

LAB 9: Buffering and Overlay in ArcGIS Pro

What You'll Learn: to apply the concepts of buffering and overlay, two common cartographic operations. You should read chapter 9 in the GIS Fundamentals textbook.

Data: All data are in \Lab9 subdirectory, including lakes.shp, roads.shp, and public lands in public_Hugo.shp. All distance units are meters.

What You'll Produce: Three maps, 1) map of lake variable distance buffer zones, 2) map of suitable recreation areas, and 3) map of suitable recreation areas on private land only.

Part One: Buffer Zones

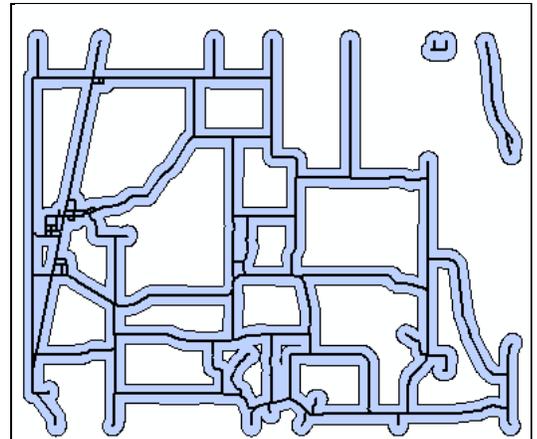
Buffering and overlay are two of the most common operations in cartographic modeling. A buffer zone is an area that is within a given distance from a map feature. When you buffer on a set of features, the output is a set of polygons. (Buffering points or lines creates a new polygon layer). Some softwares identify inside and outside regions, while others (like ArcGIS) identify the inside region. Regions are typically distinguished by different codes in an attribute table.

Fixed Distance Buffers

A fixed distance buffer applies the same distance for each of a set of features.

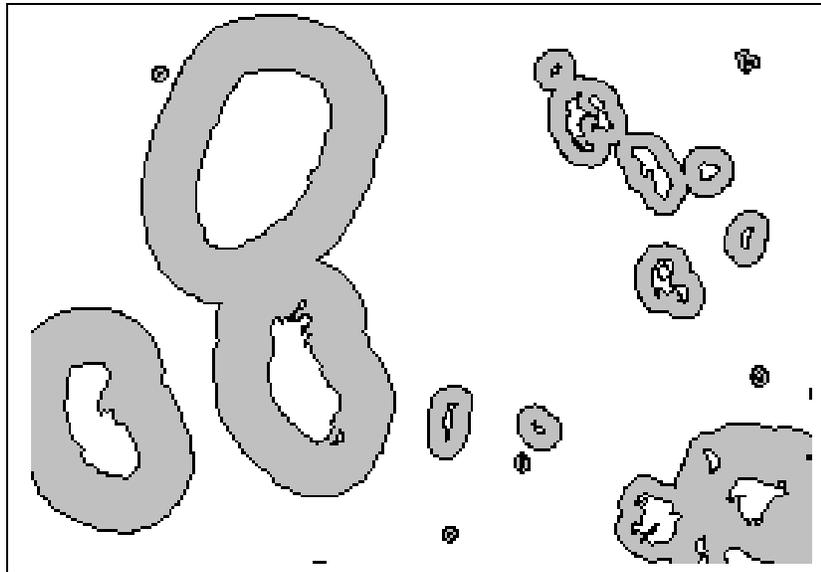
The figure on the right shows the buffer area (in blue) for a road network (thicker black lines). There will be a corresponding table with some coding to indicate the "within buffer distances" status of each polygon.

Note there is a third status possible for each polygon. We may note those that are out, but "surrounded" in that they are contained within the bounds of an "in" polygon.



Variable Buffers

Another variation on buffering will change the buffer distance depending on feature attributes (see the figure, below).



A GIS project may require buffering those lakes to map a minimum distance from shore for installing septic systems. However, the acceptable distance for septic systems may depend on lake size. A large lake could have a system within 100 meters of lakeshore, but a small lake needs a setback of 25 meters.

A variable distance buffer often uses an attribute that specifies the buffer distance for each feature. You will create a variable distance buffer in this lab, with the buffer distance related to lake size.

The buffering operation typically uses a table entry to determine buffer distance around a feature. A numeric data item is used, as shown in the column named DIST in the table to the right. Each lake with an attribute for surface of 1 will be assigned a buffer with distance 100, a surface value of 2 a buffer distance of 50, and a surface value of 3, a buffer distance of 25. Examples of lakes with the three different surface values and resulting buffers are shown in the figure above.

