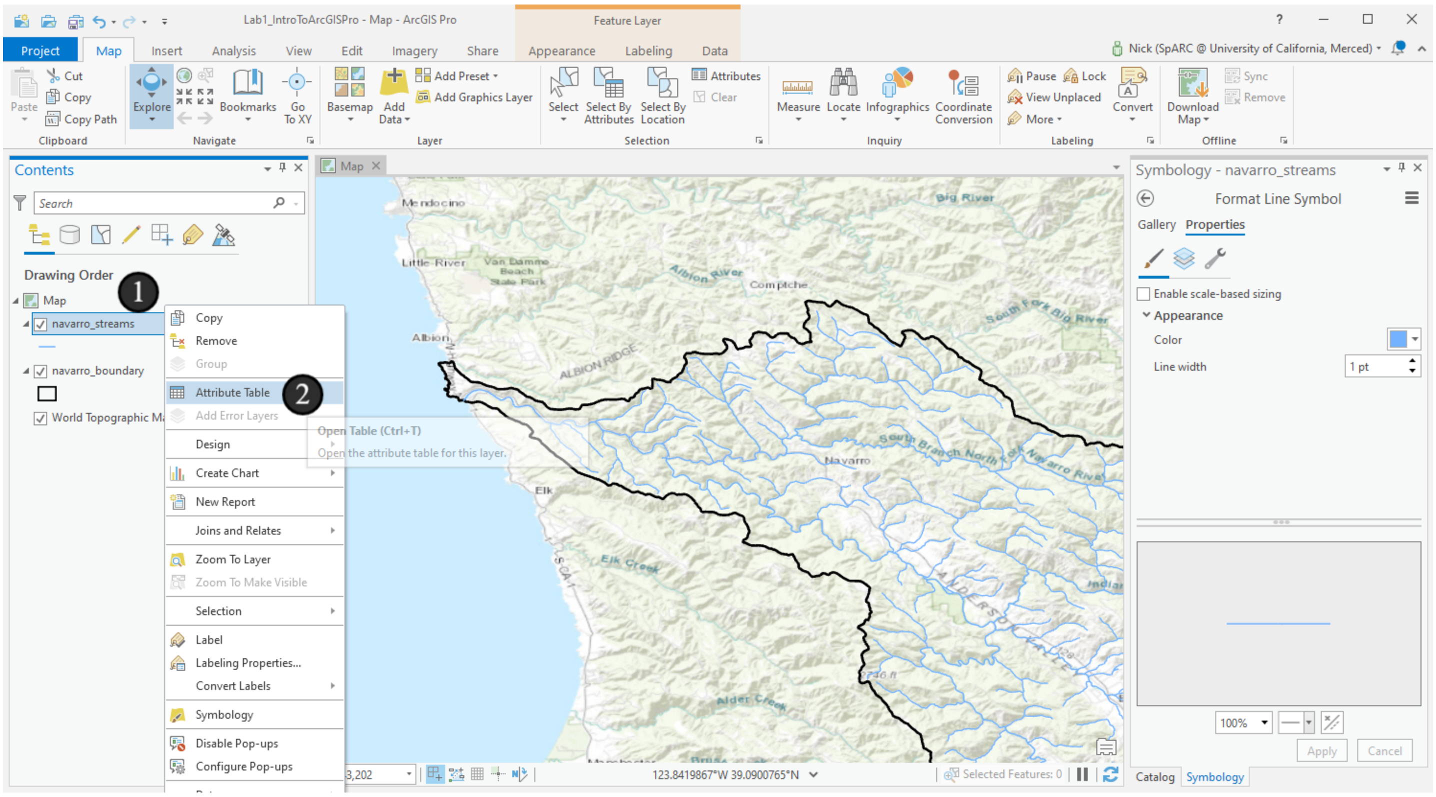
Symbology in ArcGIS Pro is very powerful, and there's quite a bit more we're not showing here (note the icon-based tabs below the properties tab) - feel free to explore the symbology options if you'd like!



5. Browsing Attributes

If *spatial* information, i.e., the location of specific features and the drawing of those features on screen, is half of GIS, then the other half is *attribute* information. Attributes are common to all database-linked data systems - the simplest in this style would be an Excel spreadsheet with attributes defining the columns and each row being a specific *record*. GIS works the same way. When we clicked on features in *Explore* mode, we pulled up the attribute information for the features we had clicked on. Now, we'll take a look at all of the attributes for our feature class (the layer).

1. Right click on *navarro_streams* in your Contents pane
2. Click *Attribute Table* in the menu that comes up.



5.1 The attribute table

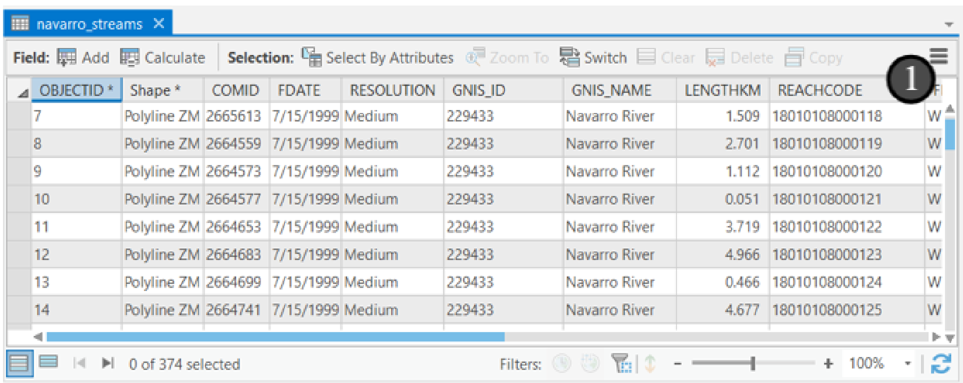
The navarro_streams *attribute table* will pop up - this window/pane is dockable, similar to the Catalog/Symbology and Contents panes. By default it docks to the bottom of the main window; you can also un-dock it so it is free-floating by clicking and dragging the tab for it.

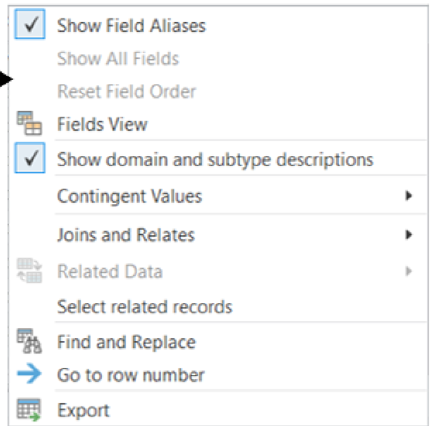
Each column in the attribute table corresponds to an individual piece of information (an attribute) that can be read for an individual feature. Note the *OBJECTID* field (column). It is a numerical, sequential field added automatically to ensure we can reference each record individually with a unique ID number - that way, everything else in the table that has other meaning can be updated without causing problems for anything that references this data by ID. National Hydrography Dataset (NHD) data also has the *COMID* field, assigned during the creation of the records. COMID is the field that is used by other NHD data to reference records and associate related data

Now, note the more understandable fields, such as *GNIS_NAME* and *LENGTHKM*. What do you think each of these fields mean? Explore the other attributes in the table too. Where could you find out what each of these fields represents?

There is also a *Shape* field, where ArcGIS stores the spatial information about each feature. It's accessible through the attributes this way, though it will only display as a word or two in the table (in this case, as *Polyline ZM*). From Python and other programming environments, you can access feature information by loading this attribute, but here is serves to emphasize that each feature on the map, as shown as records in this table, consists of spatial information in the *Shape* field along with other data in the additional fields

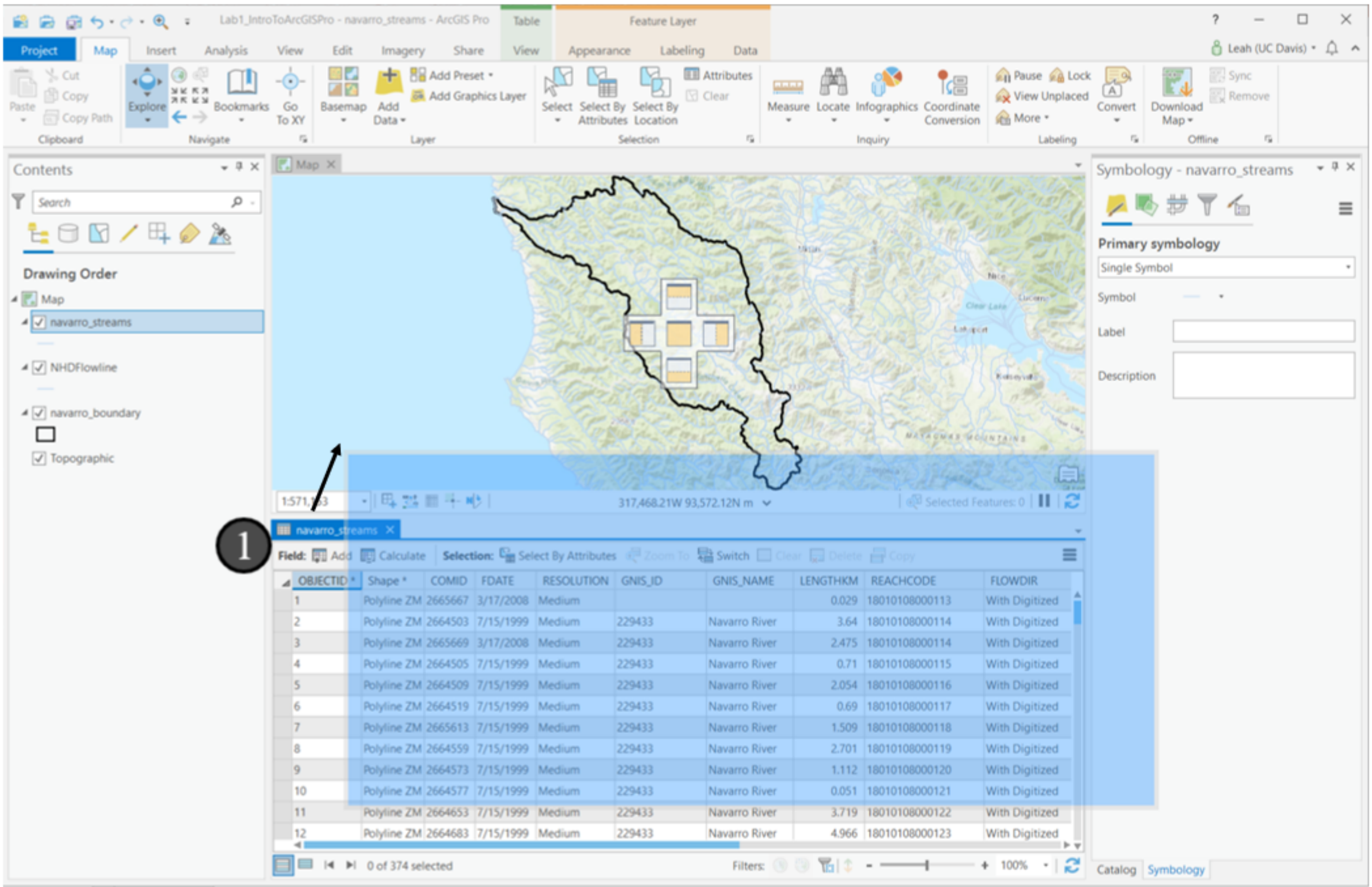
Finally, hover your mouse over some of the different tool buttons at the top of the table to see what they do. Then, click on the top right icon (1) to bring up the table menu - we won't use any of these items right now, but take a look at what options are available in here.





5.2 Move the attribute table

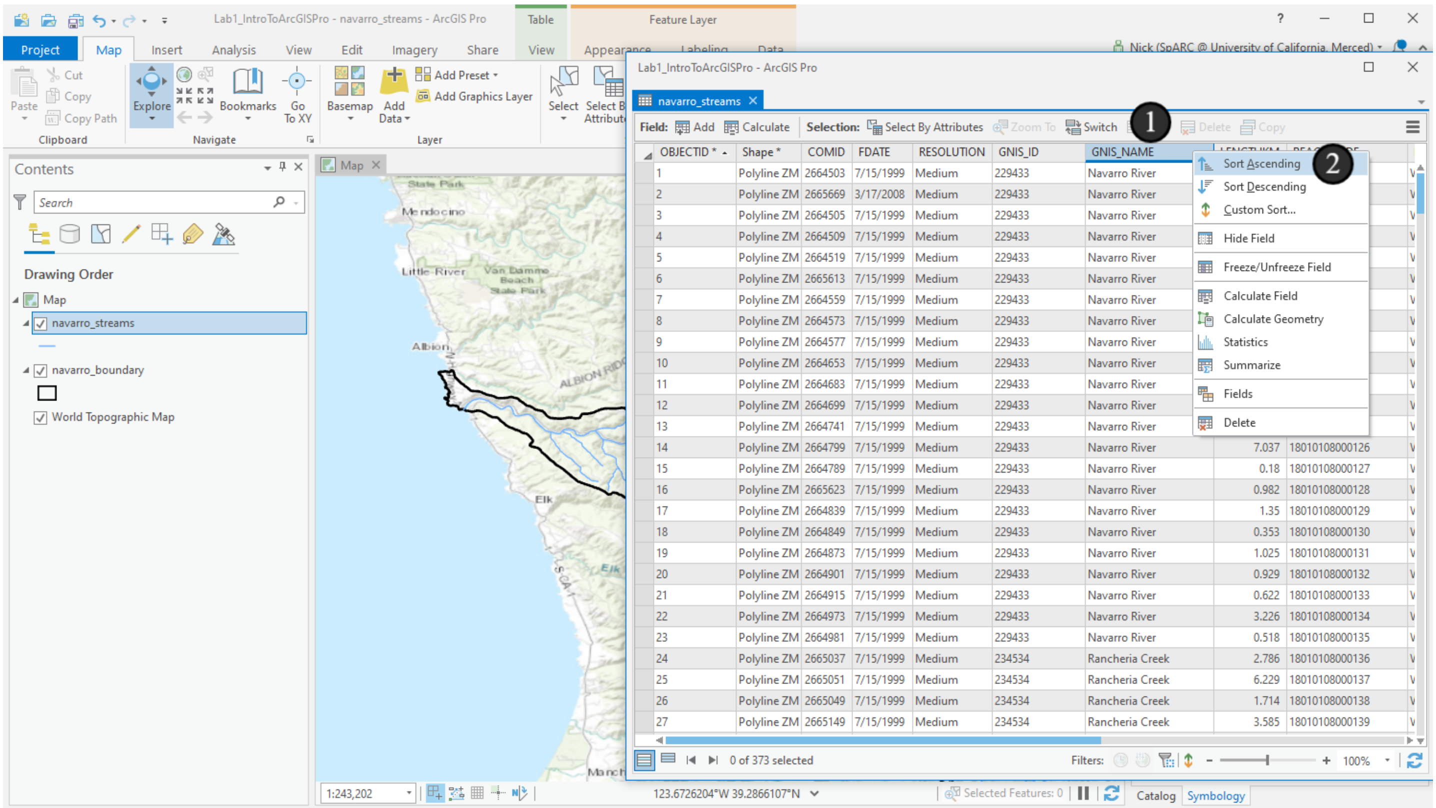
For this next step, it will be easier if we can see more of the table at once without obscuring the map. To undock the table from the bottom of the window, click and hold down the mouse button on the *navarro_streams* tab (1) and drag the window to another spot on your screen. ArcGIS will show you a blue outline of where it will place the window, and in the center of the screen shows a set of boxes that allow you to dock it to other parts of the application if you move your mouse to them. If you don't move it to any of these boxes, it will become a free-floating window when you release your mouse button.



5.3 Sorting a table

Now, let's use the table to locate features on the map. We want to see which features represent the mainstem Navarro River. If your table isn't sorted by name then

1. Right click on the header of the *GNIS_NAME* field and
2. Click *Sort Ascending* so that you see the table sorted as in the next step.

