GEOG 363 AND URBS335: Geographic Information Systems

VECTOR SPATIAL ANALYSIS

Objectives: To select a potential site for constructing a wind farm near Quebec City; by conducting a small but complete GIS project – from creation of a GIS database, to spatial analysis with the database, and then to cartographic presentation of the results.

The criteria that the site must meet are listed and described as follows:

Constraints imposed by legislation, safety guidelines, environmental preservation, etc - these constraints do not allow constructing the wind farm on locations that are too close (specific distance for each feature) from wetlands, rivers and water bodies, roads and residential and recreational areas.

➢ The site must be **at least 500 m away from wetlands** (Habitat and wildlife preservation)
➢ The site must be **at least 150 m away from rivers and water bodies** (Construction safety guidelines)
➢ The site must be **at least 150 m away from existing roads** (Construction safety guidelines).
➢ The site must be **at least 500 m away from residential and recreational areas** (Noise restriction based on a study by www.energie-eolienne.ca)

Constraints imposed by financial restrictions, building costs, etc - these constraints allow building, but areas that satisfy the criteria are preferred.

➢ The site must be **within 1000 m of existing main roads** (Reducing construction costs)
➢ The current land use of the site must be **open area** to allow the construction
➢ The area of the site must be **between 500,000 and 1,000,000 square meters**.

Your task is to locate the potential sites that meet these requirements using ArcGIS. You also need to create a map that shows the locations of the potential sites, and a report that lists each site. To achieve the goals, you need the following data layers:

Data Layer	Geographic features	Source	*Coordinate System*	Status
water_lines	Stream, small river	NRCAN 2009	NAD_1983_MTM_7	Ready
water_poly	Lake, reservoir, large river	NRCAN 2009	NAD_1983_MTM_7	Ready
wetlands	wetland	NRCAN 2009	NAD_1983_MTM_7	Ready
major_roads_lambert	Main roads	DMTI 2009	NAD_1983_CSRS_MTM_7	Needs to be (re)projected
landuse	Types of landuse	NRCAN 2001	NAD_1983_MTM_7	Data need to be joined

==**IMPORTANT!! ALWAYS SAVE YOUR FILES ON YOUR P: DRIVE AND NOT IN THE DEFAULT.GDB!**==

1. Transform the roads' coordinate system from its current projected coordinate system (NAD_1983_CSRS_MTM7) to NAD_1983_MTM_7 system; and joining *landuse* attributes data.

1.a. Transform the roads' coordinate system
We want all the data layers in our GIS database to have the same coordinate system so that the spatial analyses can be performed accurately. We have decided to use MTM zone 7 as the coordinate system for our database. However, one of our data layers is in a different coordinate system, so we need to transform its coordinate system. If you don't

remember how to perform this transformation with the *Project* tool (ArcToolbox) follow the steps:

