Lab Exercise #4: Geoprocessing **Due Thursday, 9/27/2024**

CRP 4080: Introduction to Geographic Information Systems
Fall 2024

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Location: Sibley 305, Barclay Gibbs Jones Lab
Points Possible: 100

Overview of Lab #4:

In this exercise you will use several analysis tools in ArcGIS Pro tool box to learn how to:

- Dissolve features within a layer based on an attribute
- Clip one layer based on another polygon layer
- Intersect two layers
- Union two layers
- Merge two layers together
- Buffer features by a certain distance
- Use spatial join

Some key points about Geoprocessing in ArcGIS:

1. Before doing any analysis functions in ArcGIS, you should make sure that all the data layers you will be using are in the same map projection/coordinate system, and that the data frame is also in that coordinate system. If your data layers are in different projections, your analysis may produce error messages, stop working, or be wrong. For this lab, all data is already in the same projection/coordinate system.

2. When using some of the spatial overlay tools, ArcGIS DOES NOT recalculate area, length, or perimeter, or any of the other attributes in the new shape file that results. (The attribute table won't automatically update these parameters.)

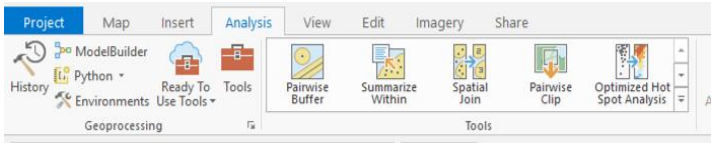

Figure 1. Analysis tools are organized into Geoprocessing tools and Tools shortcut. Here, we see the Environments tool and the Tools button, which opens the Toolbox where we can search for any tool.

3. Finding tools
The ArcGIS Toolbox contains hundreds of algorithms to process spatial data. You can search for tools, like the Define Projection and Project tools we used in the previous lab. Some common tools are also provided via shortcuts in the toolbar at the top of the ArcGIS Pro window (Figure 1).

4. Before we begin, we firstly **change the environmental settings that allow you to set up the default input/output workspace. This should become one of your routines for doing any spatial analysis in the future.**

- Within the home folder stored everything about lab_4, create an "Raw Data" folder that saves the Lab 4 data downloaded from Canvas, and an "Output" folder which you will save the outputs from running tools.
- After creating a new lab_4 project file within your home folder. You can specify Geoprocessing environment settings for your project using the Environments window. These settings are saved with your project and will be automatically used by all tools that honor the environment. Open this window by clicking Environments on the Analysis ribbon tab 

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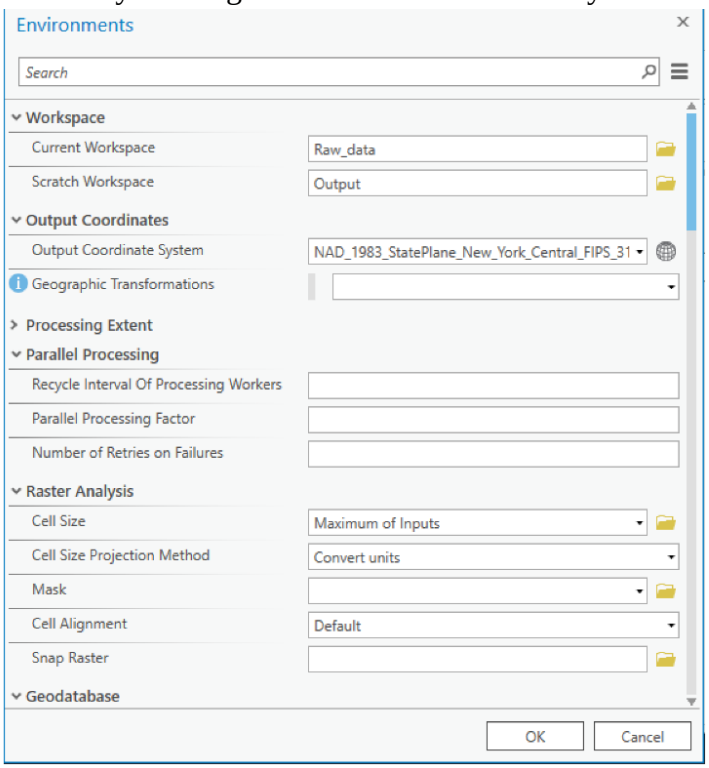
- Under the Workspace tab, set the Current workspace as the "Raw Data" folder and Scratch Workspace as the 'Output' folder you created. Hit OK. Next time, when you select input features, ArcGIS will automatically navigate you to the current workspace by default, while the output layers you created will be stored into the scratch workspace.
- Since we are working with data in New York State, you can also set the Output Coordinates to StatePlane for this specific case and all your output features will be automatically projected.