Surface	DIST
1	100
2	50
3	25

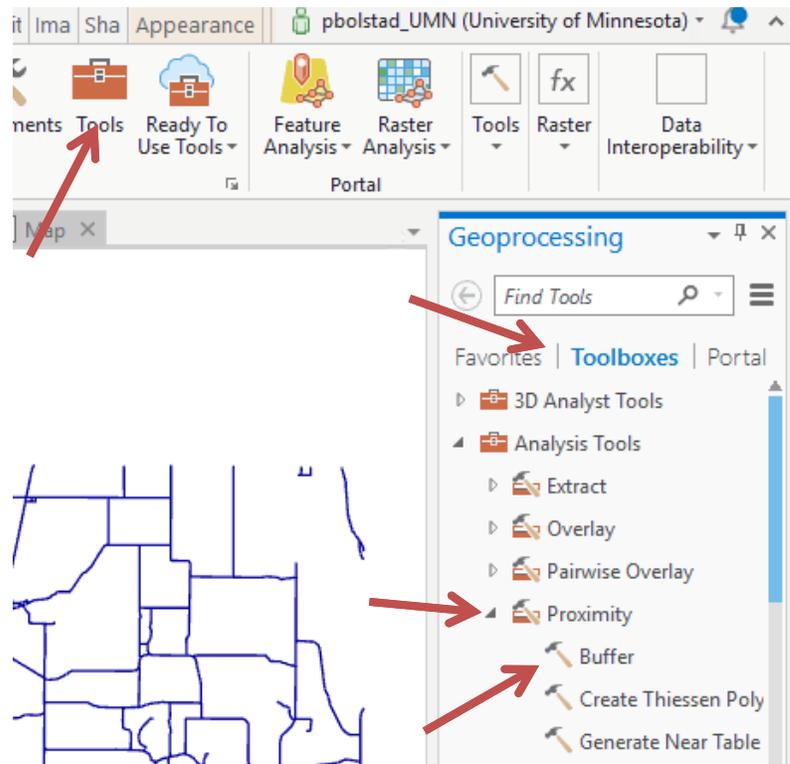
↑

This item, named dist here, is used to specify the buffer distance.

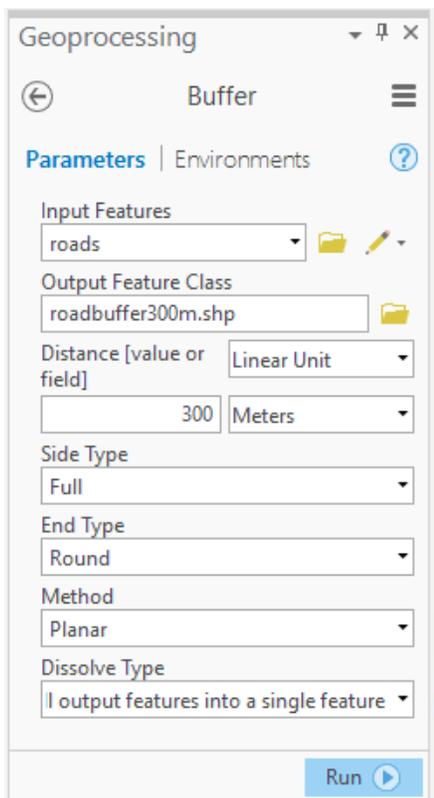
Part 1: Buffering in ArcGIS Pro

Create a new ArcGIS Pro project and add the *roads.shp* data layer.

Left click on the red **ArcToolbox** to activate the tools menu, then Analysis Tab → **Tools** to open the Geoprocessing Pane on the right hand side of the main window, then **Toolboxes** → **Analysis Tools** → **Proximity** → **Buffer**.



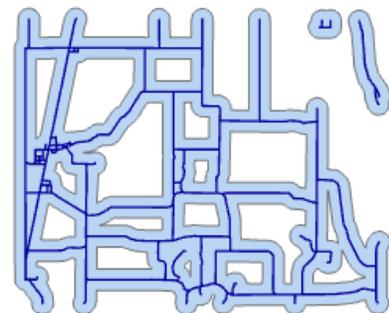
The tool (see figure below) allows you to create a buffer layer.



- Set the **Input** layer to roads.shp
- Specify the **Output Features** location and name, something like *road_buffer_300m.shp*.
- Enter the **Linear unit** as 300, and set the units to Meters.
- Set the **Dissolve Type** to Dissolve all to a single feature...
- Left click **Run**.

(Video: Buffer)

When the buffering process is finished, it should display the buffer data layer, and load it to your Map, it should look something like the thumbnail to the right.



Redo this buffer, but this time, leave the default Dissolve Type to NONE. How do the results differ? When would this be important? After inspecting, remove the undissolved layer.

Creating a Variable Distance Buffer

The second exercise will buffer the *Lakes.shp* layer using a variable distance buffer.

The buffer distances are:

- A buffer distance of 50 meters for lakes with size class 1
- A buffer distance of 150 meters for lakes with size class 2
- A buffer distance of 300 meters for lakes with size class 3

This exercise involves three steps:

- First** you open the lakes attribute table in ArcGIS Pro and insert a new field that will hold the variable buffer distance.
- Second** you use Select by Attributes to assign the distance values for the variable buffer distance (refer to Lab 8 if you don't remember the details on selecting and editing values in a table)
- Third**, you apply the buffer operation.

For our lab, specifically you should:

- Make sure the *Lakes.shp* is in your project, and open the attribute table for *Lakes*.
- Add a field to the table using the methods shown in the last two labs. Create a new long integer field named buffdist, something descriptive.
- Use the **Select by Attributes** to select each of the lake size classes. Assign the appropriate buffer distance to each lake size class, placing the value in the newly created field. Refer to the Lab 7 in this series if you don't remember how to calculate/assign fields.

Close the table. Make sure you unselect any selected polygons or the buffer will only work on selected polygons (before switching out of the table, click on the **Clear All Selected Features** tool in the Feature Layer group, along the top of the main window).



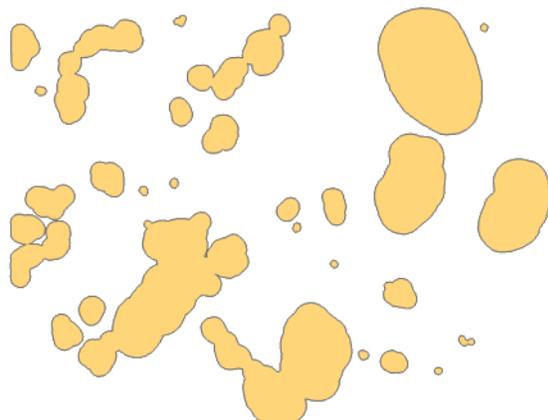
Your table should appear similar to that shown below.