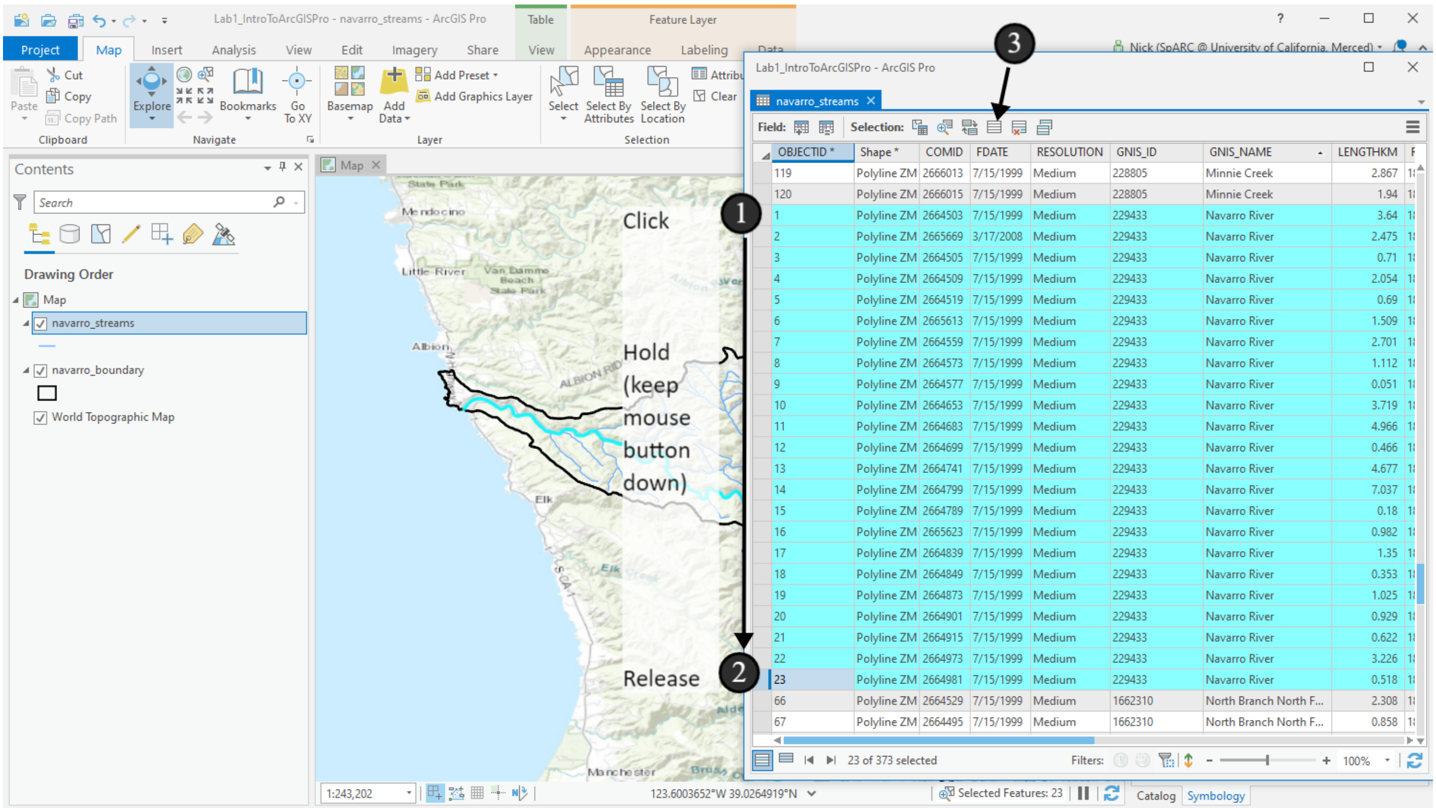


5.4 Selecting records in the table

OK, now let's go find the records with the name *Navarro River* - these will be for the segments of the mainstem of the river. You may need to scroll down relatively far since there are many segments without a value in the *GNIS_NAME* field (we call these *null* values). Find the set of now-sequential records for *Navarro River.*

1. Then to select the records (and have them show in your main data view), click in the unnamed column to the left of OBJECTID in the same row as the first record with GNIS_NAME = Navarro River. Hold the mouse button down after your click.
2. Drag your mouse down through all the records until you get to the one with GNIS_NAME = Navarro River) Release the mouse button here. You'll see the records highlighted with your selection color in the table view and in the map view. This shows us which features on our map correspond to features in our data table!
3. When you're done exploring, click the Clear Selection button either in the table window or in the main map window. The picture has an arrow pointing to it, but you can hover over the icons to see their names, or if you have a wider table window, the labels will show.

This method is very useful when you're looking through the data table and see some records that are of interest, and you want to find those same records on the map. Select them this way, and you'll see them selected on the map. Likewise, if you use interactive selection on the map like we did in the previous tutorial, you'll see records selected in the table too, so you can come inspect their attributes in bulk (for a single item you can click on it with the *Explore* tool)

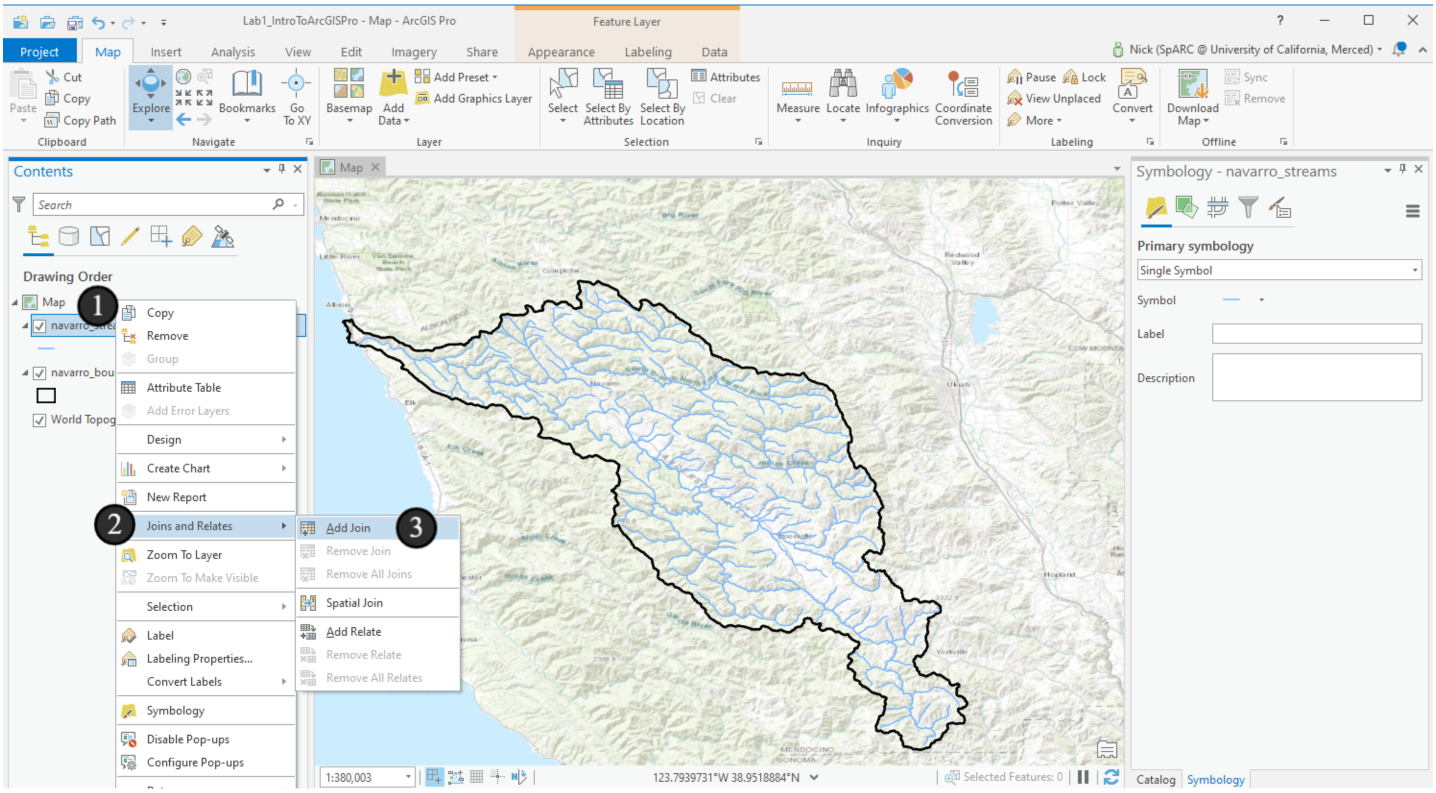


6. Adding New Attributes

Now, let's start adding more information to our map - In this case, these rivers are helpful, but since they're all lines, we don't have a good visual sense for which rivers are major and which ones are small tributaries. We can correct that by adding some additional data on the drainage area of each river segment.

Just as there are many ways to select features in ArcGIS, there are many ways to add new attributes or fields to your data for further use in your *geoprocessing* and analysis workflows. To start with, we'll add in some third party attributes via a *join*. Joins attach new attributes to an existing table by looking up rows in another table that have a common field value (such as an ID field). Remember that *COMID* field we talked about earlier that other NHD tables use - we'll use that to construct a join.

1. Bring up the menu on the *navarro_streams layer* - remember how?
2. Go to the *Joins and Relates* submenu
3. Click *Add Join* in the flyout box.

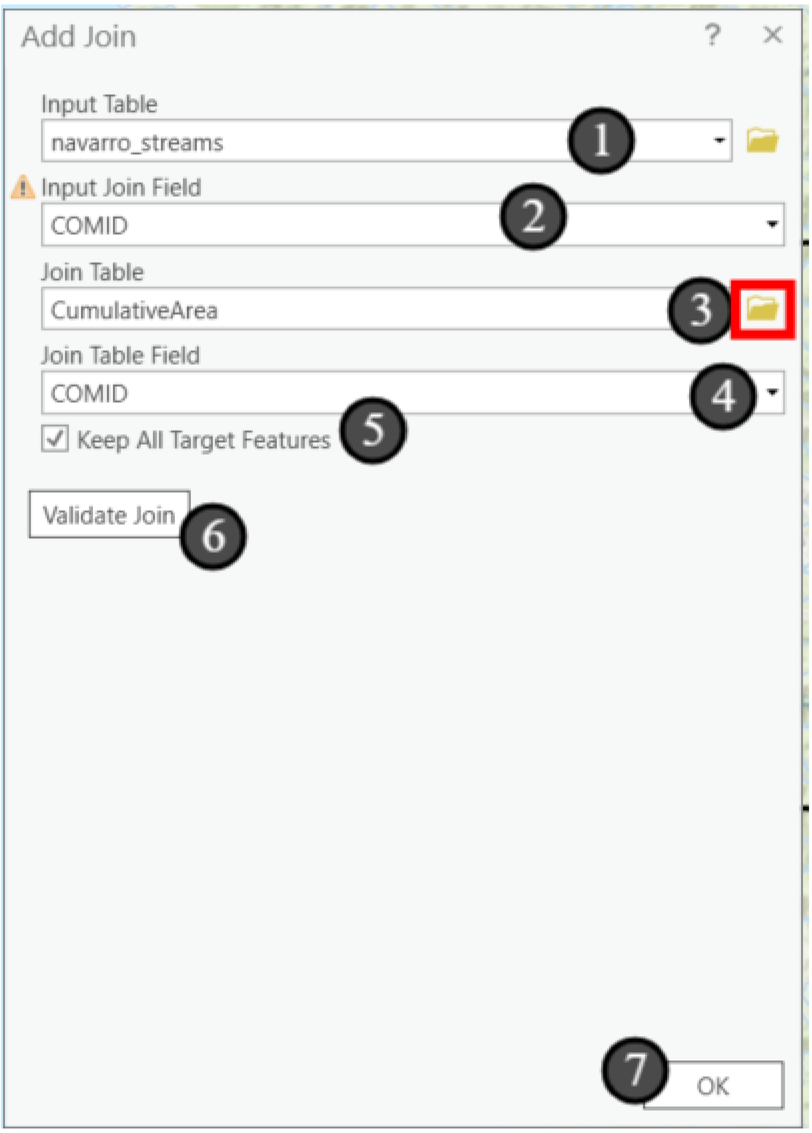


6.1 Joining Data

The *Add Join* dialog will appear. In this case, we're going to attach a table of precomputed drainage area information per stream segment. The table is in the same geodatabase you downloaded with the NHDFlowline and navarro_boundary data - you'll need to find it in a moment.

First, let's imagine what we're doing in a bit more detail. With table joins, we want to add additional values to each record in our input table by finding the matching data record in another table to attach, or join, to the end of the record. In order to find that record the two records need to share some information by each having the value in a field match. These fields don't always need to have the same name though, so you'll need to think about which fields have the information that matches for the lookup.

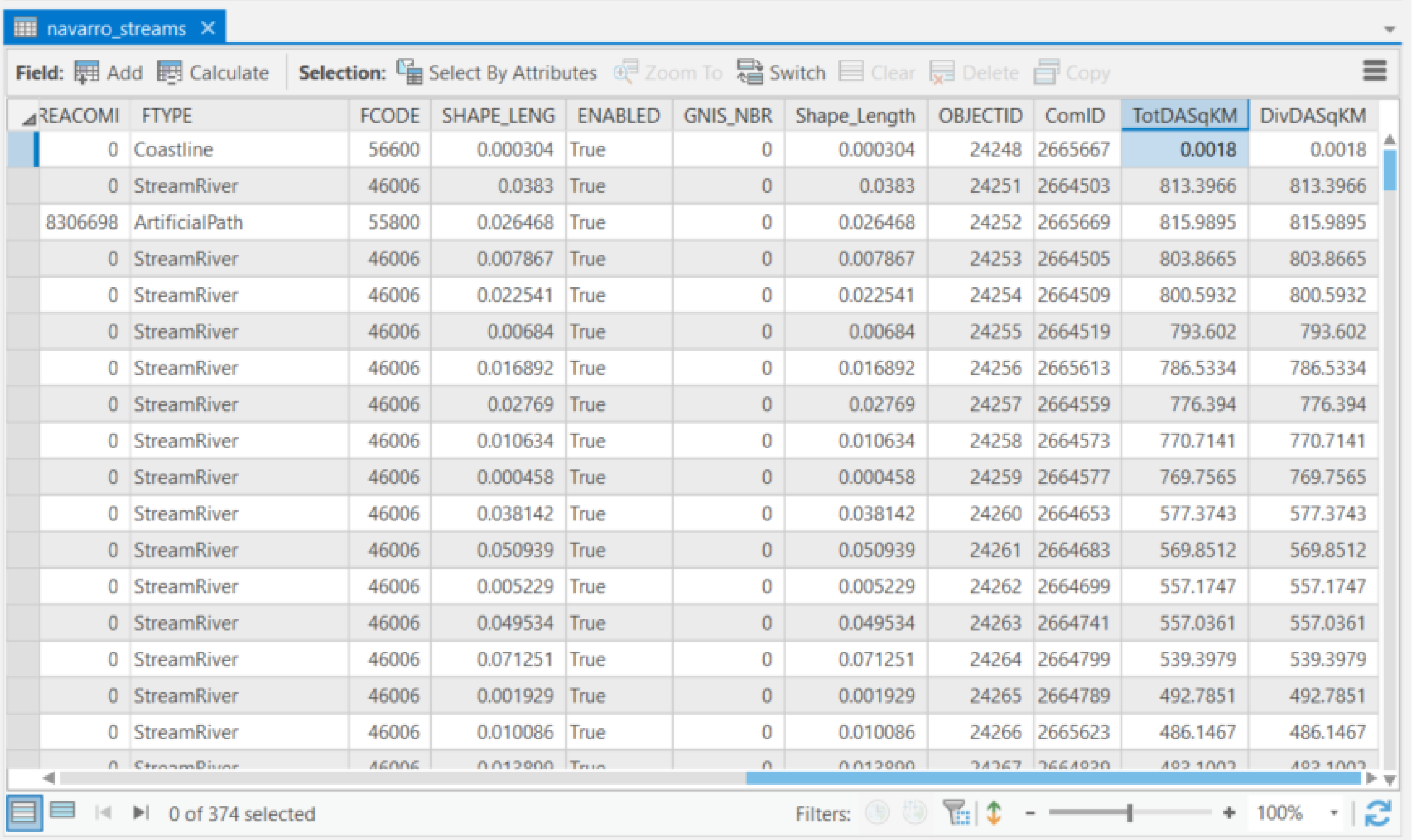
1. The *Input Table* is the table/features we want to add information to. It should be *navarro_streams* by default; if it is not, select it from the dropdown menu.
2. The *Input Join Field* is the field in the Input Table that has the values to match the other table against. As I mentioned before, we'll use the COMID attribute as our common attribute to look up. Fortunately, both tables have the COMID field so we can use it in each (and have a sense that it is the same data for both). Select it the Input Join Field dropdown. You will get a warning that the field is not indexed; that is okay.
3. The *Join Table* is the table that has the additional values we want to append as fields to the *Input Table*. Use the browse button (the folder icon at the end) to find the lookup table. Navigate to your geodatabase that contains the input data and open the table *CumulativeArea*.
4. The *Join Table Field* is the field in the Join Table that we use to match against the Input Join Field. The dropdown menu will populate with available fields from the Join Table with the same datatype as the Input Join Field (they need to match data types, such as text or floating point number, or integer, in order to be compared). Which field do you think we should use after looking through the list? Since it should have the same values as our original table, we'll use COMID.
5. Leave the box to *Keep All Target Figures* checked (*Target Features* was the old name ArcGIS used for *Input Table)*. We want all of our rivers to still be available even when there is no attribute information to attach from our join table.
6. Click *Validate Join* to confirm that we matched our tables correctly. It tells us that three records don't have a match (370 of 373 have a one to one match) - this is OK, it just means we don't have data for three stream segments. If few or no records had matches, we'd want to check if we selected the right tables and fields to match on. Close the validation box.
7. Click *OK* to finish the join and attach the data to the streams.


