

Project in AM for the Semester

Information Technologies in Areal Management discipline

Master's Degree in Human Geography, the First Year



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Introduction

Through this text the students will conduct a sample Areal Management project. The tasks they perform will help them learn the methods for performing their own GIS-AM projects. Users learn about several specific GIS analysis techniques and, what is more, they will learn how to plan and carry out a GIS-AM project.

This text provides an overview of GIS-AM analysis and presents the steps involved in conducting a GIS-AM project. It walks a user through the first step—*planning the project*. The scenario for the Areal Management project involves finding the best site for a new wastewater treatment plant for some non-existing city of *Green Valley, Somewhere in Europe*. To find a suitable site a user will need to know the *site selection criteria*. A user will then need to identify the data needed to address these criteria and use the data to find suitable sites for the plant. These are fundamental elements of a GIS Areal Management project.

Planning a GIS project in Areal Management

The steps in a GIS project

In a typical GIS analysis project, you identify the objectives of the project, create a project database containing the data you need to solve the problem, use GIS functions to create an analytical model to solve the problem, and present the results of the analysis.

Step 1: Identify your objectives

The first step of the process is to identify the objective of the analysis. You should consider the following questions when you are identifying your objectives:

- What is the problem to solve? How is it solved now? Are there alternate ways to solve it using a GIS?
- What are the final products of the project—reports, working maps, presentation-quality maps?
- Who is the intended audience of these products—the public, technicians, planners, officials?
- Will the data be used for other purposes? What are the requirements for these?

This step is important because the answers to these questions determine the scope of the project as well as how you implement the analysis.

Step 2: Create a project database

The second step is to create a project database. Creating the project database is a three-step process. The steps are designing the database, automating and gathering data for the database, and managing the database.

Designing the database includes identifying the spatial data you will need based on the requirements of the analysis, determining the required feature attributes, setting the study area boundary, and choosing the coordinate system to use.

Automating the data involves digitizing or converting data from other systems and formats into a usable format, as well as verifying the data and correcting errors.

Managing the database involves verifying coordinate systems and joining adjacent layers.

Creating the project database is a critical and time-consuming part of the project. The completeness and accuracy of the data you use in your analysis determines the accuracy of the results.

Step 3: Analyze the data

The third step is to analyze the data. As you've seen, analyzing data in a GIS ranges from simple mapping to creating complex spatial models. A model is a representation of reality used to simulate a process, predict an outcome, or analyze a problem.

A spatial model involves applying one to three categories of GIS functionality to some spatial data. These functions are:

- Geometric modeling functions—calculating distances, generating buffers, and calculating areas and perimeters
- Coincidence modeling functions—overlaying datasets to find places where values coincide
- Adjacency modeling functions—allocating, pathfinding, and redistricting

With a GIS you can quickly perform analyses that would be impossible or extremely time-consuming if done by hand. You create alternative scenarios by changing your methods or parameters and running the analysis again.

Step 4: Present the results

The fourth step is to present the results of your analysis. Your final product should effectively communicate your findings to your audience. In most cases, the results of a GIS analysis can best be shown on a map.

Charts and reports of selected data are two other ways of presenting your results. You can print charts and reports separately, embed them in documents created by other applications, or place them on your map.

What's next?

Now that you have reviewed the steps in a GIS project, you are ready to begin planning your own project. The next section presents an overview of the steps for the Greenvally wastewater treatment plant project. The first step—identifying the project objectives—is covered in this chapter. The rest of the steps comprise the remaining chapters in this book.

Planning your project

Planning is a critical step in any GIS project and can save you time and effort once you get to the database creation, analysis, and mapping steps. During the planning phase you identify the project objectives, define the criteria for the analysis, and identify the data required to support the analysis. You should also consider the approach you'll use for the analysis and what the final products of the project will be. Once you've done this, you can proceed to create the project database.

Throughout the rest of this book you will be working on a small GIS analysis project. In the process, you'll learn how to plan a GIS project and how to use ArcMap and ArcCatalog together to carry it out. While you'll be performing a specific type of analysis—finding a site for a new facility—the steps you'll follow in the project, and many of the specific tasks, will be applicable to a range of GIS projects. The scenario for the project is to find a suitable site for a new wastewater treatment plant.

The city of Greenvally is growing. To support this growth, the city is building a new wastewater treatment and recycling plant. The city plans to use conservation and wastewater recycling to help meet its expected water needs.

The diagram to the right outlines the steps in a GIS project and shows where each step is covered in the remaining chapters in this book.

In this chapter, you'll carry out step 1—identifying the project objectives. You'll also do some planning for the remaining steps.

Steps in a GIS project

Step 1: Identify the project objectives—Chapter 4

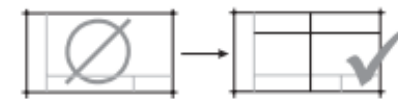
CRITERIA	DATA SET	ATTRIBUTES

Step 2: Create the project database

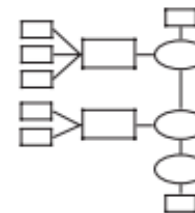
Assemble the data—
Chapter 5



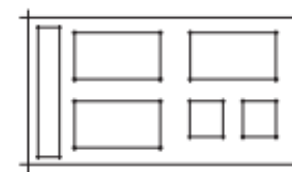
Prepare the data for
analysis—Chapter 6



Step 3: Analyze the data—Chapter 7



Step 4: Present the results—Chapter 8



Step 1: Identify the project objectives

The objective of this GIS analysis is to find a suitable site for the city's new wastewater treatment plant. The city has never used a GIS model to site a wastewater treatment plant. The existing plant was sited many years ago using a quadrangle map, acetate overlays, and the city council's knowledge of the area in consultation with the city engineer. This approach was adequate but time-consuming, and the public was not involved in the process.

The problem has become more difficult as the area has become more developed and environmental and public health regulations more stringent. The council has chosen to use a GIS model in order to speed the process and to ensure that the necessary regulations are complied with.

Because the council recognizes that siting such a plant can be controversial, it wants the analysis to identify all of the parcels that could be used for the plant site, then identify the highly suitable parcels, based on specific criteria. The possible sites will be discussed at a public meeting. The map you create for the meeting should make clear which parcels are highly suitable, which are less suitable, and which are unsuitable.

The city has provided you with a list of the criteria for a suitable site. The parcels chosen for the site must be:

- Below 365 meters in elevation, to minimize pumping costs
- Outside the floodplain, to avoid spillage during storms
- Within 1,000 meters of the river, to minimize pipeline construction for treated water that is discharged
- At least 150 meters from residential property and parks, to minimize the impact on the city's residents

- On vacant land that can be developed, to minimize land acquisition and construction costs

In addition, to further reduce construction costs, the city would prefer that the site be:

- Within 1,000 meters of the main wastewater junction (within 500 meters is considered even more suitable)
- Within 50 meters of an existing road

The plant will also require a total of at least 150,000 square meters in area.

A preliminary review of existing paper maps has shown that the most likely location for the plant is in the northwest corner of the city, near the river, and in a low-lying area. This will be the study area for the project. The GIS analysis will allow you to combine the criteria to identify specific parcels that are suitable sites.

Step 2: Create the project database

Creating the database for this project will be a two-step process. First you'll assemble the existing data and review it. Then you'll prepare the data for analysis. Some of the data will be usable as is; other layers will need additional processing. You may also need to automate some data. You'll assemble the data in Chapter 5, 'Assembling the database', and prepare the data for analysis in Chapter 6, 'Preparing data for analysis'. At this point, though, you can plan for those tasks by identifying the data layers you'll need and the sources of the data.

Assemble the project data

Several city of Greenvalley departments maintain GIS data and have working arrangements to share data for city projects. Some of this data is already stored in the city's

GreenvalleyDB database. The city also has data sharing agreements with several regional and state agencies.

Because a database containing much of the data you need already exists, you will not need to spend as much time on designing and automating your project database as you would otherwise. However, you will still need to do some database design work for your project database. You'll need to identify the dataset and any attributes required for each criteria. You'll then research the available data to see which layers will meet your needs.

Each of the city's criteria will require a layer of data for the analysis. Here is a list of the criteria and the corresponding datasets and attributes.

CRITERIA	DATASET	ATTRIBUTES
LESS THAN 365 METERS ELEVATION	ELEVATION	ELEVATION IN METERS
OUTSIDE THE FLOODPLAIN	FLOODPLAIN	N/A
WITHIN 1,000 METERS OF THE RIVER	RIVER	N/A
AT LEAST 150 METERS FROM RESIDENTIAL PROPERTY	PARCELS	LAND USE
AT LEAST 150 METERS FROM PARKS	PARKS	N/A
ON VACANT LAND	PARCELS	LAND USE
WITHIN 1,000 METERS OF THE WASTEWATER JUNCTION	WASTEWATER JUNCTION	N/A
WITHIN 50 METERS OF A ROAD	ROADS	N/A
AT LEAST 150,000 SQ. METERS	PARCELS	AREA IN SQUARE METERS

Note that the parcels dataset will be used for several criteria.

You can now take inventory of the data that you have and see which layers correspond to the required datasets. You can also identify other layers that you need to obtain or create.

To find areas below 365 meters elevation, you need a source of elevation data. A colleague at the State Department of Transportation (DOT) has provided an elevation grid. Because you simply need to know whether or not a parcel is below 365 meters, you will use a polygon of areas below 365 meters, which your colleague at DOT has created from the grid. This data is in a shapefile format.

To find parcels outside of the floodplain, you will use the City Planning Department's digital flood zone layer, stored as a feature class in the city's GreenvalleyDB geodatabase.

To identify areas within 1,000 meters of the river, you will first need a layer of the river. The County Water Resources Department has a shapefile of the river.

You will need a dataset of the parcels in your study area. The city tax assessor has a tiled database of parcels stored as shapefiles. Two of these tiles cover your study area. The parcel database includes a land use attribute that you will use to identify residential parcels—so you can buffer them to 150 meters—and vacant parcels. You will use the area attribute of the parcel shapefile to identify possible sites with an area of at least 150,000 square meters.

To find areas more than 150 meters from parks, you'll need a parks layer. The City Parks and Recreation Department has a feature class of existing parks, which is stored in the GreenvalleyDB geodatabase.

There is also a recently discovered historic site in the project study area. The city plans to develop a park around the site, but the proposed park boundary has not been placed into the park feature class yet. You will get this information into your project database by digitizing from a scanned image of the draft park boundary map.

To find parcels within 1,000 meters of the main wastewater junction, you will need a layer that includes the junction. The City Utility Department has a coverage of the wastewater mains and the junction.

To identify parcels that are within 50 meters of a road, you will use the existing streets feature class from the GreenvalleyDB geodatabase.

The table below lists the layers you'll assemble for the project database, based on the available data. The source and the format of each layer are also listed.

LAYER	SOURCE	FORMAT
ELEVATION	STATE DEPT. OF TRANSPORTATION	GRID
ELEVATION < 365 M	STATE DEPT. OF TRANSPORTATION	SHAPEFILE
FLOODPLAIN	CITY PLANNING DEPT.	GEODATABASE
RIVER	COUNTY WATER RESOURCES DEPT.	SHAPEFILE
PARCELS	CITY TAX ASSESSOR	SHAPEFILES (TILED)
PARKS	CITY PARKS AND RECREATION DEPT.	GEODATABASE
HISTORIC PARK	CITY PARKS AND RECREATION DEPT.	SCANNED IMAGE
WASTEWATER JUNCTION	CITY UTILITIES DEPT.	COVERAGE
STREETS	CITY STREETS DEPT.	GEODATABASE

The database will also include the scanned image of the historic park, which you'll use to digitize the new park. You'll also include the elevation grid, as you may want to display it on your final map.

In Chapter 5, 'Assembling the database', you'll assemble the data and organize it so it's easily accessible within a single project folder. You'll then review the data to see which layers will require additional processing.

Prepare the data for analysis

Based on your review of the data, you'll determine which layers are currently usable and which require additional processing for use in the analysis. Some of the common tasks involved in preparing data for analysis include:

- Checking data quality—making sure the data is accurate and up-to-date
- Converting data between formats
- Automating data by digitizing, scanning, converting, or geolocating
- Defining coordinate systems
- Projecting layers to a new coordinate system
- Merging adjacent layers

You'll need to perform some of these tasks for your project database. You already know, for instance, that the boundary of the proposed park surrounding the historic site will need to be digitized. You have a scanned map of the proposed boundary that you will register to the city's geodatabase and digitize using the parcels layer as a backdrop. The new park feature will be added to the existing park feature class in the GreenvalleyDB geodatabase.

You will also need to merge the two parcel tiles for your study area to make the analysis easier to perform.

Once you've reviewed the existing data, in Chapter 5, 'Assembling the database', you'll be able to see which other layers require additional processing.

Most of the data for the project is already in coverage, shapefile, geodatabase, or raster format, all of which ArcGIS can use, simultaneously. There may be cases, though, where you'll need to convert data to a different format—for example, if converting from vector to raster format or from shapefile to geodatabase feature class, for storage in an existing geodatabase.

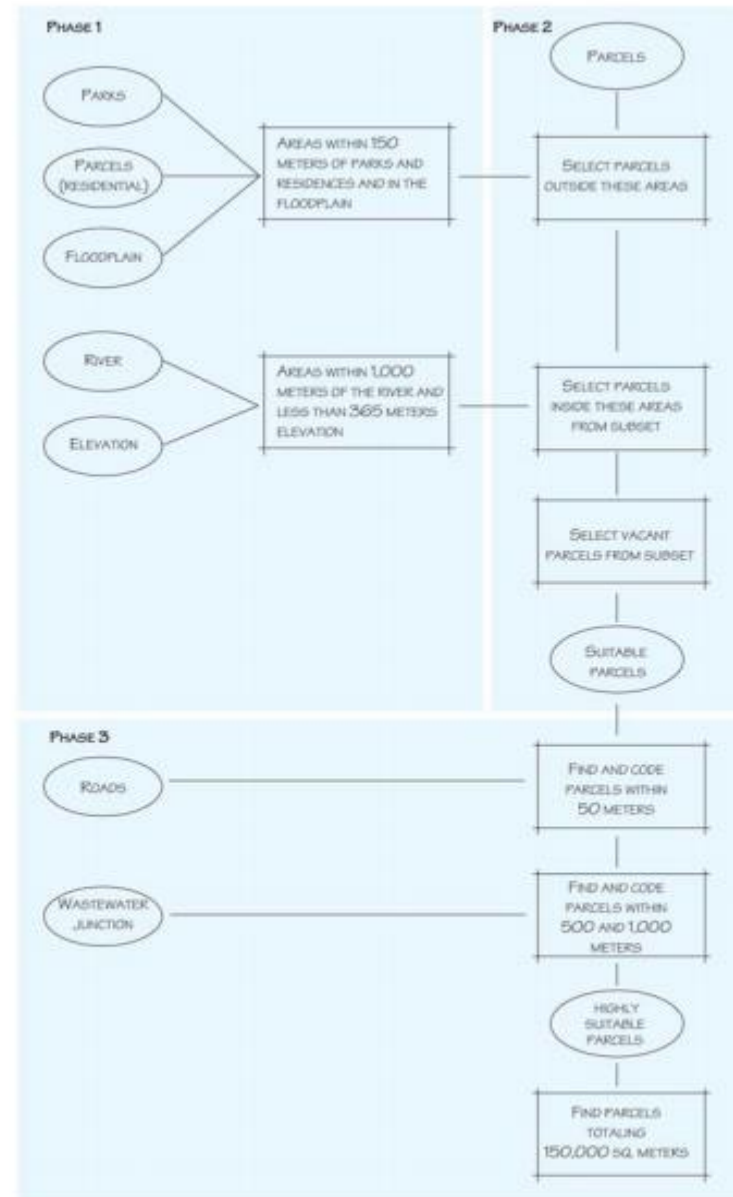
ArcGIS can display and overlay layers in different coordinate systems as long as the coordinate system for each layer is defined. You'll need to check this, especially for data you've obtained from other sources.

You'll perform the necessary data processing tasks in Chapter 6, 'Preparing data for analysis'.

Step 3: Analyze the data

During the planning stage of the project, you'll want to consider the analysis methodology and list the major steps in the process. That way you can make sure you are aware of all the datasets you will need and can include them as you create the project database. You may want to create a schematic diagram of the process as a guide.

The diagram to the right shows the process for the wastewater treatment plant siting analysis.



The analysis consists of three phases.

In the first phase, you'll create a layer of the areas the plant should be outside of and another layer of the areas the plant should be within.

In phase two, you'll use these layers to select a subset of parcels that are in a suitable location. You'll then select the subset of these that are vacant to create a layer of suitable parcels.

In the third phase, you'll consider the city's additional criteria that define the highly suitable parcels. You'll find the suitable parcels within 50 meters of a road and those within 500 and 1,000 meters of the wastewater junction, then tag them with the appropriate codes so they can be identified on the map. You'll also check to see which parcels are large enough for the construction of the plant.