FID	Shape	AREA	PERIMETER	LAKES_	LAKES_ID	ACRES	SIZE_CLS	buffdist
0	Polygon	3343.629883	349.856995	2	1	0.83	1	50
1	Polygon	4602.75	259.549988	3	2	1.14	2	150
2	Polygon	1446610	4636.379883	4	3	357.31	3	300
3	Polygon	670.765991	102.633003	5	4	0.17	1	50
4	Polygon	57587.699219	1228.130005	6	5	14.22	2	150
5	Polygon	57344.199219	1219.459961	7	6	14.16	2	150
6	Polygon	49267.601563	1470.469971	8	7	12.17	2	150

Now create the variable distance buffer:

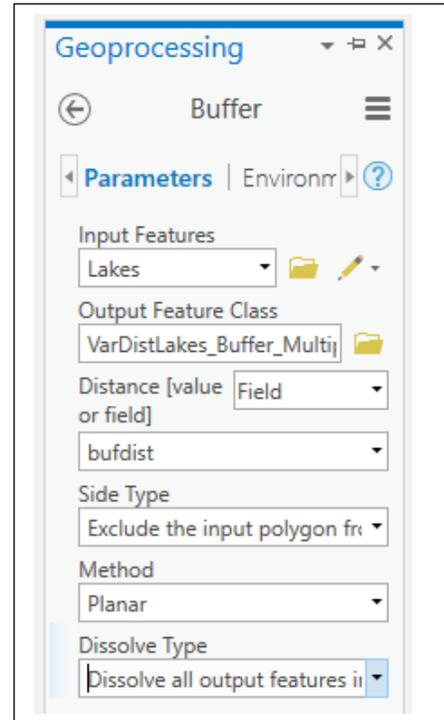
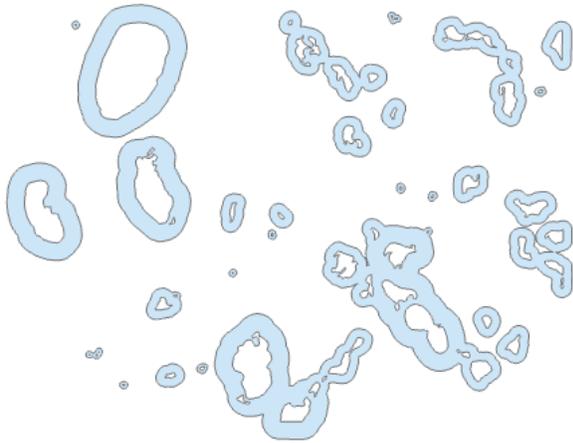
- Open the Buffer tool again.
- Make sure the *Lakes.shp* layer is **Input**.
- Name the **Output Features** something logical, such as *Var_Lake_Buffer.shp*.
- Select the **Field** (not Linear Unit) option.
- Specify the field you created in the previous step, buffdist.
- Set the **Dissolve Type** as **Dissolve all output features into a single feature**
- Click **Run** to apply the buffer.

You should get something that looks like the thumbnail to the right.



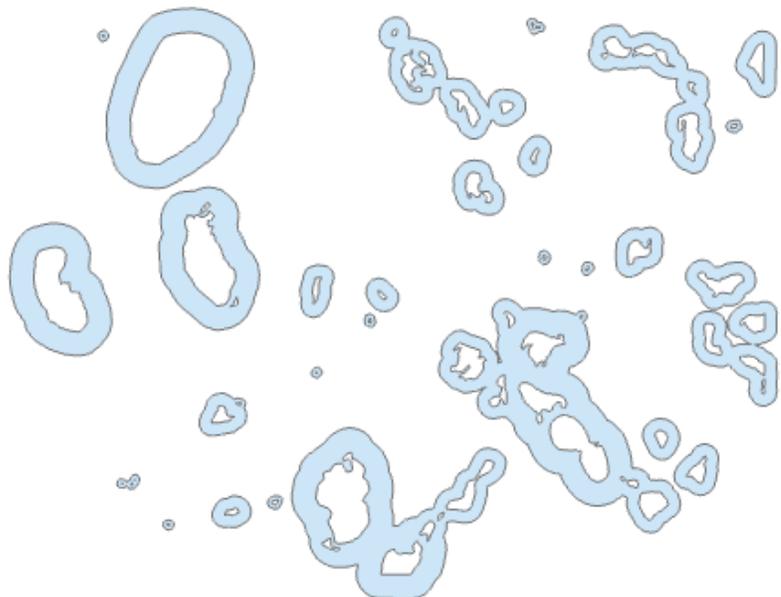
There is another variant you can invoke by selecting the Side Type of Exclude the input polygon from the buffer (see at right):

Do this for another layer, and note that you create “donut” buffers, that exclude the areas occupied by the lake polygons, as below:



Open the attribute table for either variable distance buffer.

Notice that this creates multi-part shapes (described in Chapter 2 in the textbook). If you don't remember, this means multiple polygons point to a single table row. Some further processing may require to split these into our normal arrangement, one row in the table for each polygon.



