LAB 9: Buffering and Overlay in ArcGIS - ArcMAP

What You'll Learn: to apply the concepts 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 areas within both the lakes and roads buffer zones.

Part One: Buffer Zones

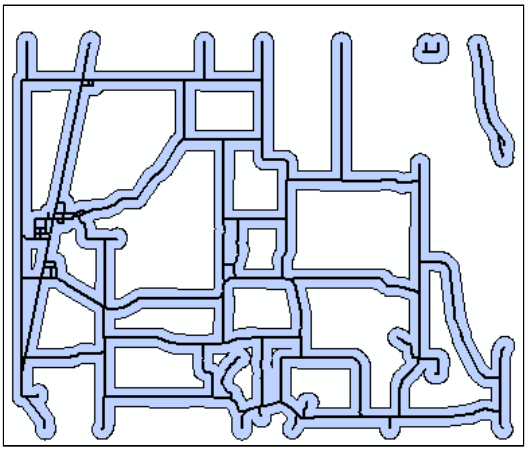
Buffering and overlay are two of the most common operations in cartographic modeling. A buffer zone is an area that is within a given distance from a map feature. Points, lines, or polygons can be buffered. Buffers are used to identify areas surrounding geographic features. For example, you may wish to keep septic systems over 100 meters away from streams, locate housing within a quarter mile of existing roads, keep hiking trails away from seasonally flooded rivers, or make sure most of your city is within some maximum distance from a fire station or school.

When you buffer on a set of features, the output is a set of polygons. (Buffering points or lines creates a new coverage that is a polygon coverage). These polygons define an **inside region**, an area less than the specified buffer distance from the features of interest (e.g., less than 300 meters from a stream), and an **outside region**, an area more than the specified buffer distance from the features of interest.

These inside and outside regions are typically distinguished by different codes in an attribute table. You should know the specific codes assigned for the software system you use.

Fixed Distance Buffers

A fixed distance buffer identifies the inside and outside region for a fixed distance away from a set of featuers. Fixed distance buffering may be applied to points, line, or polygon input, and creates polygon output.

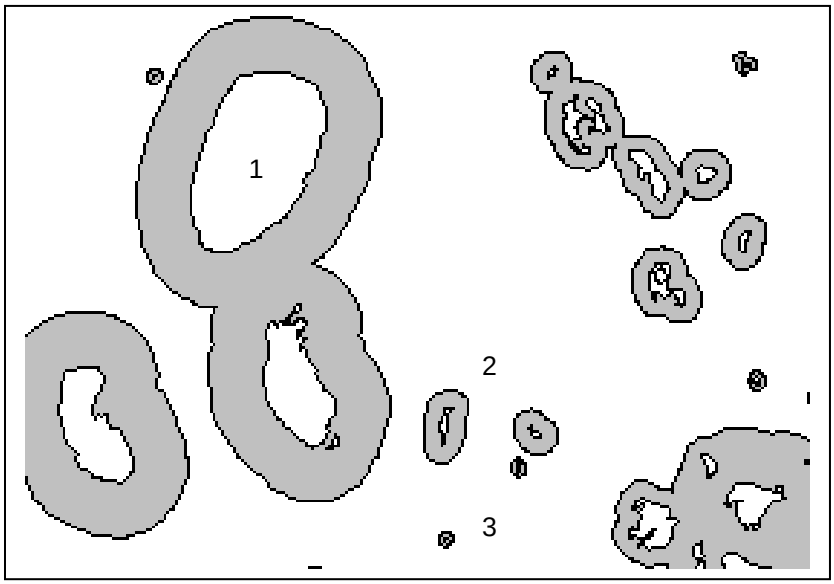


The figure on the right shows the buffer area (in blue) for a road network (thicker black lines). It separates the inside area (blue) from the outside area (white). There will be a corresponding table with some coding to indicate the in/out status of each polygon.

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 could buffer the lakes coverage by using an attribute that specifies the size class. Different sized buffers would be applied to each lake depending on the size class attribute.

You will create a variable distance buffer in this lab, with the buffer distance defined by lake size.

Variable distance buffering requires some way of specifying the distance. This is most often done with an attribute in a table. The buffering operation uses the table entry to determine buffer distance around a feature. A numeric data item must be created to specify the buffer distance, 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.