Add Join
Input Table
navarro_streams
Input Join Field
COMID
Join Table
CumulativeArea
Join Table Field
COMID
Keep All Target Features
Validate Join
OK
1
2
3
4
5
6
7

6.2 The new attribute table

Open the attribute table for *navarro_streams* again. Scroll over to the right side of the table and you'll see the joined attributes appended to the end. The field *TotDASqKM* has the total drainage area in square kilometers for each segment. Try selecting some individual records and looking at the corresponding feature in the map window - do these values make sense in their geographic distributions?

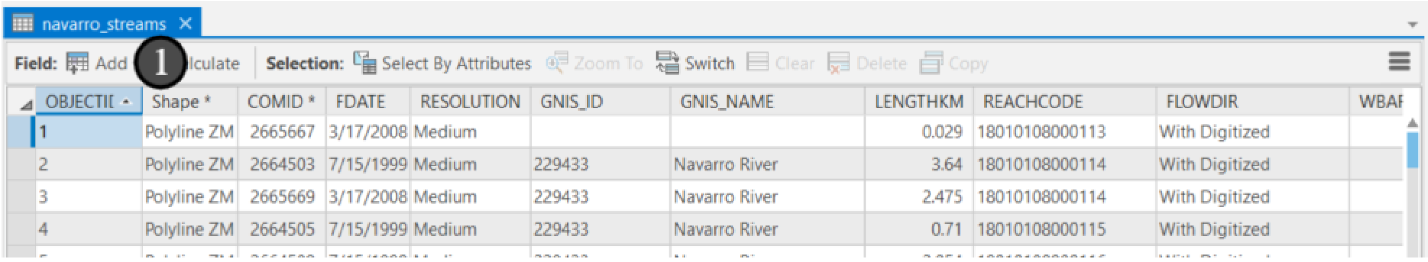
Now that we have these values joined, they stay joined within this map document (but not anywhere else). If we want a new feature class with these attributes permanently appended, we'd have to export the feature class now (or do a permanent join using a different tool in ArcGIS, the *Join Field* tool). We won't do this right now, but it is a common need.



REACOMI	FTYPE	FCODE	SHAPE_LENG	ENABLED	GNIS_NBR	Shape_Length	OBJECTID	ComID	TotDASqKM	DivDASqKM
0	Coastline	56600	0.000304	True	0	0.000304	24248	2665667	0.0018	0.0018
0	StreamRiver	46006	0.0383	True	0	0.0383	24251	2664503	813.3966	813.3966
8306698	ArtificialPath	55800	0.026468	True	0	0.026468	24252	2665669	815.9895	815.9895
0	StreamRiver	46006	0.007867	True	0	0.007867	24253	2664505	803.8665	803.8665
0	StreamRiver	46006	0.022541	True	0	0.022541	24254	2664509	800.5932	800.5932
0	StreamRiver	46006	0.00684	True	0	0.00684	24255	2664519	793.602	793.602
0	StreamRiver	46006	0.016892	True	0	0.016892	24256	2665613	786.5334	786.5334
0	StreamRiver	46006	0.02769	True	0	0.02769	24257	2664559	776.394	776.394
0	StreamRiver	46006	0.010634	True	0	0.010634	24258	2664573	770.7141	770.7141
0	StreamRiver	46006	0.000458	True	0	0.000458	24259	2664577	769.7565	769.7565
0	StreamRiver	46006	0.038142	True	0	0.038142	24260	2664653	577.3743	577.3743
0	StreamRiver	46006	0.050939	True	0	0.050939	24261	2664683	569.8512	569.8512
0	StreamRiver	46006	0.005229	True	0	0.005229	24262	2664699	557.1747	557.1747
0	StreamRiver	46006	0.049534	True	0	0.049534	24263	2664741	557.0361	557.0361
0	StreamRiver	46006	0.071251	True	0	0.071251	24264	2664799	539.3979	539.3979
0	StreamRiver	46006	0.001929	True	0	0.001929	24265	2664789	492.7851	492.7851
0	StreamRiver	46006	0.010086	True	0	0.010086	24266	2665623	486.1467	486.1467

7. Adding a field

Now, we want to add a field to our data table to subset the streams by drainage area. We want to know which streams have a drainage area of more than 50 square kilometers. In the attribute table pane, click the *Add* button (1).

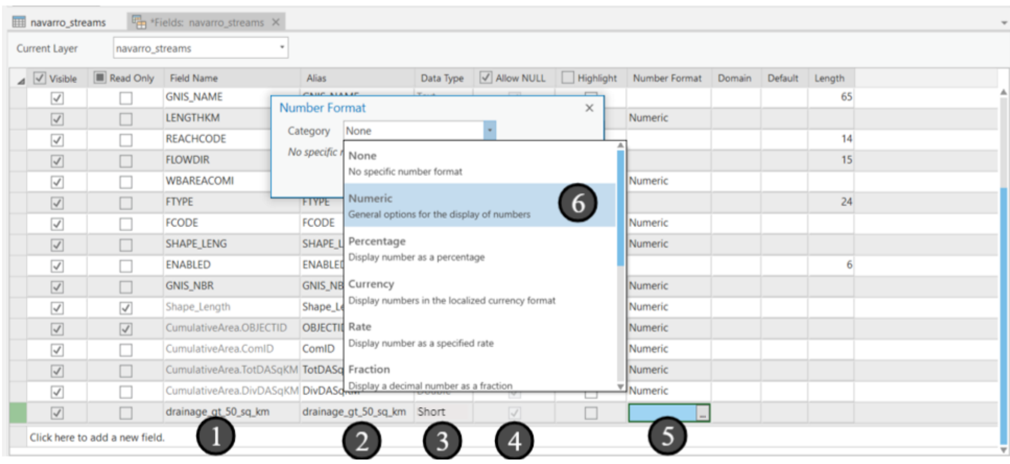


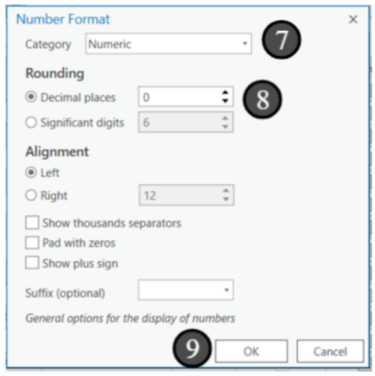
7.1 Setting field properties

A new tab named **Fields: navarro_streams* will appear in the pane. Each row in this table corresponds to a field (column) in the main navarro_streams attribute table, and this is where we define which fields are available. We're going create a new field so that in following steps we can give it a value of 1 for streams with a drainage area of over 50 square kilometers, and 0 for all of the rest.

ArcGIS starts a new row in this table for us and fills it with default values that we'll change:

1. In the Field Name column of this new row, enter the name *drainage_gt_50_sq_km* (it's a long name, but avoids confusion by telling us it indicates whether the segment has a drainage greater than 50 square kilometers).
2. Enter the same name in the Alias column - you could enter something different here - the Field Name is the true name, but the Alias can show in some places and be a nicer representation of the name. It's useful when publishing datasets, but can often create *more* confusion internally while you're still working on a dataset
3. Enter *Short* (an abbrevation for Short Integer) in the Data Type column, since we're going to just have values of 1 and 0.
4. Leave the box checked in the *Allow NULL* column. All of the values in the main attribute table will initially be NULL.
5. Now let's set some number display options. In the *Number Format* column, click on the field entry and then click the button with three dots.
6. In the dialog box that pops up, select *Numeric* from the *Category* dropdown menu. This will open the full Number Format dialog box.
7. Category will now be listed as Numeric.
8. Because we will only have integers in our dataset, we don't want any decimal places to display. Set Decimal places to 0.
9. Click OK to close the dialog box.



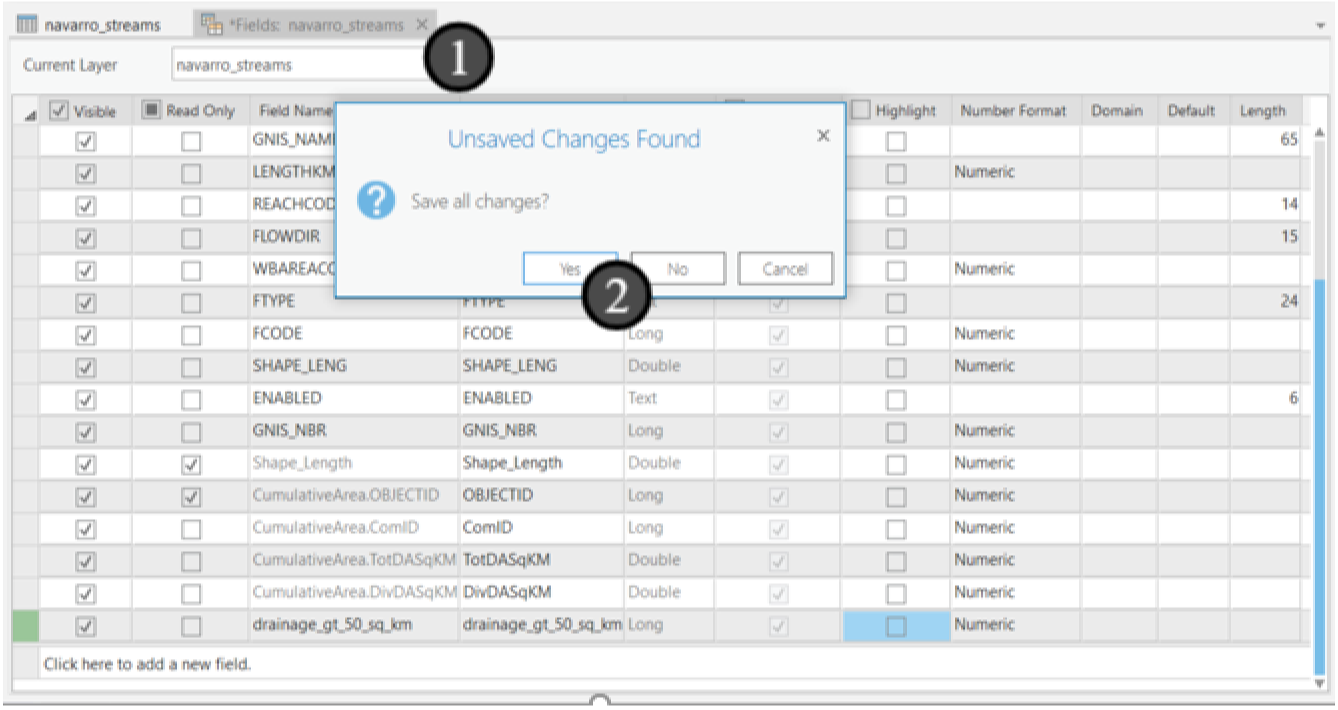


7.2 Save and close

1. Close the **Fields: navarro_streams* tab.
2. When prompted, click *Yes* to save all changes.

Note that you could also have clicked the *Save* button on the ribbon above - a new ribbon tab automatically was added and activated when we switched to editing fields that has new tools and options for the current context.

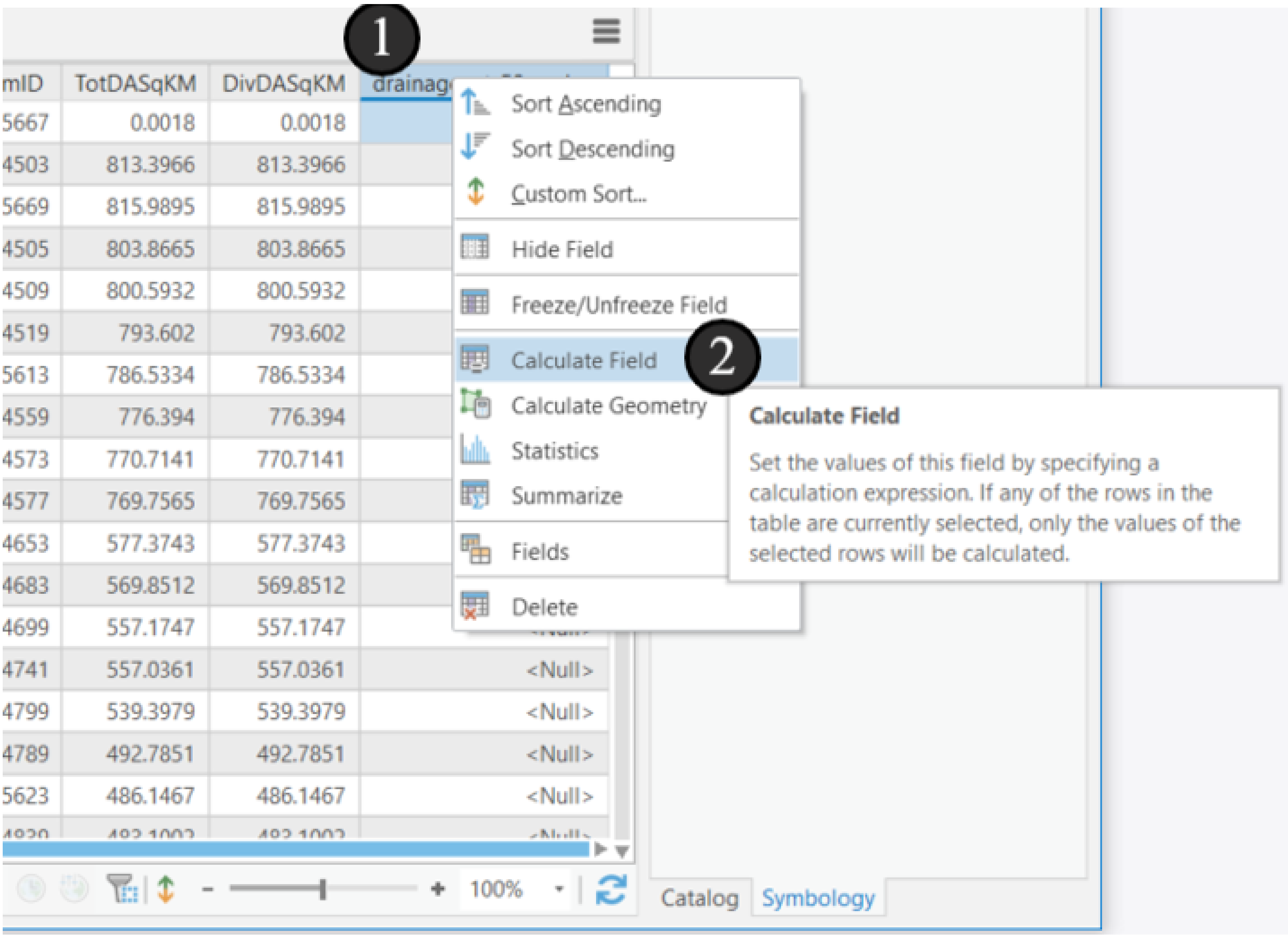
(Speaking of saving, have you saved your project recently? Here's your reminder to save your work!)



8. Adding values to the field

Now let's *populate* that field with a value indicating whether or not that feature has a drainage greater than 50 square kilometers. For this, we want to use the *Calculate Field* tool. This tool helps us attach values to fields programmatically. It can do anything from basic to complicated value assignment of attributes and is a staple of interactive GIS analysis work - we'll do a very simple calculation now.