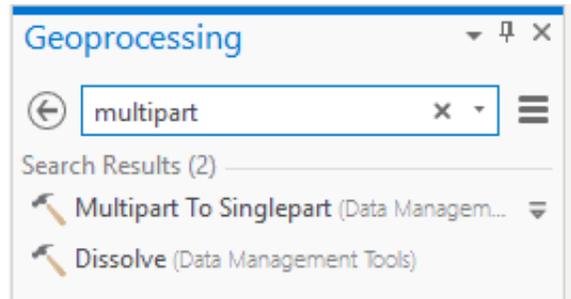
1:86,222 | 92.9003287°W 45.1199454°N | 0

VarDistLakes_Buffer_Multipar | Lakes_Buffer1

Field:	Selection:	OBJECTID	Shape	Shape_Length	Shape_Area
		1	Polygon	140007.455524	13923372.770765

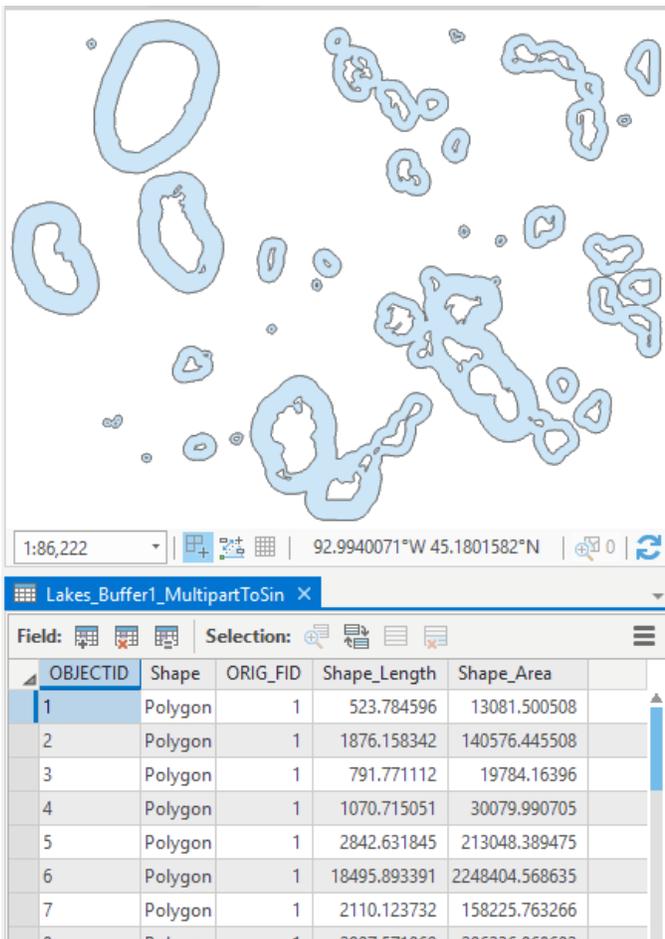
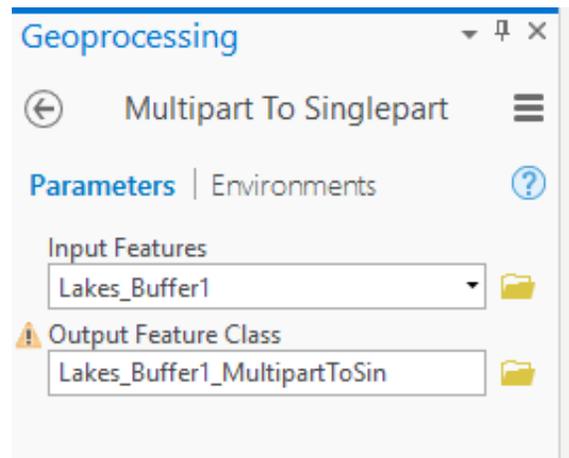
We can split the multipart shapes to single part shapes with a tool, **Multipart to Singlepart**.

Use the geoprocessing tool search window to find the tool by typing Multipart and then the search icon:



Note that the tool has only two parameters, an input and output file.