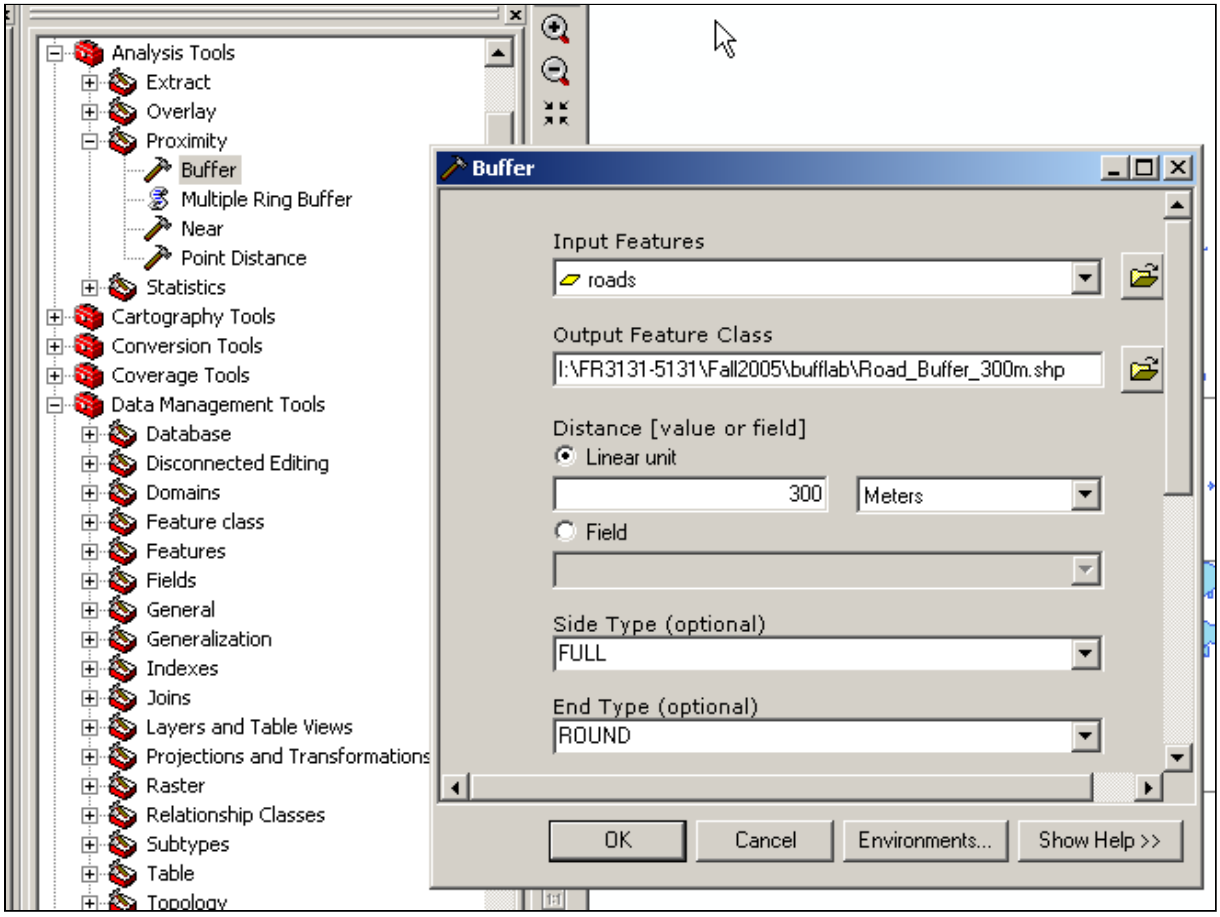
Part 1: Buffering in ArcMAP

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

Left click on the red **Toolbox** to activate the tools menu, then **Analysis Tools → Proximity → Buffer**.

(Video: L9_1_Simple_Buffer.mov)

The displayed window (an example in the figure below) allows you to create a buffer layer derived from an Input feature layer in a manner you specify.



- 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** to All
- Left click **OK**.

When the buffering process is finished, it should display the buffer data layer. You should close the 'completed buffer' dialog box.

Creating a Variable Distance Buffer

The second exercise will buffer the *Lakes.shp* layer using a variable distance buffer (***Video: L9_2_Var_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 500 meters for lakes with size class 3

This exercise involves three steps.
First you open the lakes attribute table in ArcMap and insert a new field that will hold the variable buffer distance.

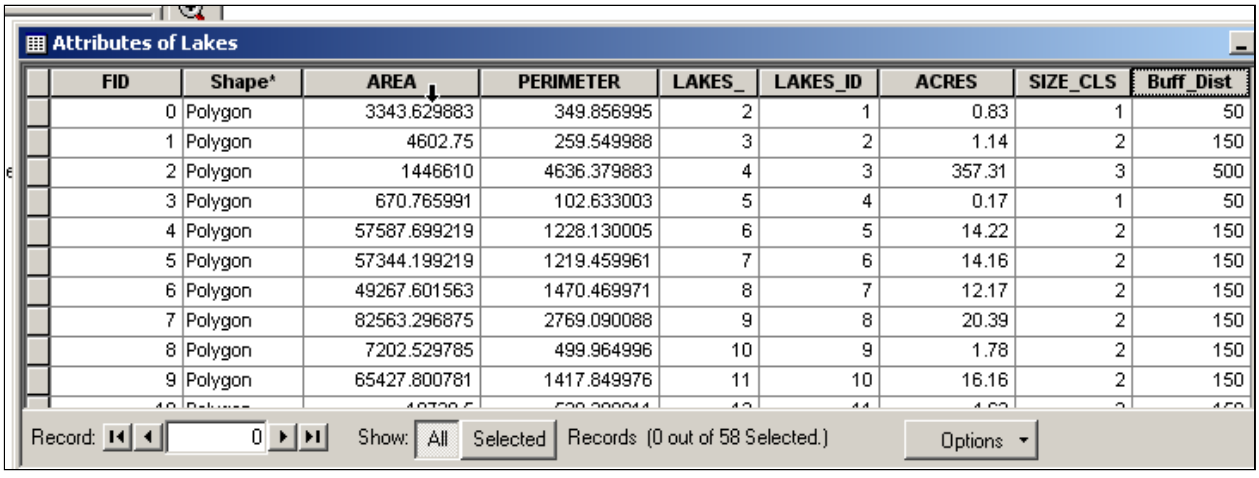
Second you use Select by Attributes to assign the attribute values for the variable buffer distance (refer to Lab 7 if you don't remember the details on selecting and editing values in a table)

Third, you apply the buffer operation.
To do this:

- Add the file *Lakes.shp* to your project, open the attribute table for *Lakes*.
- Left click **Options →Add field**, and 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 just created field. Refer to the lesson 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 **Selection →Clear All Selected Features**).