While the schematic shows the major steps in the process, there are a number of interim steps you'll complete in each phase. You'll develop the detailed methodology and perform the analysis in Chapter 7, 'Performing the analysis'.

Step 4: Present the results

During project planning you should consider the purpose and audience for your final products. For this project, you'll present the results of the analysis on a presentation-quality map that shows the parcels that are suitable and highly suitable sites. The map will be presented to a general audience at a public meeting.

While you don't need to design the map layout at this point, you'll want to consider the layers that will be shown on the map. In addition to the analysis layers, you may want to include other layers that will provide context for the analysis results and make the map easier to read and understand.

For this project, in addition to the layers you'll use and create during the analysis, you'll want to show the elevation grid as a backdrop so map readers can see the areas of lower and higher elevation in the city, as elevation has a major impact on the location of the wastewater treatment plant.

You'll design and create the presentation map in Chapter 8, 'Presenting the results'.

What's next?

Now that you've reviewed the steps involved in a GIS project, identified the project objectives, and engaged in some project planning, it's time to get started.

You'll assemble the data for the project and review the data in the next chapter.

Creating the Project Database

Organizing the project database

There are many ways to organize a project database. One good strategy is to create a single project folder, then subfolders to hold the input datasets, and another subfolder to hold the datasets you create during the analysis.

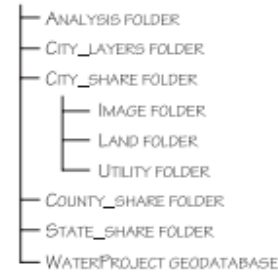
As with many GIS projects, the data for your project comes from several different sources. Some of it is in different data formats or in different coordinate systems. Most of the data has already been collected for you. Here is where the data currently resides:

LAYER	NAME	FORMAT	CURRENT LOCATION
ELEVATION	ELEVATION	GRID	STATE_SHARE FOLDER
ELEVATION < 365 M	LOWLAND	SHAPEFILE	STATE_SHARE FOLDER
FLOODPLAIN	FLOOD_POLYGON	GEODATABASE	GREENVALLEYDB GEODATABASE
RIVER	RIVER	SHAPEFILE	COUNTY_SHARE FOLDER
PARCELS	PARCEL_1, PARCEL_2	SHAPEFILES (TILED)	CITY_SHARE\LAND FOLDER
PARKS	PARKS_POLYGON	GEODATABASE	GREENVALLEYDB GEODATABASE
HISTORIC PARK	HISTORIC.TIF	SCANNED IMAGE	CITY_SHARE\IMAGE FOLDER
WASTEWATER JUNCTION	JUNCTION	COVERAGE	CITY_SHARE\UTILITY FOLDER
STREETS	STREET_ARC	GEODATABASE	GREENVALLEYDB GEODATABASE

You'll copy the data—to maintain the original as a backup—and organize it in a single project folder to make it more accessible. You'll also create a new folder to store the data you'll create during the analysis.

There is no single way to structure a project database; it partly depends on personal preference. The goal is to minimize duplication of datasets and to have the data well organized and easily accessible. This will help avoid confusion during the project as well as if you need to revisit the project in the future. Before you start to create the folders on disk and move the datasets around, it's a good idea to sketch out the organization of the project folders.

PROJECT FOLDER



The City_share, County_share, and State_share folders are stored locally on your computer, but they could represent shared folders accessed over a network. You can use ArcGIS to manage and display GIS data on any shared drive on your network.

You'll also want to think about how to name the new datasets you'll create and to also create naming conventions. Using meaningful names can help you see at a glance what each dataset is. For example, if you merge two parcel datasets, you might name the output parcel01mrg to indicate that it was the first parcel dataset created and the

operation was a merge. If you then edit the dataset, you might name the edited version parcel02edt, and so on.

You'll use ArcCatalog to copy the folder containing the shared data to a new location so you can work with it while maintaining the original data. You'll then create the new personal geodatabase to hold several of the new datasets you'll create. You'll also create the two new folders: one to contain the layers from the city's GreenvalleyDB geodatabase and another to contain the layers you create during the analysis. Here are the steps:

- Copy the project folder.
- Create a connection to the project folder.
- Create the WaterProject personal geodatabase in the project folder.
- Create the City_layers folder in the project folder.
- Create the Analysis folder in the project folder.

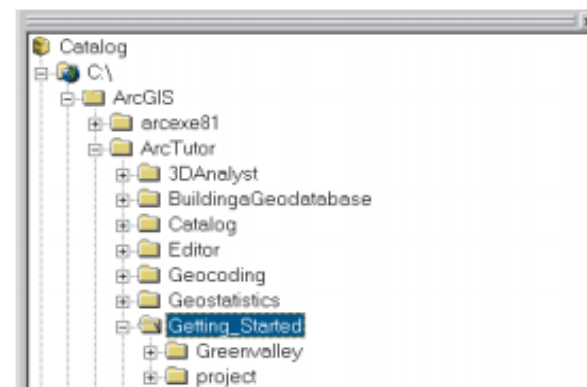
If you have not already done the tutorial in Chapter 2, 'Exploring ArcCatalog and ArcMap', you will need to check with your system administrator to learn where the tutorial data is installed. Before you start the project you will also need to make a folder connection in ArcCatalog to the Greenvalley folder (use the instructions in Chapter 2).

Copying the project folder

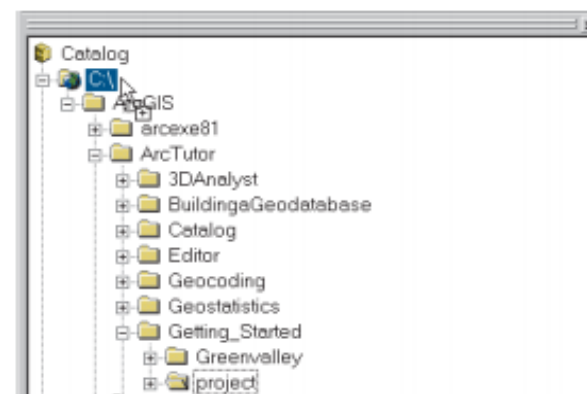
The project folder contains data that other organizations are sharing with you. You'll copy the whole folder to your own drive.

1. Click Start, point to Programs, point to ArcGIS, and click ArcCatalog.

2. Navigate to the ArcGIS\ArcTutor\Getting_Started folder. Double-click the Getting_Started folder to show its contents.



3. Click the project folder, hold the Ctrl key, drag the folder from its current location, and drop it onto your C:\ drive or any other local drive or folder.

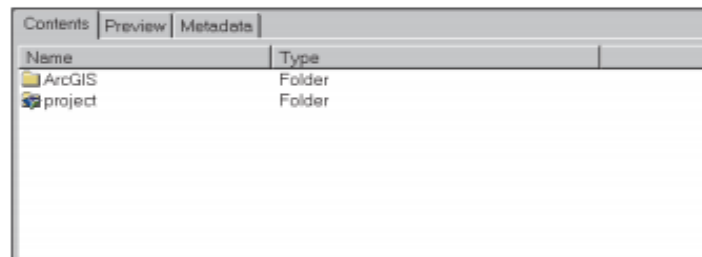


Substitute your local drive or folder for C:\ for the rest of this chapter.

Dragging a folder to another drive—for example, from the C:\ drive to the D:\ drive—copies the folder and its contents to the new location. Dragging to another location on the same drive moves the folder. To copy a folder to another location on the same drive, hold the Ctrl key while you drag.

4. When ArcGIS is finished copying the data, click C:\ in the Catalog tree to view the contents of the C:\ drive on the right side of the Catalog window.

You can see that the project folder is listed.



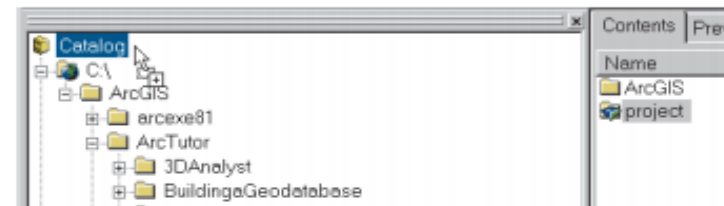
Now that you've copied the project folder, you can work on your copy of the data without modifying the original data.

Connecting to the project folder

If you have many folders on a drive, it can become tedious to scroll to one you use frequently. Making a connection puts that folder at your fingertips. You'll create a connection for the project folder.

In the tutorial, you made a folder connection by clicking Connect to Folder and browsing. Here is a quicker way:

1. Click the List button . Navigate to the project folder in the right side of the Catalog window (the Contents tab should be selected).
2. Click the project folder and drag and drop it onto Catalog at the top of the Catalog tree.



The new folder connection—C:\project—is now listed in the Catalog tree.

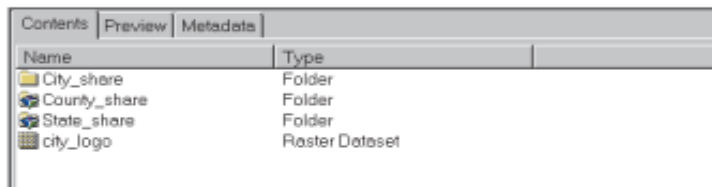


The connection is a shortcut to the project folder. For the rest of the project, you'll access the data in the project folder using this connection.

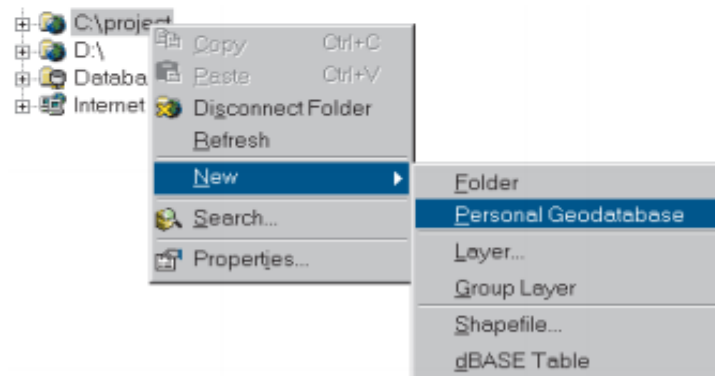
Creating a personal geodatabase

Next, you'll create a personal geodatabase within the project folder to store several of the updated and new datasets you'll create during the project. Using a geodatabase is an efficient way of storing, accessing, and managing data.

1. Click the project folder connection you just created to see its contents in the right side of the Catalog window.

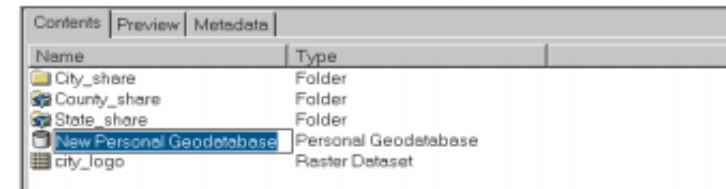


2. Right-click the project folder connection, point to New, and click Personal Geodatabase.

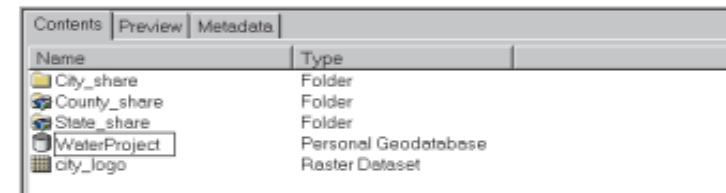


You will see additional options if you are using ArcInfo.

The new geodatabase is listed in the right side of the Catalog window with its name highlighted (New Personal Geodatabase).



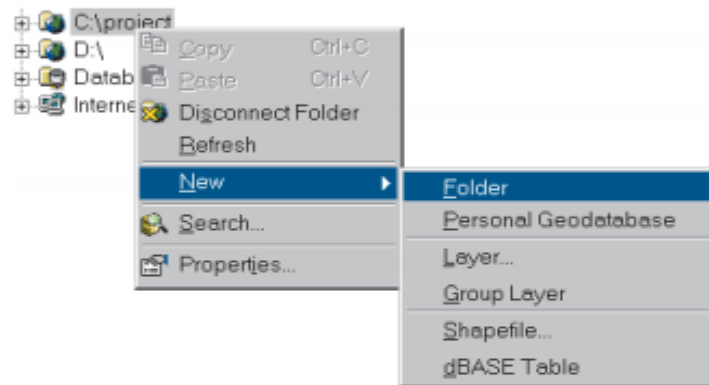
3. Rename the geodatabase by typing "WaterProject" over the highlighted text. Press Enter.



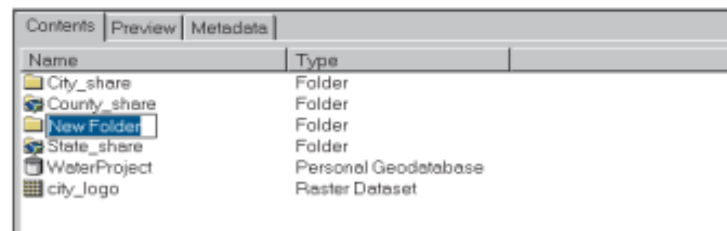
Creating the City_layers and Analysis folders

Now you'll create two new folders under the project folder to hold the layers from the city's GreenvallyDB geodatabase and the new layers you'll create later during the analysis.

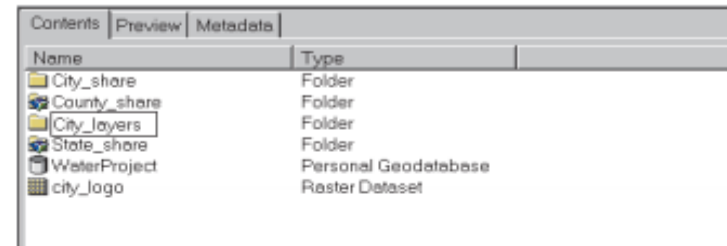
1. Right-click the project folder, point to New, and click Folder.



The new folder is listed on the right side of the Catalog window with its name highlighted—New Folder.

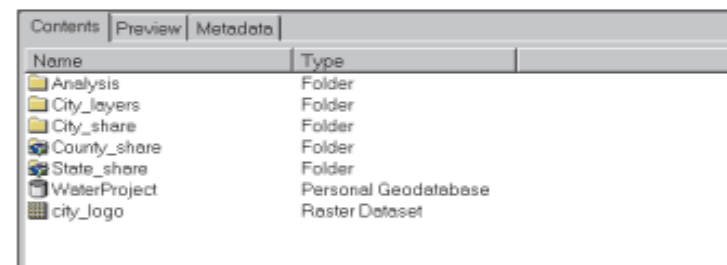


2. Rename the folder by typing "City_layers" over the highlighted text. Press Enter.



Create the Analysis folder the same way.

3. Right-click the project folder, point to New, and click Folder. Rename the folder "Analysis".



If you make a mistake and create the folder in the wrong location or misspell the name, simply right-click the folder, click Delete or Rename, and start over.

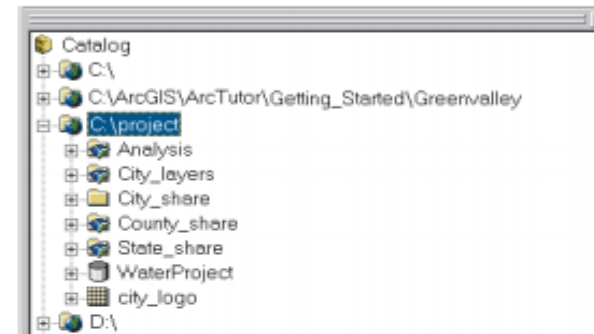
Adding data to the project folder

Three of the data sources you need—parks, streets, and the flood zone—are in the city's GreenvalleyDB database, which is already on your local drive. Since you'll be modifying the parks feature class by adding the new historic park, you'll copy it to the WaterProject geodatabase you just created. That way, you maintain the original data as a backup. You won't be modifying the other two feature classes—only using them for display and analysis. Rather than copying them, you'll create layers in the project folder that point to the original data in the GreenvalleyDB geodatabase. This will let you access the data from within the project folder without creating duplicate datasets. This is especially useful when accessing data over a network. Here are the steps:

- Copy the parks feature class from the GreenvalleyDB geodatabase to the WaterProject geodatabase.
- Create the streets layer in the City_layers folder.
- Create the flood_zone layer in the City_layers folder.

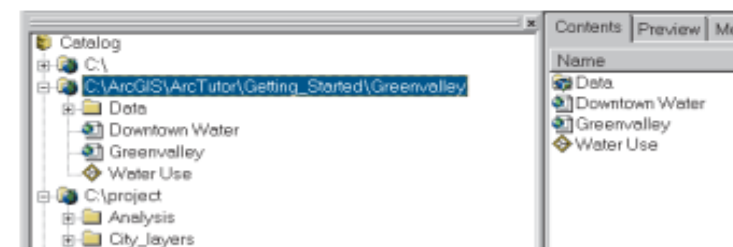
Copying the parks feature class to the WaterProject geodatabase

1. Click the plus sign next to the project folder in the Catalog tree to expand the contents.



2. Double-click the Greenvalley folder connection in the Catalog tree.

The contents appear in the right side of the Catalog window.