Video: Multi2singlepart



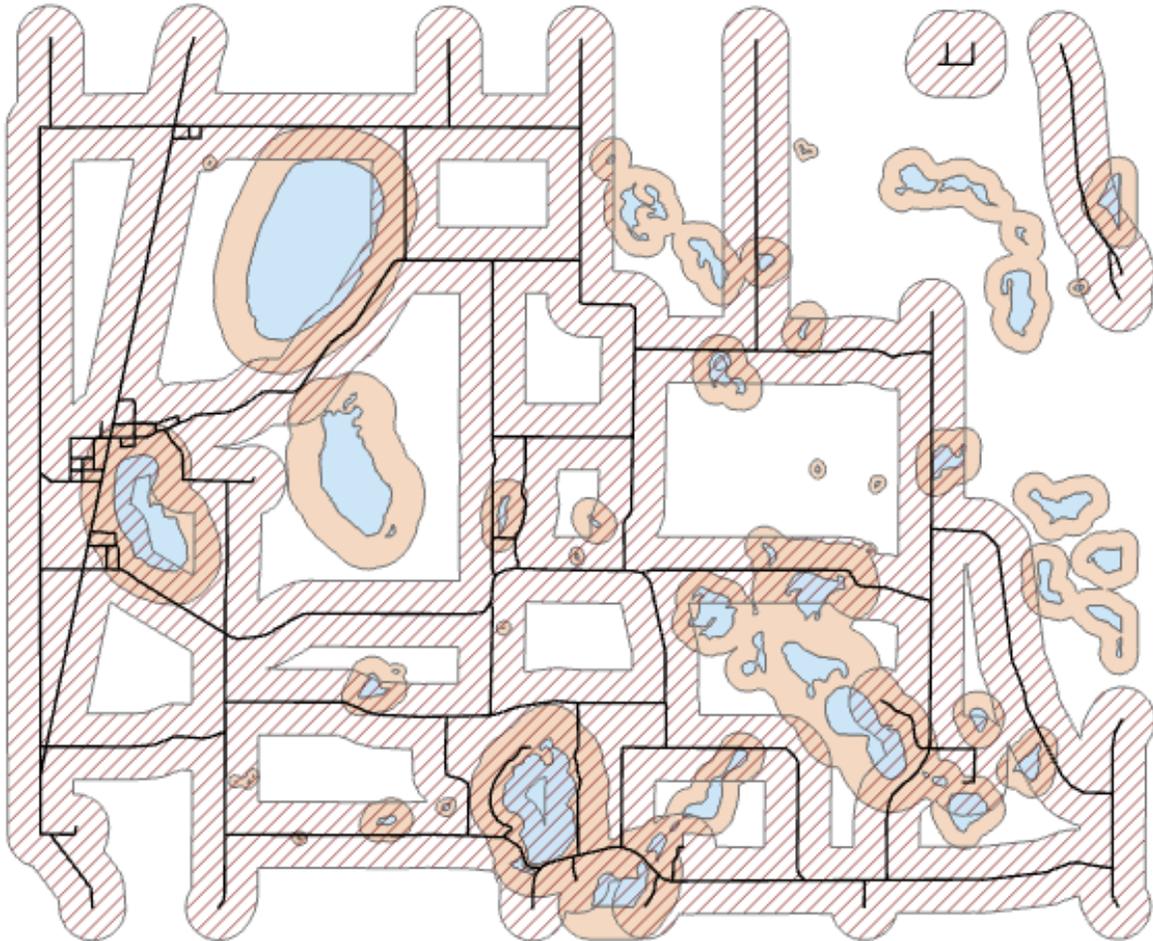
Apply the tool to one of your lakes buffers layers, and verify that it breaks the multipart feature into singlepart features by looking at the resultant attribute table (see at left, below):

Add a layout to your project, and place the the roads, dissolved fixed distance road buffer, lakes, and dissolved variable distance lake buffer layers so that you can see all three, as in the figure below.

Create and print/export a layout with the roads, lakes, and their buffers, as in the view shown here. Make sure the order is as shown here, so you may see most of each layer. The order is, from the top, 1) roads, 2) road buffer, 3) lakes, 4) lake buffer.

Make sure to symbolize the various layers so that you can see the boundaries of the lakes and lake buffers under the roads buffer (use hatching and transparencies).

The Map portion of you layout should look something like the figure at below for full credit.



Add a title, your name, descriptive text in the TOC/legend, and include a scale bar, and north arrow.

Export a PDF and turn it in on the class Canvas site.

Part Two: Overlay in ArcGIS Pro

Overlays are another common operation, as described in Chapter 9 of the textbook.

Our goal in this exercise is to find potential campgrounds for a State Park. A campground needs to be close to lakes. However, these will be 'drive in' sites and they must also be close roads. The final map will show locations that are both within 50, 150 or 300 meters of a lake (depending on the size of the lake) and within 300 meters of a road.

We have already created our starting Layers. These are the variable distance lakes buffer, and the fixed distance roads buffer from the previous exercise.

In ArcGIS Pro we must modify input layers prior to overlay so that we may easily interpret the results after overlay. We add a field to each input data layer that specifies the factors we wish to use later in our analysis.

In our current exercise, we wish to identify areas that are inside the lake buffers. We create a new item (column) in the single-part lakes buffer table, name it something like `insd_lbuf`, and give it a value of 1 for all the lake buffer polygons.

Make sure you use the last lake buffer we asked you to create, the **variable distance lake buffer**, with the buffers only outside the features.

You should be able to do this without step-by-step instructions, please refer to previous descriptions in this and other labs if you're unsure on some steps. When you are done, you should have an attribute table for the lakes buffer that looks like the figure on the right.

OBJE	Shape	ORIG	Shape_Length	Shape_Area	insd_lake
1	Polygon	1	523.784596	13081.500508	1
2	Polygon	1	1876.158342	140576.445508	1
3	Polygon	1	791.771112	19784.16396	1
4	Polygon	1	1070.715051	30079.990705	1

Do the same for the road buffer layer. Add a new attribute named something like `insd_rbuf`, and assign it a value of 1 to indicate it is inside the road buffer, see figure at right.

We don't worry about assigning a value for areas outside the buffer in this exercise, because of the way ArcGIS Pro views the vector world. Areas outside of polygons do not have a boundary nor a record in the attribute table associated with them.

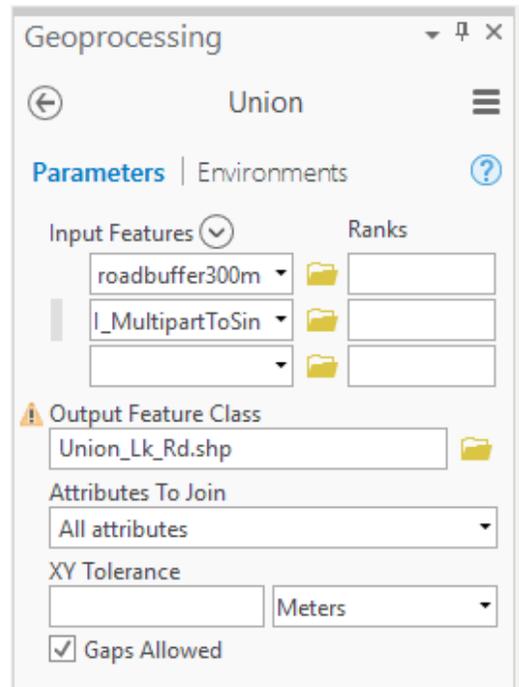
FID	Shape	Id	insd_rdbuf
0	Polygon	0	1

Overlay the two layers with the Union command:

- Select **ArcToolbox** → **Analysis Tools** → **Overlay** → **Union**
- Specify the input layers – the only outside lake buffer layer and 300 meter road buffer.
- Specify the output layer something like Union_Lk_Rd.
- Run

(Video: Union).