1. Right click on the header of the new field we just added.
2. Select *Calculate Field*.

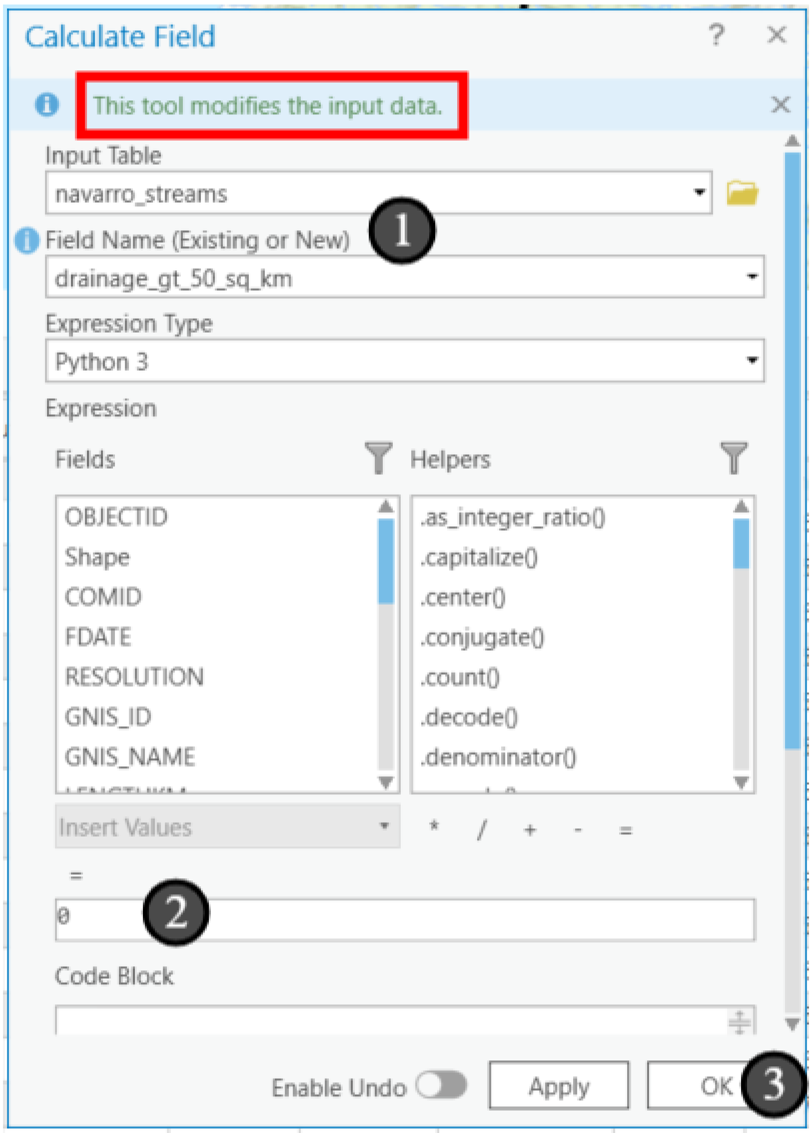


8.1 Calculate Field

First, note at the top the warning that says *This tool modifies the input data* - many tools in ArcGIS create a new item as their output and it's easy to become accustomed to that behavior - pay attention when you see this warning so you don't accidentally modify something you intended to leave alone - for now, we expect this, so it's OK.

The Calculate Field tool gives us plenty of flexibility when updating or changing values in fields. It might look somewhat similar to *Select By Attributes*. In this case, we're just going to assign all of our records a value of 0 - meaning that they don't have a large drainage area, regardless of size - we'll then overwrite the value for the areas larger than 50 square kilometers in a few steps.

1. Double-check that the Input Table reads *navarro_streams* and the Field Name is the field that we just created (drainage_gt_50_sq_km)
2. In the box under the line that simply says "=", type 0.
3. Click OK.


Calculate Field
This tool modifies the input data.
Input Table
navarro_streams
1
Field Name (Existing or New)
drainage_gt_50_sq_km
Expression Type
Python 3
Expression
Fields
Helpers
OBJECTID
Shape
COMID
FDATE
RESOLUTION
GNIS_ID
GNIS_NAME
.as_integer_ratio()
.capitalize()
.center()
.conjugate()
.count()
.decode()
.denominator()
Insert Values
* / + - =
=
0
2
Code Block
Enable Undo
Apply
OK
3

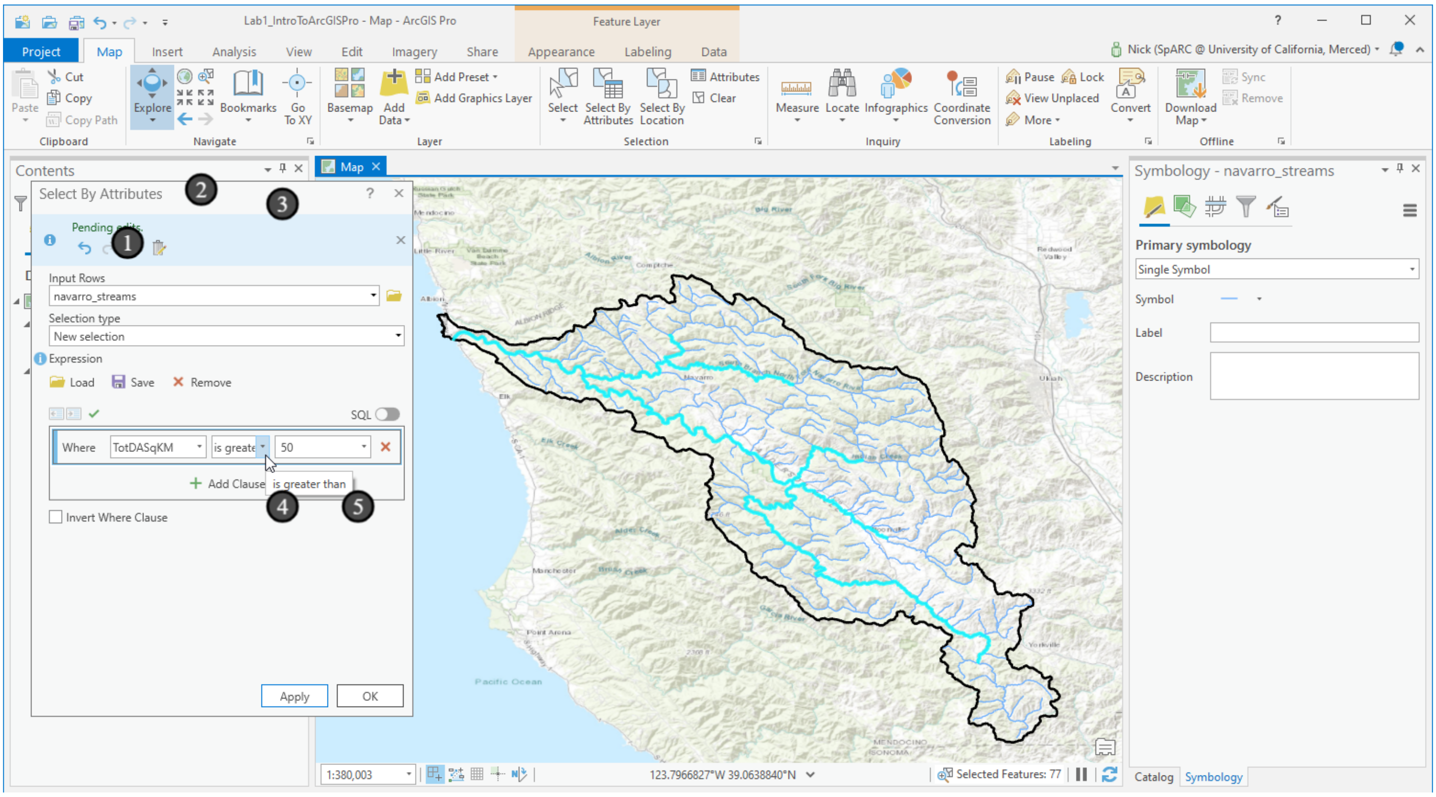
8.2 Select by Attributes again

Now, select by attributes all of the streams with values in the TotDASqKM field greater than 50. Use the same process you used previously for select by attributes, but this time you'll need to manually type in the value. Open up the Select By Attributes tool again (on the main ribbon). After you click *Add Expression*, start building your query.

1. Find *TotDASqKM* in the first dropdown menu
2. Select *is greater than* in the second menu
3. Type 50 in the final dropdown box.

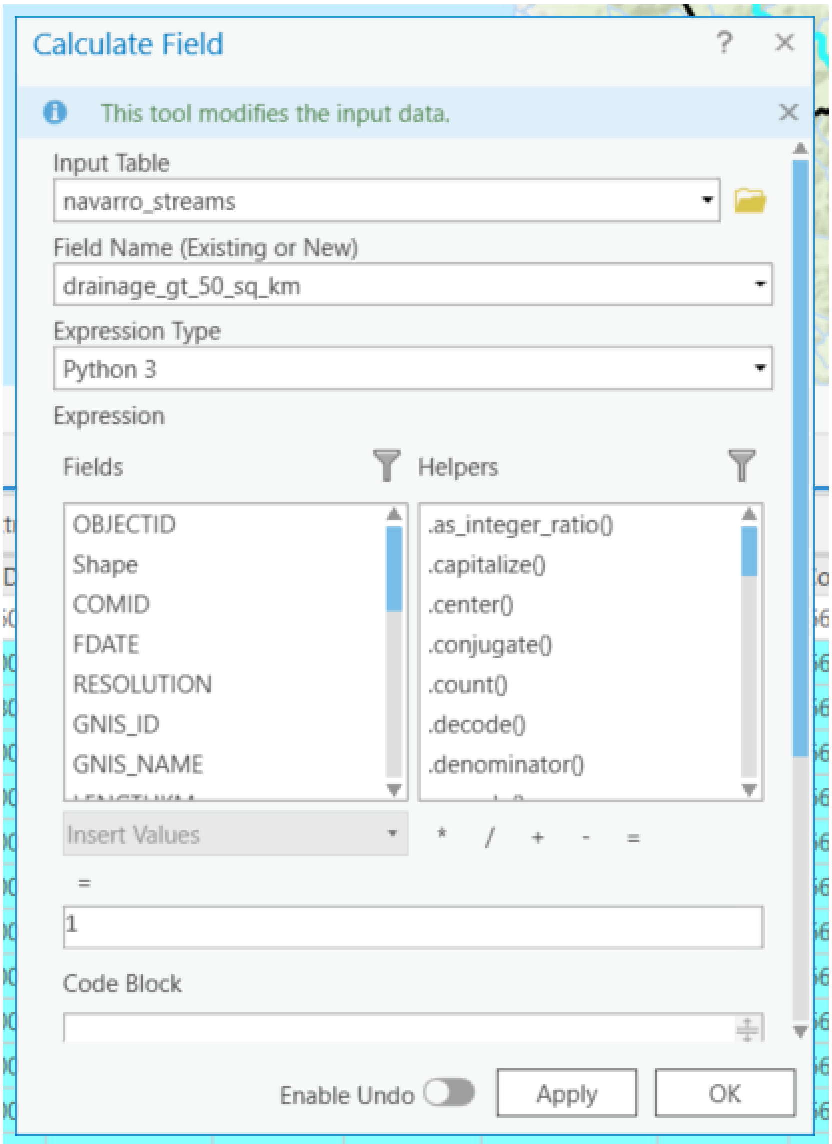
Use the SQL toggle to check your query - does the code look correct? Click *Apply* to check your selection (4), and *OK* to close the dialog box (5).

Take a look at the selected rivers on your map. Do these look like the river segments you would expect to have larger drainage areas?



8.3 Field Calculator Again

Now, with the selection active, run the Calculate Field tool on the same field as before (our new field) - remember how to get there? Open the attribute table and right click on the *drainage_gt_50_sq_km* field to star tthe tool. This time place 1 in the bottom box instead of zero so the selected values get assigned to 1. Click OK to run the tool.



8.4 Inspect our results

What happened here? If we take a look through the results, most of them are still zero, but all of the selected records have a value of 1 now. This is what we wanted, but what do you think happened inside ArcGIS to make this work?

Remember from before that most tools in ArcGIS only operate on the selected set. This includes the Field Calculator. In this case, what we did to use that was set a default value of zero for all of the records, then gave just the records that met our criteria the value of 1.

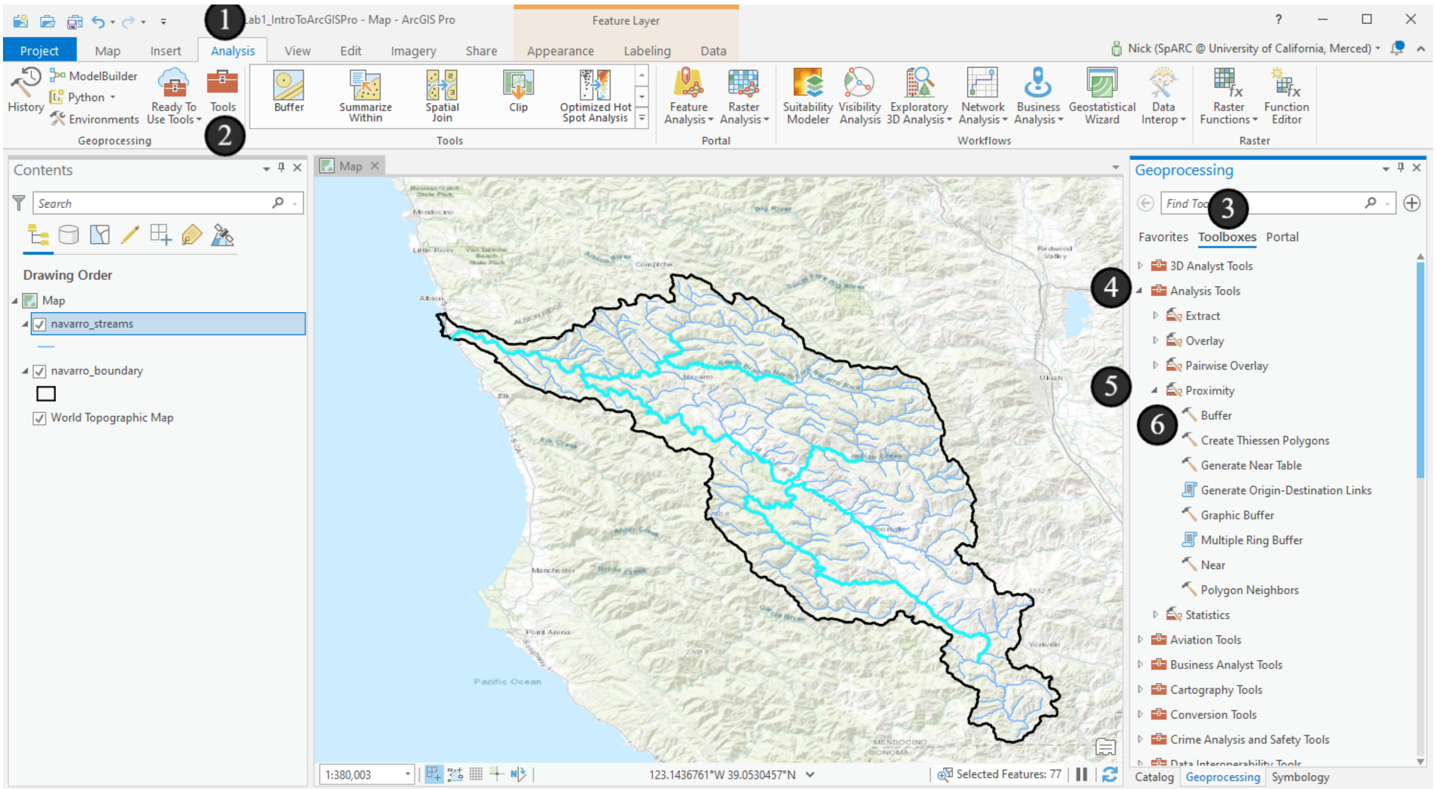
As a bonus, can you figure out how to do that same operation of calculating the correct values for this field without involving Select By Attributes? Hint: It's one step and all within Field Calculator, but it involves using a Python expression (Answer at the end of this tutorial).

OBJECTID	ComID	TotDASqKM	DivDASqKM	drainage_gt_50_sq_km
24292	2666229	81.216	81.216	1
24293	2666221	75.519	75.519	1
24294	2666277	59.5179	59.5179	1
24295	2666295	54.9612	54.9612	1
24296	2666847	44.9973	44.9973	0
24297	2664961	102.2697	102.2697	1
24298	2664921	98.505	98.505	1
24299	2664837	85.0977	85.0977	1
24300	2664895	80.0352	80.0352	1
24301	2664909	38.1015	38.1015	0
24302	2664907	32.2434	32.2434	0
24303	2664893	29.916	29.916	0
24304	2664905	28.5129	28.5129	0
24305	2664967	17.0046	17.0046	0
24306	2665011	4.6062	4.6062	0
24307	2665005	0.9333	0.9333	0
24308	2664595	192.3786	192.3786	1
[illegible]	[illegible]	[illegible]	[illegible]	1

9. Geoprocessing: Buffers

Leave your selection active now. We're going to get a new set of features representing the area within 100 meters of these large segments of the river. We want to find out what soils are near the portions of the watershed with large flows. To accomplish this, we'll need to do some *geoprocessing* with a new set of tools that you haven't directly used yet.