Part 1. Dissolving Features within a Layer based on an attribute

Dissolving combined geographies that have the same value for a specified (usually categorical) attribute. In the following example, we will dissolve traffic analysis zones (TAZs) in Tompkins County, based on their "type" attribute.

1) Add the following layers to your map:
   a) Tompkins County Traffic Analysis Zones (TAZ2010) from ArcGIS Online[1] (by searching Tompkins County Traffic Analysis Zones);
   b) TCMunis from the lab data folder.

[1] Note that the data set is marked "deprecated (not recommended for use)". This is because there are errors in the geocoding of the data, as we will see in the dissolve function. We will not address these issues in this lab, but in a future lab we will.

2) Open the attribute table for TAZ2010 and examine AREA_TYPE attribute, which classifies each TAZ as rural, suburban, urban, etc.
3) Symbolize TAZ2010 according to category of AREA_TYPE.
4) Overlay the municipal boundaries so that the TAZs are revealed beneath them.
5) Find the Dissolve tool (or pairwise dissolve tool). You can either search for the tool in the geoprocessing search bar (see figure 2) or find the function under the Manage Data section in the Tools shortcuts (You have to scroll down). This opens a dialog (Figure 3).

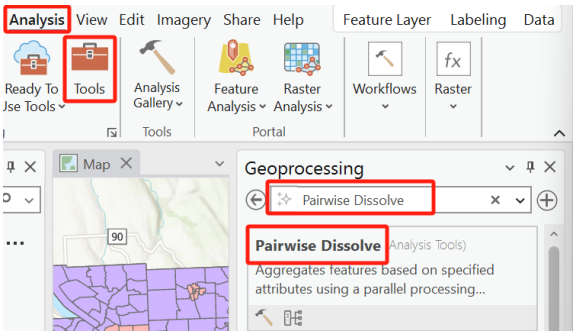
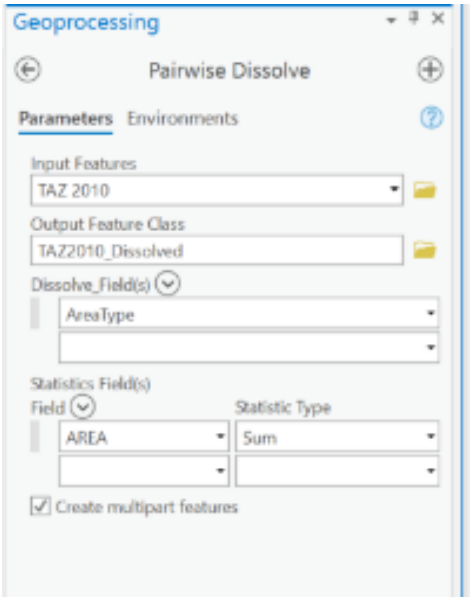


Figure 2: search for the Pairwise Dissolve function

6) In the dialogue box:
   a) Select TAZ2010 as the input Feature,
   b) Confirm the output name (e.g., TAZ2010_Dissolve) and location,
   c) Under 'Dissolve_Field(s)' select AreaType; this is the attribute on which you want to dissolve.
   d) Select *AREA* in Statistics Field(s).
   e) Under Statistic Type, select SUM. This will create a column with the sum of the area of TAZs with the same type.
   f) Click Run.



Review and compare the new data and the original one: The new shapefile, TAZ2010_PairwiseDissolve, is inserted into the table of contents.

Modify the symbology of the new layer according to AreaType, as in Step 1. Note the difference between the dissolved and original TAZ dataset. Note that we now have a field entitled 'SUM_AREA' which is the aggregation of all the TAZs within that particular area type (the units are square feet, reflecting the state plane projection). However, a lot of the attribute information has been lost because we did not select a method for combining attributes across features of the same AreaType. We could also have done something similar with population and a few other variables.

Now we can make a table showing the results of the dissolve analysis.