In the tutorial in Chapter 2, you created a connection to the Greenvalley folder. If the connection is no longer active, navigate to the Getting_Started folder, expand its branches, and click the Greenvalley folder.

3. In the Catalog tree, double-click Data, double-click GreenvalleyDB, and double-click the Parks feature dataset.

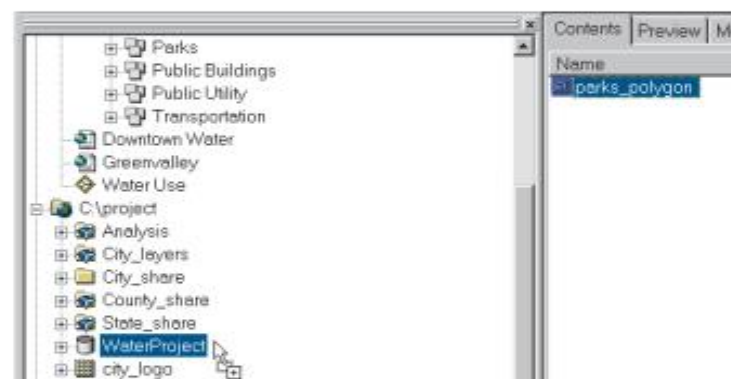


The GreenvalleyDB geodatabase is organized using feature datasets such as hydrology and transportation. Feature datasets are useful for grouping related feature classes within a geodatabase. For example, you might include feature classes, such as water mains, laterals, junctions, and pumps, within a feature dataset named WaterSystem. All the feature classes within a feature dataset have the same geographic extent. In addition, the feature classes maintain

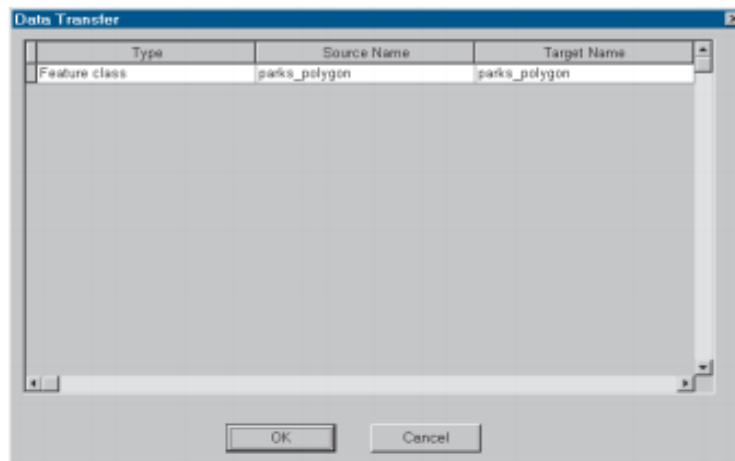
some common topological relationships. So, for example, if you edited the junction feature class and moved the location of a water junction, the attached lines in the mains and lateral feature classes would move accordingly.

Since the WaterProject geodatabase you created will contain only a few feature classes, it's not necessary to use feature datasets.

4. Click and drag the parks_polygon feature class to the WaterProject geodatabase in the Catalog tree. Scroll down if the WaterProject geodatabase isn't visible.

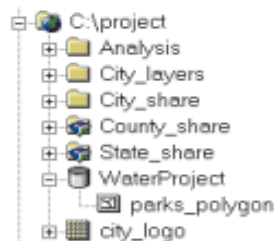


5. Click OK on the Data Transfer dialog box that appears.



6. When the transfer is complete, click the plus sign next to the WaterProject geodatabase in the Catalog tree.

The parks_polygon feature class is listed.

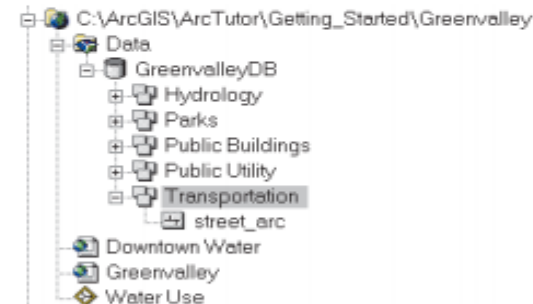


Creating the streets and flood zone layers

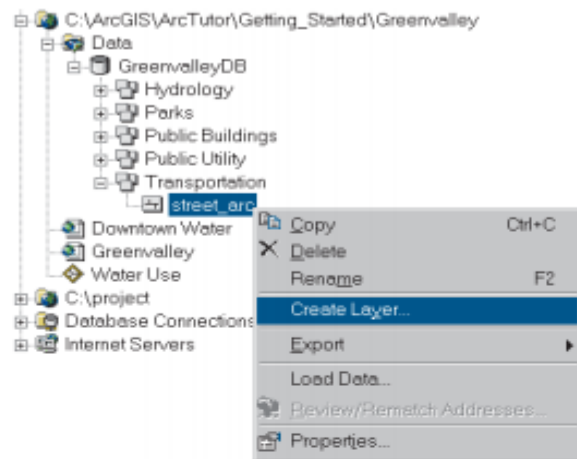
Unlike the parks feature class, you won't be modifying the streets and flood zone data—you'll simply be using the data in the analysis process. So, rather than copying the data into the project folder, you'll create layers to serve as shortcuts to the data. That way, you maintain a single copy of the data in the GreenvalleyDB but will be able to access the data from within the project folder.

The contents of the GreenvalleyDB geodatabase should still be visible in the Catalog tree. If not, double-click the Greenvalley folder to show its contents, then double-click Data, and double-click GreenvalleyDB.

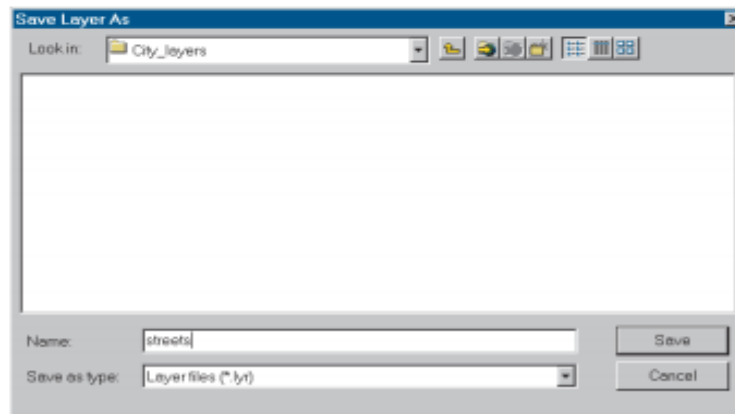
1. Double-click Transportation.



2. Right-click `street_arc` and click Create Layer.



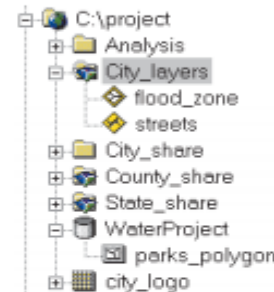
3. In the Save Layer As dialog box, navigate to the `City_layers` folder in your project folder and type “streets” to name the layer. Click Save.



The streets layer is created in the `City_layers` folder.

Use the same procedure to create a layer for the flood zone data.

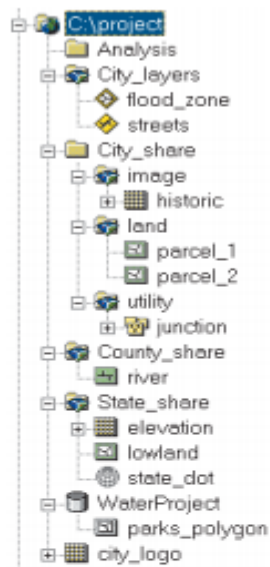
1. Double-click the Hydrology feature dataset in the Catalog tree, right-click the `flood_polygon` feature class, and click Create Layer.
2. Navigate to the `City_layers` folder in your project folder and type “flood_zone” to name the layer. Click Save.
3. Click the project folder in the Catalog tree and double-click the `City_layers` folder.



The two layers are listed; you may need to click Refresh on the View menu to see them.

The streets and flood_zone layers are now stored with your project data. The actual data for each layer is stored in the GreenvalleyDB database. This database is on your local drive in this case, but it could just as easily be a remote database accessed over a network.

At this point, you've organized all the existing project data. Now you can access all the data from within the project folder. Your project folder should look like this:



You may need to open each folder and the geodatabase to see all the layers.

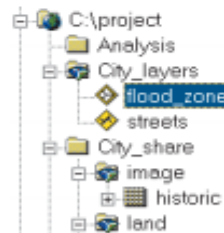
Previewing the data in ArcCatalog

So far you've organized the project data by copying data folders and files. It's a good idea to review each dataset to see what the spatial data looks like and what attributes it has. Doing so will help you make sure you've assembled the datasets you need. You will also be able to determine if any of the data needs additional processing to be usable for the analysis.

You have several options for examining the data. ArcCatalog lets you quickly preview the features and attributes in each individual dataset. ArcMap lets you display the datasets together, change how they're displayed, and zoom in on them to take a closer look. You'll use both ArcCatalog and ArcMap to review your data.

Previewing the streets and flood_zone layers

1. Navigate to and click the flood_zone layer in the Catalog tree.



The right side of the Catalog window displays the name of the layer, along with its type and a gray square containing an icon representing the flood_zone polygons.



2. Click the Preview tab.

The flood_zone polygons are displayed.



While you're here, you can create a thumbnail view of the flood_zone layer. This will let you quickly see what the layer looks like as you navigate through the Catalog tree. Since you just created the layers, the thumbnails don't exist yet.

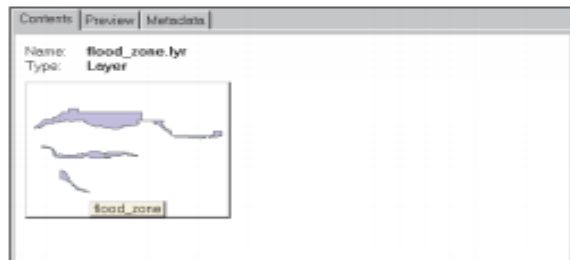
3. Click the Create Thumbnail button on the toolbar.



Nothing happens on the screen, but the thumbnail is created and stored with the flood_zone layer.

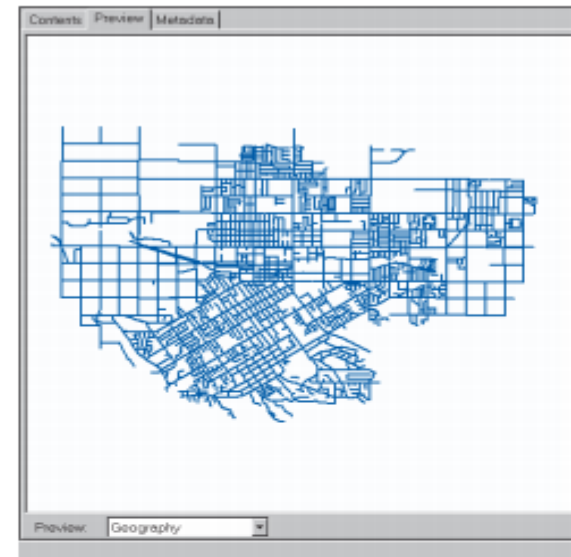
4. Click the Contents tab.

Rather than the gray square you saw previously, you see the thumbnail showing the actual flood_zone polygons.



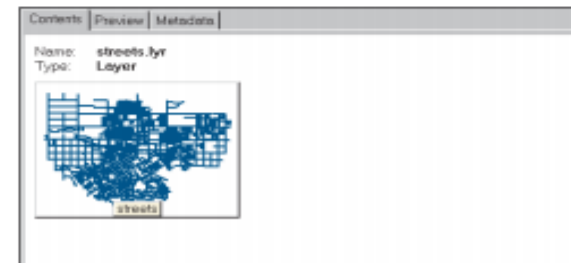
Now preview and create a thumbnail for the streets layer.

5. Click the streets layer in the Catalog tree and click the Preview tab.

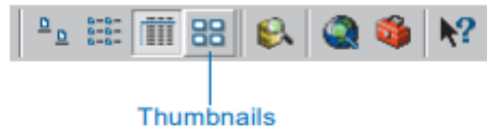


The streets are displayed.

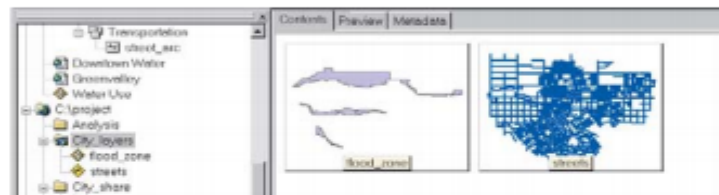
6. Click the Create Thumbnail button on the toolbar.
7. Click the Contents tab to see the thumbnail.



- Click the City_layers folder in the Catalog tree, then click the Thumbnails button on the toolbar.



The thumbnails you just created for these layers are displayed.



Thumbnails are useful for quickly previewing all the spatial data in a particular folder or geodatabase.

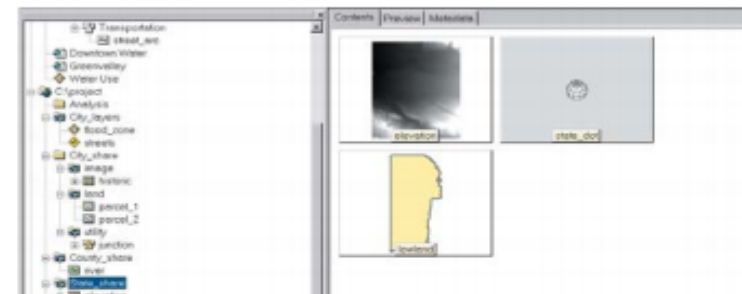
Exploring the other data folders

You can preview the other datasets by looking at the contents of the other folders in the project database. The thumbnails for these datasets already exist.

- Click the plus sign next to the City_share folder in the Catalog tree to list its contents.
- Click the image folder.

Since the Contents tab is selected and the Thumbnail button on the toolbar is also selected, the thumbnail for the historic park TIFF file displays.

- Click the land folder to see the two parcel shapefiles you'll be working with, then click the utility folder to see the water junction coverage.
- Click the State_share folder to display the thumbnails for the elevation grid and lowland shapefile.



The State_share folder also contains a file named state_dot.prj that contains the coordinate system definition for Department of Transportation data. Your colleague at the state DOT wisely included it in case there was a question about the coordinate system of the elevation datasets. Since it's not a geographic dataset, there is no thumbnail.

Previewing the river shapefile

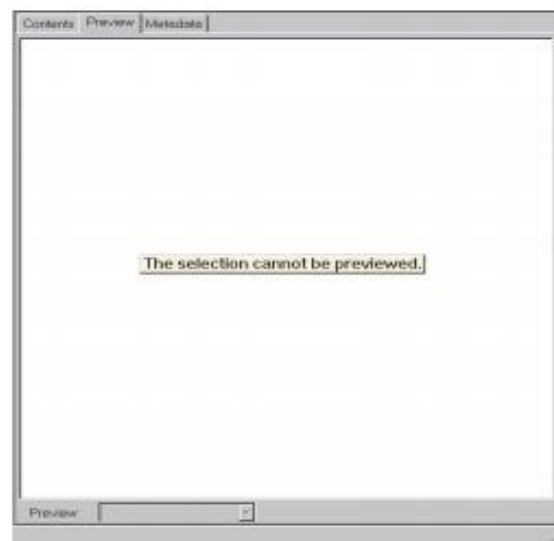
The County_share folder contains the river shapefile created by the County Water Resources Department.

- Double-click County_share to show the folder's contents, if necessary.



The river thumbnail appears. The shapefile contains a single river. You can take a closer look to make sure you have the right shapefile.

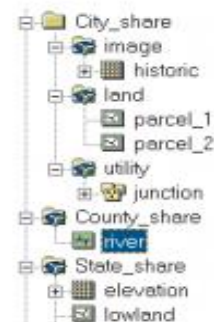
2. Click the Preview tab.



You get a message saying “The selection cannot be previewed.” That’s because the County_share folder is still selected.

The Preview tab previews a single dataset only. In contrast, the Contents tab displays all the datasets in a folder or geodatabase as thumbnails, a list, or icons representing the datasets. The Contents tab will also show you the contents of a single dataset. For shapefiles, feature classes, or image files, it displays the name and type of the dataset, along with the thumbnail. For coverages, the Contents tab lists the files comprising the coverage.