1. Click on the *Analysis* ribbon tab
2. Click the *Tools* button. This will open the *Geoprocessing* pane on the right side of your screen.
3. The tool we're looking for is listed under the *Favorites* tab, but to give you a sense of the tool structure select the *Toolboxes* tab
4. Expand the tree under *Analysis Tools*
5. And then again under *Proximity*
6. Click Buffer to open the Buffer Tool.

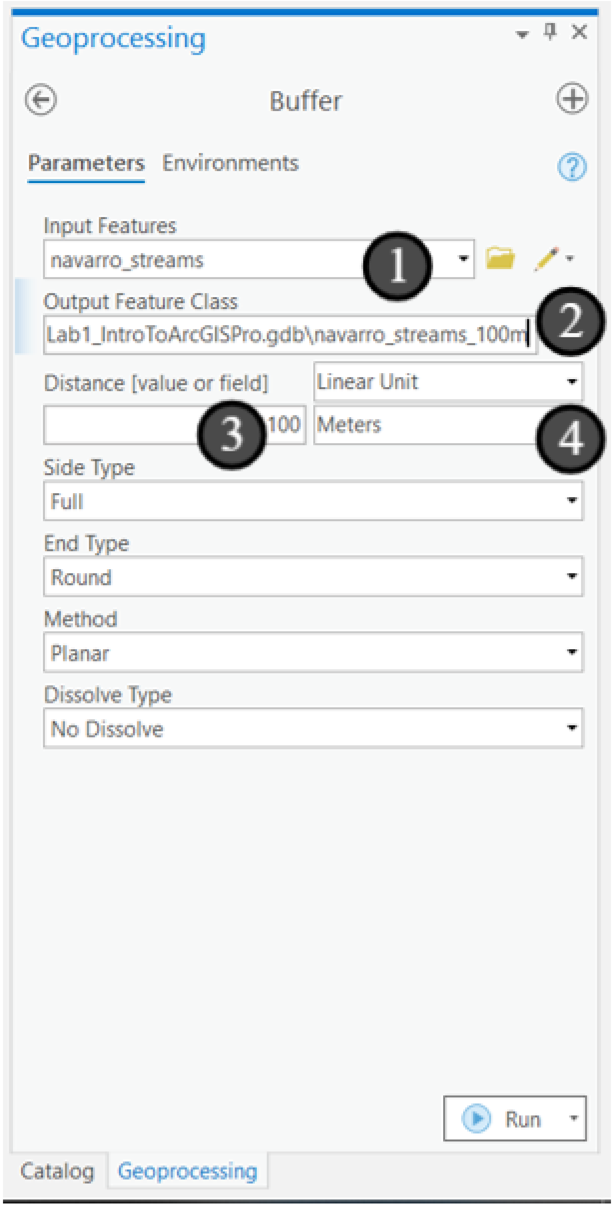


9.1 The Buffer Tool

This a *geoprocessing tool* called *Buffer*. Most geoprocessing tools will have a similar format, with a set of parameters for input, based on the tool. If you hover over the blue question mark in the upper right corner of the pane, you'll get the contextual help popup for the tool at large; if you click on the button, it will take you to an online help page. Esri's online documentation is excellent and thorough (honestly, the documentation alone is a great reason to use ArcGIS). If you ever have a question about the software, especially with a geoprocessing tool or how it works, starting with that documentation is the best resource. As you hover over each field, a blue information circle will appear to the left of the field; if you hover over that icon, you will get a help popup for that field.

The Buffer tool takes features we already have and gives us new features with a specified distance added around the original features. You can think of it as you requesting to know what's within a certain distance of the locations you're interested in and receiving a polygon showing you the area within that distance. In this case, we'll use it to create polygons representing 100m to the side of each stream. (can you think of how this might differ from an on-the-ground measurement of the same distance?)

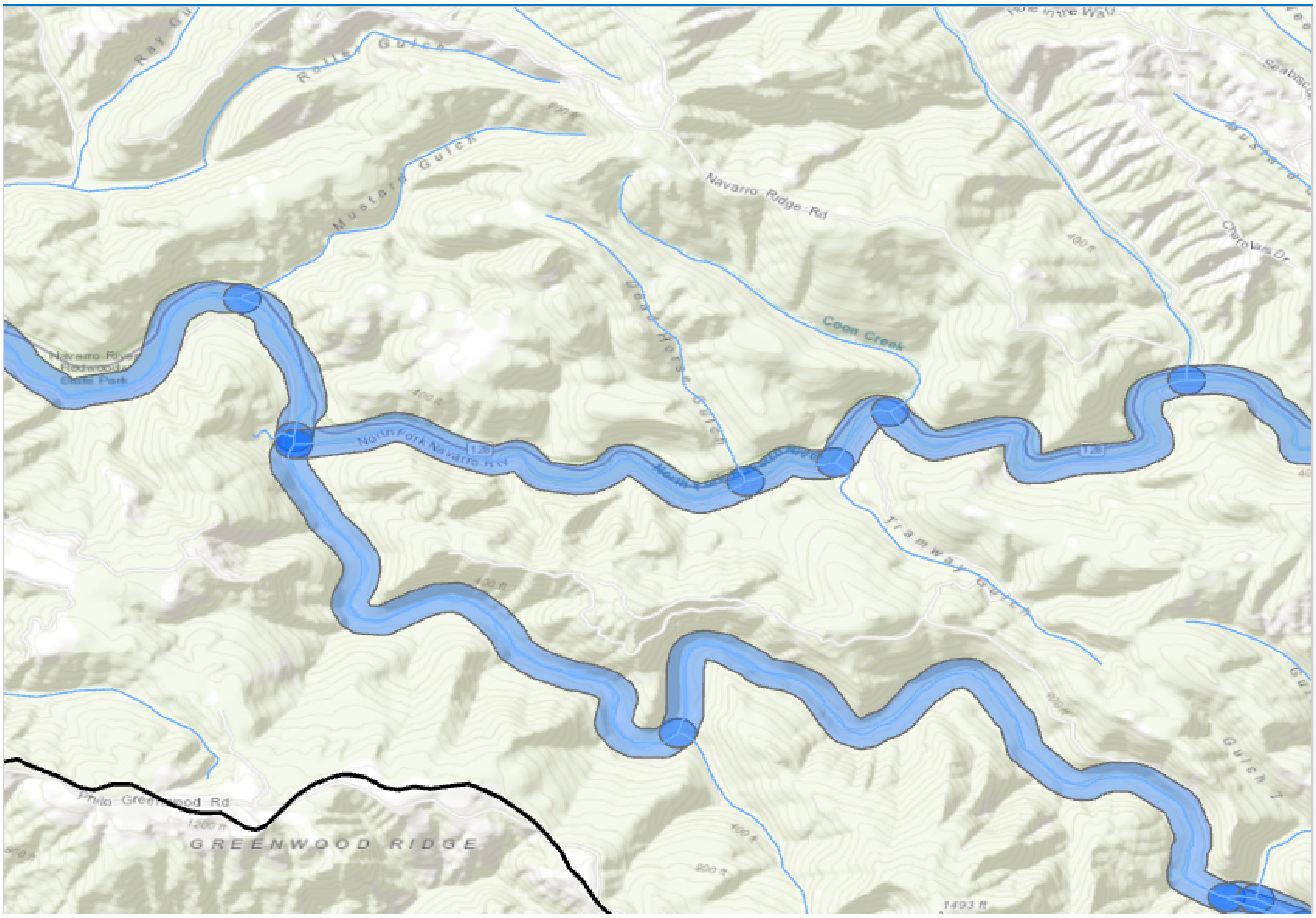
1. Select *navarro_streams* from the *Input Features* dropdown - we're going to create the buffers around that
2. ArcGIS will create a default output feature class in our project geodatabase. Leave the location the same , but rename the output feature class to *navarro_streams_100m*.
3. Set Distance to 100
4. Leave *Linear Unit* selected and change the units to Meters.
5. Leave the rest of the default options (if you're curious what they do, check out the tool help by clicking on the blue question mark at the top!) and click *Run* to execute the geoprocessing tool. It will run in the background with a progress bar at the bottom of the pane, then it will put the results into the Contents pane. Once it loads, feel free to change the symbology and layer order as you see fit.


Geoprocessing
Buffer
Parameters
Environments
Input Features
navarro_streams
1
Output Feature Class
Lab1_IntroToArcGISPro.gdb\navarro_streams_100m
2
Distance [value or field]
Linear Unit
100
3
Meters
4
Side Type
Full
End Type
Round
Method
Planar
Dissolve Type
No Dissolve
Run
Catalog
Geoprocessing

9.2 Explore

Zoom in and explore the new data you've just created and clear your selection. Why are there rounded spots in the middle of the polygons?

The rounded spots are because we left one of the default options on the geoprocessing tool set that creates a separate 100m buffer for each stream segment, which means that we (usefully) have a separate polygon for each segment, but we also have overlap in the polygons where the segments end. If we changed options in the tool, we could have *dissolved* these polygons into a single polygon and the overlaps would be merged.

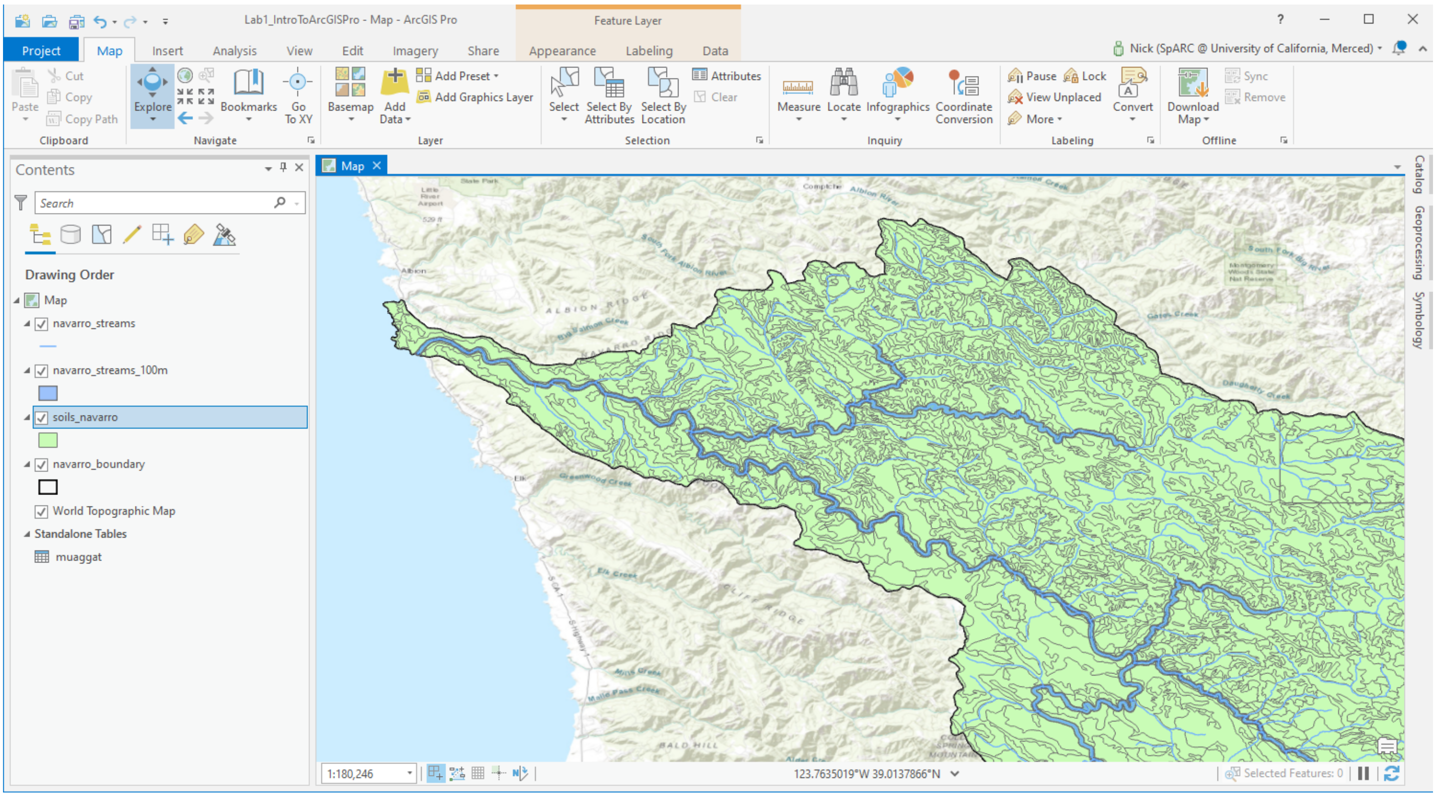


10. More geoprocessing

Now we're going to analyze the soils drainage of that stream corridor we just created.

Add in a new data layer named *soils_navarro* from your source geodatabase. What could be done better in the naming of this feature class?

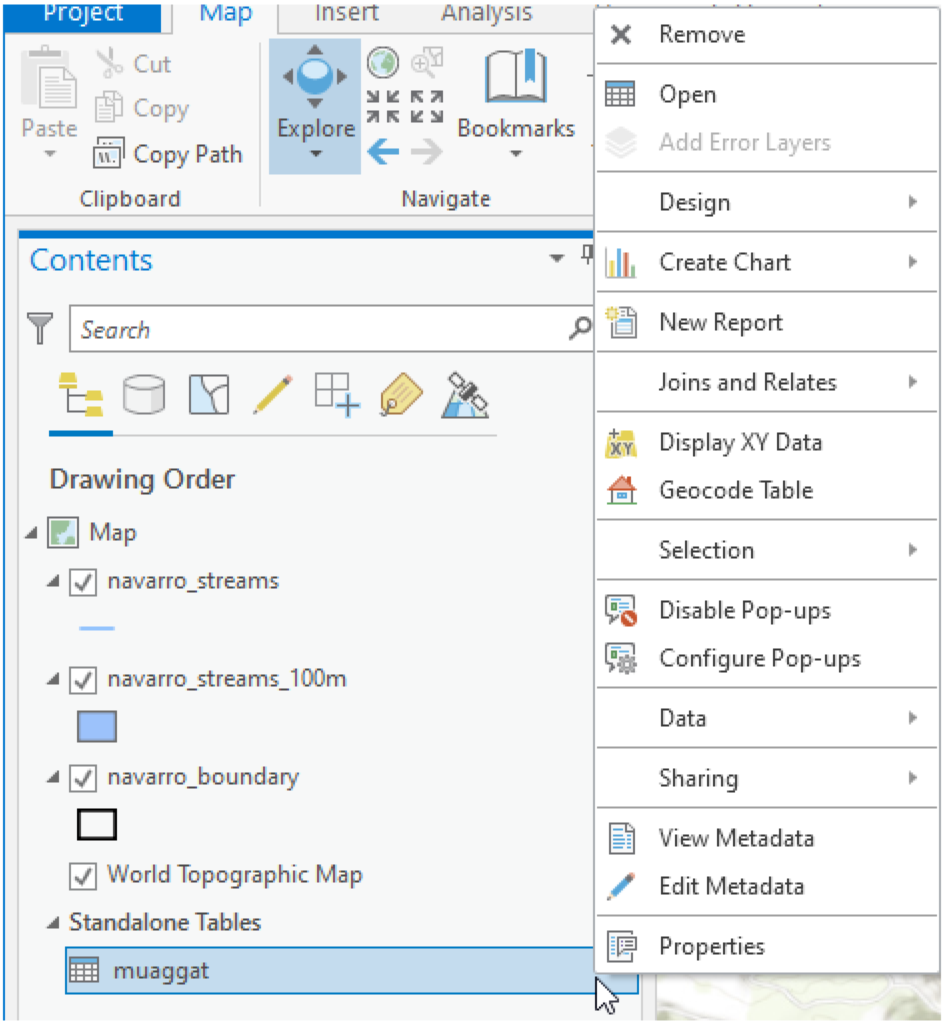
Take a quick look at the attribute table for this dataset and see if you can get any understanding of it before we proceed.



10.1 Add in another data table

Now we're going to add in a data table to associate with the soils layer. Use the add data button, but this time add the table named *muaggat* from the source geodatabase.

