ENVR/GEOG 260 – Introduction to Geographic Information Systems
<u>LAB 4 – Introduction to Spatial Analysis and the Geodatabase</u>

Due date: Thursday, November 14, 2002

<u>NOTE</u>: This lab is fairly extensive, but there are many instances where I ask you to address specific items or questions in your lab write-up. **<u>These will be denoted by bold face and underlined text</u>**. Be sure that you address these items in your write-up, as this is where much of your grade will come from!

As in previous labs, you will be using the <u>Getting to Know ArcGIS Desktop</u> as a primary reference book for many of the functions in this exercise.

<u>Introduction</u>

The purpose of this lab is to:

1. Allow you to become familiar with some basic spatial analysis operations with ArcGIS (buffering, clipping, selection operations);
2. Show you the basic structure of the "Geodatabase", a spatial database structure that ESRI has incorporated into ArcGIS;
3. Show you haw you can use ArcGIS to address "what-if" questions using spatial analysis.

The basic idea behind this lab is this: You have been asked by the UR Physical Plant to come up with an estimate of potential monetary property loss based on fires occurring in buildings around campus. You will be given data that allows you to estimate how accessible a building is from a fire hydrant, as well as an approximate building value on a per-square-foot basis. The Physical Plant understands that your estimates are rough approximations; your job, ultimately, is to show where the campus needs to place new fire hydrants in order to provide fire protection to the building around campus.

Assume that the Henrico County Fire Department has informed you that the maximum practical length of a fire hose from a fire hydrant is 100 meters. Your task in this exercise is to figure out the total potential loss due to fire on the UR campus based on complete accessibility to fire hydrants. In other words, if a building is not completely within 200 meters of a fire hydrant, it cannot be saved from fire, and thus could be completely destroyed in the resulting conflagration. On the other hand, if a building is within the prescribed 100 meters of a hydrant, you might be able to save the building by nipping the fire in the bud. Your job, therefore, is to figure out which building might be destroyed, and which ones might be saved, and what the resulting destruction could be in terms of monetary loss. To help you in your calculations, the Physical Plant has estimated that a typical building can be completely rebuilt for about $230/ft^2/floor, given that an average UR building has 2.75 floors.

<u>Data</u>

The data are in "zipped" format, which means you need to "unzip" the data to your network drive prior to starting the lab. I suggest you create a folder specifically for this

Lab 4 assignment, and place the data files into that folder. (Proper organization in advance of starting any project will make things go much more smoothly in any project!) The data are included in a file called "lab4data.zip". This file contains:

- UR-area building data ("bldgs_ur", derived from Lab 1)
- UR-area street data ("pavecln_ur", derived from Lab 1)
- UR fire hydrant data ("hydrants_ur", derived from the combined efforts of the class in Lab 2)
- UR campus outline shapefile ("UR_outline")
- a TIF image of the UR area ("UR_DOQQ.TIF") along with a reference file ("UR_DOQQ.TWF")
- This lab sheet

LAB PROCEDURES

The procedures for this lab fall into six general areas:

1. Transforming the existing data into a common projection/coordinate system
2. Trimming ("clipping") the shapefiles to include only the UR campus area
3. Creating a geodatabase to hold the vector data, and importing the data into the geodatabase
4. Creating a buffer around the fire hydrants such that you can identify the buildings that are within a set distance from a hydrant
5. Identifying those buildings that are outside the operational range of one or more hydrants
6. Calculating the potential monetary loss to the University (assuming complete property destruction due to fire) based on a given property replacement value

1. Data preparation

Open ArcMap, ArcCatalog, and ArcToolbox. Use ArcCatalog to create a link to your Lab 4 folder containing the data. Add the Lab 4 data to an empty layer, and arrange the files in a comprehensible fashion on your TOC, altering the Symbology as necessary to make viewing the data easier**. Include a screenshot of this in your write-up.**

Using the ArcCatalog, look at each layer's metadata, and identify the data type (point, line, etc.), projection, datum, and measurement unit (i.e., feet, meter, degree, etc.) for each feature, placing the data into the table below:

Layer Name	Type	Projection	Datum	Unit
bldgs_ur				
pavecln_ur				
hydrants_ur				
UR_outline				
UR_DOQQ				

Your next step is to change your data into a common projection/coordinate system. One of the limitations of ArcView is that, while you can use raster images in a variety of projections, you can't change raster images from one projection/coordinate system to another. Since you can change the vector data in this regard, but not the raster data, it is logical to change the vector data into the same coordinate system as the raster image. Use the Projection Wizard in ArcToolbox to reproject the shapefiles into the same coordinate system as the raster image, giving them new names that are descriptive (and therefore won't be confusing to you later on). Place these new data sets, along with the raster image, into a new map layer, applying the appropriate symbology to the data and rearranging as necessary. (You can import the symbology from the previous layers, using the techniques demonstrated in class for Lab 3.) **Include a screenshot of this in your write-up.**

2. Spatial Analysis I: Clipping

In order to make the data analysis easier from a processing standpoint, it is often useful to trim the data down to include only those areas of interest. If you know in advance what spatial area you are interested in (e.g., the UR campus boundary), an effective way to do this is to use a shapefile containing the boundary of your area of interest. One of the files you transformed in the previous step contained this outline information.