3. Click the river shapefile in the Catalog tree.



Examining the data in ArcMap

The Contents and Preview tabs in ArcCatalog give you a quick overview of what your data looks like. However, the thumbnail images aren't drawn to scale or in the correct geographic space. Plus, each dataset is displayed separately. To see how the datasets relate to each other geographically, you need to display them in ArcMap. This will let you confirm that the datasets all overlap with your study area.

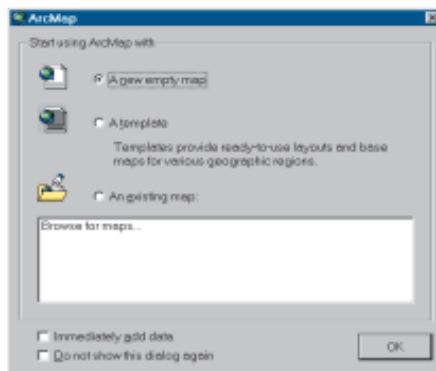
Opening a new map

1. Click the Launch ArcMap button in ArcCatalog to start ArcMap.

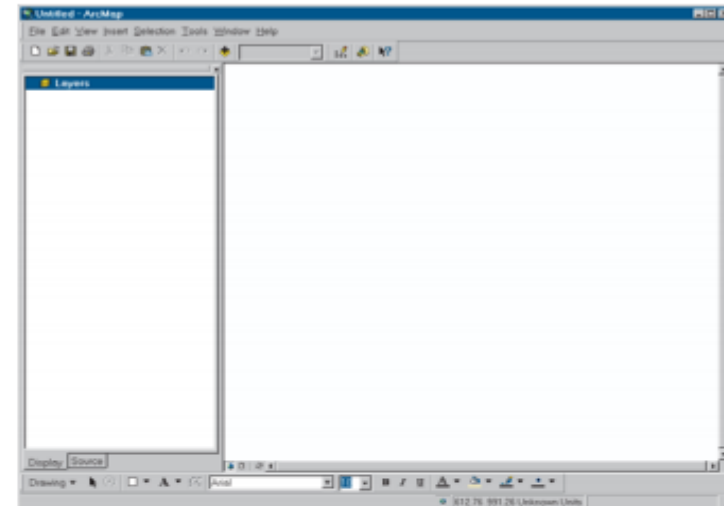


Launch ArcMap

2. If the startup dialog box appears, click the option to use A new empty map and click OK.



If the startup dialog box doesn't appear, ArcMap automatically opens a new map.



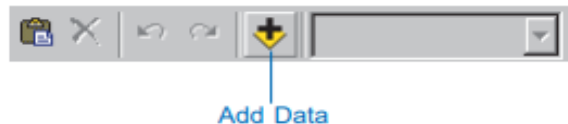
You can think of ArcMap as providing two functions: (1) a workbench, or desktop, where you view, query, edit, and combine geographic data and (2) a canvas, or page, where you compose (layout) maps for display. You usually work in Data view for the former and Layout view for the latter, although you can also work with the data in Layout view. Data view is the default when you start a new map. You'll do most of the work for your project in Data view. You'll work with Layout view in Chapter 8, 'Presenting the results'.

Adding the parcel layers to the map

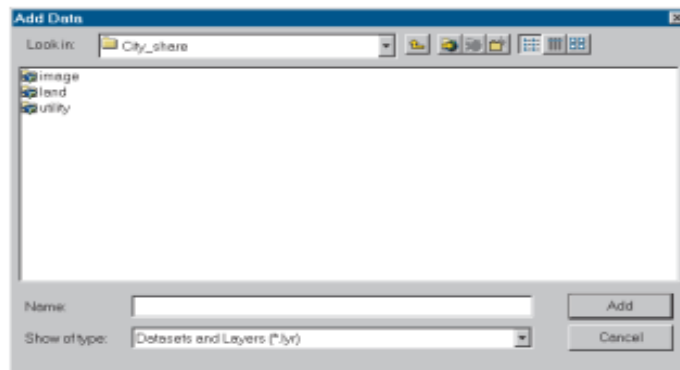
The two parcel layers you've obtained from the city assessor's office constitute the area in which you'll focus your search for a wastewater treatment plant site. You'll combine the two layers in the next chapter, but for now you can display them together to get a better sense of the area you'll be working in.

There are two ways to add data to a map. You can use the Add Data button on the ArcMap toolbar and navigate to the location of the dataset, or you can drag datasets from ArcCatalog and drop them on the map. The end result is the same, so which you use is a matter of preference. You'll get a chance to use both in this section.

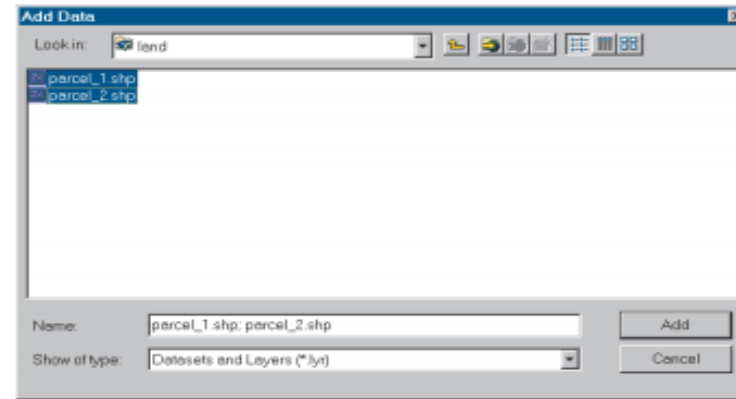
1. Click the Add Data button on the ArcMap toolbar.



2. Navigate to the City_share folder under the project folder.

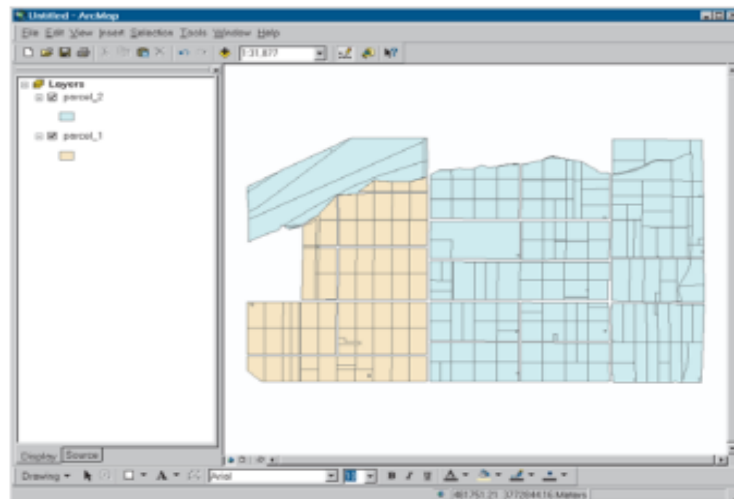


3. Double-click the land folder.
4. Click the parcel_1 shapefile, then press the Shift key and click the parcel_2 shapefile so both are selected.
5. Click Add.



The parcels are listed in the table of contents and displayed on the map. You can see that they're adjacent.

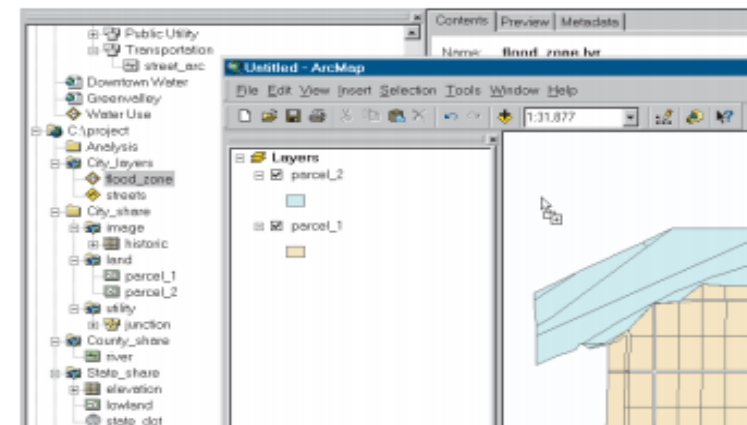
When you add a dataset to a map, ArcMap uses a color that it selects. The colors on your map may not match the ones shown here. You can change the colors and symbols for the layers on your map, as you'll see later in this chapter.



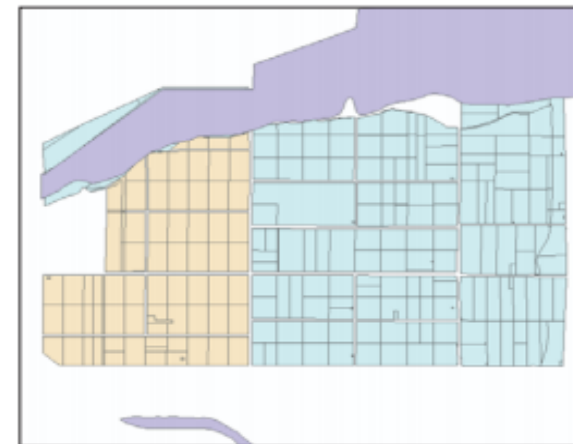
Adding the rest of the city data to the map

Now you'll add to the map the streets and flood_zone layers from the City_layers folder, the parks feature class from the WaterProject geodatabase, and the wastewater junction coverage from the City_share folder. As an alternative to adding data to a map using the Add Data button, you can add data simply by dragging the datasets from ArcCatalog.

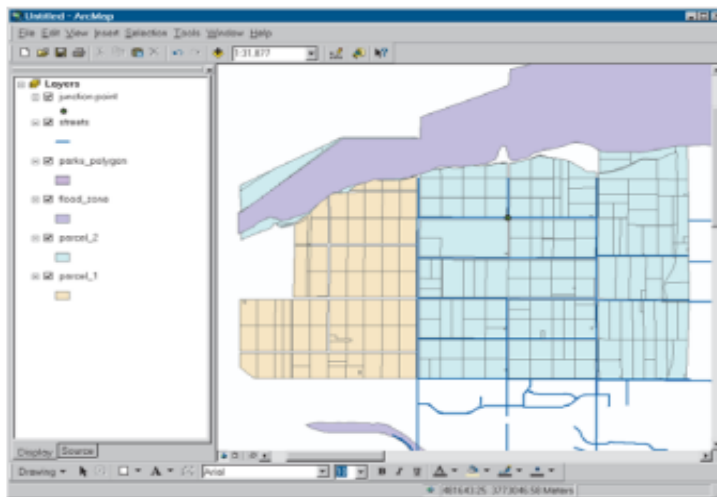
1. Make sure both the ArcCatalog and ArcMap windows are visible.
2. In the Catalog tree, navigate to the project folder.
3. Double-click City_layers, if necessary, to display its contents.
4. Click flood_zone and drag it onto the map.



The flood_zone feature class is drawn on the map.



5. Click the streets layer and drag it onto the map.
6. In the Catalog tree, open the utility folder under the City_share folder. Click and drag the junction coverage onto the map.
7. Finally, open the WaterProject geodatabase, if necessary, and click and drag the parks_polygon feature class onto the map.

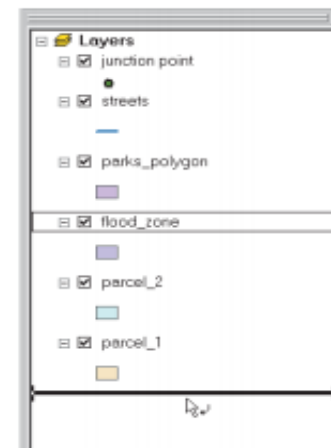


Now you've displayed most of the project datasets, stored in various folders and in different formats, all on the same map.

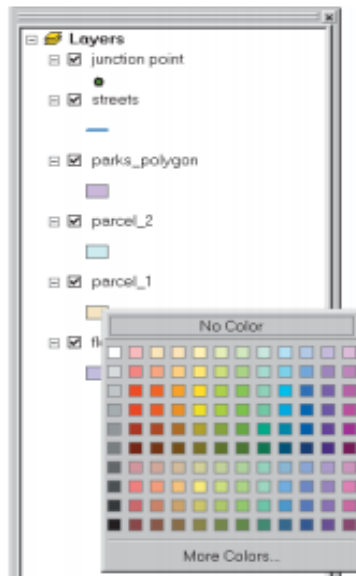
By default, ArcMap draws point features, such as the junction, on top of line features, such as the streets. It draws polygon features under the others. Within each type, the drawing order depends on the order the data was added to the map, with the most recent addition on top. You can rearrange the drawing order by clicking and dragging layers up or down in the table of contents. You can also choose your own colors and symbols for the layers.

Since the flood_zone layer is drawn on top of the parcels, it partially obscures them. You'll display the parcel outlines on top of the flood_zone so you can see the flood_zone beneath.

8. In the ArcMap table of contents, click the flood_zone layer and drag it to the bottom.



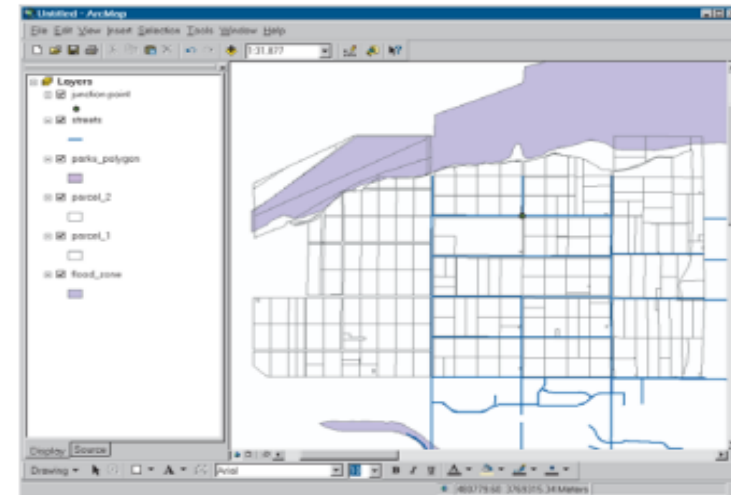
9. Right-click the legend symbol under parcel_1.
10. Click No Color at the top of the color palette.



Do the same for the parcel_2 coverage.

11. Right-click the legend symbol under parcel_2 and click No Color on the color palette.

The parcel outlines are displayed, and you can see the flood zone area underneath.

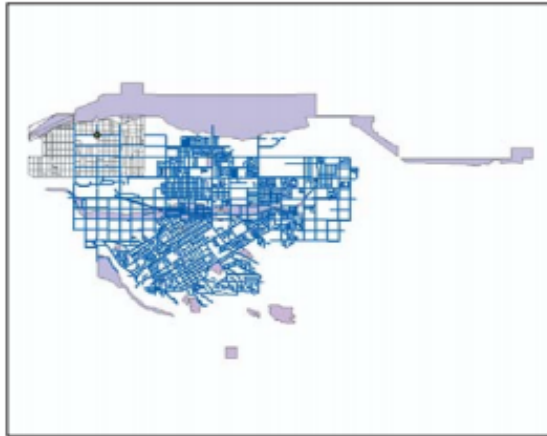


You're still zoomed in to the study area delineated by the parcel coverages. To get the big picture, zoom to the full extent of the datasets.

12. Click the Full Extent button on the Tools toolbar.



Now the map extent includes the additional datasets you've added to the map. You can see where the parcels you're focusing on are in relation to the rest of the city.

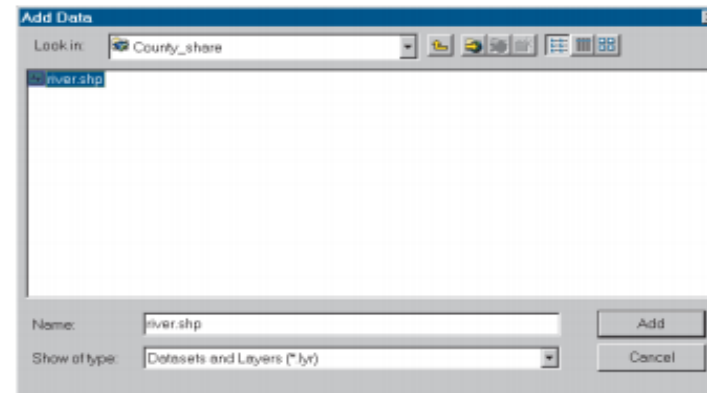


Adding the river shapefile to the map

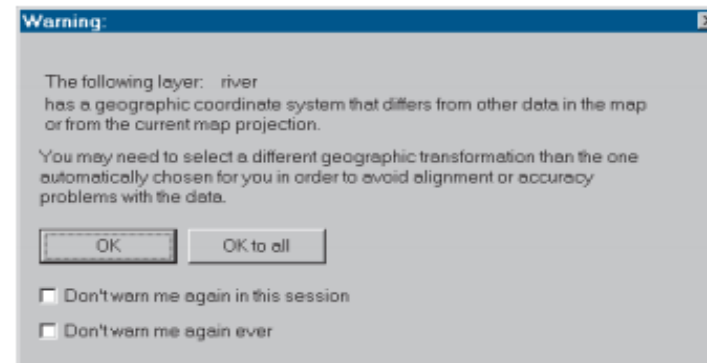
Next you'll add the river shapefile, from the County Water Resources Department, to the map.