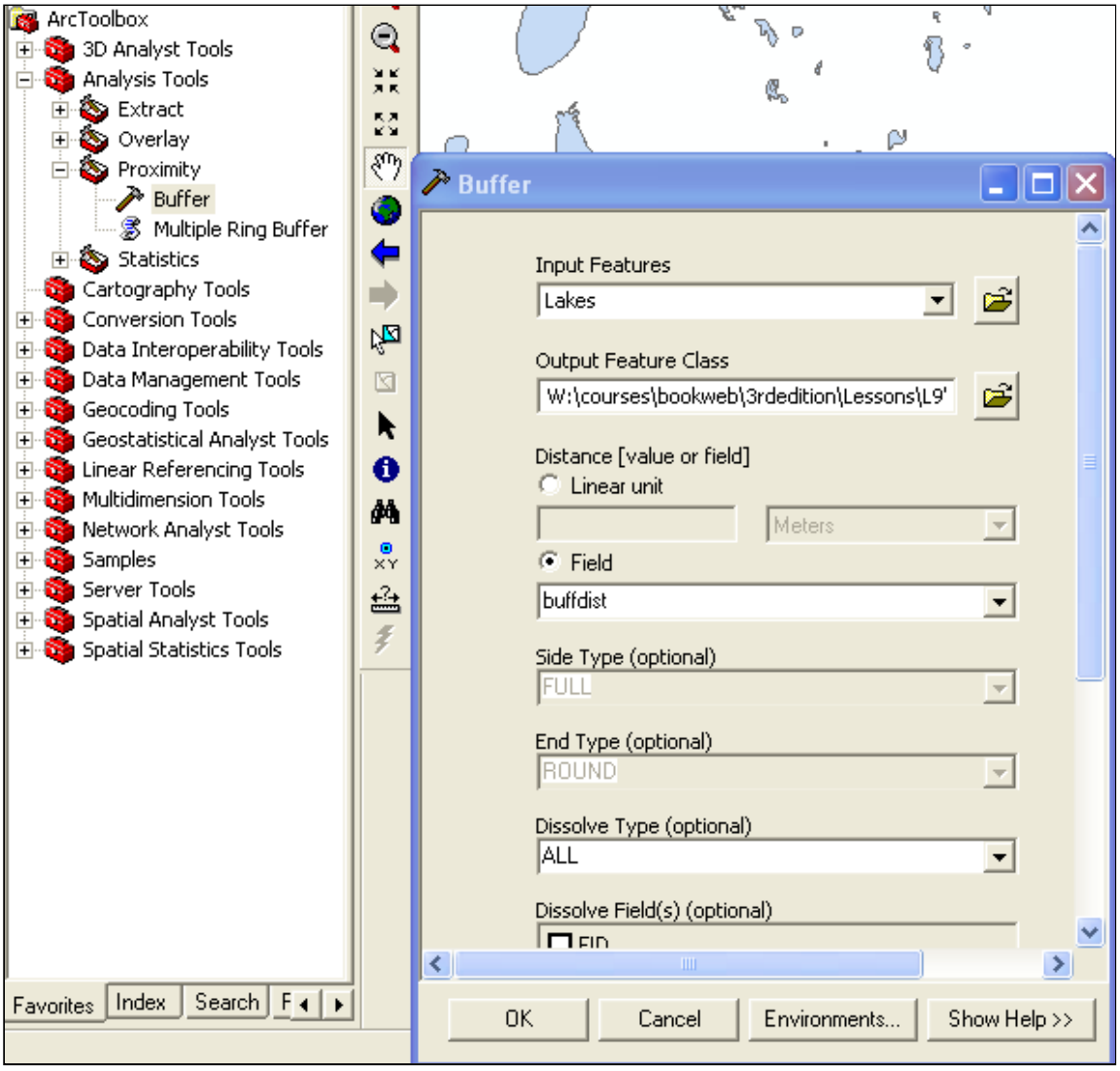
Your table should appear similar to that shown below.



FID	Shape*	AREA	PERIMETER	LAKES_	LAKES_ID	ACRES	SIZE_CLS	Buff_Dist
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	500
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
7	Polygon	82563.296875	2769.090088	9	8	20.39	2	150
8	Polygon	7202.529785	499.964996	10	9	1.78	2	150
9	Polygon	65427.800781	1417.849976	11	10	16.16	2	150

Now create the variable distance buffer:

° Left click in the **Toolbox → Analysis Tools → Proximity → Buffer**.



° Make sure the *Lakes.shp* layer is **Input**.
° Name the **Output Features** something logical, such as *Var_Lake_Buffer.shp*.
° Select the **Field** (not Distance Unit) radio button.
° Specify the field you created in the previous step, buffdist.
° Select **Dissolve Type** as **ALL**.

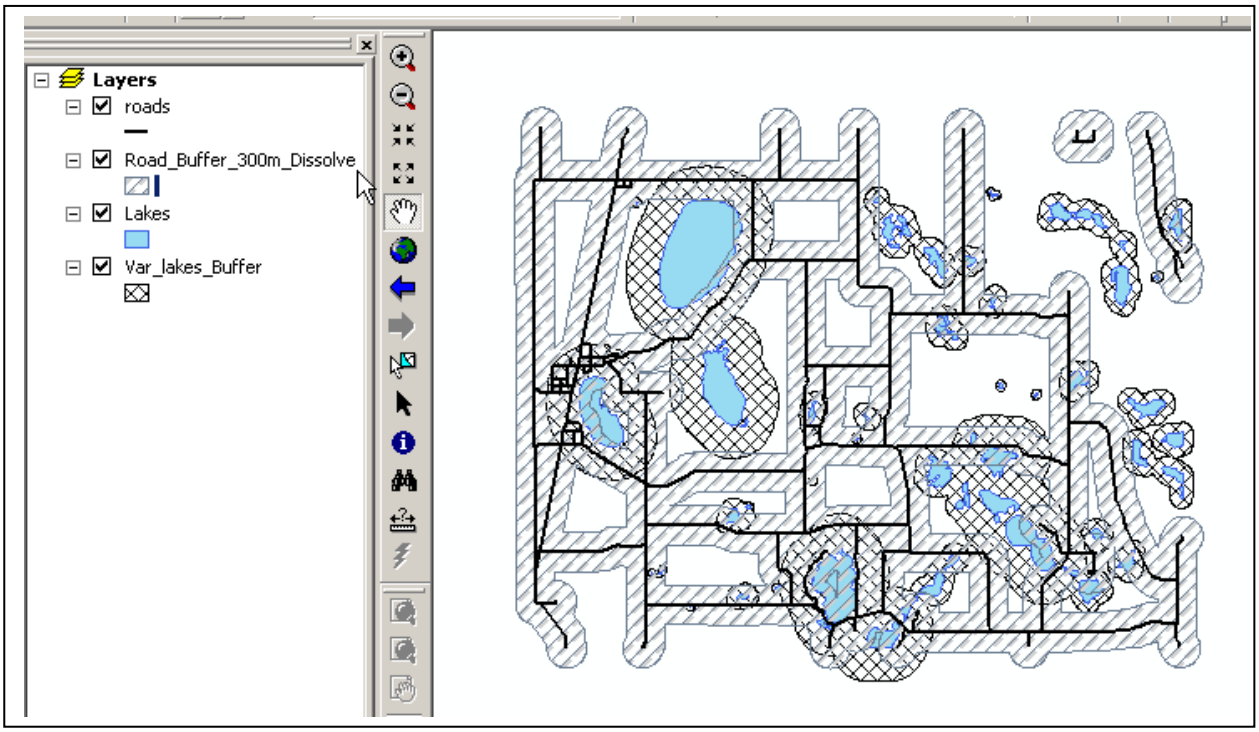
When the buffering process is finished, it should display the buffer data layer, close the 'completed buffer' dialog box.