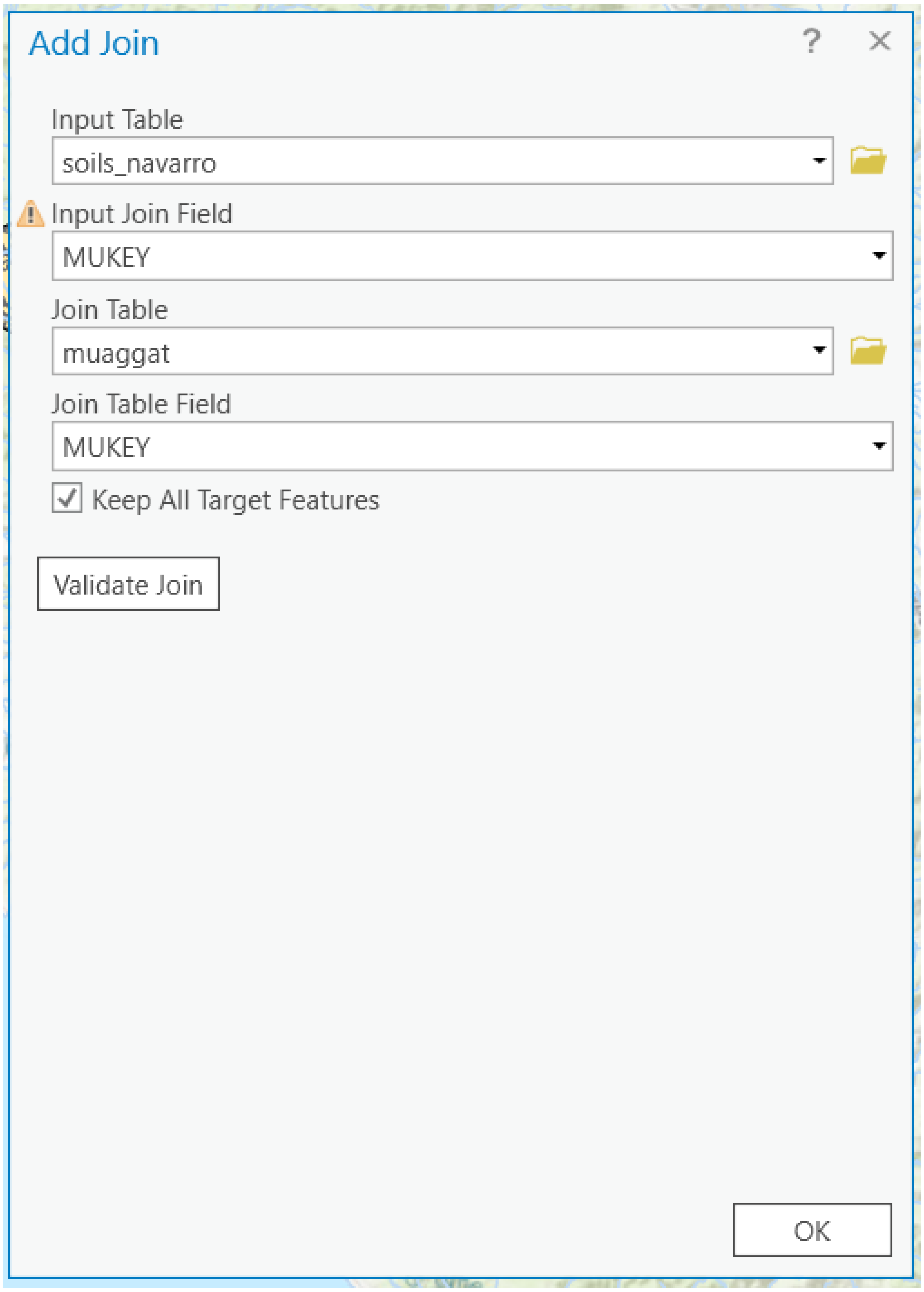
1. Notice how the table is labeled in the Contents pane in a separate section. Try clicking on the gray cylinder at the top of the Contents pane. What do you notice? The default is to display layers in their *drawing order* on the map. Since tables aren't drawn, they get a separate section, but if you have a lot of data from different sources and need to know which tables refer to which map layer or came from which sources, you can switch views to quickly see related datasets.
2. For now, switch back to the default view. Do so by clicking the first button to the left at the top of the Contents pane. If you have time, feel free to explore the other options for how to view your map contents here
3. To inspect the new table, right-click on the table name in the contents pane as you would a regular map layer, and select *Open*. Look at the column names - what do you think this table is for?



10.2 Add a join

Now we want to join our soils layer with the additional information in the muaggat table that we just added. Create a join (same way as the previous join) for the features to the table based on the common field *mukey* (map unit key). Fill in all of the fields and select OK to run the tool.

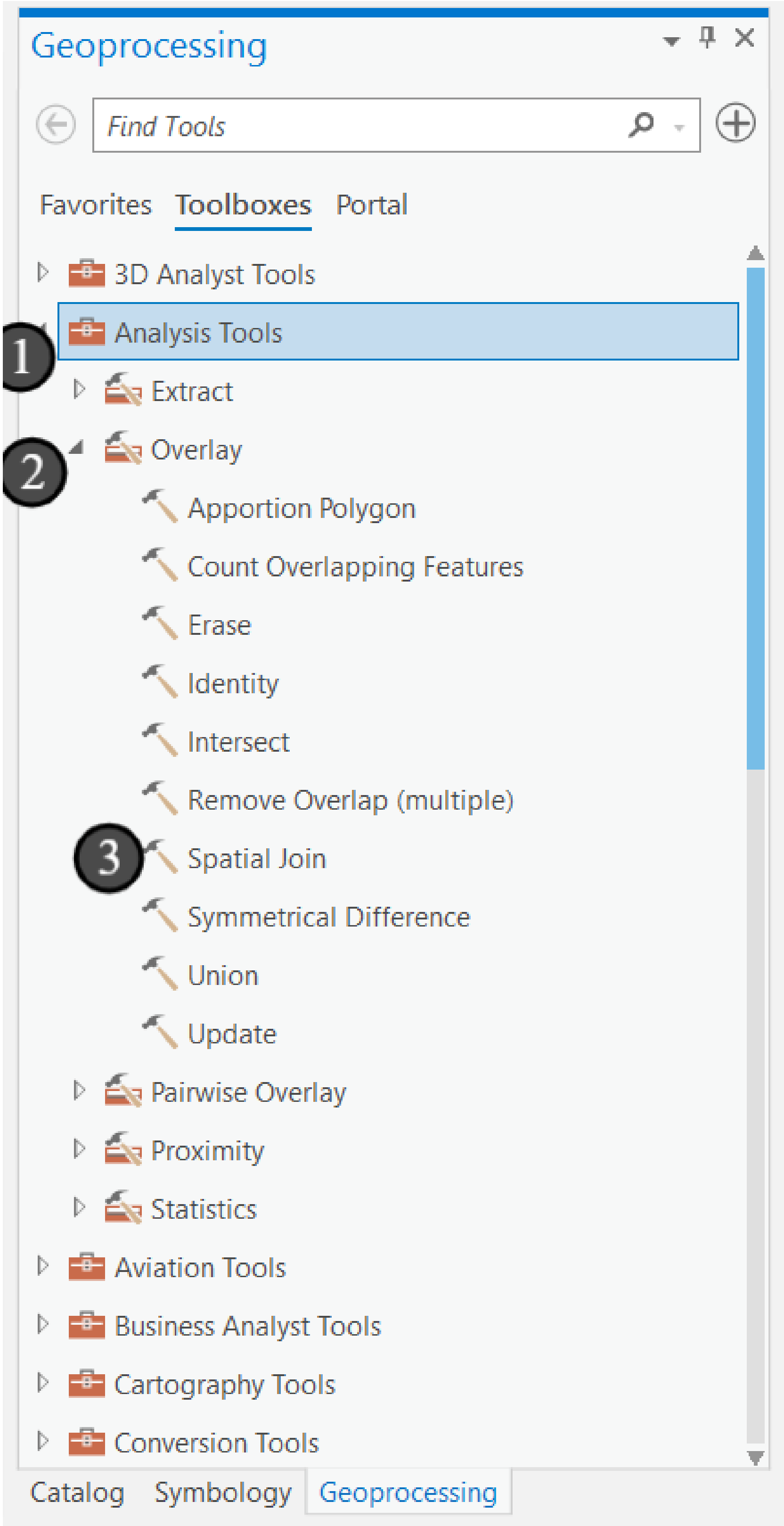
Open the attribute table for the *soils_navarro* layer. What has changed?



10.3 Spatial Join!

Now we want to attach soils information to our buffered streams. To do this, we'll use the *Spatial Join* tool - it operates on the same basis as *Select By Location* where it determines a spatial relationship between sets of features, but it then attaches attributes from one set of features to another. Also, notice the word *join* in the name - it is the same concept as the table joins we've been doing, but instead of using a common table field to attach attributes, it uses a common location.

1. Expand *Analysis Tools* in the *Toolboxes* tab of the *Geoprocessing* pane - if you closed *Geoprocessing,* recall that it's on the *Analysis* ribbon as an icon named *Tools*.
2. Expand the *Overlay* toolset
3. Click on *Spatial Join* to open the tool.


Geoprocessing
Find Tools
Favorites
Toolboxes
Portal
3D Analyst Tools
Analysis Tools
1
Extract
2
Overlay
Apportion Polygon
Count Overlapping Features
Erase
Identity
Intersect
Remove Overlap (multiple)
3
Spatial Join
Symmetrical Difference
Union
Update
Pairwise Overlay
Proximity
Statistics
Aviation Tools
Business Analyst Tools
Cartography Tools
Conversion Tools
Catalog
Symbology
Geoprocessing

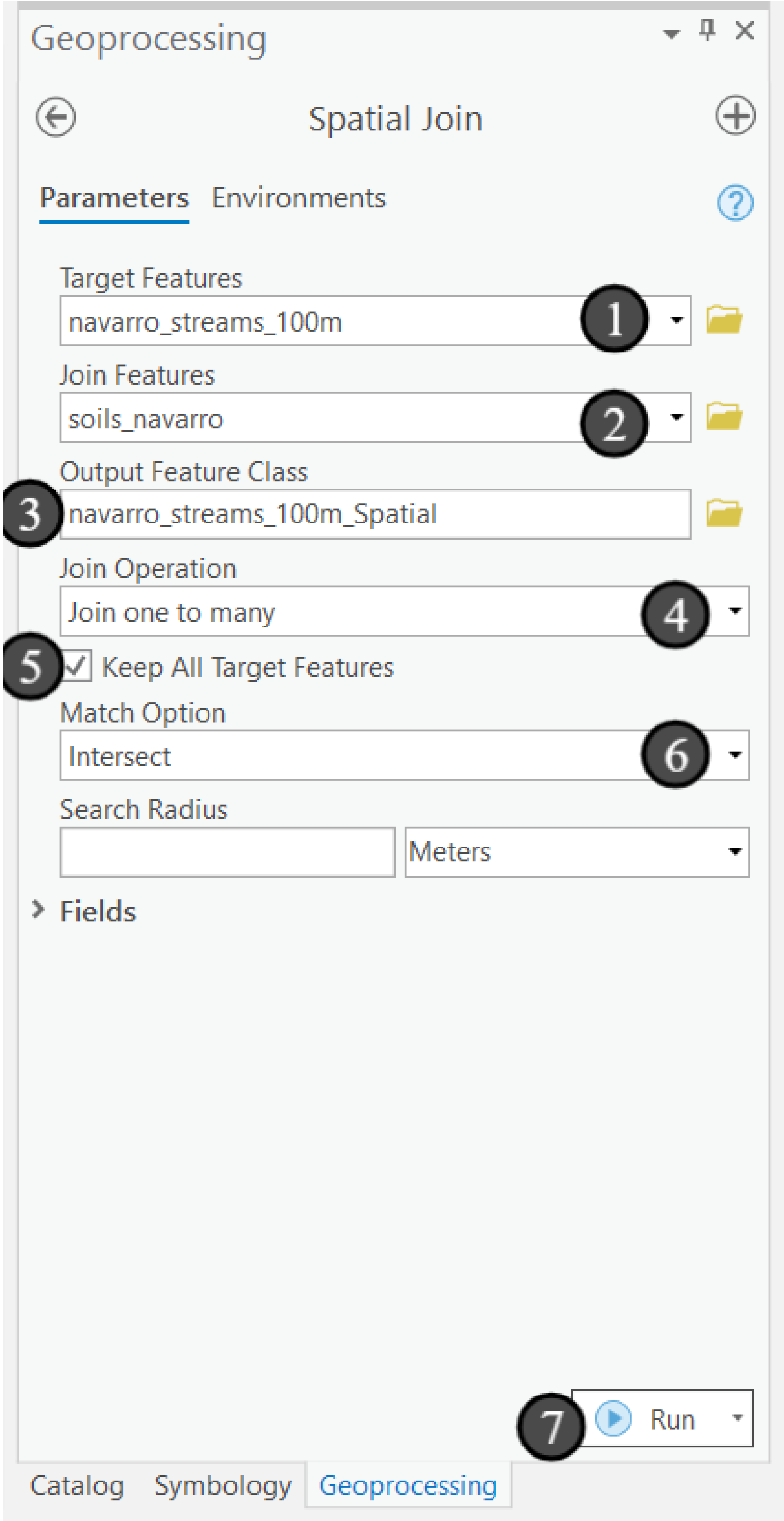
10.4 The best tool in the toolbox

Spatial Join has some slightly confusing terminology for newcomers, but it will make sense when you get used to it. We first need to understand which features are our target features and which are our join features. The *join features* get attached to the *target features* (so earlier, *navarro_streams* was our *target* and the table we attached was our *join table*. It works the same here, but with an even more important distinction that the spatial information that is retained is that of the target features. The end result is a layer that looks like the target features, but has attributes of both for a given location.

As a reminder of our objective now, we want to know what soils are within 100 meters of the streams.

1. Select *navarro_streams_100m* for the *Target Features* - we want to attach features to this layer and keep the stream segment representations.
2. Select *soils_navarro* as the *Join Features*.
3. Use the default name for the *Output Feature Class*
4. Select *JOIN_ONE_TO_MANY* as the *Join Operation*. This option will keep duplicate records in the stream buffer layer whenever multiple soils polygons intersect it - this will let us see the complete set of soils features in the buffer zone.
5. Make sure *Keep all Target Features* is checked so that even features without a match are retained.
6. Make sure that *Intersect* is the *Match Option* - this setting is similar to the same setting in *Select By Location*. Leave the *Search Radius* field blank.
7. Click *Run* to run the tool.

Bonus question: what options would we change here if we wanted to only get one result for each matching record and we wanted to know all the drainage classes that applied to it?