1. Click the Add Data button on the ArcMap standard toolbar.
2. Navigate to the County_share folder under the project folder.

3. Click river.shp and click Add.



ArcMap displays a message that the river shapefile has a geographic coordinate system that differs from other data in the map. All the datasets you've added up to this point are from the city, and all use the same geographic coordinate system (Transverse Mercator). Apparently, the river shapefile uses a different coordinate system than the city data.

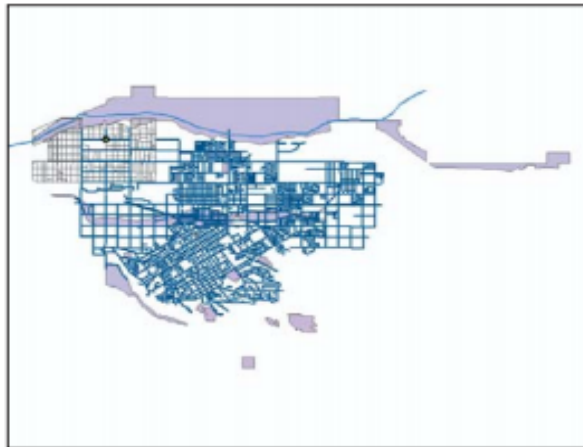


Every dataset uses a geographic coordinate system to link the coordinates stored in the GIS to actual locations on the surface of the earth. The coordinate system allows the GIS to determine where geographic features are located in relation to each other. There are many different coordinate systems used with geographic data. You can display the coordinate system for a dataset in ArcCatalog. ArcToolbox lets you define or change the coordinate system for a dataset. You'll get a chance to do this in the next chapter, where you'll also learn more about what a coordinate system is.

When you create a new map in ArcMap, the coordinate system used by the first dataset you add to the map, in this case the parcel_1 shapefile, defines the coordinate system for the entire map. If you add a dataset that doesn't use that same coordinate system, ArcMap will attempt to transform it on the fly so it displays correctly with the other data.

4. Click OK to close the Warning message box.

ArcMap transforms the river to the same coordinate system as the other datasets so it can be displayed.

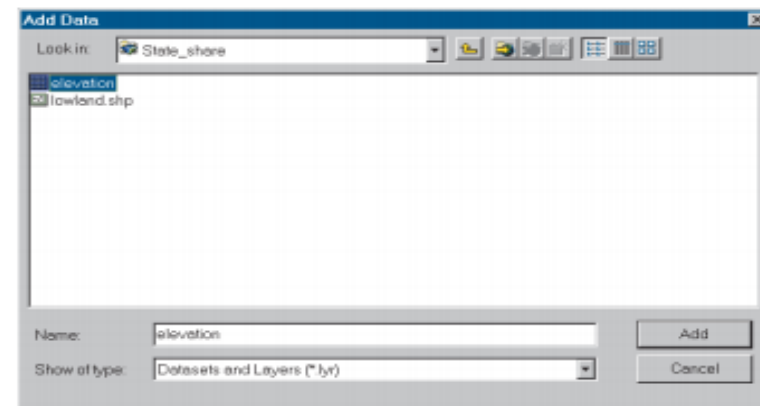


You could just leave the shapefile in its original coordinate system, but since it will eventually be added to the city's GreenvalleyDB geodatabase, you'll want to put it in the same coordinate system as the rest of the city's data. You'll do that in the next chapter.

Adding the elevation data to the map

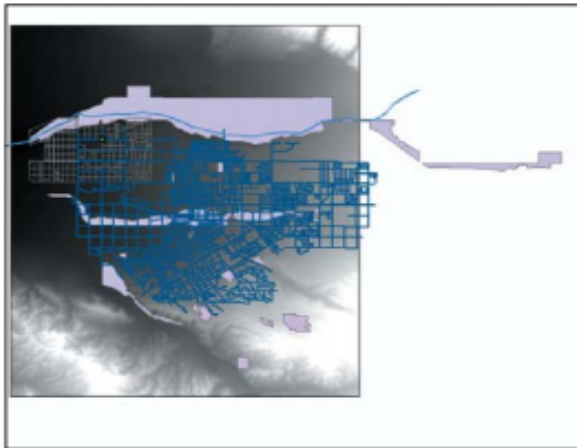
Next you'll take a look at the elevation data from the state Department of Transportation.

1. Click the Add Data button and navigate to the State_share folder.
2. Click elevation and click Add.



As with the river shapefile, ArcMap warns you that this dataset has a coordinate system that differs from other data on the map. Apparently the elevation data is also in a coordinate system different from that used by the city for its data.

3. Click OK to close the Warning message box. ArcMap adds the elevation grid to the map.

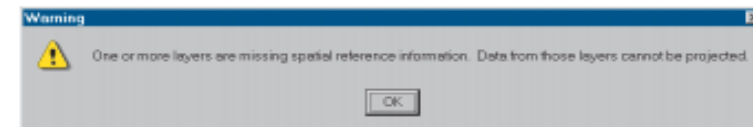


Since the grid is raster data, which is displayed as a continuous layer, it is added to the bottom of the table of contents and is drawn beneath the other layers. You can see that the grid doesn't underlie the entire city but does coincide with your study area.

Now add the lowland shapefile to the map.

4. Click the Add Data button and click lowland.shp, then click Add.

ArcMap warns you that the layer is missing spatial reference information and can't be projected.



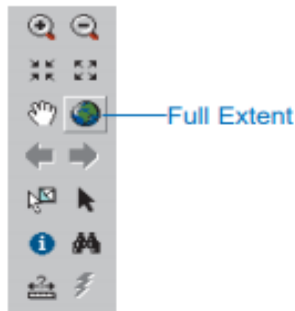
ArcMap can only transform data on the fly if the data is in latitude-longitude, which ArcMap can recognize, or if the coordinate system for the data has been previously defined, as it was for the elevation grid.

Apparently, the coordinate system was not defined for the lowland shapefile when it was created from the elevation grid. Presumably, it is in the same coordinate system as the elevation grid, but ArcMap doesn't know that at this point.

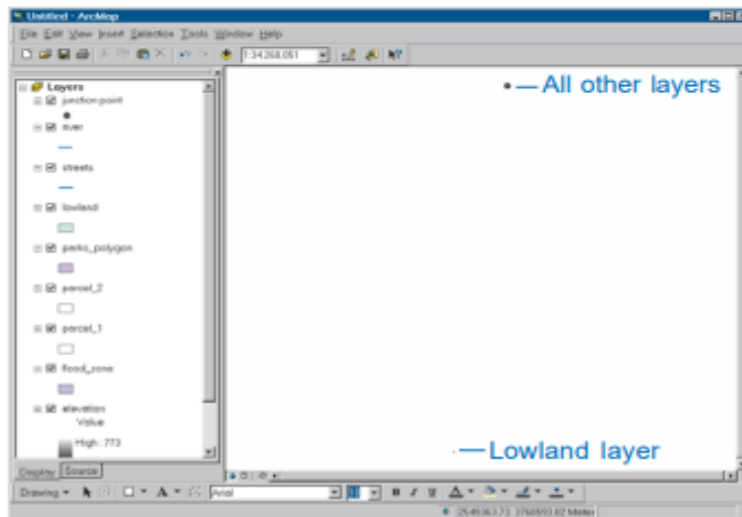
5. Click OK to close the Warning box.

ArcMap adds the data. You'll notice that while lowland appears in the table of contents, it doesn't appear on the map (it should appear on top of the layers that are listed below it in the table of contents). That's because it's in another—unknown at this point—coordinate system, so it can't be displayed correctly with the other data.

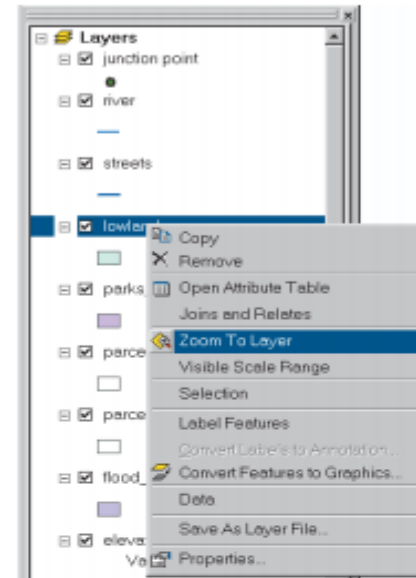
6. Click the Full Extent tool.



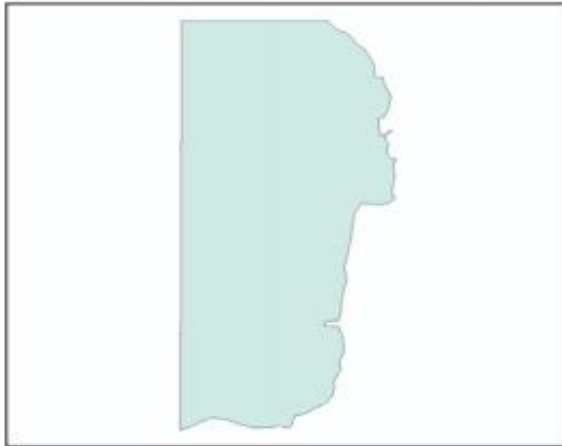
There is a tiny dot at the bottom of the screen (that's the lowland shapefile) and a slightly larger dot at the top of the screen—that's the rest of the data. ArcMap adjusts the extent to the full range of coordinate values in both coordinate systems and draws all the layers within that extent.



7. Right-click lowland in the table of contents and click Zoom To Layer.



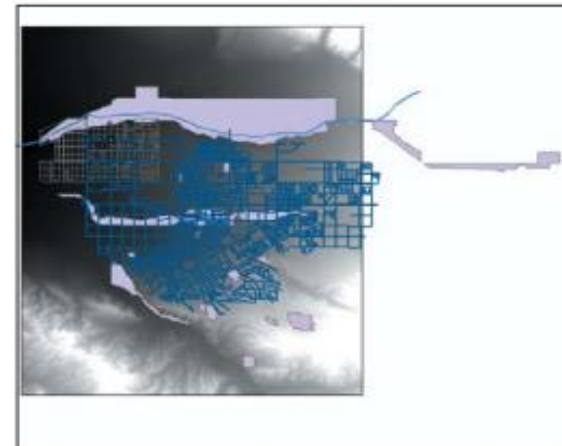
Now you can see the lowland shapefile but not the rest of the data. You'll define the coordinate system for lowland in the next chapter so you can display and overlay it with the other data.



8. Click the Go Back to Previous Extent tool, then click it again.



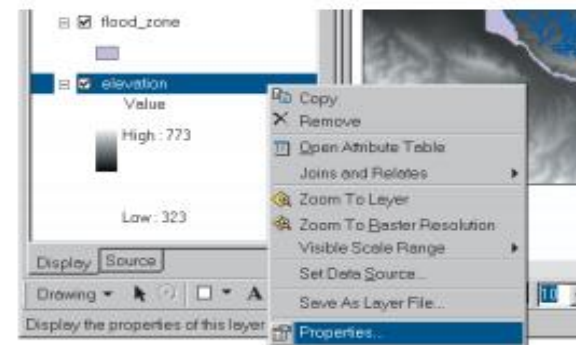
The other datasets should now be displayed.



Creating a layer from the elevation grid

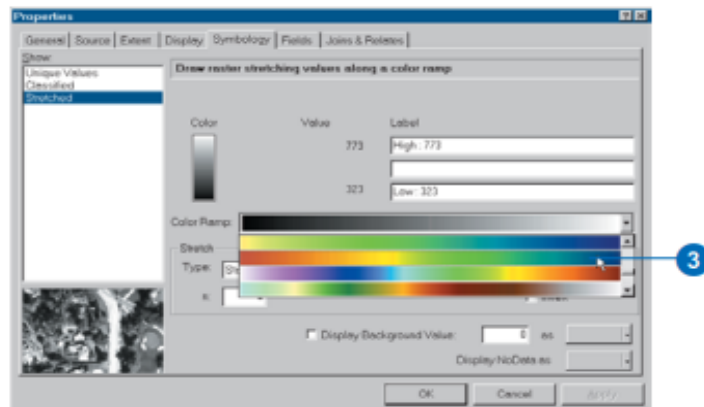
By default, the elevation grid is displayed using a grayscale. You'll be displaying the elevation grid on the final map later in the project, so while you're here, you'll create a new layer with the symbology you want to use.

1. Right-click elevation in the table of contents and click Properties.



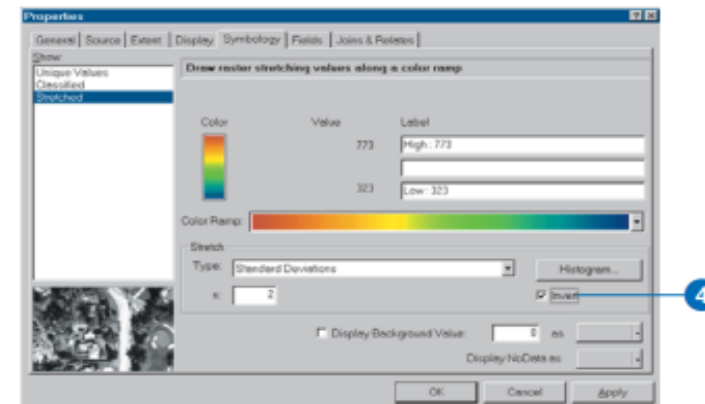
The Properties dialog box appears.

2. Click the Symbology tab.
3. Click the Color Ramp dropdown arrow, scroll down to the color ramp appropriate for representing elevation (from orange through yellow and green to blue), and click it.

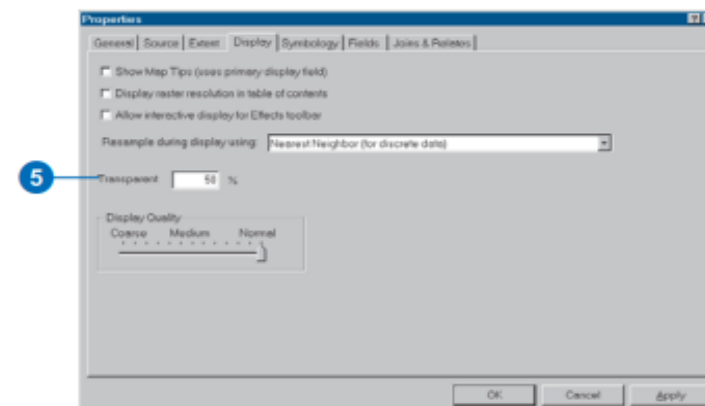


The default for this ramp is orange for low values and blue for high. You want to reverse the color ramp for the elevation grid.

4. Check the Invert check box.

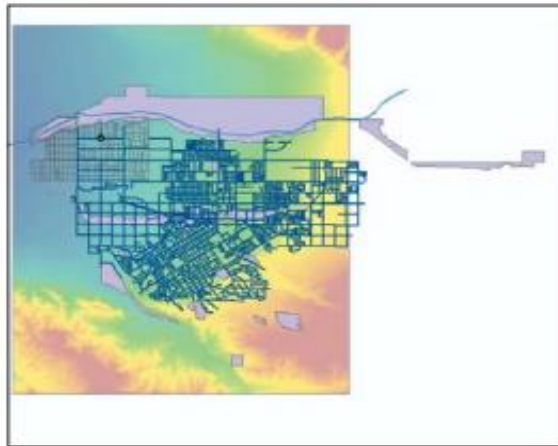


5. Click the Display tab and type "50" in the Transparent text box.



This will make the colors less intense, so it will be easier to see the other layers displayed on top of the grid.

- Click OK. The grid is displayed using the color ramp and transparency settings you specified.



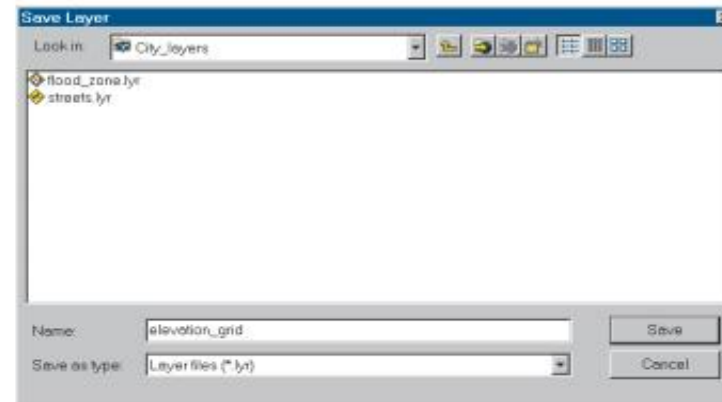
So far, the display settings for the elevation grid are valid only for the current map. To make sure the grid is displayed this way when you create your final map, you'll save it as a layer file.