Arrange 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.

Your data view should look something like the figure below.

Create a layout, and label each layer with descriptive text in the TOC/legend, and include a scalebar, north arrow, and title.



Part Two: Overlay in ArcMAP

Overlays are another common cartographic modeling operation. An overlay is the primary way to combine information from two separate themes. Overlays are most common for polygonal data, and perform a geometric intersection, which results in a new layer with the combined attributes of both initial layers.

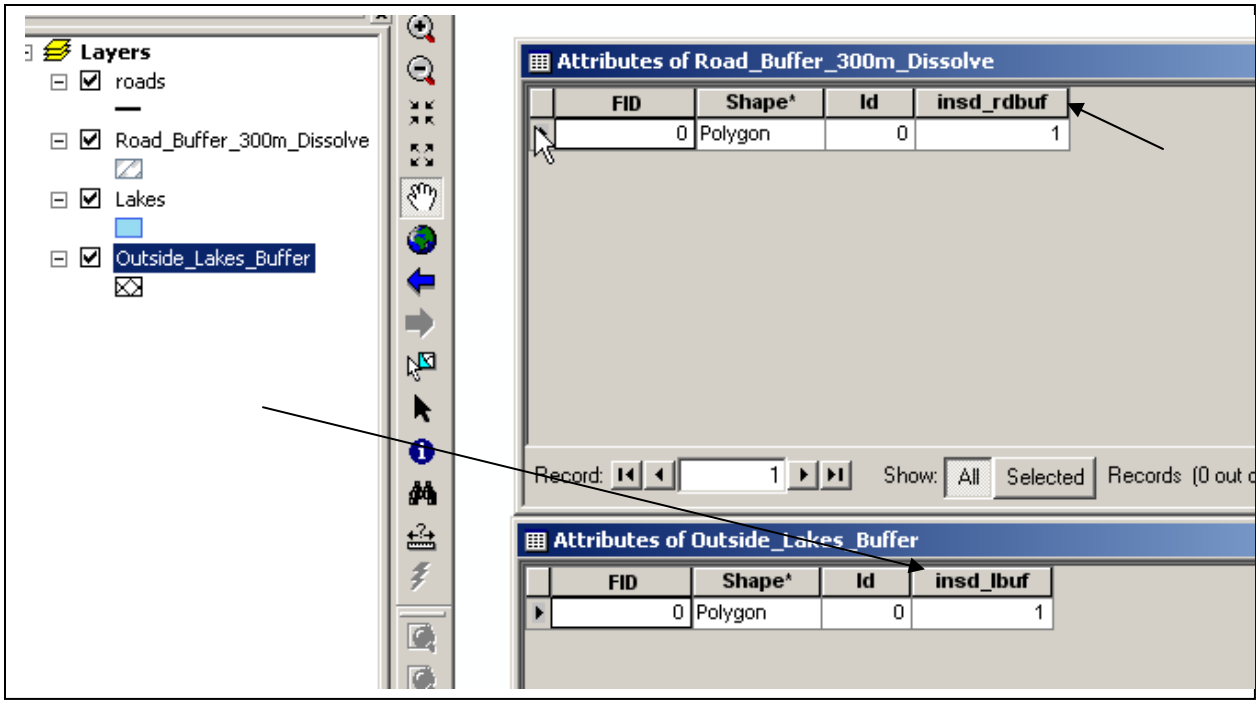
Our goal in this exercise is to find potential campgrounds sites for a State Park. The campground needs to be within the buffer zone created for the lakes. However, these will be 'drive in' sites and they must also be within the buffer zone of the roads. The final map will show locations that are both within 50, 150 or 500 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 ArcMap 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 buffers in the lake buffer layer. We create a new item (column, attribute) in the lakes buffer table, name it something like insd_lbuf, and give it a value of 1 for all the lake buffer areas (you should know how to do this by now, without step-by-step instructions).

Do the same for the road buffer layer. Add a new attribute call it insd_rbuf and assign it a value of 1 to indicate it is inside the road buffer.



We don't worry about assigning a value for areas outside the buffer in this exercise, because of the way ArcMap views the vector world. Areas outside of polygons do not have a boundary nor a record in the attribute table associated with them. We cannot assign a value for these "outside" areas in each input layer, because there is nothing to attach the value to. Some other vector packages define a bounding polygon for the outside world, and when using raster overlay we often assign values for both the inside and outside areas. We usually don't in vector overlay in ArcMap.

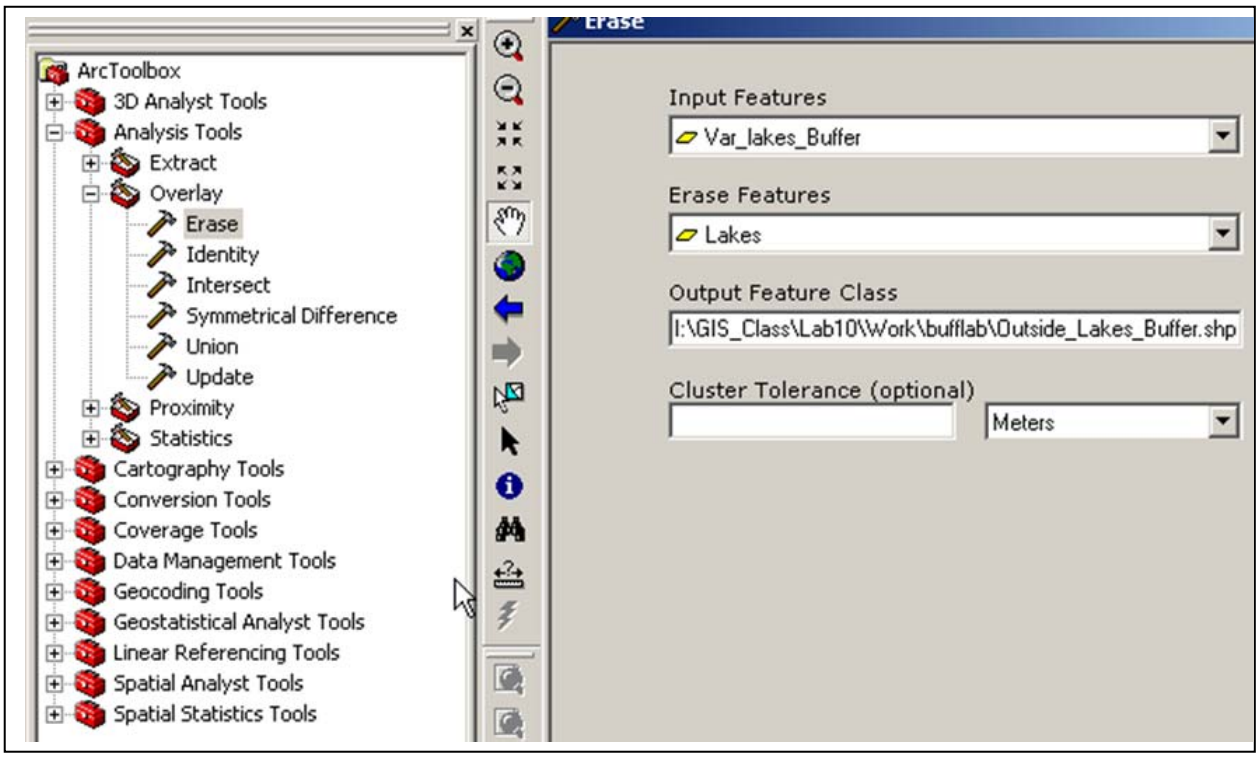
Before we overlay the two layers with the "Union" command, we need one more preparation step. The lake buffers layer we created has buffered areas that include the lake as well as the land near shore. We only want campsites on dry ground so we will "erase" the lake from the lake buffer layer.