Examine the “unioned” layer and open the attribute table for this layer. Select the polygons that are both within the roads buffer and within the lakes buffer; they will have values of 1 for both the insd_rdbuf and insd_lake attributes created and assigned earlier (see the figure below for some hints).



You can use the Select by Attributes tool, visible on the Map tab, to select those polygons that meet both the inside lake buffer AND inside road buffer criteria.

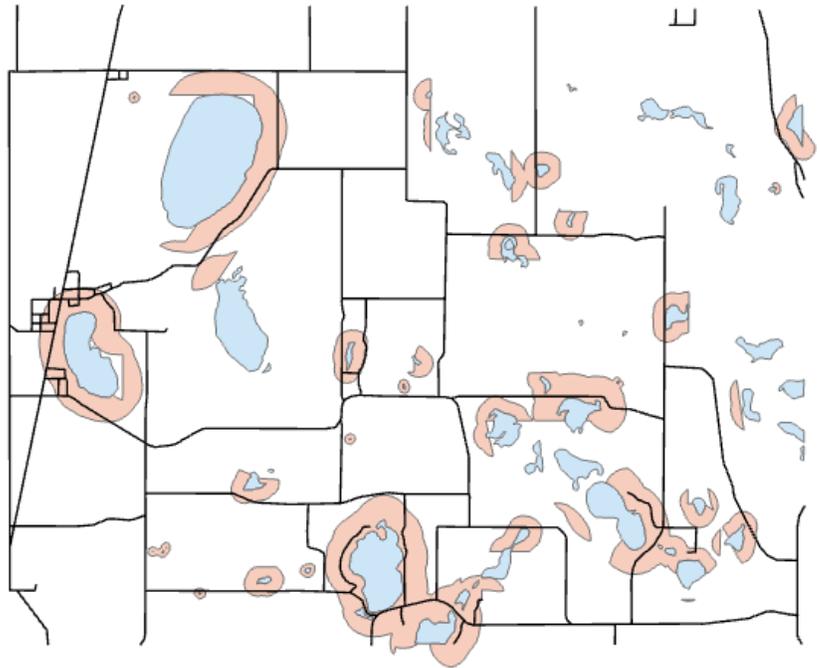
Refer to previous work if you're fuzzy on how to add clauses to your selection.

Once the features are selected, you can right click on the union output and use the **Data** → **Export Features** to save only the selected features, with a name something like Acceptable_Areas

You should create singlepart features for the Acceptable_Areas layer. There is no easy way to tell if there are multipart features if it isn't obvious, e.g., 1 table record while there are multiple polygons. We need to calculate areas further on, and so need to ensure that they are singlepart so the individual polygon areas are correct.

Select Toolbox → **Data Base Management** → **Features** → **Multipart to Singlepart**. This will ungroup the combined polygons to and create a row in the attribute table for each polygon. You should have 33 records in the table for the singlepart file.

Display the **roads**, **SINGLE PART Acceptable_Areas**, and **Lakes** in the view. It should look something like the figure at right:



Now you need to determine the size, in hectares, of your acceptable sites. (**Video: Area**).

Open the attribute table and add a float or double field named "Hectares".

Right click on the table column heading for the Hectares and left click on **Calculate Geometry** in the dropdown menu.

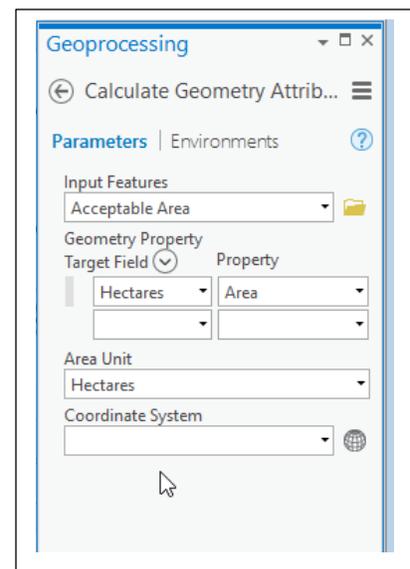
The Target Field is Hectares (or whatever you named it in the table) the Property is Area and the Area Units are Hectares, then Run.

The new Hectares column should be populated with numbers, with values between 0 and 200.