- Right-click elevation and click Save As Layer File.



The Save Layer dialog box appears.

- Navigate to the City_layers folder, name the layer "elevation_grid", and click Save.



Now when you want to display the elevation grid again, you can just add the elevation_grid layer to the map and it will be drawn using the display settings you specified.

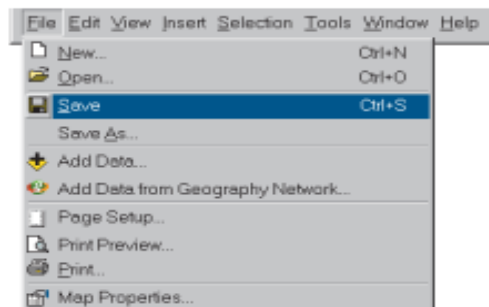
Layers store a shortcut to a data source and, optionally, information about how the data should be displayed on the map. Any time you add a dataset to a map in ArcMap, you create a layer since the map stores the data source and the symbology associated with it. When you save the map, the layer information is also saved.

As you've seen, you can also create layers as separate files. These layer files can be used to store symbology and other information, so the data is displayed the same way each time it is added to a map (as you just did with the elevation grid layer). They can also be used to access a data source without having to navigate to the actual location of the data (as you did earlier with the streets and flood_zone layers).

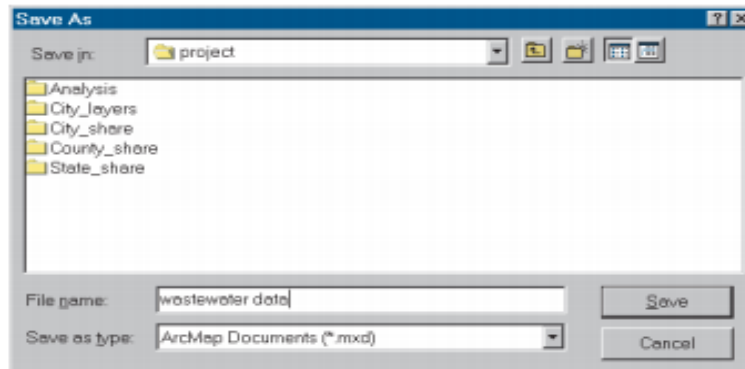
Saving your map

The map you've been using to assemble your project database is a working map. You'll be displaying and using some of these same layers in the next chapter. Save the map now so you can use it in the next chapter and won't need to add the layers again.

1. Click File and click Save.

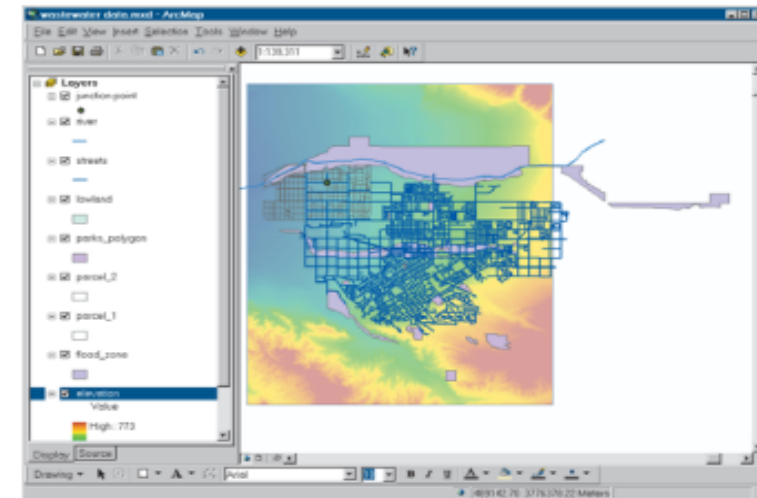


2. Navigate to the project folder.
3. Type "wastewater data" in the File name text box.



4. Click Save.

The map is saved as a map file. Notice that the name of the map now appears in the title bar.



You're done using ArcMap for the time being, so go ahead and close it.

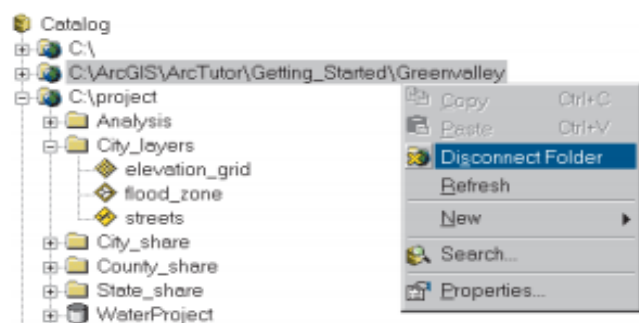
5. Click File and click Exit, or simply click the Close button (X) in the upper-right corner of the ArcMap window.

Cleaning up the Catalog tree

At this point, you've made folder connections, created and copied folders, and created layers to organize your project database. The Catalog tree in ArcCatalog is beginning to appear cluttered. Before you begin working with the data in the next chapter, clean up the Catalog tree. This will make it easier to find the data you need later.

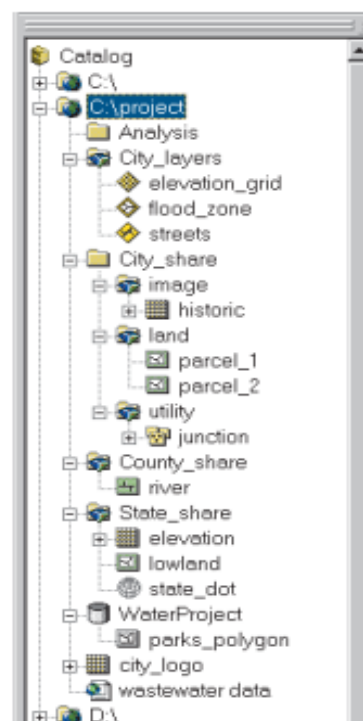
The connection to the tutorial folder you created in Chapter 2 is unnecessary now that you have copied the project folder and the files supplied by the city, county, and state. Deleting this connection will make more room in the tree.

1. Right-click the ArcGIS\ArcTutor\Getting_Started\Greenvalley folder connection and click **Disconnect Folder**.



The folder connection is removed from the Catalog tree.

Now the Catalog shows only the data that you need for the project. You may need to click View and click Refresh or close and reopen ArcCatalog to see the `elevation_grid` layer and the wastewater data map you created since you last used ArcCatalog.



Preparing Data for the AM Project

Data preparation tasks

For this project, you'll need to perform several tasks to prepare your data for analysis. You'll be working with data from various sources and in various formats: shapefiles, geodatabase feature classes, coverages, and rasters. ArcGIS lets you display and combine data in these formats without converting it. You'll define the coordinate system for the lowland shapefile so it can be displayed and combined with the other data. Then you'll project the river shapefile to the same coordinate system as the city's existing data and export it to the WaterProject geodatabase so it's ready to be placed into the city's geodatabase. The section 'What are coordinate systems?', later in this chapter, provides a brief overview of coordinate systems and map projections.

You'll also update the parks feature class with the new historic park so it, too, will be ready to be placed back into

the city's geodatabase. Finally, you'll merge the two parcel layers that comprise your study area.

Here are the processing steps to prepare the data for analysis:

- Define the coordinate system for the elevation data.
- Project the river shapefile to the city's coordinate system.
- Export the river shapefile to the WaterProject geodatabase.
- Digitize the historic park into the parks feature class.
- Merge the parcel layers.

You'll primarily be working with shapefiles since that's how most of the data came to you, but you'll also be working with data in the WaterProject personal geodatabase. A personal geodatabase is useful for processing data on a local computer that will become part of a large, multiuser geodatabase.

Defining the coordinate system for the elevation data

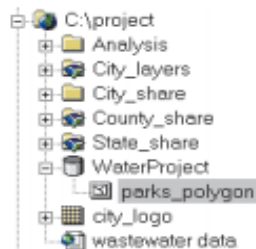
The elevation grid and lowland file are in a different coordinate system from the rest of the data. That's not a problem as long as the coordinate system is defined for those datasets. Without this information, however, ArcMap can't do a geographic transformation, and the data can't be displayed or overlaid with the other project data. While the coordinate system for the elevation grid is defined, when the lowland shapefile was created from the grid, the coordinate system information was not included. You need to define the coordinate system for the shapefile.

If you closed ArcCatalog at the end of Chapter 5, 'Assembling the database', you'll need to reopen it now.

Checking the coordinate system information

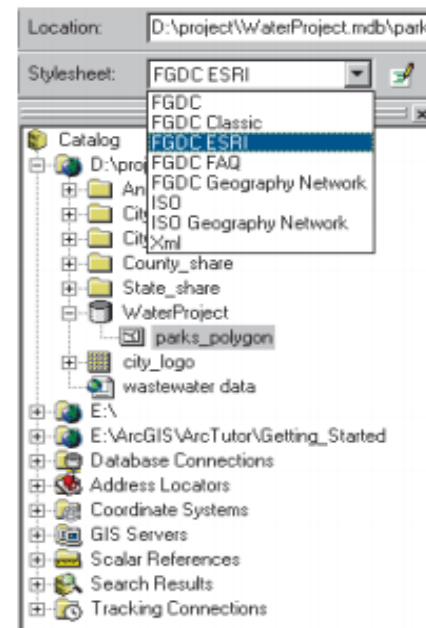
Before defining the coordinate system for the lowland shapefile, you'll check the coordinate system definitions for the city data and for the elevation grid. You'll do this by examining the metadata for the datasets.

1. In ArcCatalog, navigate to the WaterProject geodatabase under the project folder in the Catalog tree.
2. Open the database to list its contents, then click the parks_polygon feature class.

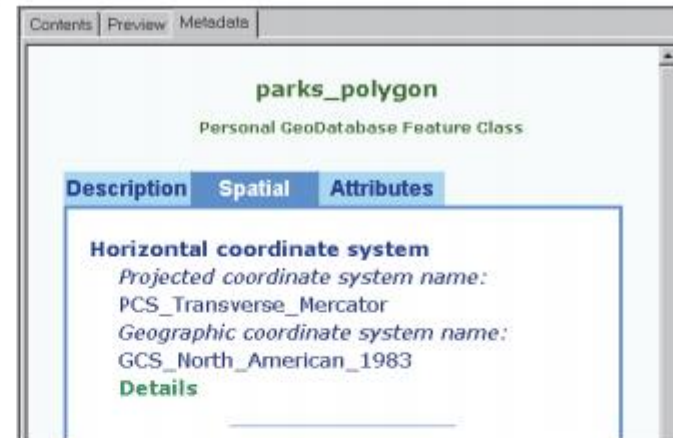
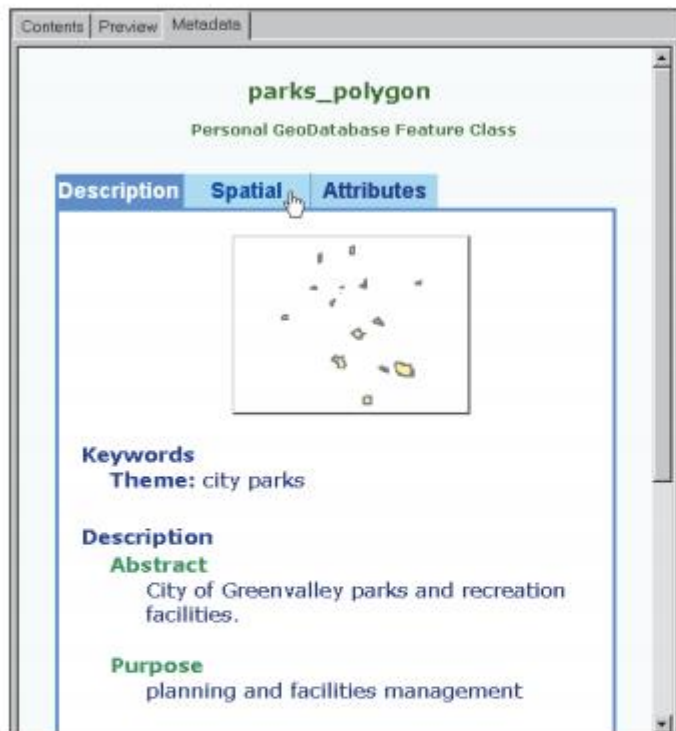


This feature class, which you copied from the city's GreenvalleyDB, is in the same coordinate system as the rest of the city's data.

3. Click the Metadata tab.
4. Click the Stylesheet dropdown arrow and click FGDC ESRI.



5. Click the Spatial tab in the metadata panel.



You can see that the coordinate system for the parks_polygon feature class uses a Transverse_Mercator projection.

Metadata contains information about each dataset. Some of the information is assigned and maintained automatically by ArcGIS; other information you add interactively. Metadata is invaluable when sharing datasets and for documenting GIS projects.

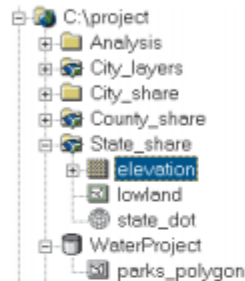
In this project you'll use metadata to get information you need for several of the steps. Metadata lets you store a great deal of information about a dataset: source, processing status, data quality, attribute values, and much more. For several of the datasets, we've provided some of the key information you'll need for the project.

In an actual GIS project you'd also use metadata to keep track of modifications you make to existing datasets and to document new datasets you create during the project. Adding or updating the metadata for a dataset takes a little extra time, but it pays off if you need to reuse the dataset in

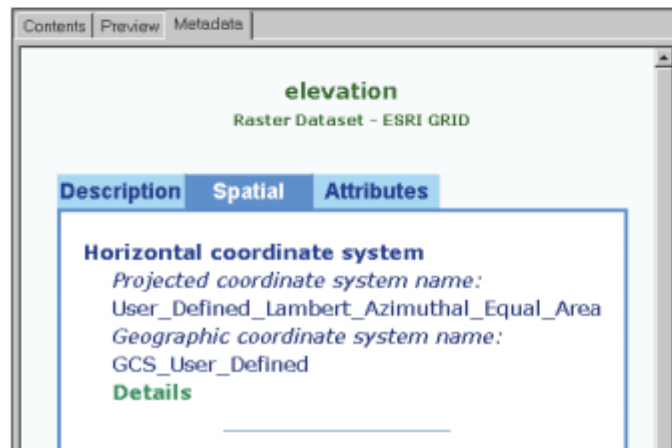
the future, share it with another department or organization, or reconstruct your processing steps.

Now check the coordinate system for the elevation grid.

6. Navigate to the State_share folder in the Catalog tree, open it, and click elevation.



7. Click the Spatial tab. When you select a new dataset, ArcCatalog defaults the metadata display to the Description tab.



You can see that the elevation grid is in a coordinate system that uses a Lambert_Azimuthal_Equal_Area projection.

Finally, check the coordinate system information for the lowland shapefile.

8. In the State_share folder, click lowland.

9. Click the Spatial tab.

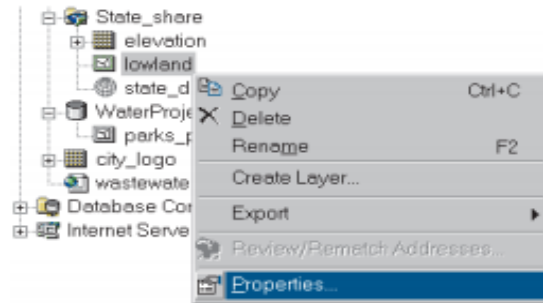
The metadata lists the bounding coordinates for the shapefile but doesn't list the coordinate system since it is unknown.

When you previewed the data in Chapter 5, 'Assembling the database', ArcMap was able to transform the elevation grid on the fly and display it with the other project data since the coordinate system was defined and stored with the grid. Because the coordinate system for the lowland shapefile is unknown, ArcMap was unable to transform it.

Defining the coordinate system for the lowland shapefile

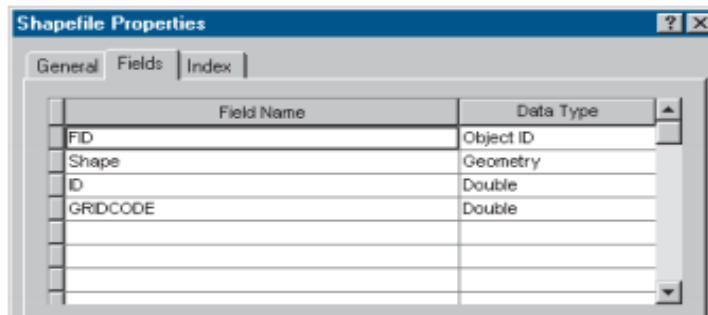
Presumably, the coordinate system for the lowland shapefile is the same as for the elevation grid since the shapefile was originally created from that grid. But you don't know for sure. Thoughtfully, the analyst at the Department of Transportation who sent you the data also included a spatial reference file that defines the coordinate system the department uses for all its data. You'll use the file state_dot.prj to define the coordinate system for the shapefile within ArcCatalog.