Geoprocessing
Spatial Join
Parameters
Environments
Target Features
navarro_streams_100m
1
Join Features
soils_navarro
2
Output Feature Class
3
navarro_streams_100m_Spatial
Join Operation
Join one to many
4
5
Keep All Target Features
Match Option
Intersect
6
Search Radius
Meters
Fields
7
Run
Catalog
Symbology
Geoprocessing

10.5 Joined attributes

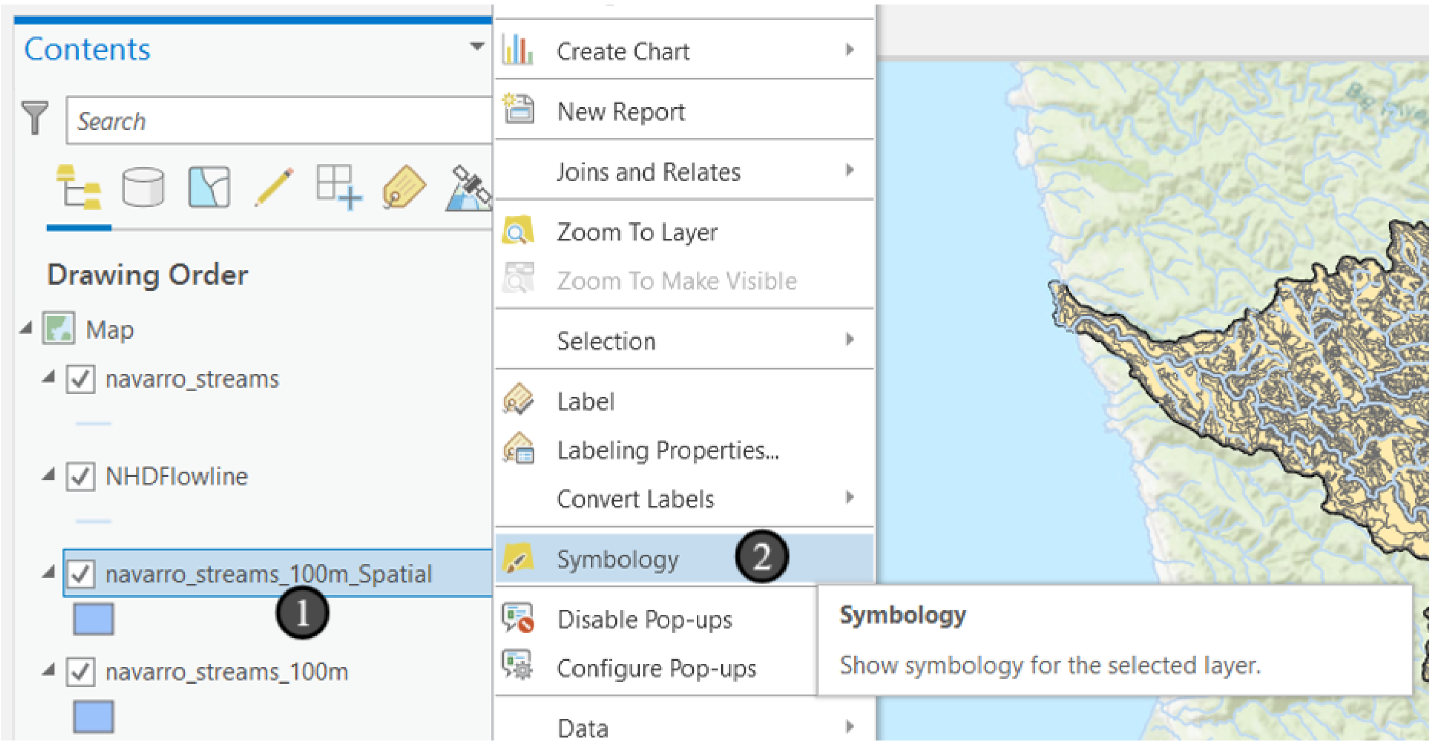
We'll get a new layer back in the Contents pane with the attribute information from:

- Our buffered streams,
- The soils feature data
- The data that was joined to the soils features at the time we ran the spatial join

Let's now symbolize that data based on the newly attached drainage class information:

1. Right click on *navarro_streams_100m_Spatial*
2. Click *Symbology* to bring up the Symbology pane

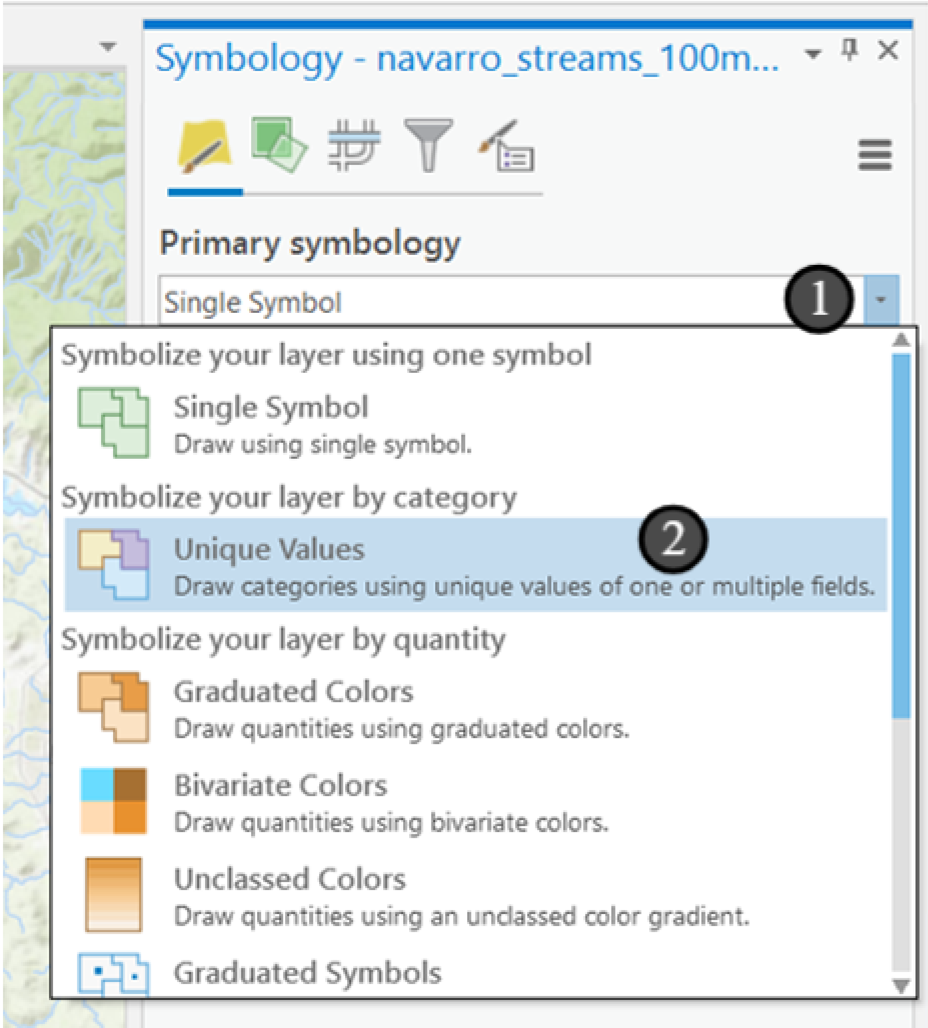
Bonus question - we could have potentially performed this join with another geoprocessing tool, which would have split the buffers along the lines of the soil unit boundaries and still performed the attachment of attributes like the spatial join. Which tool is it? Hint, it's also in the Analysis tools *toolbox* in the Overlay *toolset* where Spatial Join is located.



11. Symbology!

Until now, we've mostly used some pre-built symbology options, but here is where you can dig in and make custom map displays based on attributes.

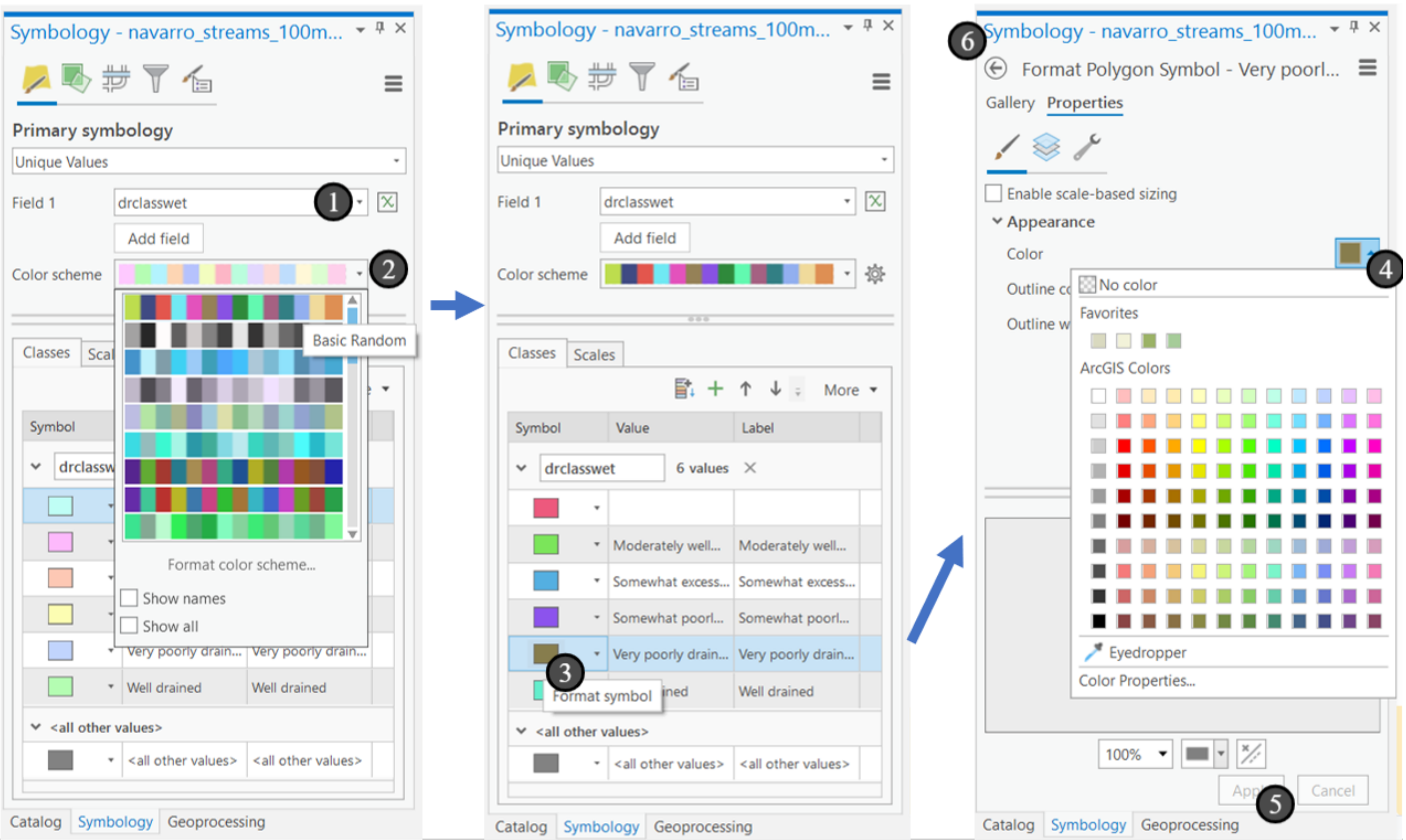
1. To start with, open the dropdown for Primary symbology and
2. Click *Unique Values* - we have a set of categorical values we want to use as the basis for our symbols, and we'll choose symbols for each. Previously, we've only represented each feature in the same feature class with the same symbol, but now we can show each one based on values in its attribute table.



11.1 Setting symbology by unique values

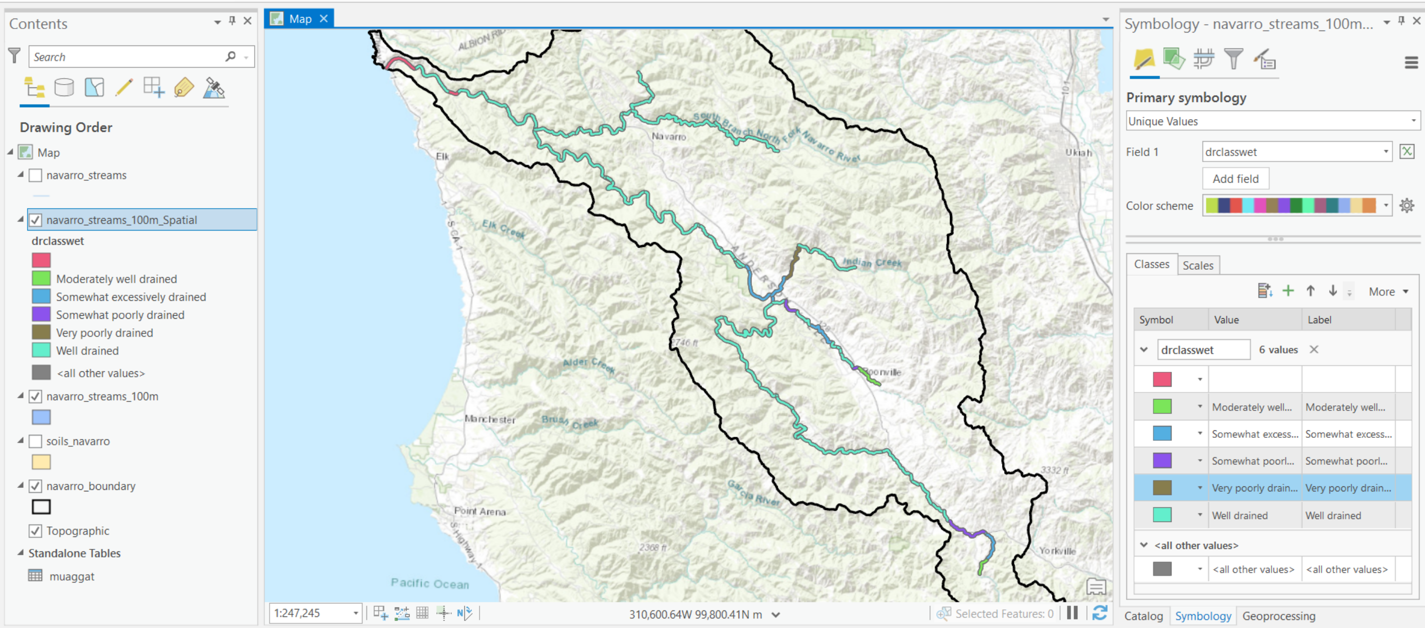
Now, we need to select the field that contains the values we want to use to determine the way each feature is displayed.

1. Select *drclasswet* - the drainage class field - from the Field 1 dropdown.
2. You can change the colors used for each one either by selecting a new *color ramp*
3. or manually by clicking on the color patch, which will open up a new pane.
4. Choose a new color by clicking on the Color dropdown. Feel free to do either one, or some combination of the two.
5. To show the results on the map, click the *Apply* button at the bottom of the pane.
6. And then select the back arrow to return to the main panel.



12. Visualizing the data

Turn off the navarro_streams layer and zoom to the extent of *navarro_streams_100m_Spatial*. Zoom around the map and inspect the results and the attribute tables. Normally, we'd continue our analysis from here now that we have the drainage class infromation, but that's the end of the analysis for this lab. Instead, we'll now begin making a map with this data. First, if you haven't already, change the symbol colors to be more appropriate for drainage class (maybe light to dark blue depending on drainage - something that has a continuous feel - there will be options in the color scheme dropdown).

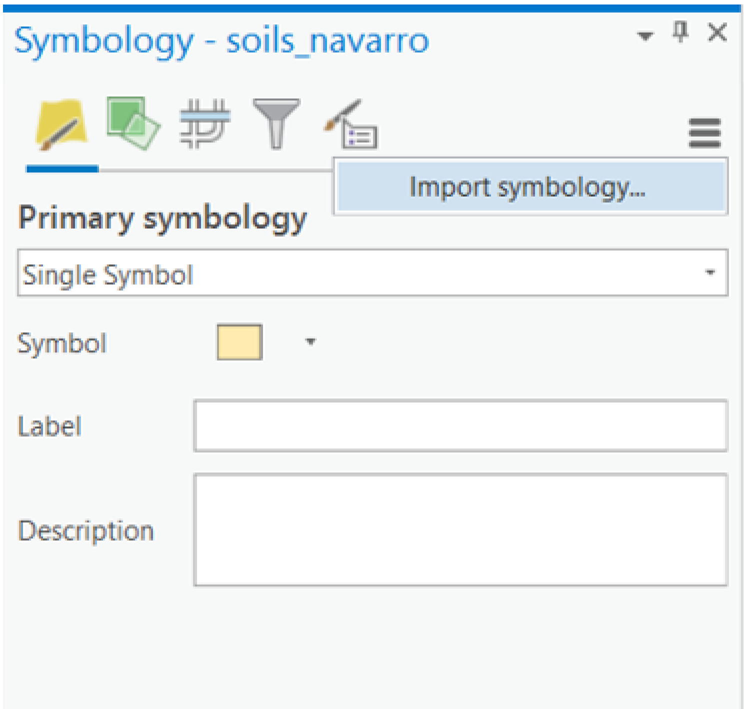


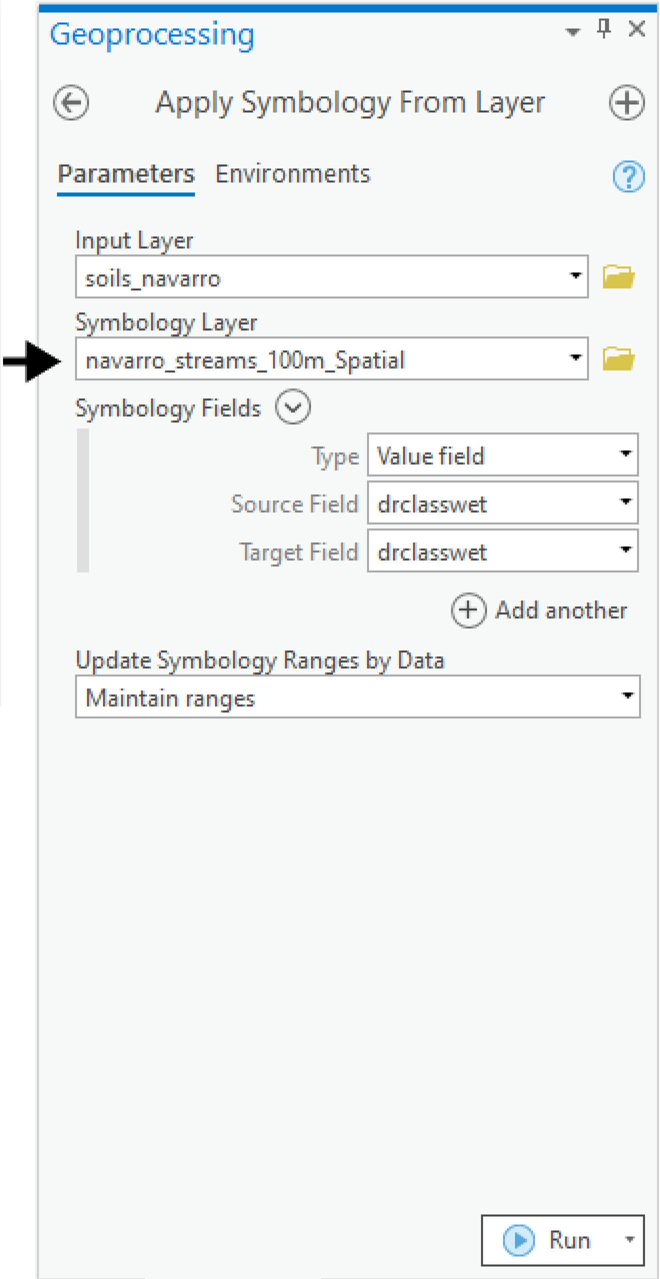
12.1 Importing Symbology

Now, for our map, we want to draw the drainage class for all of the soils - not just the soils near the rivers. Let's copy our symbology over from our stream buffered soils layer.