a. In ArcCatalog copy all the files from the **H: drive (Lab6) to your P: drive.**
b. Add data and select the ***landuse*** file from Lab6 folder (from your personal drive); Add data again and select ***major_roads_lambert***. You should get a message saying the coordinate system differs. Say OK (Close): the layers overlap but we need to transform ***major_roads_lambert*** in the coordinate system of any of the other files (e.g. ***landuse***).
c. Click on the *ArcToolbox* icon to launch *ArcToolbox.*
d. Click on *Data Management Tools > Projections and Transformations.*
e. Double click on *Project.*
f. In *Input Dataset or Feature class* click on the arrow and select **major_roads_lambert***.*
g. In the *Output Dataset or Feature class* change its name into: ***major_roads.shp (make sure that you save the data on your p drive).***
h. In the *Output Coordinate System* click on the icon which opens the *Spatial reference Properties* window. In this window click on *Import* and select **landuse.shp**. By doing that you will attribute the coordinate system of ***landuse*** to ***major_roads.*** Click Add. Click OK. Make sure your *Output Dataset or Feature class* name is still **major_roads.shp**.
i. In *Geographic Transformation (Optional)* select NAD_1983_CSRS_To_WGS_1984_1 + *NAD_1983_To_WGS_1984_1*
j. Remove the other "transformations" listed above it in the menu. Click okay.
k. You can check the coordinate system of your file: right click on **major_roads** > *properties > source*. It should be NAD_1983_MTM_7.
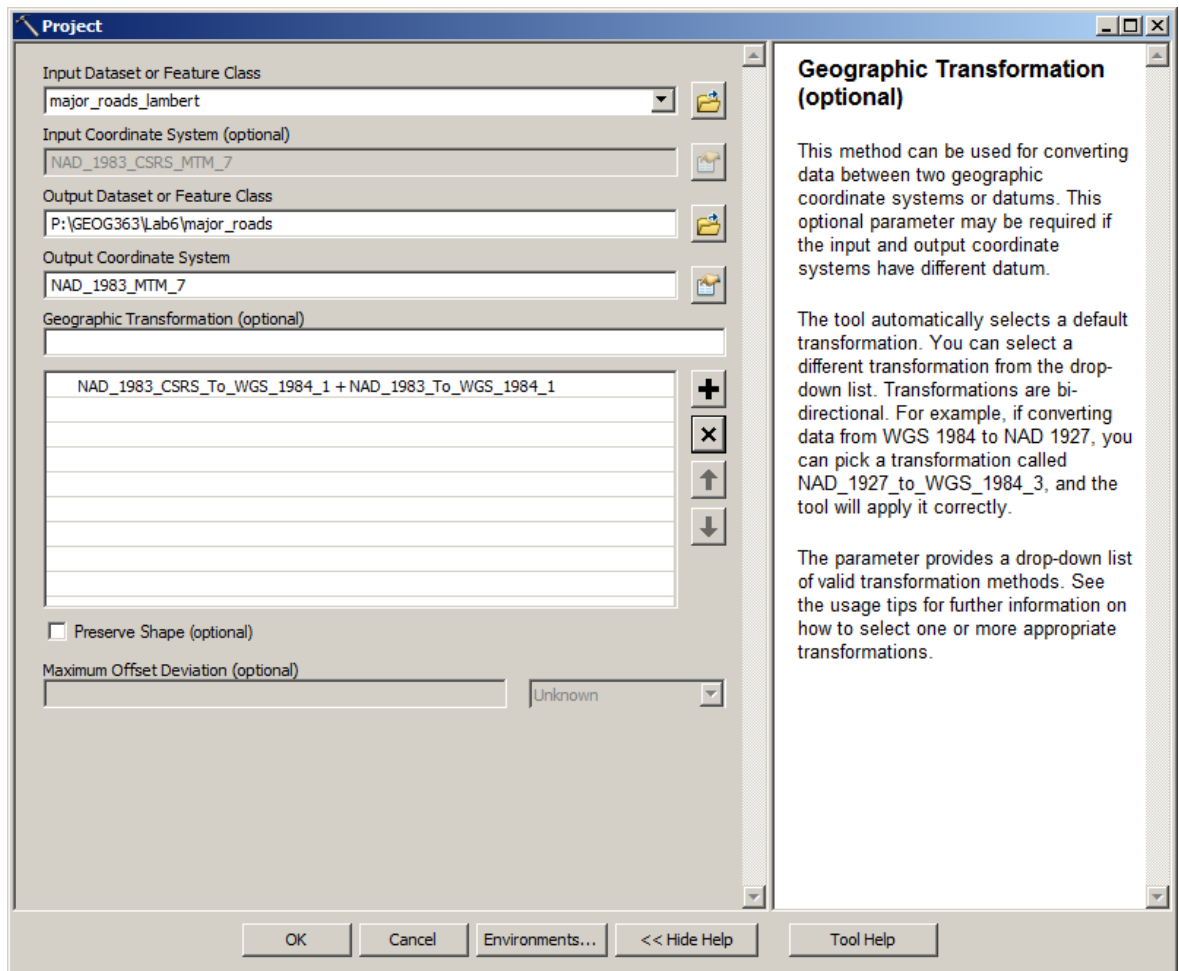
l. You can remove **major_roads_lambert** from your ArcGIS document.
All your shapefiles should now be in the same coordinate system. You will be able to do spatial analysis.