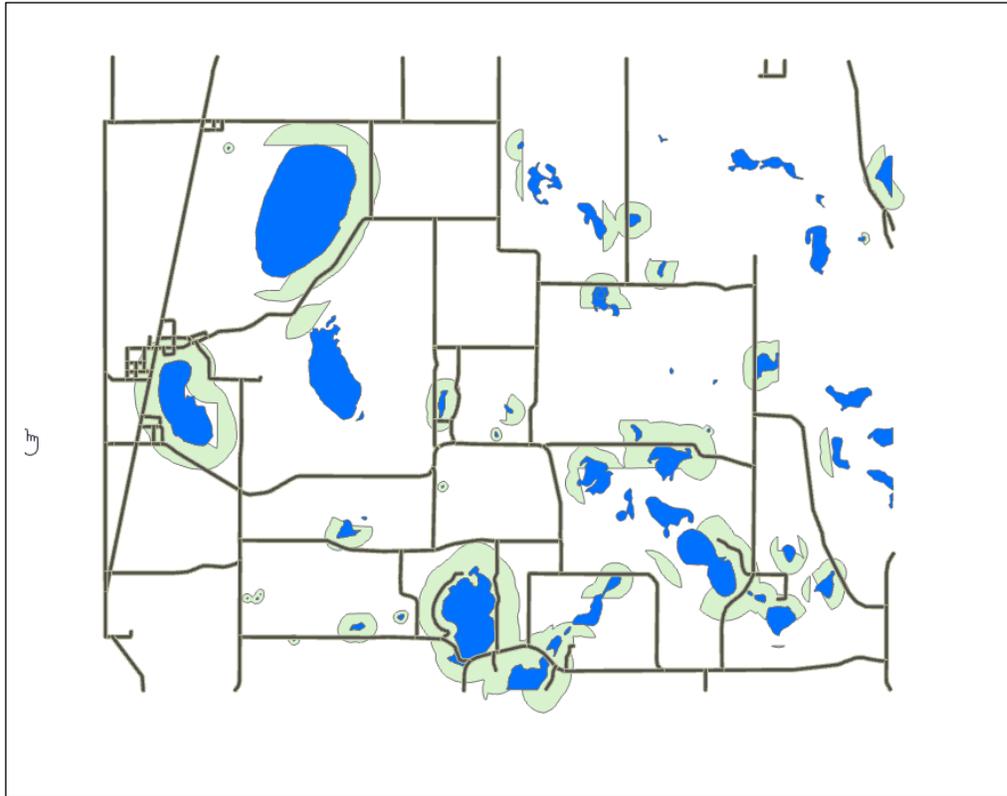
Right click on the Hectares column, and then left click on Statistics (as shown in previous labs). This should display a set of summary statistics (you may need to also click on Chart Properties).

Count should be 33. If it isn't, perhaps you selected the wrong layer, or made a mistake in the processing chain.

The total area should be over 700, but below 800. If it is way off, perhaps you selected incorrect units in calculating geometry.



You second Map should look as below:

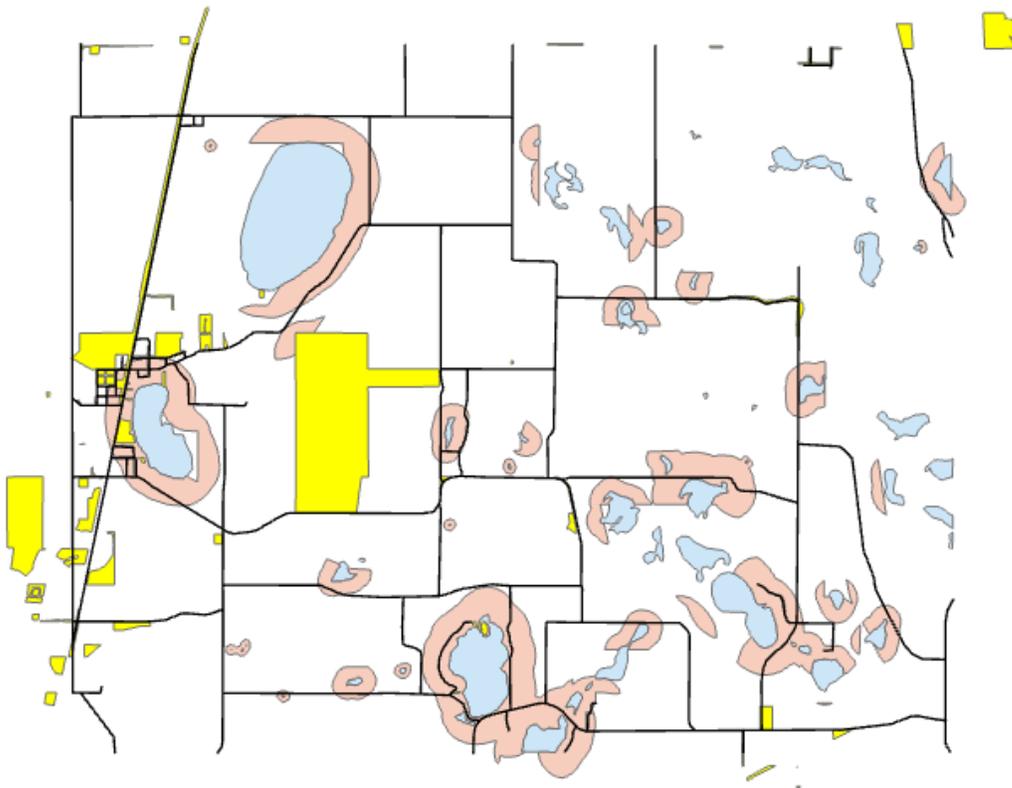


Add Scale Bar, North Arrow, Legend, Title and add a text box which states the TOTAL AREA in hectares which would be available for Campsites.

Part 3: Private land in your proposed Campsites locations

We wish to now eliminate areas from consideration that are currently **PUBLIC** land.

Create a new project, add a Map, and add the layers *roads.shp*, *Lakes.shp*, *acceptable areas.shp*, and *Public_Hugo.shp* (see figure below).