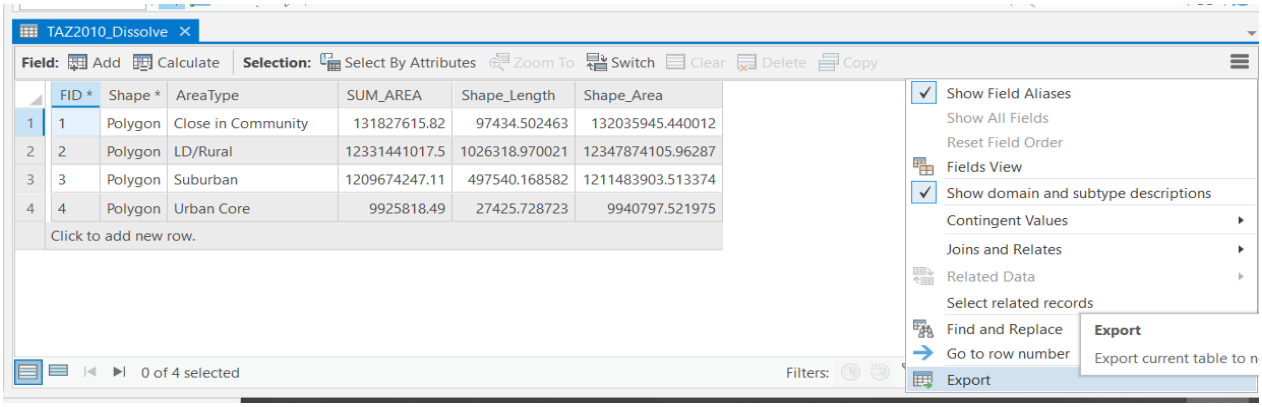


Figure 4. Export attribute table to a table in .dbf format

Use the 3 bars ☰ in the upper right of the attribute table to Export the table for *TAZ2010_Dissolve*– but assign it a different name under Output Table than TAZ2010_dissolve.dbf, since a file of this name already exists into your own folder.

Open the.dbf in Excel

Note that ArcGIS creates several files when exporting the attribute table, including a dbase table and an xml file. Be sure to open the dbase table, not the xml file. If you are not sure, change the file type to 'All files' when opening within excel. Also note if you fail in opening the .dbf, you can firstly open an empty Excel and drag the .dbf into it. Adjust column width if you have "###" symbols in Excel.

Calculate a new column with the Percentage of total area for each TAZ type. You can also manipulate the table in Excel to make it look more presentable.

Map 1: a map that shows the dissolved traffic analysis zones across Tompkins County, with the municipal boundaries overlain. Provide a summary table that includes the Name of Area Type and the percent of the total of each type on the map layout (as well as a legend, the date created, projection information, etc.). You do not need to include the total area of each watershed.

Note: The easiest way to insert a table into a Map layout is to copy and paste the table directly from Excel. Also, be aware that two decimal digits is sufficient.

Save your project.

Part 2. Clipping a layer

Clipping a layer limits the area of that layer to the overlapping features in another layer. It does not combine attributes. Clipping aids spatial analysis by removing unnecessary data. For instance, if we wished to analyze watersheds (that do not conform to administrative or political boundaries) within the City of Ithaca, we may want to remove any watershed areas that extend beyond the city limits. To do so we would want to *clip* the watersheds layer to the city boundary.

1. Insert a new Map to your project and name it 'Clip.'
2. Add the following shapefiles: *watersheds, TCmunis (Tompkins County Municipalities)*
3. Open the attribute table for *watersheds,*
4. Examine the information and Symbolize using unique values of WATERSHED (not WATERSHEDS).
5. Arrange the municipal boundaries on top and style them with no fill so you can see the watersheds below.
6. As you have done in previous labs, export a layer with only the City of Ithaca (not the Town of Ithaca). We will use this to clip the watersheds to the City of Ithaca.
7. Clip watersheds to fit the City of Ithaca boundaries.

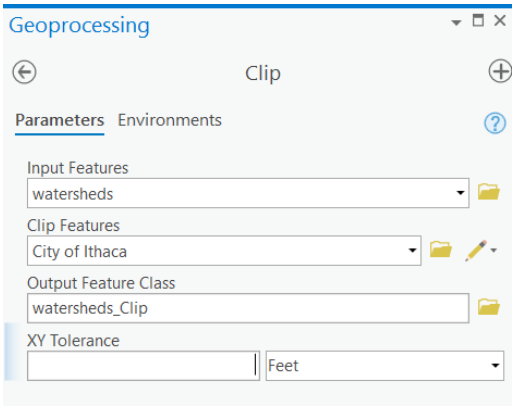


Figure 5. Clipping watersheds based on the boundary of Ithaca City

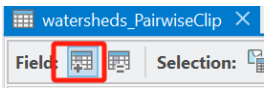
a. Open the Clip (choose Pairwise Clip if you are using ArcGIS Pro v3.3) tool (under tool group) . This opens a dialog box or pane (Figure 5).
b. In the dialogue box: Select *watersheds* as the input layer
c. Enter *city of Ithaca* as the clip feature, which you just created, and
d. Specify a file name and location to save the new file.
e. Click Run

Examine the Attribute Tables. Of the 15 watersheds in Tompkins County, only six are partially within the City of Ithaca.