1.b. Getting landuse attributes data in
Along with the spatial data, we also received a separate attribute database that contains land use types data. This attribute database is stored in an excel spreadsheet. In a previous lab you learned how to link external attribute data to the spatial data. The basic idea is to link the external excel table to the built-in attribute table of the Shapefile. In this step, we are going to attach the land use data to the land use polygons in the **landuse** shapefile.

a. The table we are going to link to the **landuse** shapefile is called **landuse_types.xls**. Add this table to your project (note: **the data are in Sheet1$**). Right click on it in the Catalog tree and open the attribute table: the field labelled as *land_type* contains the code of each land use type that is described in the field named *Category*.
b. Now you are ready to link these land use attributes to the *landuse* polygons with the table-joining tool in ArcMap**.** You need to know which table is *target table*, which table is *join table*, and which fields should be used as the linking key. If you forgot some technical details, refer back to our previous labs (Lab5).
c. Save the joined table (right click on **landuse** > Data > Export data.) to **landuse_join.shp** on your **p-drive**.
d. Your database is now ready. Save your document (on your P: drive, you choose the name for this GIS project).
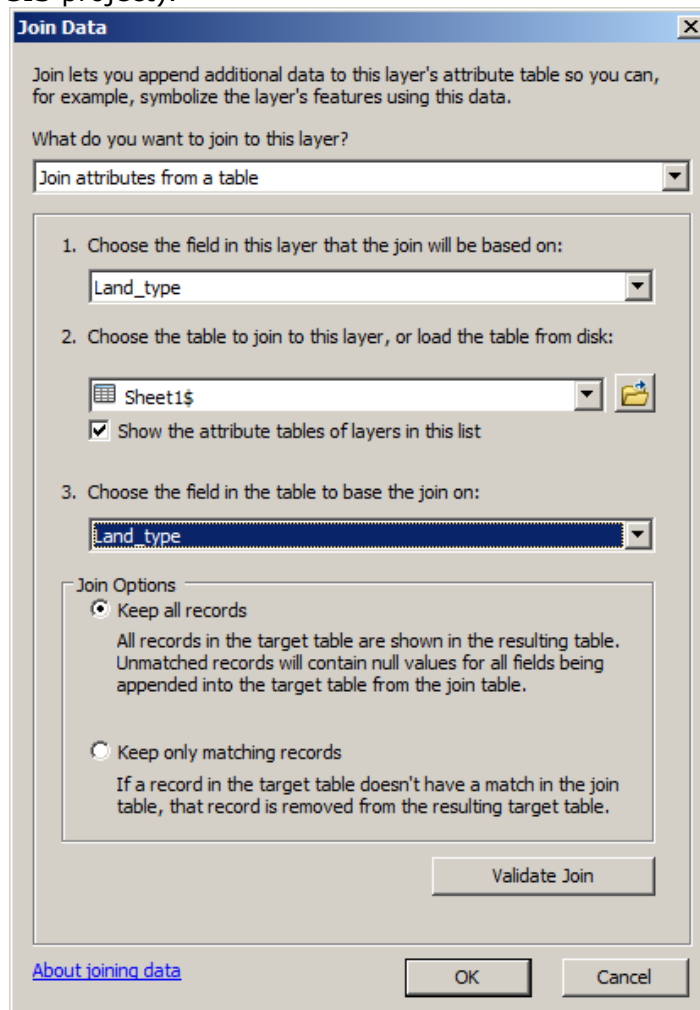
**2. Finding the constrained areas for each of the six conditions**
2.a. Finding areas which are 500 m away from wetlands (constraint 1)

Construct buffers around the specified features. There are different ways to generate buffers. The simplest one is probably to use the Buffer tool. You can find it in the Geoprocessing top menu OR in the toolbox: Analysis Tools > Proximity > Buffer.