1. Right-click lowland in the Catalog tree and click Properties.



The Shapefile Properties dialog box appears.

2. Click the Fields tab.

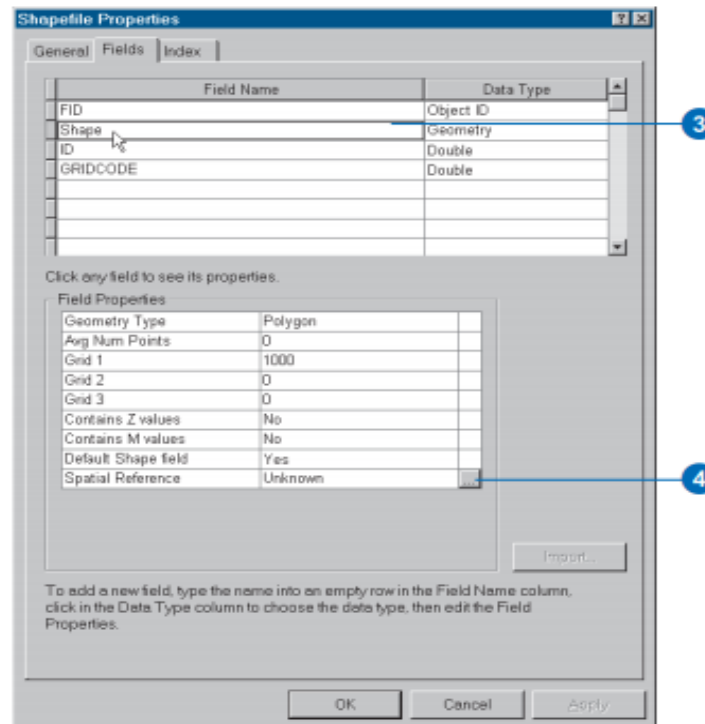


The fields in the shapefile's attribute table are listed. The Shape field contains the coordinate information for the shapefile.

3. In the Field Name list, click the row containing Shape.

The properties for the Shape field are displayed below in the Field Properties list. You can see that the Spatial Reference property is listed as Unknown.

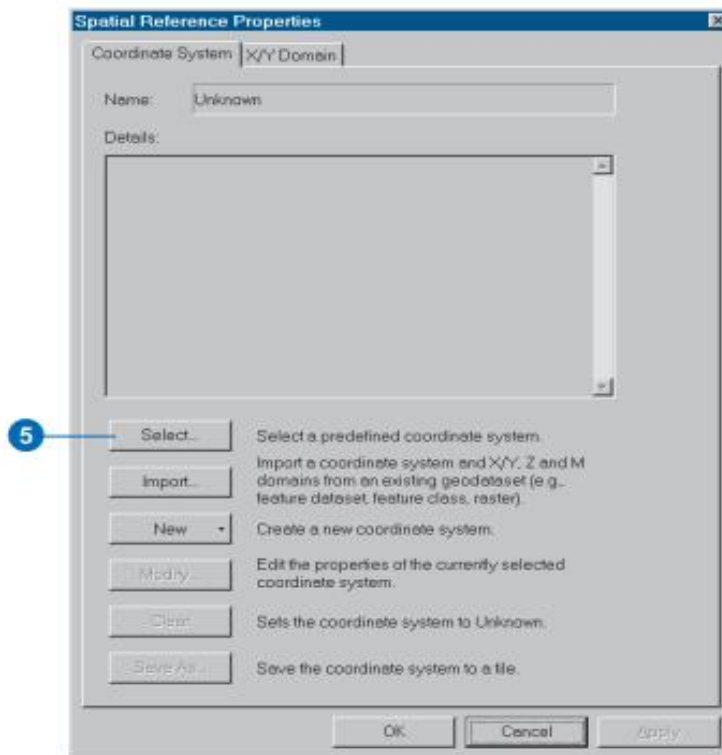
4. Click the button with the ellipses (...) to the right of Spatial Reference.



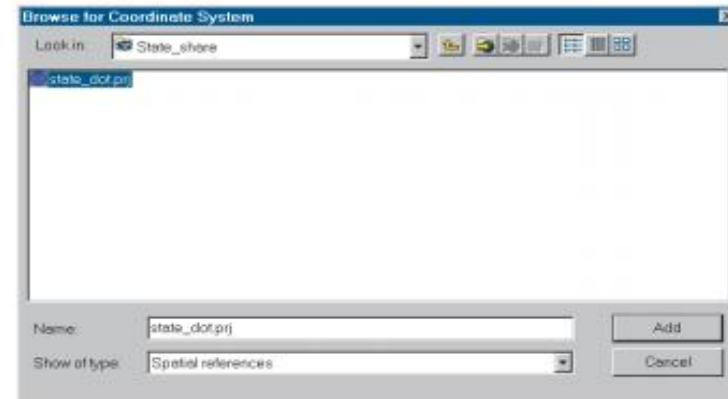
The Spatial Reference Properties dialog box appears.

You'll be defining the coordinate system by selecting a predefined coordinate system, specifically the one contained in the state_dot.prj file that accompanied the elevation and lowland data.

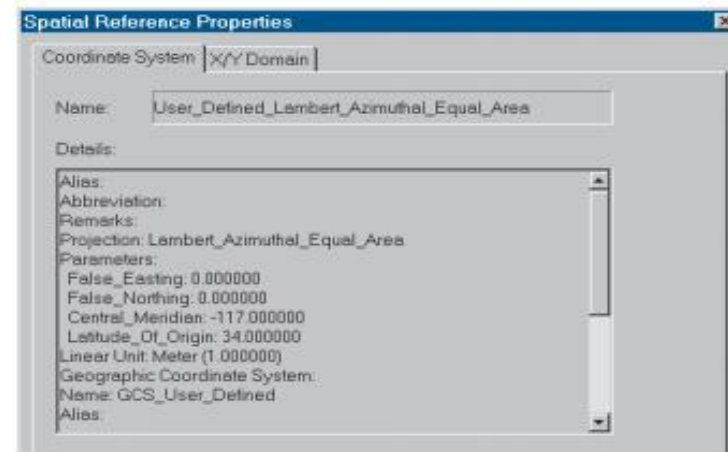
5. Click Select.



6. Navigate to the State_share folder under the project folder connection, click state_dot.prj, and click Add.

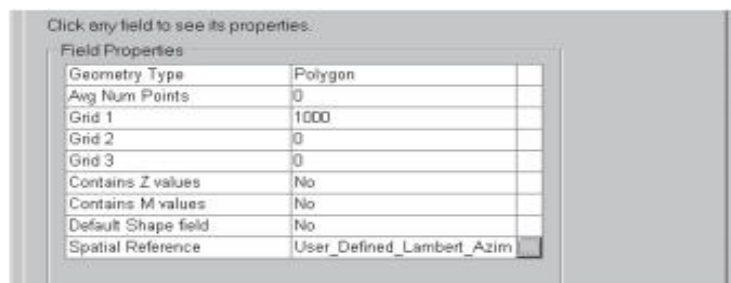


The name of the coordinate system appears in the Spatial Reference Properties dialog box, and the details are listed. You can see that they're the same as for the elevation grid.



7. Click OK to close the Spatial Reference Properties dialog box.

The name of the coordinate system now appears in the Field Properties list.



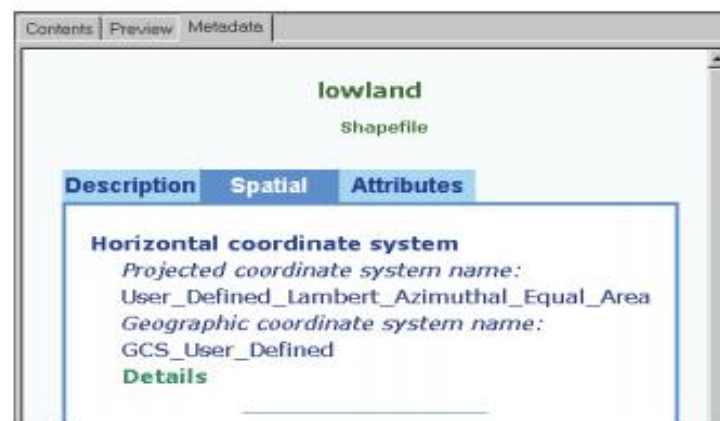
8. Click OK to close the Shapefile Properties dialog box.

You can verify the new coordinate system in the metadata.

9. Click View and click Refresh, then click the Spatial tab.



You can see that the coordinate system for the lowland shapefile is now defined.

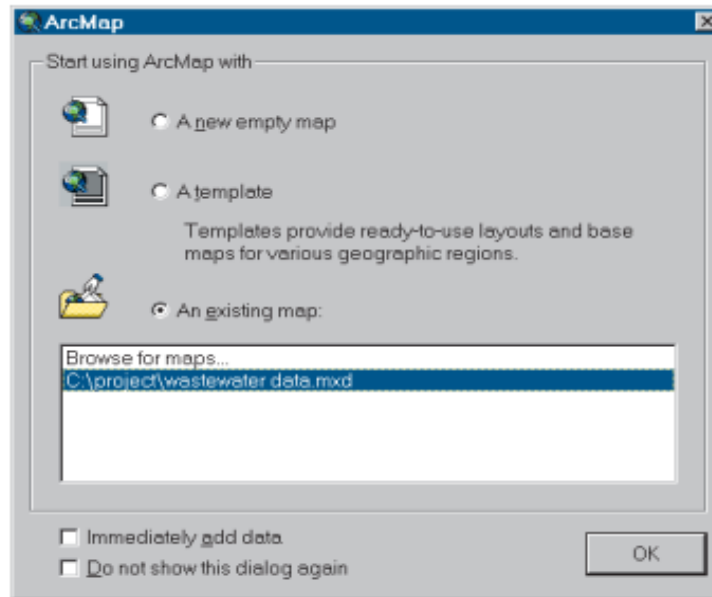


With the coordinate system defined, the lowland shapefile should now display correctly with the other project data and can be used in overlay operations during the analysis. You can check this in ArcMap.

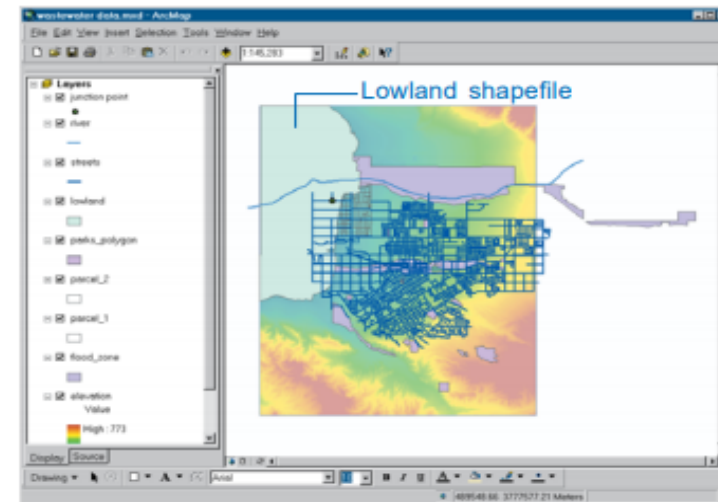
10. Click the Launch ArcMap button on the toolbar.



11. In the startup dialog box, click wastewater data.mxd and click OK. If the startup dialog box doesn't appear, click File on the ArcMap toolbar and click wastewater data.mxd.

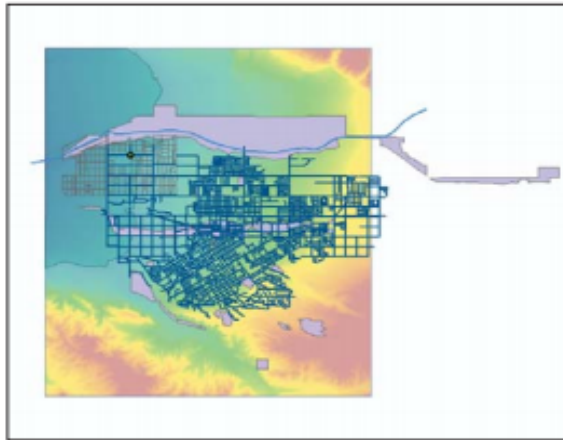


The lowland layer now appears in the same geographic space as the other project data.



12. Click lowland in the table of contents and drag it to the bottom so it displays beneath the elevation grid.

You can see the layer under the elevation grid and see that it does in fact encompass the lowest elevations in the city.



13. Close ArcMap. You won't be using this map again, so click No when prompted to save changes to the map.

Projecting the river shapefile

The next task is to project the river shapefile into the same coordinate system as the data in the city's GreenvalleyDB geodatabase. According to your colleague at the county Water Resources Department, the river shapefile is in geographic coordinates (latitude and longitude). The rest of the data in the city's database is in the Transverse Mercator coordinate system, which is a projected coordinate system. As long as a dataset is in geographic coordinates, ArcMap can transform it on the fly to display and overlay it with the other data (as you saw in the last chapter).

However, the river data will eventually be placed into the city's GreenvalleyDB database, so you'll want to project it into the same coordinate system as the rest of the city's data to be consistent.

Projecting the shapefile is a two-step process: first you'll define the coordinate system for the shapefile; then you'll define the output coordinate system and project the file. You'll do both of these tasks in ArcToolbox. ArcToolbox contains a number of data management and conversion tools and wizards.

Defining the coordinate system for the river shapefile

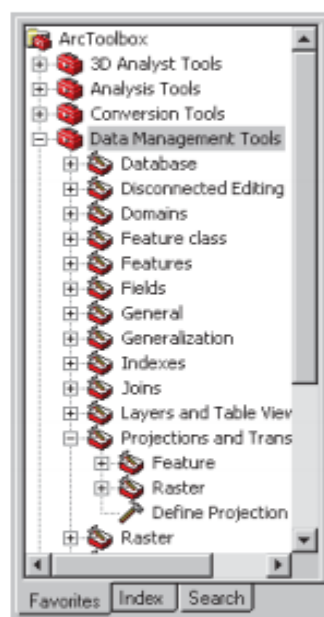
1. In ArcCatalog, click the Show/Hide ArcToolbox button on the toolbar.



Show/Hide ArcToolbox

The ArcToolbox window appears.

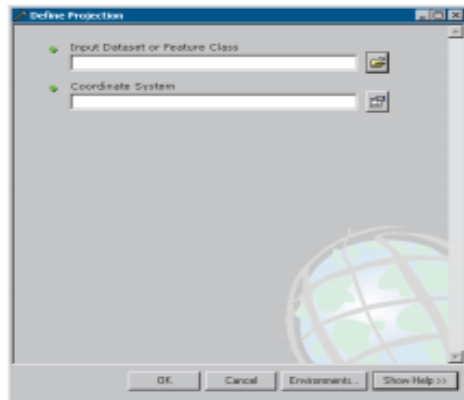
2. Double-click Data Management Tools in the ArcToolbox tree; double-click Projections and Transformations, then double-click the Define Projection tool. If you are using ArcInfo you will see additional tools not shown here.



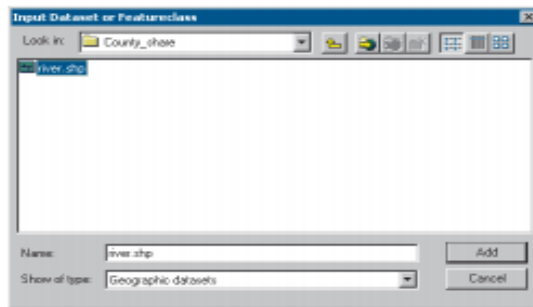
The Define Projection dialog box appears.

You defined the coordinate system for the lowland shapefile using the Properties dialog box in ArcCatalog. ArcToolbox provides an alternate way of defining a coordinate system.

3. Click the Input Dataset or Feature Class browse button and navigate to the County_share folder under the project folder.



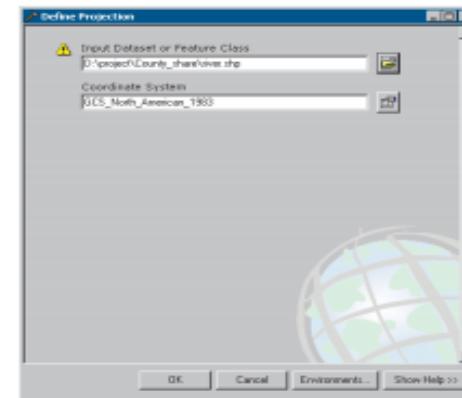
4. Click river.shp and click Add.