Compare the Area values for a watershed in tables of this clipped layer and the original layer. Notice that the Area (square feet) and Acres column haven't changed. This is because the clip function only affects the geography of the layer, not the attributes. To update the Area to be accurate, we need to update the areas values by editing the table and calculating some values.

Note: if you save your data in a geodatabase, a new attribute Shape_Area is added to your Attribute Table, and it is different from the AREA attribute. This is a newly calculated area based on the new geography.

We can calculate this value separately if you are not working in a Database.



1) Open the attribute table and select '*Add Attribute'*. This opens a dialog.
2) The input table is the name of the new layer (should be the default, e.g. "watersheds_clip).
3) Give a name, New_Area, to this new field.
4) 'Double' for the Data type (this refers to the types of field data allowed in each cell; see here for a description of the various field data types) and 'Numeric' for the Number format (limit the rounding to 2 decimal places).

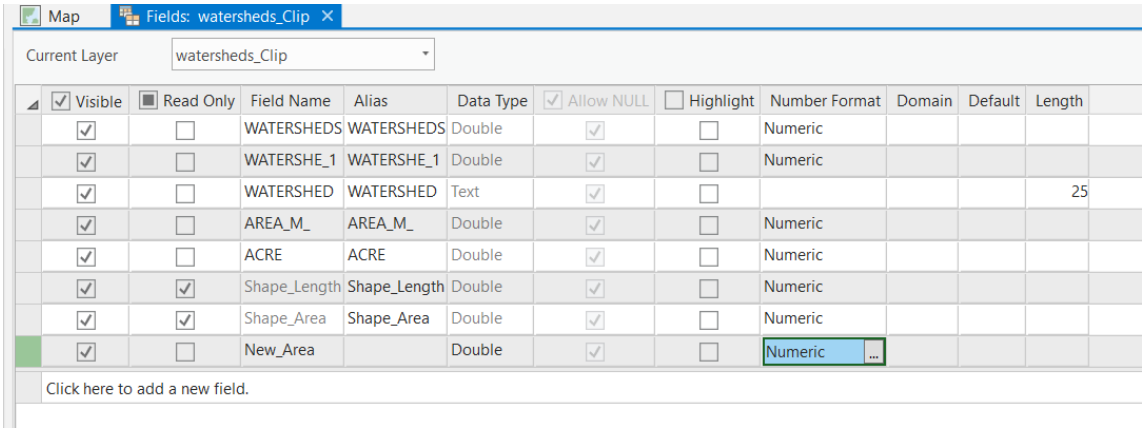


Figure 6: Specify the field properties

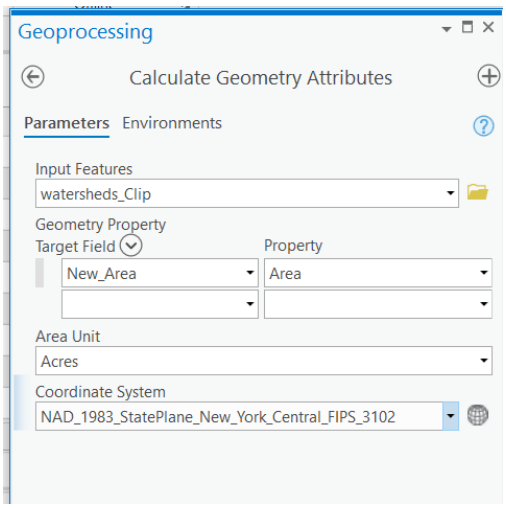


Figure 7: Calculate Geometry

Click Save 

on the ribbon above when completed. There should now be a new column called 'New Area' that is populated with *Null (or zero)* values.

5) In the attribute table, right click 'New_area', select 'Calculate Geometry'.

6) Set the Target field to New_area, the Property to Area, the area units to Acres (choose international acres/US survey acres if you are using ArcGIS Pro 3.3), and the Coordinate system to the Current map (NY State Plane central) (Figure 7). Click Run.

Now export your new attribute table, open it in Microsoft Excel to create a table with only the watershed names and areas.