Create a buffer around *wetlands*; the Linear distance is *500 meters*; the *Side Type* is Full and the *Dissolve type* is *All*; the buffer output needs to be **saved on your P:drive** as a shapefile (not geodatabase). You can also change the output name and call it *wetlands_500m*. The created file is automatically saved as a shapefile. Save your project.
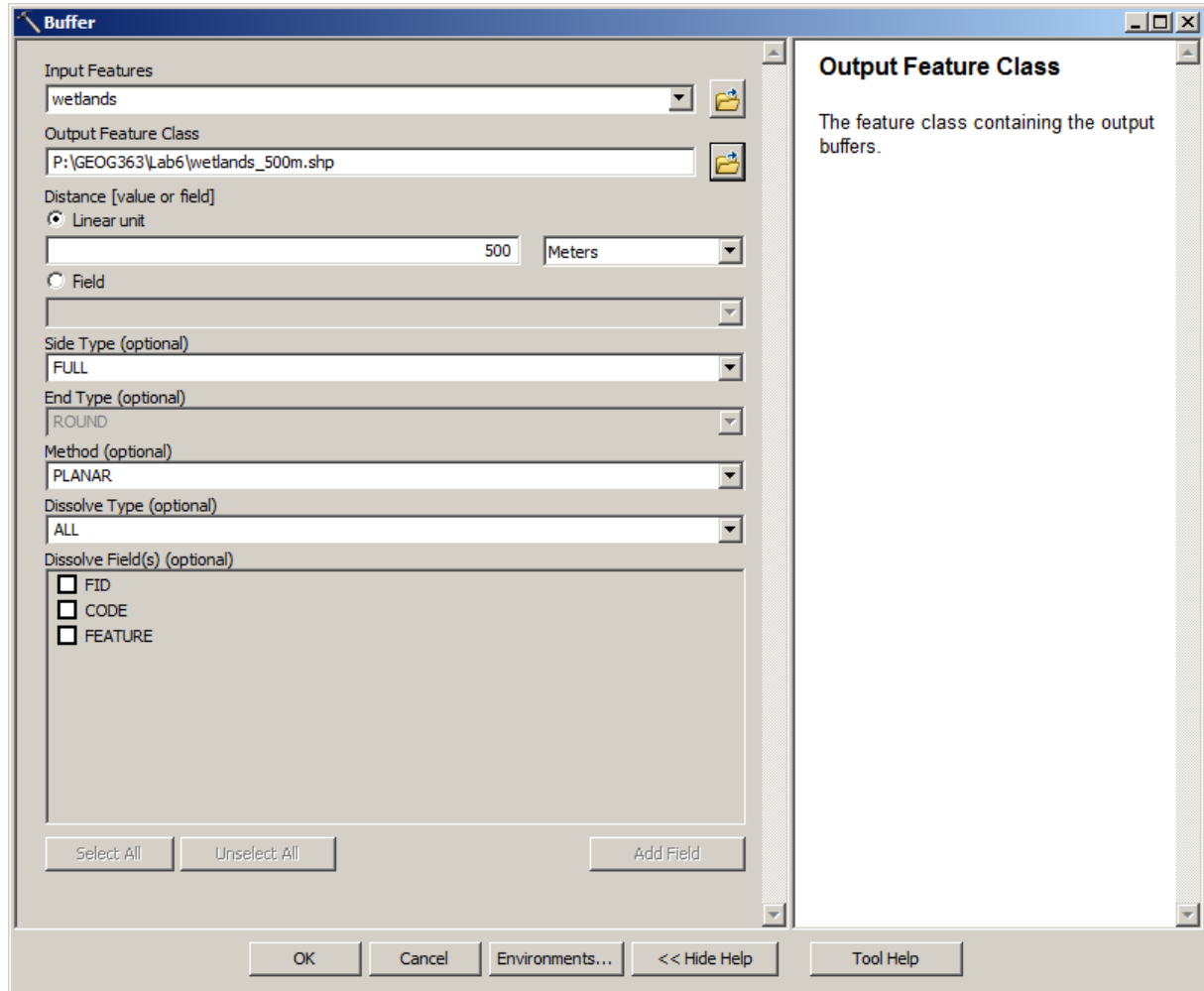
2.b. Finding areas 150 m away from rivers as well as areas 150 m away from water bodies (constraint 2).

Use the same buffering process with the **water_lines** layer and the **water_poly** layer to find area that meets this criterion. Name your new files **water_lines _*150m*** and **water_poly _*150m***.

2.c. Finding areas 150 m away from existing roads (constraint 3).