Note: Student Home version of ArcGIS 9.3 does not have ERASE. This is a ArcEditor version, with a one-year time out. Some functions are missing, including Erase, the ability to work with topology, and others.

If you do have the Erase function (only in the ArcInfo version of ArcGIS located in Skok 35 or Green 210A labs), perform the following steps.

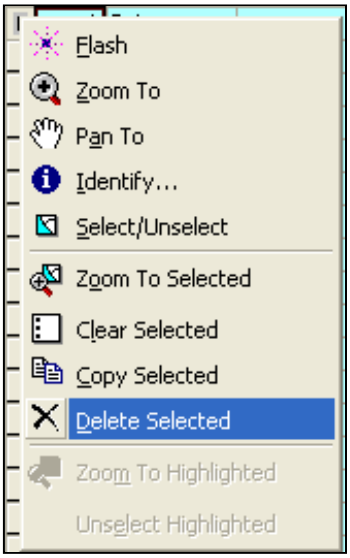
First, open the Toolbox, then →**Analysis Tools→ Overlay → Erase**

- Specify **Input Features** as the variable lakes buffer
- Specify the **Erase Features** as the lakes layer
- Set the output destination in the output feature class
- **OK** to apply the buffer



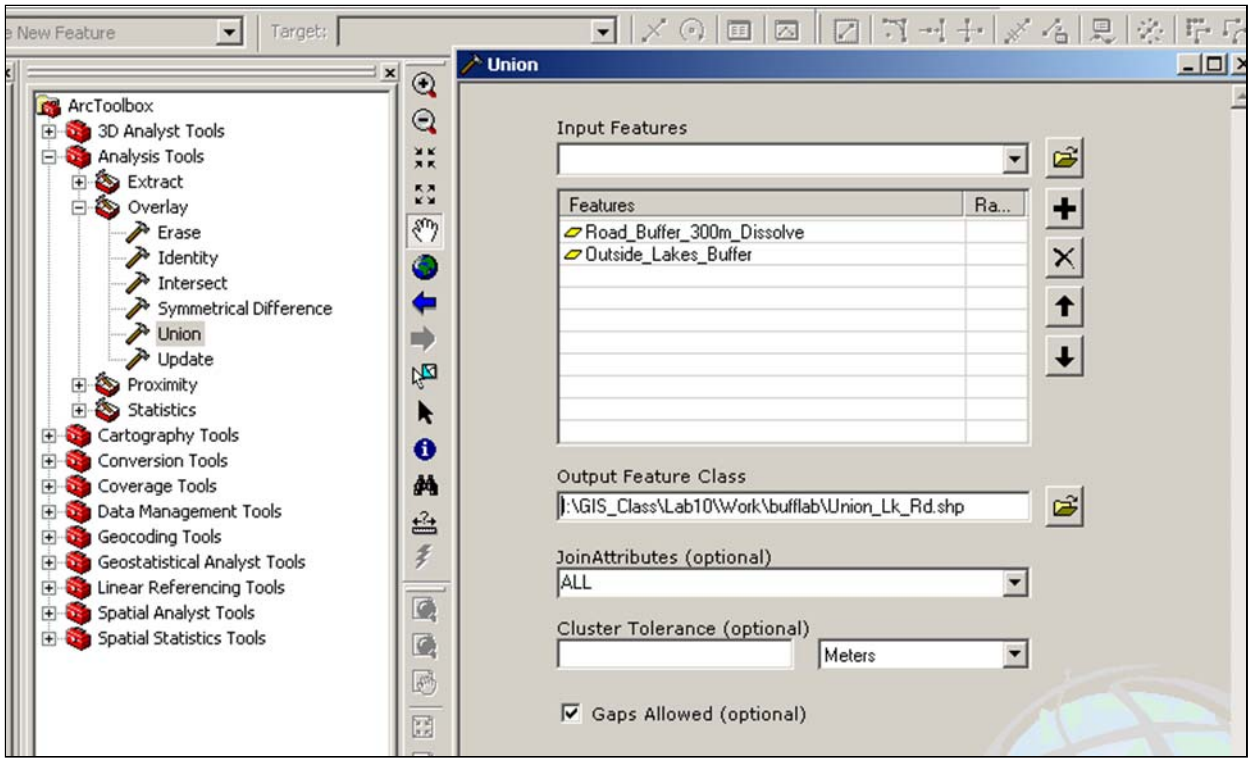
Workaround: If you don't have the Erase function in your toolbox, do the following: Open the table of the file that will be used as the "eraser", in this lab the *Lakes* (**Video: L9_3_Workaround_Erase**).