Map 2: Create a map layout that shows the watersheds in the City of Ithaca, clipped to the city boundary. Provide a summary table that includes the watershed name, total number of acres of each watershed within the city and the percentage of the total watershed area within the city boundaries (you can calculate this in Excel).
Note: keep two decimal places for percentages. \

Part 3. Intersecting features from multiple layers

Next you will use the intersect functionality to identify all tax parcels located within an Agricultural District in the Town of Danby. Intersecting features from two layers allows us to combine geographies more flexibly than clipping. The output file contains attributes from both input layers, and depending on the logical expression we use, it can combine all of the geographic areas from both layers or a subset.

1. Create a new Map and name it 'Intersect.'
2. Add the following shapefiles to ArcMap:
    a. TCmunis
    b. *agdist* - agricultural districts for Tompkins County
    c. *dparcl2014* - tax parcels in the Town of Danby as of 2014
3. Create a shapefile of Town of Danby boundaries and remove TCmunis from the Table of Contents.
4. Go to the Analysis tab and select *Intersect (or pairwise intersect).*
5. In the dialogue box:
    a. In the Input Features drop-down list, click *agdist* and *daprcl2014* as the input layers,
    b. In the Output Feature Class, specify a file name, *parcel_agdist*, and
    c. Click Run.

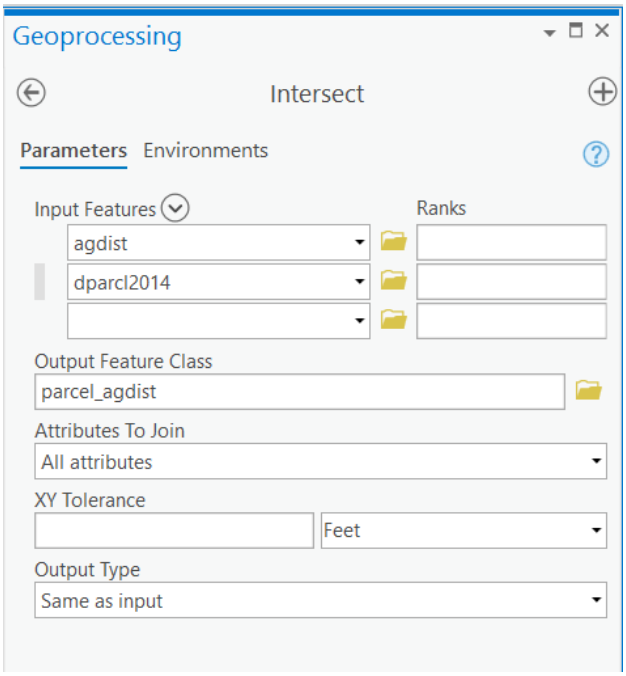


Figure 8. Intersecting agricultural districts with tax parcels in the Town of Danby

6. Review the output shapefile. The Intersect function selected only those Danby tax parcels that are located within the boundary of Agricultural District 1 and Agricultural District 2. Open the attribute table of this layer, *parcel_agdist*, and notice that the table has a DISTRICT field with values of 1 or 2 from the *agdist.shp*, as well as parcel information from the *daprcl2014 polygon* layer.

7. Right click on the column header for the "MUNICIP" field and Click 'Sort Ascending' (or double click the field name).

8. Scroll down and note that there are several parcels that belong to the Town of Ithaca, Town of Newfield, Town of Dryden and Town of Caroline (if you zoom in, you will see that these are by and large sliver polygons left over from the intersect).

9. Select only the Town of Danby's tax parcels and export the selected parcels to your folder, *danby_parcel_ag*.

Map 3: Create a map layout depicting Tax Parcels in Danby that are located within a designated Agricultural District. Symbolize this layer according to District #. Include Town of Danby boundary. Provide a table that includes: the number of tax parcels and total acreage (use the field name: Calcacres) in both Agricultural District 1 and Agricultural District 2 in the Town of Danby.

Save your ArcGIS project.

Part 4. Buffering Features

A *buffer* is a region of a specified distance that surrounds certain features and can be uniform or variable in width; buffers can be effective for performing analysis that examines the proximity of one feature to another. For this exercise, you will apply a *uniform* buffer around all fire department facilities to determine the extent of the service area, and to identify the areas which fall outside of the existing Service Areas.

1. Create a new Map, and name it 'Buffer'
2. Add the following shapefiles to ArcGIS:
    a. TCmunis- municipal boundaries in Tompkins County.
    b. *landmark* - landmark buildings in Tompkins County.