Use the same buffering process with the **major_roads** layer to find area that meets this criterion. Name your new files **major_roads _*150m***.

2.d. Finding areas 500 m away from residential and recreational areas (constraint 4).

For this constraint you will first need to select areas whose **landuse type is residential OR recreational.**

a. Selection > Select By Attributes. Choose the appropriate file and field (lab04 if you don't remember). You need to add an operator and a second part to the equation to **also** select the category 'Parks and Recreational'). You may need to play with the items on the panel for a while to learn how to build the query in the bottom window (Note: when you have selected a field, you can click on "Get Unique Values" to see which values are available for this field). Click **Apply** to select the polygons. Check the **attribute table of landuse** to see how many polygons have been selected (at the bottom of the table). You should have 64 landuse records selected out of 263.

b. Use the same buffering process with the **landuse** layer (note: ArcGIS will create a buffer only around the 64 selected objects, by default) to find area that meets this criterion. Name your new shapefile **resid_recre_500m**.

c. When done, **Clear Selected Features**, for the next step

2.e. Finding areas whose landuse type is open area (constraint 5).

Use the same selecting process as step 2.d.a. but this time you only have to select the category 'Open Area'. Once done, check the **attribute table of landuse**: you should have 115 records selected out of 263. Save this selection: right click on **landuse** > Data > Export data. Make sure **Selected features** is selected in the drop down menu and save your file in your **P: drive**. Name your new files **land_openarea**. Say **OK** to add it to map as a layer.

2.f. Finding areas within 1000 m from existing roads (constraint 6).

Use the same buffering process with the **major_roads** layer to find area that meets this criterion. Name your new files **major_roads_1000m**.

3. Combine

3.a. Finding areas that meet at least one of the four first constraints (unsuitable for the site)

You need to combine these **4 criteria** that are inappropriate for your wind farm (note: **you must combine 5 files** in total, since 2 files were needed for "constraint 2": 150 m away from river as well as 150 m from water bodies)

Click ArcToolbox > Analysis Tools > Overlay > Union (or Geoprocessing menu, Union). In Input feature class, add the five shapefiles you want to union. In output feature class give an appropriate name (e.g. **unsuitable**) and **save in your p:drive.** Do not change the other options. Click OK. You have unionized the 5 files into one file. Open its attribute table and make sure this file contains **27 records**. If features are selected, *Clear Selected Features*.

This file contains many small polygons (result of the Union process). In order to aggregate these neighbouring polygons into larger polygons (to reduce their number) you can use the **dissolve tool** in the Geoprocessing menu. Select *unsuitable* as the input feature and name the output feature **unsuitable_final**. At the bottom of the dissolve window **uncheck the *Create multipart features (optional)* box**. Keep the other default options and click OK. You have created five polygons in which it is unsuitable to build your wind farm. Save your project.

## 3.b. Finding areas that meet the two last constraints (suitable for the site)

Since these two constraints are required for a site to be suitable, what you need to do is to find the intersection set of the features from these two layers. This intersection set includes the areas you want.

Use ArcToolbox > Analysis Tools > Overlay > Intersect, to combine the two layers. In *Input feature class* add the two shapefiles you want to intersect. In *output feature class*

give an appropriate name (e.g. **suitable**). Open the attribute table: this file should include 89 polygons.