- Add a field to this file, call it something like to_erase. Make it a short integer.
- Use the table Field Calculator to assign a value of 1 to to_erase for all lake polygons.
- Union the eraser (*Lakes.shp*) and the target (*lakes buffer.shp*) files
- Open the union table. **Select by Attributes** all to_erase = 1 records .
- **Start Editing** the union data layer, right click on the selection square at the left end fo any selected row in the table and then left click the **Delete Selected** option (see figure at right). This will delete all the selected records.
- **Save and Stop Edits**.



The final step is to overlay the two buffer layers (***Video: L9_4_Union***).

- Select Toolbox → **Analysis Tools → Overlay →Union**
- Specify the input layers –Outside_Lake_Buffer and Road_Buffer_300m_Dissolve.
- Specify the output layer Union_Lk_Rd.
- Press OK.

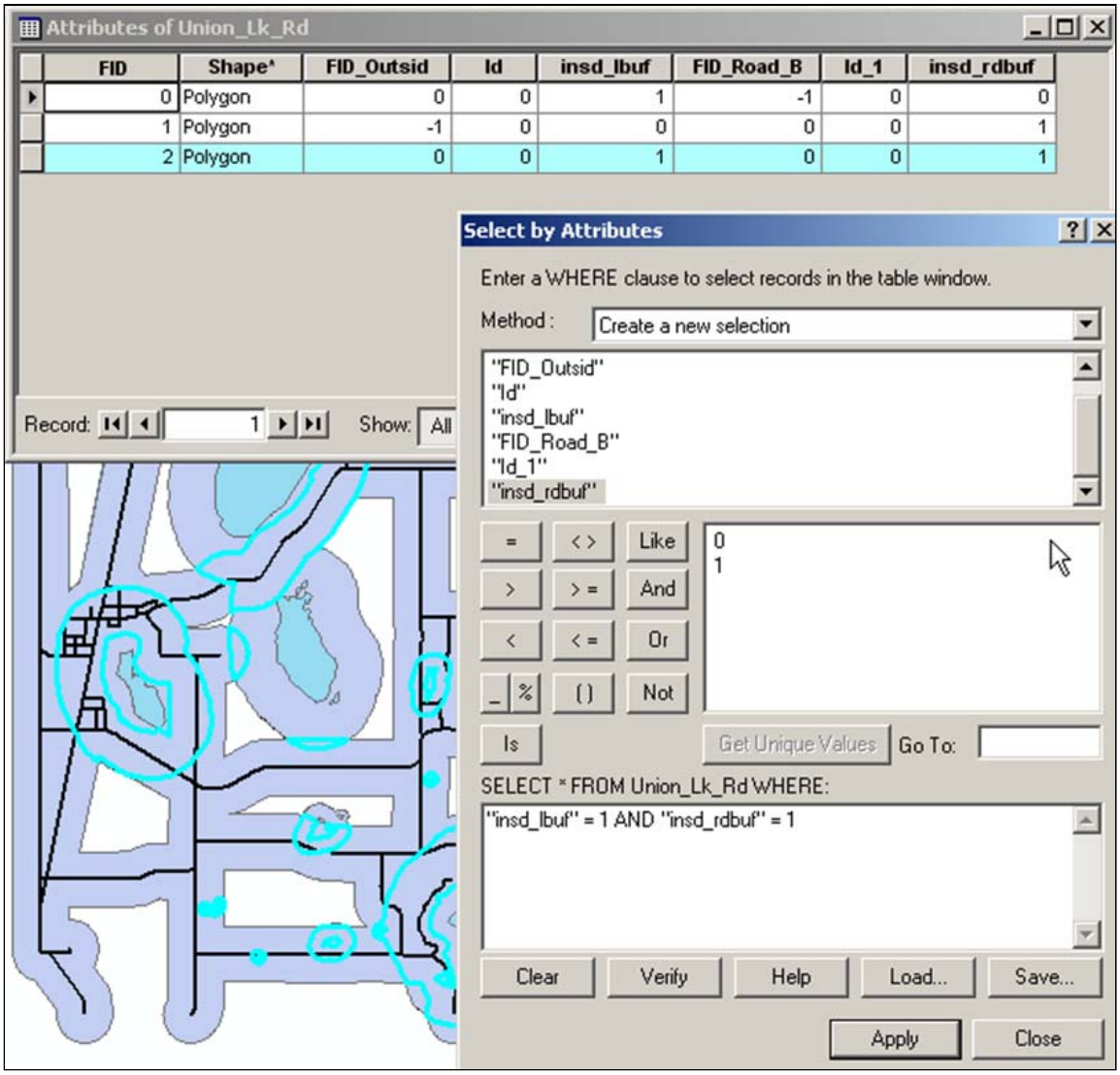


Examine the “unioned” layer and open the attribute table for this layer. Select the polygons that meet both the within the roads buffer and the within the lakes buffer criteria (see the figure below for some hints).

Note the number of records selected.

Why do you have only 3 records? You can see more polygons on the screen.

ArcMap groups polygons in the data files when performing analysis. When we are finished with our analysis we will “ungroup” polygons in the file, creating an table row for each polygon.