Now we will make a fire department shapefile:

3. Open the attribute table for the *landmark.shp* layer. This lists public institutions and facilities in Tompkins County. If you scroll, you will see that the attributes information includes street addresses – this data has been geocoded – something we will be exploring later on.
4. Select all fire stations based on the "SERV_TYPE" attribute, and
5. Save a new data layer to be added to your project
6. Go to the Analysis tab and select *Buffer*.  (or pairwise buffer)
7. In the dialogue box:
    a. Add a buffer to the new fire departments layer
    b. Specify a file name, *Fire_dept_Buffer*, and location to save the new file,
    c. Set the buffer linear units to 3 **Miles** (US Survey Miles if you are using ArcGIS Pro 3.3) (Note that we could also buffer the feature based on a particular attribute field) and
    d. Select Dissolve Type as "ALL".
    e. Click Run (Figure 9).

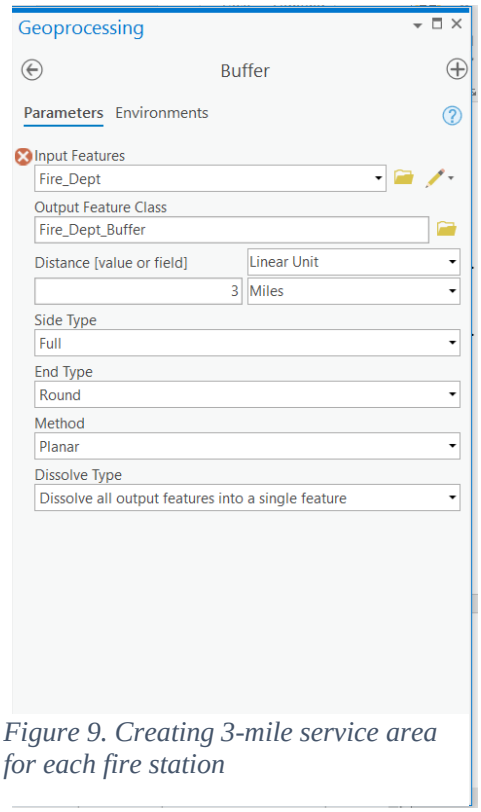


Figure 9. Creating 3-mile service area for each fire station

Now add *TCroads* and clip the roads layer to match the spatial extent of the buffer layer. You know how to do this from previous instructions.

Map 4: Create a map layout that includes fire stations and all roads that fall within 3 miles. In addition, you should include your buffer polygon and municipal boundaries.

Save your project. We will continue this analysis in the next section.

Part 5. Union Two Layers

A union is a topological overlay of two polygon datasets that combines the spatial extent and the attribute information of both input layers. Thus, Union is similar to intersect in that both retain the attribute information of both. Where they differ is in the spatial extent (think of an 'and' verses an 'or' statement). In this example, you will Union the areas that fall outside the service areas of the Fire Department buffer layer with the corresponding area of municipalities in Tompkins County.

Note: no need to create a new Map,

1. TCmunis - municipal boundaries in Tompkins County.
2. *fire_dept_Buffer*, created in part 4.
3. Go to the Analysis ribbon and select *Union* 

4. In dialog box:
   a. Select the three-mile Buffer of Fire Stations (from part 4), *Fire_dept_Buffer*, and *TCmunis.shp* as the input files and
   b. Specify an output file name, *Fire_dept_Buffer_Union*.
   c. Click OK. The new layer, *Fire_dept_Buffer_Union*, is added to the table of contents.
   d. Remove the 3-mile buffer layer, *Fire_dept_Buffer*, from the ArcGIS Pro.
   e. Position the Fire Departments layer at the very top of the table of contents, and *TCmunis.shp* at the very bottom.

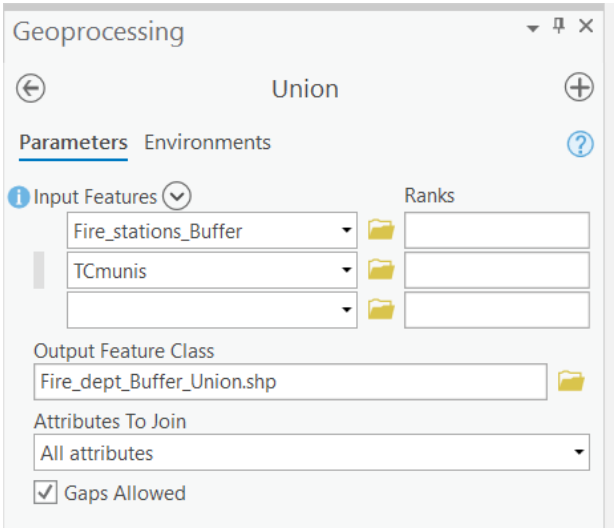


Figure 10. Union of two layers: Fire_Dept_Buffer and Municipalities

5. Examine the output of the Union: Open the attribute table for the Unioned layer and notice the field titled: *FID_ Fire_dept_Buffer_Union (FID_Fire_D)*. Each record has a value of either "-1" or "0". Those records with a value of "0" fall **within** the 3-mile service area, and those with a value of "-1" fall **outside** the 3-mile buffer within Tompkins County.