4. Finding the areas satisfying the six conditions

To find areas that meet the six constraints, you will use the overlay tool "erase" (ArcToolbox > Analysis Tools > Overlay > Erase). Drag your "suitable data" into **Input Features**, and your "unsuitable data" to the **Erase Features**. Name your output file **potentialSites.shp** (make sure that you save it on your p drive)**.** Click OK. This file should have 32 polygons.
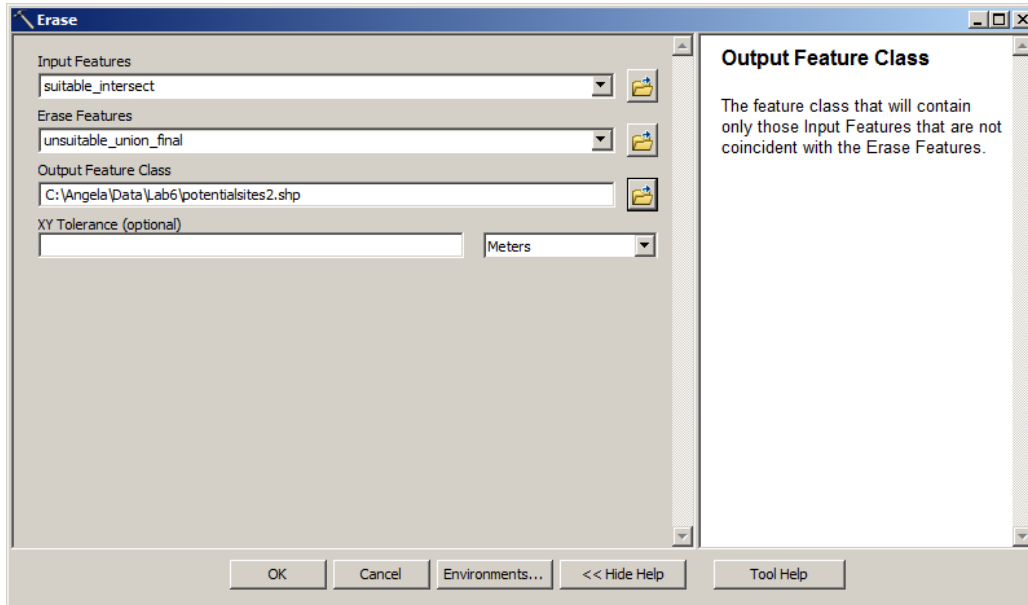
ERASE

Creates a feature class by overlaying the Input Features with the polygons of the Erase Features. Only those portions of the input features falling outside the erase features outside boundaries are copied to the output feature class.

INPUT

ERASE FEATURE

OUTPUT
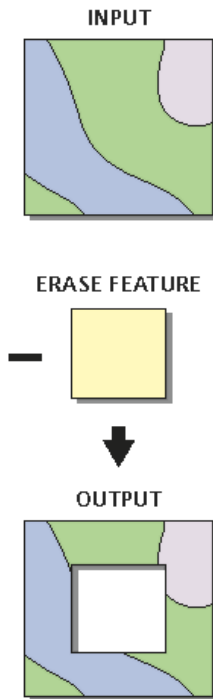
5. Calculating the surface of the resulting polygons (constraint 7)

To see which of these polygons meet the last constraint (surface between 500,000 and 1,000,000 square meters) we need to calculate the surface of these polygons. But before calculating the areas, we need to **regroup contiguous polygons together**. As you can see in **potentialSites**, a same site can be divided into several polygons. This is the consequence of the multiple overlaying we have done so far. To combine the contiguous polygons we need to use the **Eliminate** tool. Eliminate merges the selected polygons with neighbouring polygons based on shared border.

  a. *Clear selected features.*

  b. Select all the features in **potentialSites**. Right click on **potentialSites** and go to *Selection > Select all.*

  a. In **ArcToolbox**: Data Management Tools > Generalization > Eliminate. Select **potentialSites** as the *input layer* and name the *output layer* **potentialSites_merged**. Uncheck the *Eliminating polygon by border (optional)* box. Press OK. You have merged the contiguous polygons. Open the attribute table: This file should include 17 polygons.

To see which of these polygons meet the last constraints (surface between 500,000 and 1,000,000 square meters) you need to calculate the surface of these polygons. ArcGIS can calculate the surface (and perimeter) of polygons. To calculate this surface, open the attribute table of **potentialSites_merged**, click on **Options** and select **add field.** Name the field *area* and select *long integer* as *Type* (the precision refers to the number of decimals: we can leave it at 0). Click Ok. You have created a new empty field. To calculate the surface right click on the field title (*area*) and select *Calculate Geometry*. Read the warning message and click *Yes*. By default you are calculating the area in square meters. Click OK. You now have the area of each polygon in square meters.

You can now use select by attribute function in order to select the polygons with a surface between 500,000 and 1,000,000 square meters. These 4 polygons are the sites that meet your 7 constraints. Export them as a new shapefile. They are the potential site for constructing a wind farm in this area near Quebec City.