The clipping feature is one of several tools contained in the "Geoprocessing Wizard" (Tools> Geoprocessing Wizard). The tool you are interested in at this point is labeled "Clip one layer based on another," which is outlined in GTKAD starting on page 283 in Chapter 11. Follow the direction in the text to clip the projected vector layers using the UR campus boundary layer, giving each new layer a descriptive name. **Examine the attribute tables for the new layers. Are there any differences between the old and new attribute tables? Why or why not?**

3. Creating a geodatabase

With the release of ArcGIS 8.1, ESRI has introduced a new tool for holding and using geospatial data: the "geodatabase". The geodatabase, which is constructed along the lines of a Microsoft Access database, allows you to create a data "container" that can contain multiple data types. There are a variety of reasons why you might want to use such a data container, but we will focus on just two of these reasons:

1. You can pull together a variety of data types (shapefiles, tables, ArcInfo coverages, etc) into a single "package", thus simplifying data organization;
2. When importing projected polyline and polygon features, the geodatabase automatically creates and updates the attribute tables to include fields that contain length (for polyline) or area and perimeter (for polygon). When performing geospatial operations (clipping, intersections, etc.), these fields are automatically updated, and reflect the coordinate system in use by the features.

For this exercise, you will create a "personal geodatabase" in ArcView, containing the vector features you have projected and clipped in the previous part of this assignment. This is done in ArcCatalog. Using the instructions in chapter 14 of GTKAD, create a personal geodatabase, using the clipped projected data you created earlier. Individually add each of the vector features, and then create a new map containing the all features in the geodatabase.

To illustrate the differences between the old and new attribute tables, open up the shapefile attribute table for the projected version of the "buildings" shapefile, and list the fields. Then, open up the version of "buildings" in the geodatabase, and list the fields. What additional fields are present in the geodatabase version? What are the units of the new fields?

4. Spatial Analysis II: Creating buffers

The process of creating buffers around features is a very important operation in spatial analysis, and forms the basis for much of the modeling capability in GIS. In ArcGIS, it is very simple to create buffers, assuming you have already applied a projection and coordinate system to your data. This is done using the "buffer wizard", found under Tools>Buffer Wizard in ArcMap.

With the geodatabase containing your clipped and projected data loaded into a new map frame, and your data properly arranged for easy viewing, start the buffer wizard. Using the direction in your text, and following the on-screen directions, create a buffer layer around the fire hydrants. Be sure to set the buffer distance to 100 meters, and save the results as a separate layer in your map. **What sorts of features (lines, points, etc.) were created using the buffer wizard? Examine the attribute table, and list the fields in the database. Arrange the buffer layer on your map in a logical manner, and include a screenshot in your report.**

5. Identify the UR buildings that are not completely within 100 meters of a fire hydrant.

The way you select features based upon their proximity to another feature is found under Selection>Select by Location. Choose that you wish to "select layers from", make sure that only your clipped building layer is checked, choose "are contained by", and choose the buffer layer you created in the previous step. Since the buffer has already been chosen to delineate an area 100 meters from the hydrants, set the buffer to zero, and choose "meters" as the unit. When you are satisfied with your selection method, click Apply. **What happens on your map screen?** Close the selection dialog, and notice that your selection remains on your map.

At this point, you have selected (that is, you have identified) all the buildings that are within 100 meters of a fire hydrant. Since you want the buildings that are outside of a 100-meter radius from any hydrant, you need to "switch" (that is, toggle) the selection. This is done by right-clicking on the building layer to bring up the context menu, and going to Selection>Switch selection. **What happens when you do this?**

You also want to export the selected buildings to their own layer. This is also found under the context menu; go to Selection>Create layer from selected feature. This will place the buildings outside the 100-meter radius into their own layer. You can then save this layer into its own shapefile by right-clicking on the selected layer, going to Data>Export data, and specifying a shapefile name. (If you wish, you can import this shapefile into your geodatabase.) **Open the attribute table of your selected buildings, and right-click on the field heading for the area of the buildings and choose "statistics". How many buildings are not completely inside a 100-meter radius from a fire hydrant? How much total square footage is indicated? What is the average size building among those selected? (Be careful of the units!)**

6. Calculate the potential loss given a catastrophic fire.

It would be a simple matter to simply take the summary values from the preceding section to calculate total loss for the building as a whole, but the administration would like to see how much each individual building in this selection would cost to replace, since it is extremely unlikely that *all* of the buildings would go up in flames at once. Therefore, we would like to have this information appended on to the attribute table for the selection layer. The procedure for modifying an attribute table with calculations from another part of the table was covered in a prior lab. **Using these methods, and based on the shape area for each building in the selected area, convert the footprint area for each building into an approximate cost for replacement, based on the assumption that the replacement cost (per square foot of actual building space) is $230, and that an average building has 2.75 floors. Include a screenshot of both the attribute table and the statistics after the calculations are done (as per the previous section). Be careful of your units!! What is the largest building cost being shown, and what campus building does this correspond to? Do you think this figure is accurate, based on the assumptions of replacement cost? Why or why not? If not, what assumption is being violated in this building?** Alter the symbology for this layer, giving a descriptive label (i.e., a name) to each unique building. (You will probably have to consult a campus map for assistance.) **Include a screenshot of the resulting map, showing only on the buildings, the hydrants, the buffer, the raster image, and the streets.**