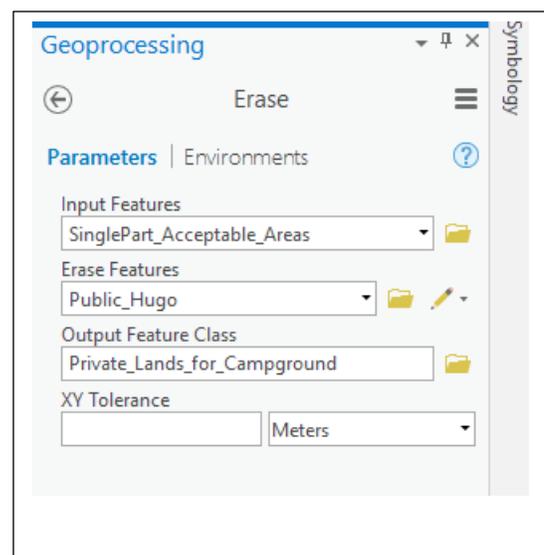


Open the ArcToolbox, then → **Analysis**
→ **Overlay** → **Erase**

To erase the interior portions, open the
ArcToolbox pane, then → **Analysis Tools** →
Overlay → **Erase**

- Specify **Input Features** as the single part candidate areas you created above
- Specify the **Erase Features** as the Public_Hugo layer
- Name the output something like Private_Lands_for_Campground
- **Run** to apply the Erase

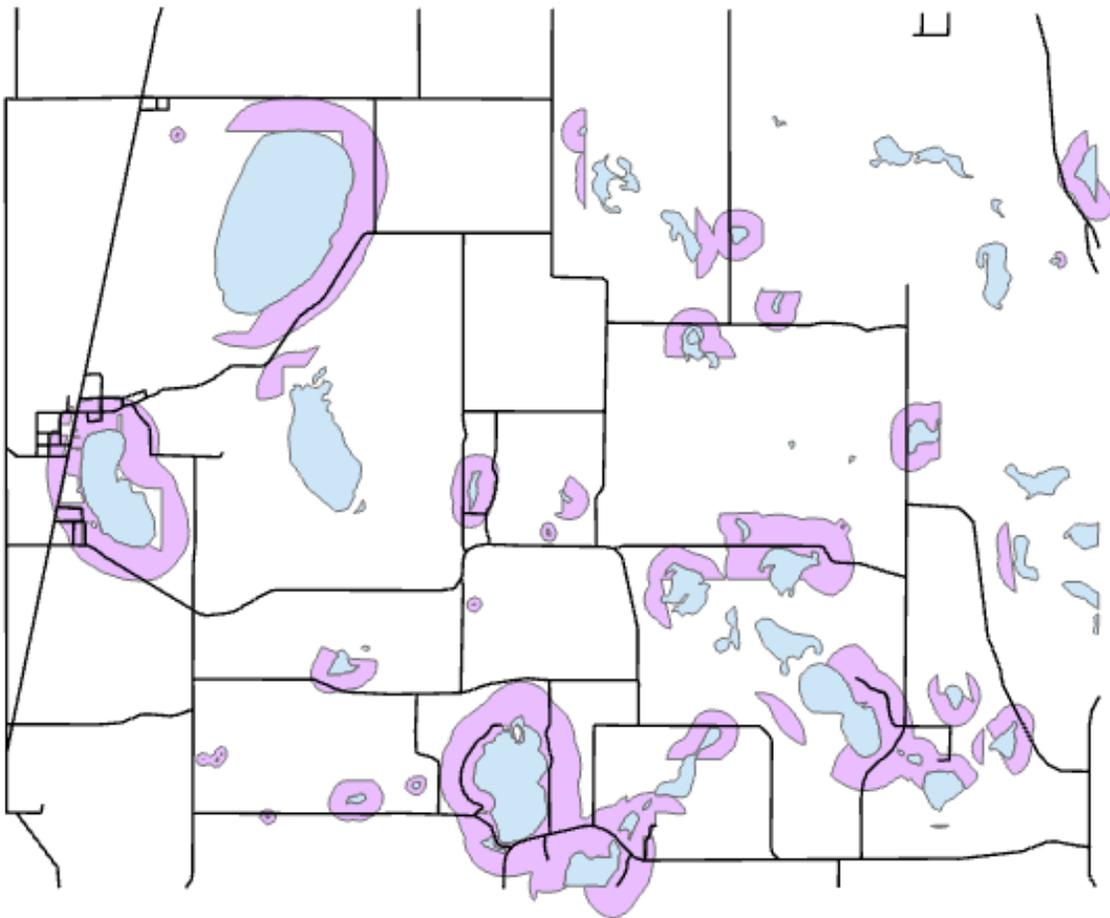
(**Video: Erase**).



Recalculate the areas of Private_Lands_for_Campground polygons.

Convert to singlepart shapes (see previous instructions for multipart to singlepart), and calculate the size of each polygon, in **hectares**, as you did above, remembering that the previous field "hectares" found in your file was not updated during the erase operation. If you reuse that field (instead of creating a new one) you must recalculate the area measurements.

Create a Layout that includes roads, lakes, and single part Private_Lands_for_Campground layer you just created (see below).



Label each layer with descriptive text in the legend, and include a scale bar, north arrow, and title.

Make sure you add descriptive text and the amount for both estimates of the areas suitable for campgrounds, total, and only on private land, in hectares, e.g.,

Total area of land suitable for campgrounds: xyz hectares (basically the Map 2 text field)

Area on private land suitable for campgrounds: abc hectares

Print or Export a map from this layout.

MAPS TO TURN IN:

- Hugo, MN Lake and Road Buffers
- Hugh, MN Areas suitable for Campgrounds
- Hugo, MN Areas suitable for Campgrounds only on PRIVATE LAND