(not shown) Click on the *soils_navarro* layer in the Contents pane to make it the active layer in the Symbology pane.

1. In the upper right hand corner, click on the menu button (looks like a stack of horizontal lines)
2. Click *Import symbology*
3. In the *Apply Symbology From Layer* geoprocessing tool that opens in the same pane, the Input Layer should already say soils_navarro - this is the layer we'll be applying symbology to. In the Symbology Layer field, select *navarro_streams_100m_Spatial* from the dropdown. This is the layer to import the symbology from.
4. For the Symbology Fields, select *Value field* for Type, and *drclasswet* for both Source Field and Target Field so that it matches the symbology from navarro_streams_100m_Spatial to soils_navarro on the basis of those two fields
5. In the *Update Symbology Ranges by Data* dropdown, choose *Update ranges*. This option makes sure that if the layer we're importing from and the layer we're importing to have different spreads of values in their data that the layer we're importing to's values are used to set the color
6. Leave the next field as the default and click *Run*.

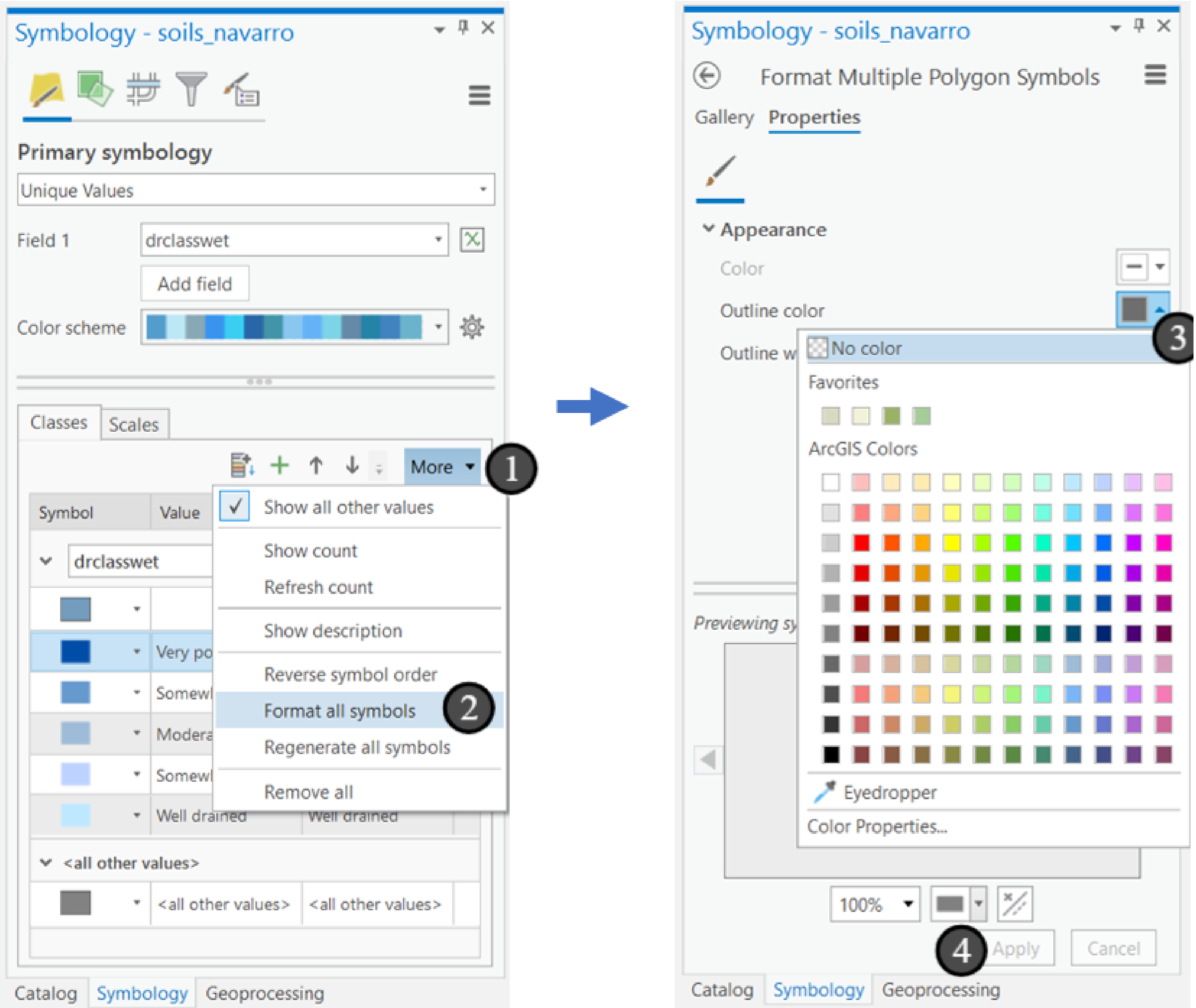

Symbology - soils_navarro
Import symbology...
Primary symbology
Single Symbol
Symbol
Label
Description


Geoprocessing
Apply Symbology From Layer
Parameters
Environments
Input Layer
soils_navarro
Symbology Layer
navarro_streams_100m_Spatial
Symbology Fields
Type
Value field
Source Field
drclasswet
Target Field
drclasswet
Add another
Update Symbology Ranges by Data
Maintain ranges
Run

12.2 Changing all the symbols at once

Often, having outlines on soils layers can be a distraction when viewing a large area, so let's remove the outlines. Go back to the Symbology pane for *soils_navarro* either by right-clicking on the layer in the Contents pane or selecting the *Symbology* tab at the bottom of the right-hand pane.

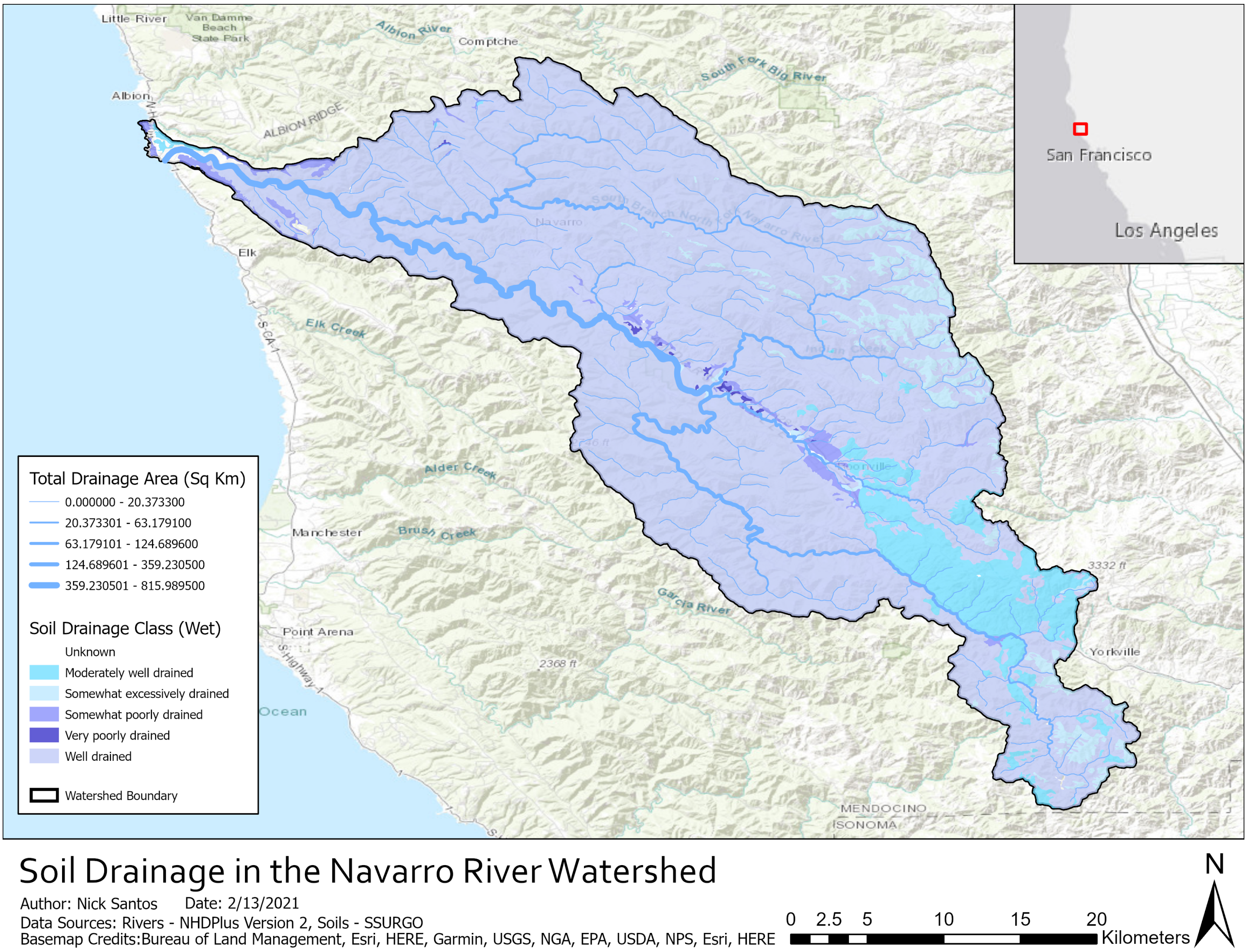
1. Click on the *More* dropdown on the far right of the line of icons at the top of the *Classes* tab.
2. Select *Format all symbols*.
3. Click on the dropdown next to *Outline color* and select *No color* to remove the outline from the patches. Everything else we don't change will stay as it is for each class (such as the fill color)
4. Click *Apply*.



13. Making a map from here

Now we have the analysis done for our map of soils and streams in the Navarro watershed. It's time now to make the print map (finished product shown here). But that's for the next lab!

That's it for this lab. In this lab, you learned how to work with selections, attribute records, field calculations, symbology, and basic geoprocessing. In the next lab, you'll use this same map document again to make a fully laid out, ready to publish version of the map, so make sure to save your project now so you can return to this point.



14. Bonus answers

Calculating a field

In the tutorial, we calculated whether segments had a large upstream drainage or not by doing multiple field calculations and a selection. Instead of doing that whole process, we also could have just used the expression (make sure no rows are selected first):

```
!CumulativeArea.TotDASqKM! > 50
```

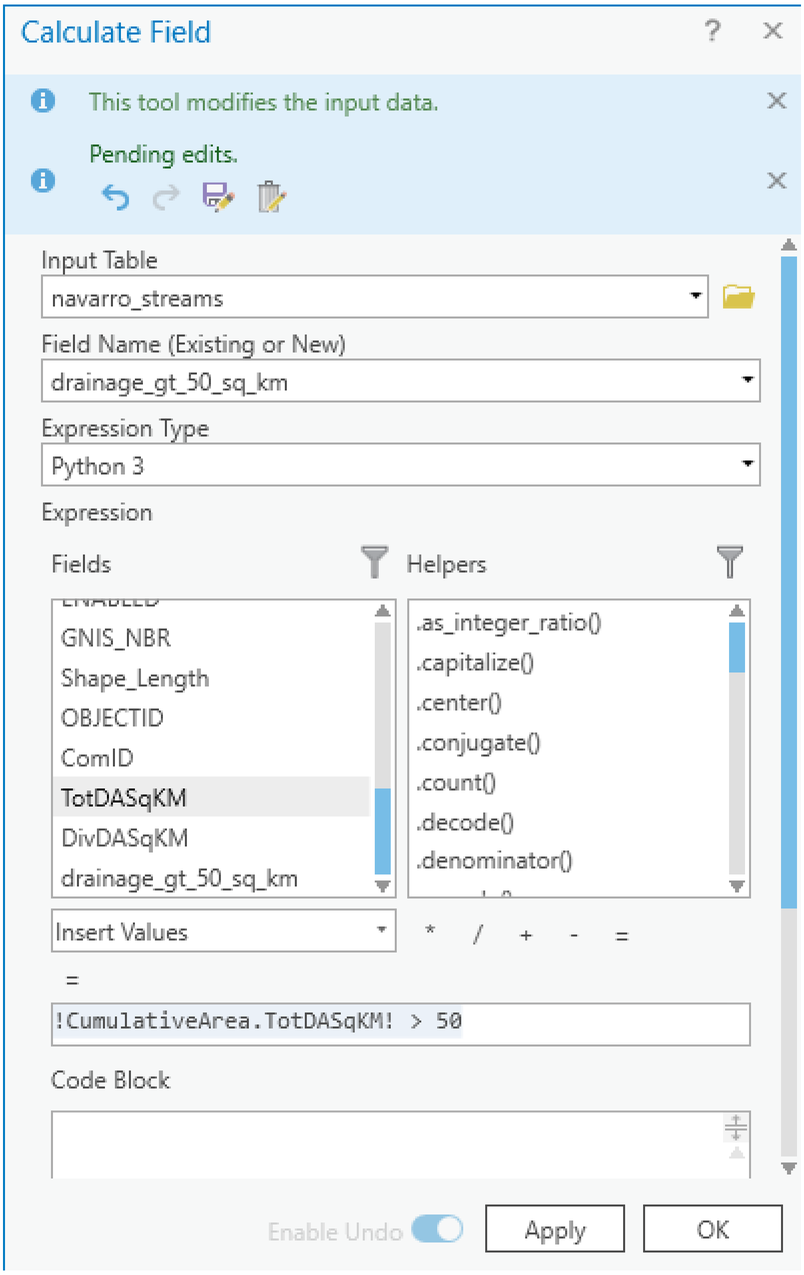
The expression evaluates to *True* or *False* for each row, depending on the value in the TotDASqKM field, and values of True are automatically converted to 1 in the Short Integer field type and values of False are automatically converted to 0.

Single record during spatial join

If we want to make sure we have only one record after the spatial join, we can select *Join one to one* instead of *Join one to many*. That makes sure that we only get one result, but doesn't define *which* attributes get attached when there is more than one. Then, at the bottom, we'd expand the fields option and scroll down the lefthand side until we see *drclasswet*. If we click on it, we'll get options for how this field is handled and merged when multiple options are available. Change the merge rule to *Join* which will keep all options, but merge them into a single text string. You can set a *Join Delimiter* of a comma and a space to make it nice and readable.

Alternative to Spatial Join

The *Intersect* tool. In many ways, it's a special case of the Spatial Join tool since it transfers attributes, but also modifies the input spatial data (*geometries*). It keeps only the overlapping parts of polygons, and splits the polygons along the lines of each features. It would be useful if we wanted more granular information on soils near the rivers. Its tool help shows a visualization of that process if you want more information.


Calculate Field
This tool modifies the input data.
Pending edits.
Input Table
navarro_streams
Field Name (Existing or New)
drainage_gt_50_sq_km
Expression Type
Python 3
Expression
Fields
Helpers
GNIS_NBR
Shape_Length
OBJECTID
ComID
TotDASqKM
DivDASqKM
drainage_gt_50_sq_km
.as_integer_ratio()
.capitalize()
.center()
.conjugate()
.count()
.decode()
.denominator()
Insert Values
* / + - =
=
!CumulativeArea.TotDASqKM! > 50
Code Block
Enable Undo
Apply
OK