We will now create a new shapefile based on the Unioned layer containing only areas **outside** the service buffer zones. While we could do this as we did earlier, by selecting attributes and exporting a new layer, we will try a different approach this time.

a. In the attribute table for *Fire_dept_Buffer_Union.*, choose 'Select by Attributes. 

b. Write an expression for a new selection as: "FID_ Fire_ d" = 0. A value of "0" means the service area **within** 3 miles.
c. Click Apply.
d. Hit "Delete" button on the keyboard or the "Delete" button in the attribute table. The remaining records are all the features that fall outside of the 3-mile service areas.
e. Go to the Edit tab and click Save.

You now have a layer of all areas in Tompkins County that fall outside of the existing Fire Department Service Areas.

Tip: This type of buffer analysis does not consider road networks or barriers. Rural areas have fewer roads and therefore it may take longer to reach a home within a 3- mile radius; thus, the radius of service areas in rural areas would likely be smaller than it would for a truck responding to a call in the urban core. This type of buffer analysis also doesn't take into account certain physical barriers, such as Cayuga Lake, which impacts the real extent of a station's service area.

Map 5: Create a map layout that shows Fire Stations (labeled with the Fire Station name), the Tompkins County municipal boundaries, and the Gaps in the fire service area.

Save your project.

Part 6. Merging Layers

Use Merge when you want to combine two or more adjacent layers (that share a common border) into one large layer that contains all their features. The main difference between Merge and Union is that Merge does not operate on the geographies of the layers. Merge simply adds features from one layer to another layer.

1. Create a new Map entitled 'Merge' and
2. add the following shapefiles from the folder:
    a. East_hydro — hydrography for the Ithaca East USGS 7.5' Quadrangle
    b. West_hydro — hydrography for the Ithaca West USGS 7.5' Quadrangle
    c. Go to the Analysis tab and select *Merge.*

    d. In the dialogue box:
        i. in the Input Features drop-down list, select both the *East_hydro* layer and the *West_hydro* layer as the layers to merge.

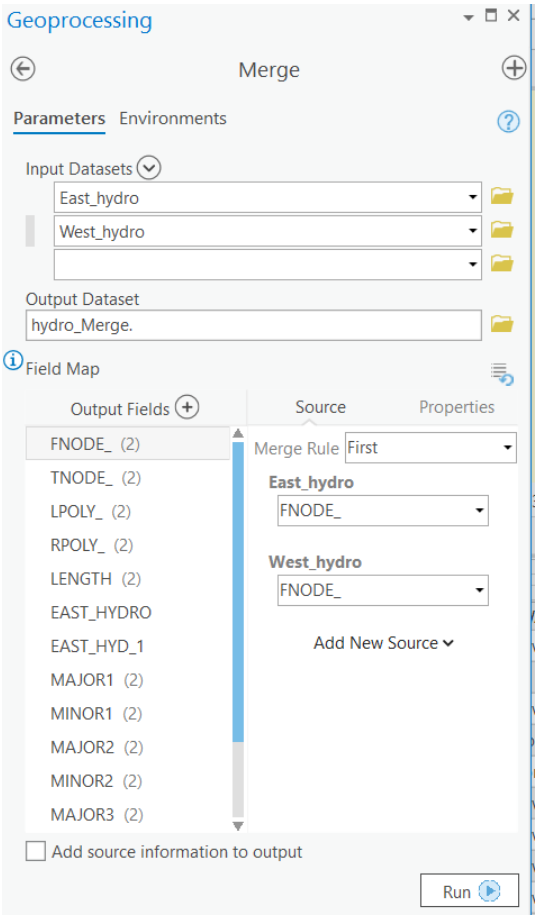


Figure 11. Merging two layers: East_hydro and West_hydro

ii. Specify the name and location of the output shapefile in your personal Lab 4 folder, *hydro_Merge*. Click Run.