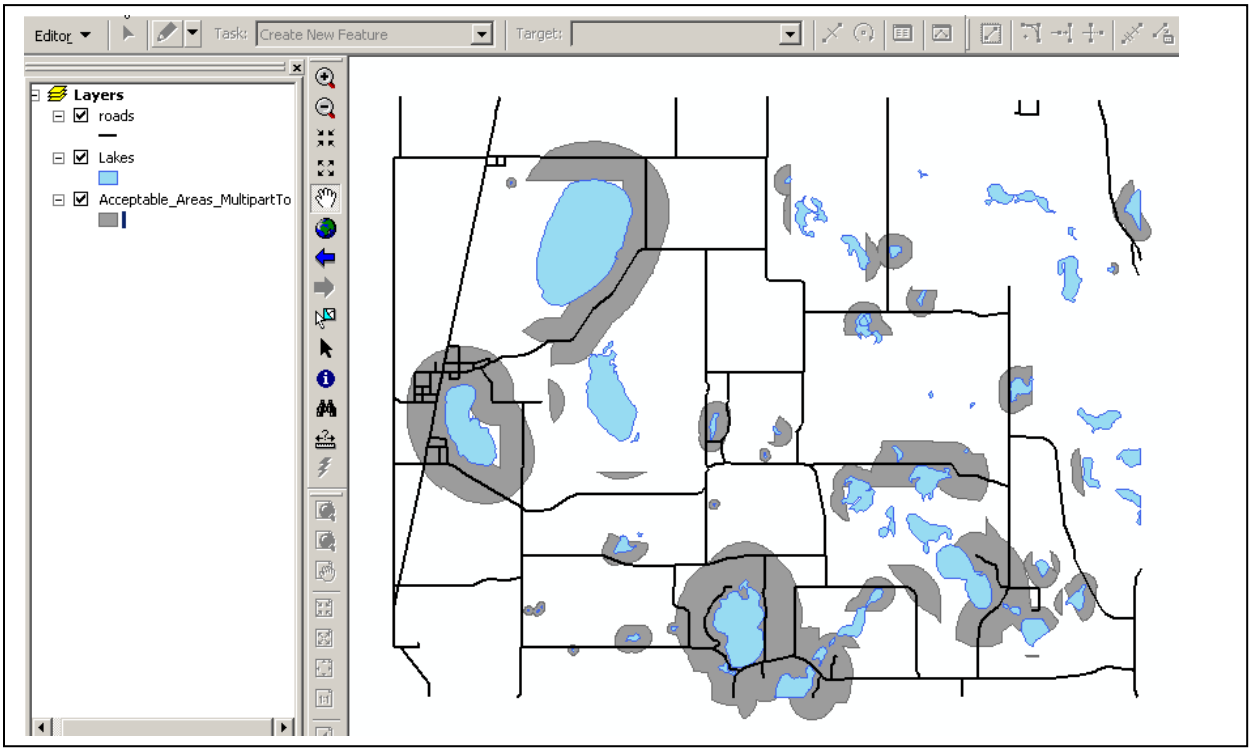
Create a new field on the union attribute table (in_both) to identify those areas that meet both the inside road buffer and inside lake buffer criteria.

Use **Select by Attributes** to find those areas with insd_lbuf=1 **and** insd_rbuf = 1, and assign them a unique flag (assign the number 1) using the **Field Calculator**.

- Close the attribute table, make sure the *Union_Lk_Rd* layer is selected and right click on the layer name in the TOC. Select **Data →Export Data** and export only the selected (where in_both =1) to a file called *Acceptable_Areas*.

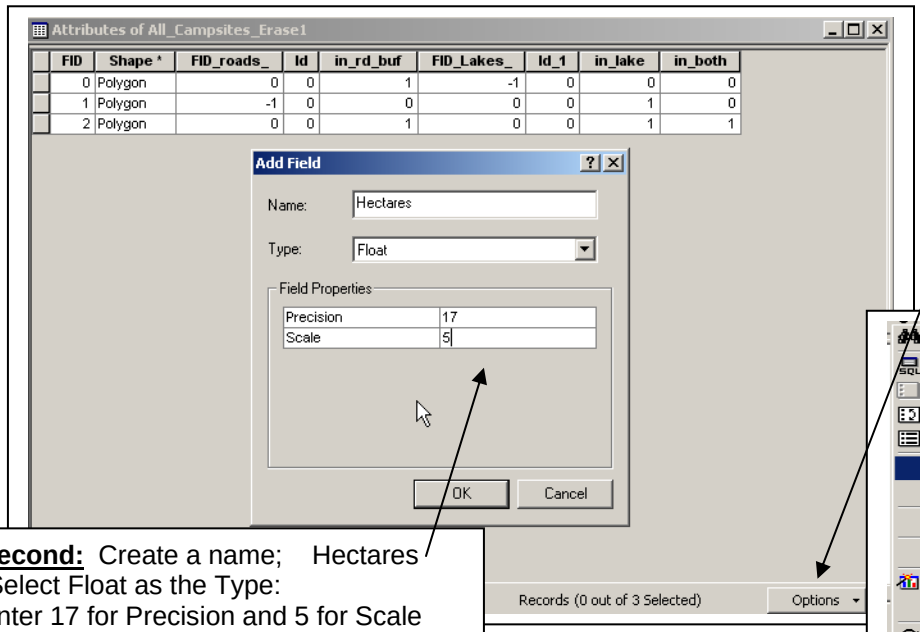
- Select Toolbox → **Data Base Management → Features → Multipart to Singlepart**. (***Video:L9_5_Multipart2singlepart.mov***). This will ungroup the combined polygons to and create a table row for each. You should have 32 records in the table for the singlepart file.

  Display the *roads*, singlepart *acceptable areas*, and *lakes* in the view. It should look something like the figure, below.



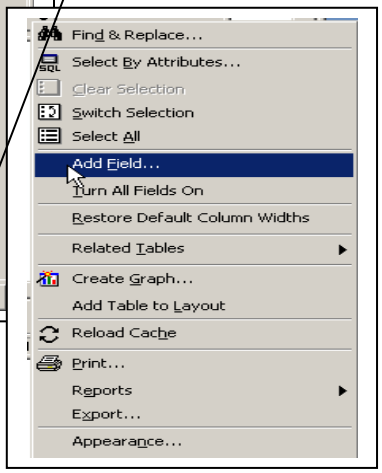
Now before you print/export the map you need to determine the size (in acres or hectares) of your acceptable sites. Instructions are on the next page.

To measure area, do the following for a layer (*Video:L9_6_Add_Area*).