Map 6: Create a map layout that depicts your newly merged hydrology layer clipped to the City of Ithaca boundaries

Part 7: Spatial join

Create a new Map entitled 'Spatial Join'
Spatial Join joins the attribute tables of two layers based on common spatial locations. When the geographies of the two layers to not align perfectly, there are multiple ways that a spatial join could operate. To account for this case, we will have to set the parameters of the join to achieve our desired output.

1. Add the following shapefiles to your new Map:
    a. Tompkins County Municipal Boundaries from ArcGIS Online (by searching TCmunis); Do not use the TCMunis from the data folder.
    b. *landmark.shp* - landmark buildings in Tompkins County.
2. Go to the Analysis ribbon and select *Spatial Join* 

3. Under 'Target Features' add landmark.
4. Under 'Join Features' add the municipal boundaries.

By specifying this order, we are instructing Arc to join municipal boundaries to landmarks based on spatial location. This implies that the attributes of municipal boundaries will be joined to the attributes of landmarks where they overlap.

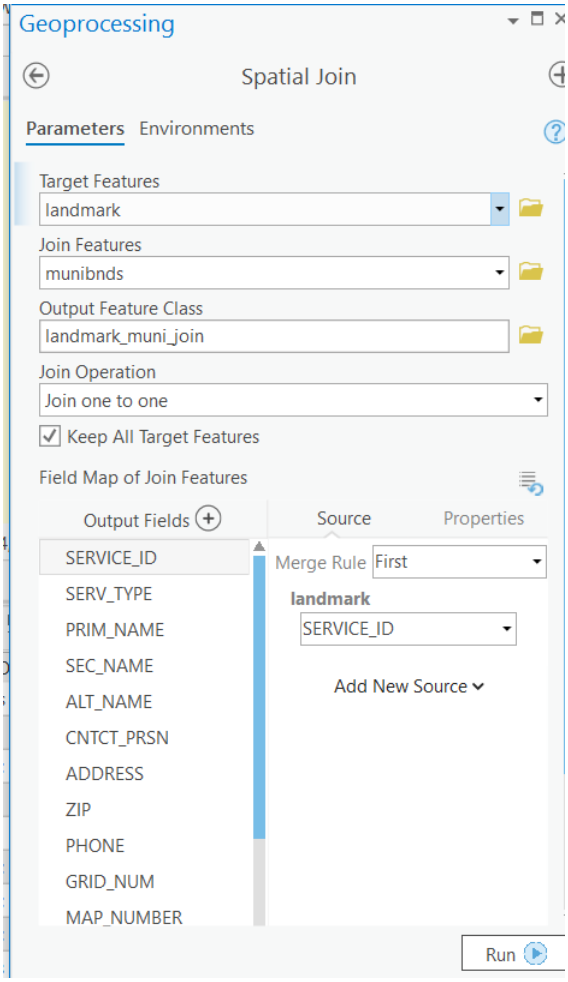


Figure 12. Spatial Join (Join one to one)

5. Save the file as something you will remember.
6. Under 'Join Operation' note your options: 'One to many' or 'one to one'. Select one to one, which will assign one municipality to each of the 856 landmarks.
7. Click Run.

Open the attribute table of your new spatially joined landmarks layer. You will see each landmark has accompanying information (if you scroll over) concerning the municipality. Note that we have not altered the original geography. Also note the 'Join count' attribute which reflects the one-to-one relationship between landmarks and municipalities.

Discussion Question: Now run a second spatial join, this time with municipal boundaries as the target layer and landmarks as the join feature. Compare and contrast the two spatial joins, referring to the join_Count column and the total number of features in the attribute table.

Submit your responses to the question above.

LAB 4 DELIVERABLES

1. **Map layout for Maps 1 – 6: 10 points each**
2. **Summary tables for Maps 1 – 3: 5 points each**
3. **Answers to Part 7. 10 points**
4. **Additional Analysis. Complete the following overlay analysis. 15 points total**

   Identify all areas within the Fall Creek watershed that lie within 500 feet of streams and lie within an Agricultural District. Use the following input shapefiles:

   Watersheds.shp - polygon theme of watersheds in Tompkins County (Note: this is a shapefile of watershed already clipped to Tompkins County boundaries)

   Hydrology: A shapefile of streams within Tompkins County

   agdist.shp - A polygon theme of agricultural districts in Tompkins County.

   Create a map layout of the results. Please reference data (i.e. Municipal boundaries, or anything else you think may be useful in helping the reader interpret the map). **In addition, include a short write up of the steps you followed to complete this task** (2 points)

   Question: *What percentage of Fall Creek watershed meet these criteria?* This will require you to recalculate areas (3 points)