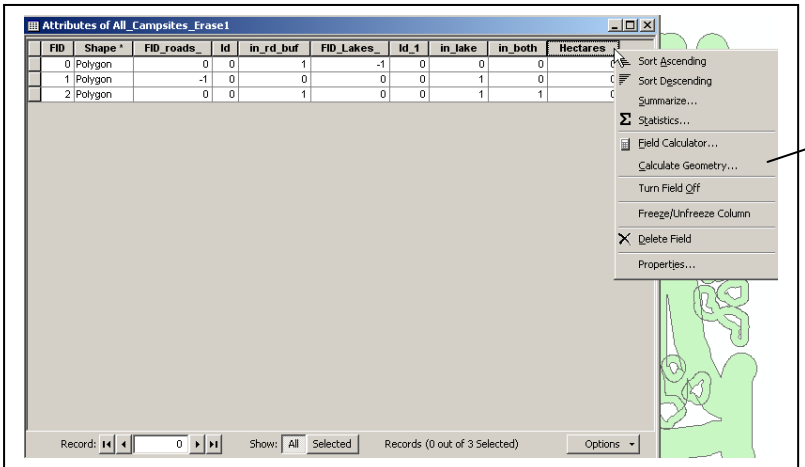


First
Open the "Attribute Table" then
Select **Options**

Add Field

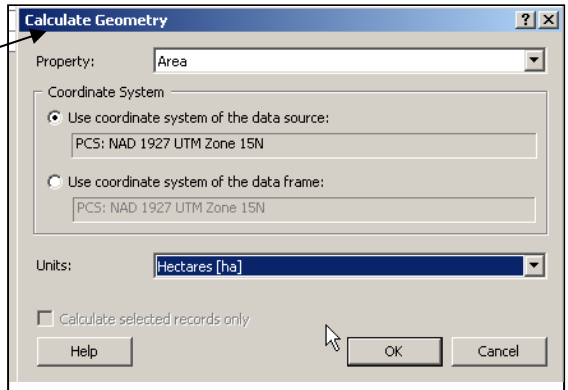


Second: Create a name; Hectares
Select Float as the Type:
Enter 17 for Precision and 5 for Scale
Select OK



Third : Right click on the column Hectares to bring up a menu, then left click on **Calculate Geometry**.

Select **OK** to the "Outside an Edit Session" warning question



Finally: Use the **Property** drop down to **Select Area** and the **Units** drop down to set the units to Hectares

Left click on **OK**

If necessary, query the table, use Select by Attributes to select your coded field (in_both). There should be 32 records.

Select a column, then Right click on the column heading for the Hectares column.

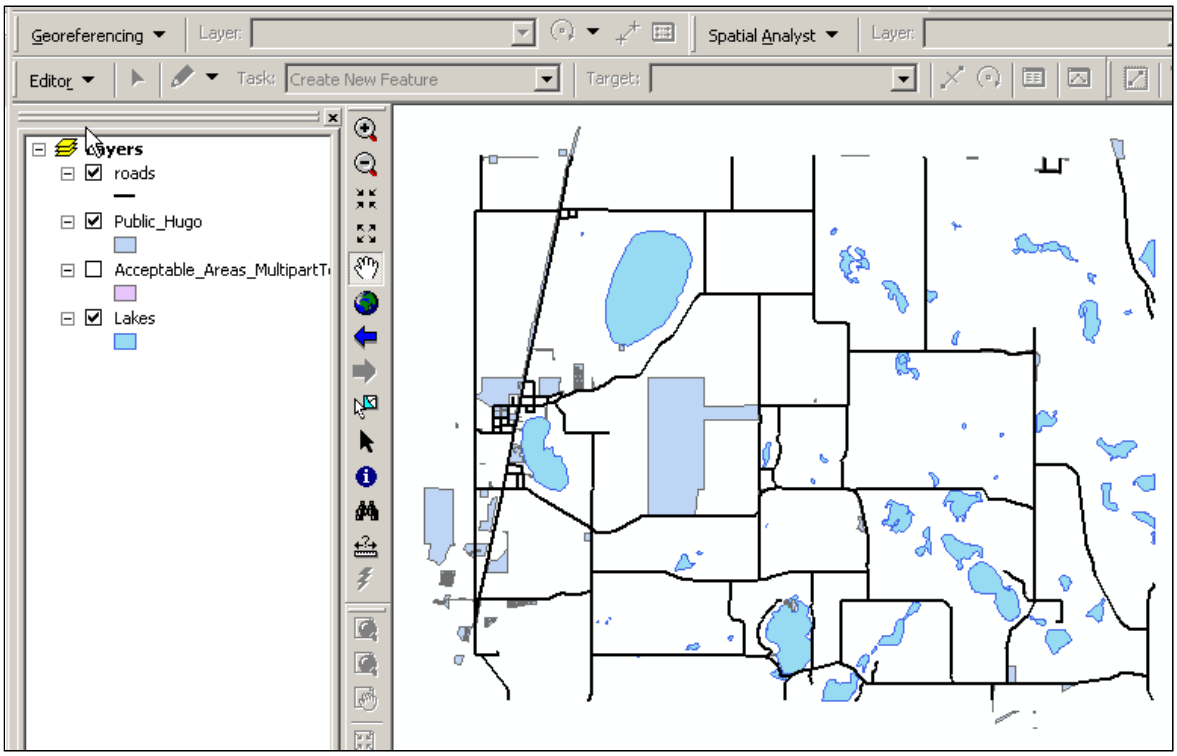
Select Σ Statistics... Note the sum of the size of your potential campsites. *(It should be 1,161 hectares)*

When records are selected, *marked in blue*, the Σ Statistics... will sum only the selected records. When nothing is selected Σ Statistics... will sum all the records in the table.

Create a layout with the *roads*, *lakes*, and *acceptable campsite* areas. Label each layer with descriptive text in the legend, and include a scalebar, north arrow, and title. Make sure you add to your map the calculated total acceptable campsite acres or hectares.

PART 3 Estimate the amount of Private (non-public) land in your proposed Campsites locations.

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



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

Remember, if you have the ArcMap Student (or ArcView) edition, you do not have the Erase tool, and should use the **Workaround** described earlier.

- From the *acceptable areas* layer, use the *Public_Hugo* as the Erase Features
- Layer. This removes the publicly owned land in Hugo from your Acceptable Areas.
- Name you new layer;in the Output Feature Class to '*Campgrounds_on_Private_Land'*. This is the land that would need to be acquired if the community wants to build campsites.

Remeasure the Campground_on_Private land and note it size in acres or hectares. Subtract it from your previous area calculation (the total Acceptable Areas from Part 2).

Create a Layout that includes roads, lakes, and Acceptable Campsites on Private Land.

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

Make sure you add the size of the acceptable campsite in acres or hectares and the size in acres or hectares of the campground on private land.

Print or Export a map from this layout, your third and final map for this lesson.

MAPS TO TURN IN:

(via WebVista as .pdf's)

- Hugo, MN Lake and Road Buffers
- Hugo, MN Areas suitable for Campground
- Hugo, MN Areas suitable for Campground, private land only