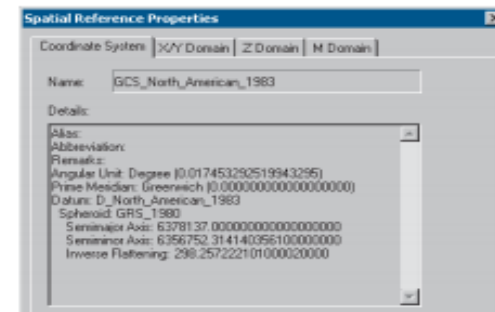
The shapefile is listed. The coordinate system is listed as GCS_Assumed_Geographic_1. ArcGIS attempts to determine the shapefile's coordinate system based on the dataset's coordinate values. In this case, ArcGIS has

determined that the shapefile is in geographic coordinates—latitude—longitude—however, you need to explicitly define the geographic coordinate system before you can project the data.

5. Click the button next to Coordinate System.



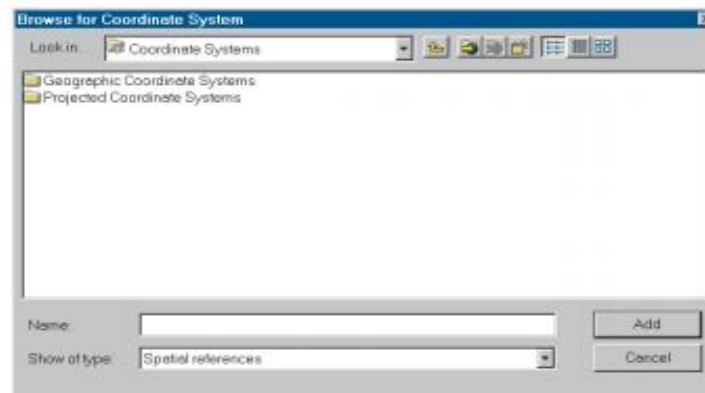
The Spatial Reference Properties dialog box appears.



There are three ways of defining a coordinate system: using a predefined coordinate system stored as a .prj file, matching the coordinate system of an existing dataset by specifying the name of the dataset, or interactively specifying a projection and a datum and their associated parameters. In this case, you'll be specifying a predefined coordinate system.

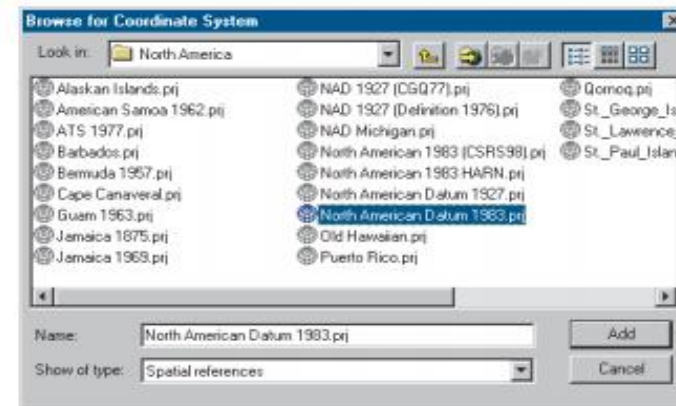
6. Click Select on the Spatial Reference Properties dialog box.

The Browse for Coordinate System folder opens.

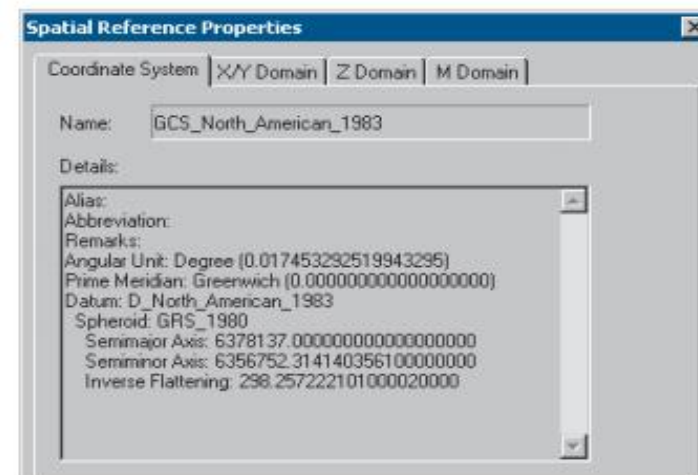


ArcGIS provides many predefined coordinate systems for you to use, stored as .prj files. The files include all the coordinate system parameters including the map projection type and parameters, measurement units, and so on. You can also define custom coordinate systems and save them as .prj files—for example, the state_dot.prj file.

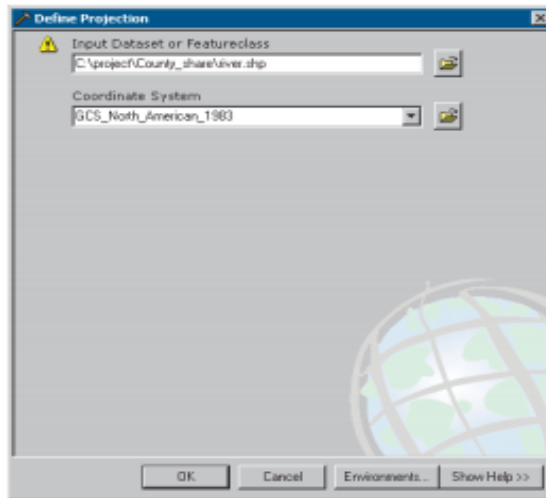
7. Double-click Geographic Coordinate Systems and double-click North America.
8. Click North American Datum 1983.prj and click Add.



The coordinate system information is displayed in the Details window.



9. Click OK to close the Spatial Reference Properties dialog box.
10. Click OK.
11. Click Close to close the Define Projection dialog box.



The coordinate system of the river shapefile is now defined. To verify this, in ArcCatalog navigate to the County_share folder, click river, click the Metadata tab, and click the Spatial tab. The coordinate system is now listed as GCS_NorthAmerican_1983. You may need to close ArcCatalog and restart it to see this.

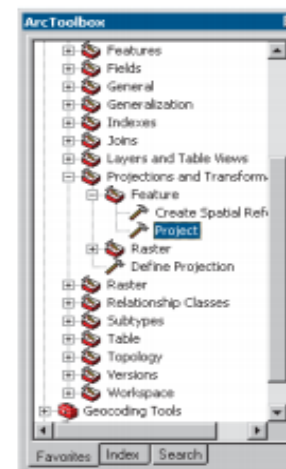
Projecting the shapefile

When you define a coordinate system, you simply tell ArcGIS what projection the dataset uses and what units the coordinates are stored in. When you project a dataset, on the other hand, ArcGIS actually creates a new dataset with

the coordinates transformed from the existing coordinate units—in this case, decimal degrees—to a new coordinate system—in this case, Transverse Mercator meters. You specify the input dataset and the coordinate system to project into, and ArcGIS creates the new dataset.

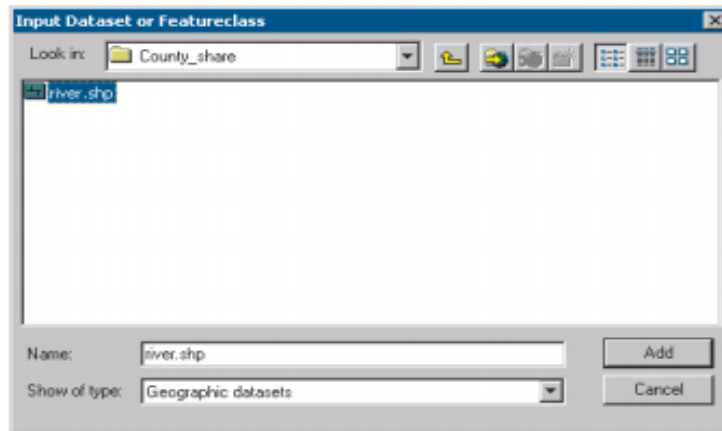
Because you have data that is already in the Transverse Mercator coordinate system used by the city, you can simply specify a dataset to match to. The Project tool will get the coordinate system parameters from the existing dataset and create a new river shapefile in that coordinate system.

1. In ArcToolbox, double-click Feature under Projections and Transformations in the Data Management tools, then double-click Project.



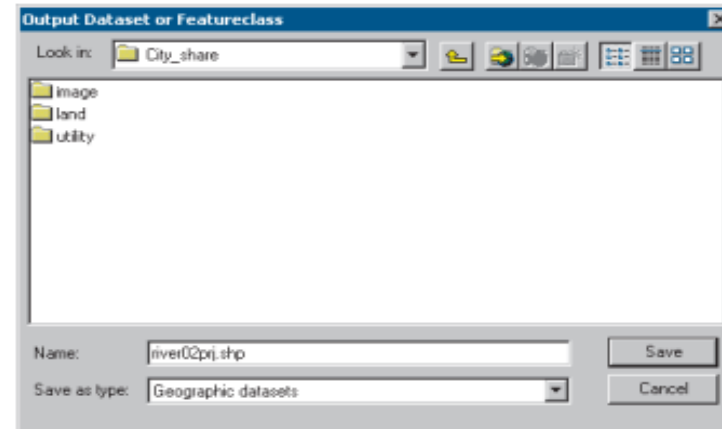
2. Click the Input Dataset or Feature Class browse button and navigate to the County_share folder under the project folder.

3. Click river.shp and click Add.



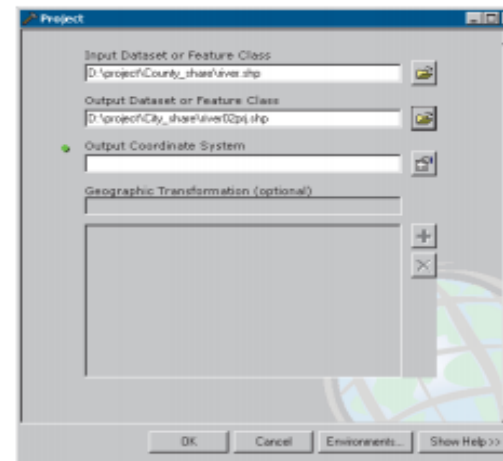
You need to specify a name for the projected shapefile and a location where it will be stored. You'll put it in the City_share folder since it will eventually become part of the city's database. You'll name it river02prj since it will be the second version of the river dataset and will have been projected.

4. Click the Output Dataset or Feature Class browse button and navigate to the project folder. Double-click City_share, then type "river02prj" in the Name text box.



5. Click Save.

The City_share folder is listed as the location to store the projected shapefile river02prj.



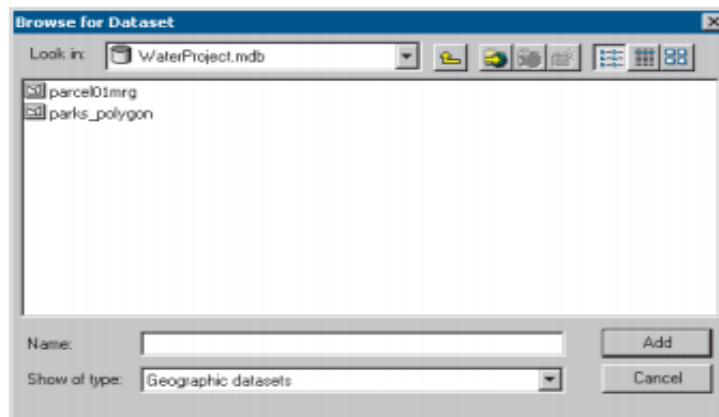
6. Click the button next to Output Coordinate System.

The Spatial Reference Properties dialog box appears.

This is the same dialog box you used to define the coordinate system for the lowland shapefile and the river shapefile. In those cases you specified a spatial reference (.prj) file. This time you'll specify an existing dataset from which to get the coordinate information. You know the parks feature class is in the right coordinate system since you copied it directly from the city's existing geodatabase.

7. Click Import and navigate to the WaterProject geodatabase under the project folder connection.

8. Click parks_polygon and click Add.



The dialog box displays the coordinate system, and you can see it's the correct one: PCS_Transverse_Mercator (PCS stands for Projected Coordinate System).

9. Click OK to close the dialog box.

10. Click OK.

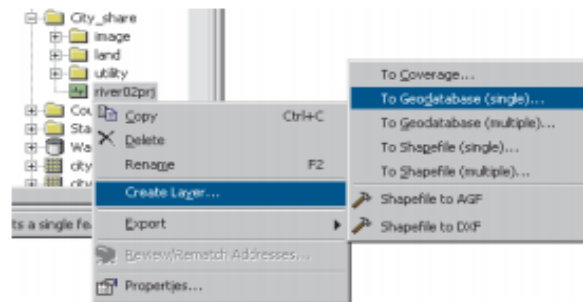
11. Click Close to close the Project dialog box.

The Project tool projects the river shapefile to match the coordinate system of the data in the city's database. The projected shapefile, river02prj, is saved in the City_share folder.

Exporting the river shapefile to the geodatabase

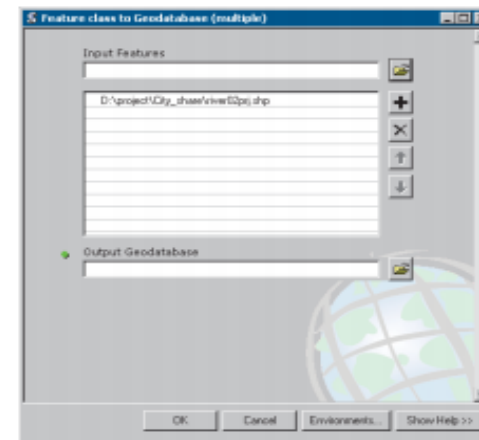
The projected river dataset will eventually go into the city's geodatabase. You'll export the dataset to a feature class in the WaterProject geodatabase now, so it will be in the right format to be copied into the city's geodatabase later.

1. In the Catalog tree, navigate to the City_share folder, right-click river02prj, point to Export, and click To Geodatabase (multiple).

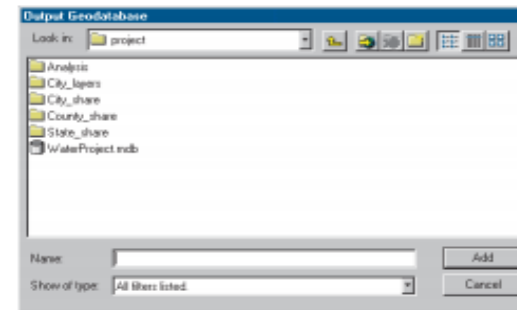


The Feature Class to Geodatabase (multiple) dialog box appears.

2. Click the Output Geodatabase browse button and navigate to your project folder.



3. Click WaterProject.mdb and click Add.



4. Click OK.

A dialog box appears showing the script's progress.

5. Click Close when the script finishes.
6. Navigate to the WaterProject database and double-click to display its contents.
7. Right-click river02prj and click Rename.
8. Type "river03exp" and press Enter.

The next task is to update the parks layer with the new historic park.

Digitizing the historic park

You need to add the new historic park to the parks layer so you can include it in the buffer around parks you'll create during the analysis. The Parks Department has not yet added the planned Homestead Historic Park to the parks feature class in the city's database, though it has settled on the boundary. You'll digitize the park boundary from a scanned image of the boundary drawn on a map.

You'll digitize the new park into the copy of the parks feature class in the WaterProject geodatabase. The updated file will replace the original file in the city's database later, after the Parks Department checks to make sure the new park was added correctly.

After opening a new map in which to do the digitizing, you'll register the scanned image to the streets layer. You'll then digitize the park boundary and add the attributes for the new park.

Opening a new map

You'll digitize the new park in a new map in ArcMap. You'll need to add four datasets to the map: the existing parks feature class that you'll be adding the new park to; the scanned image of the park boundary (stored as a TIFF file), which you'll use as a guide while digitizing; the streets layer that you'll use to register the scanned image; and the parcel_2 coverage that you'll use to snap the park boundary to since the boundary aligns with the parcel boundaries.

1. Click the Launch ArcMap button on the ArcCatalog toolbar.

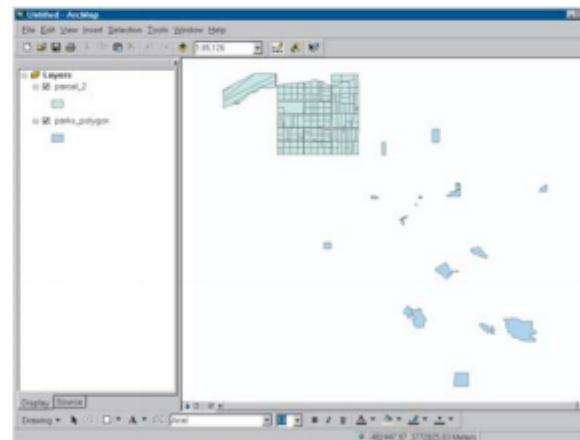
If the ArcMap startup dialog box appears, click the option for A new empty map and click OK.

Arrange ArcMap and ArcCatalog so you can see both.

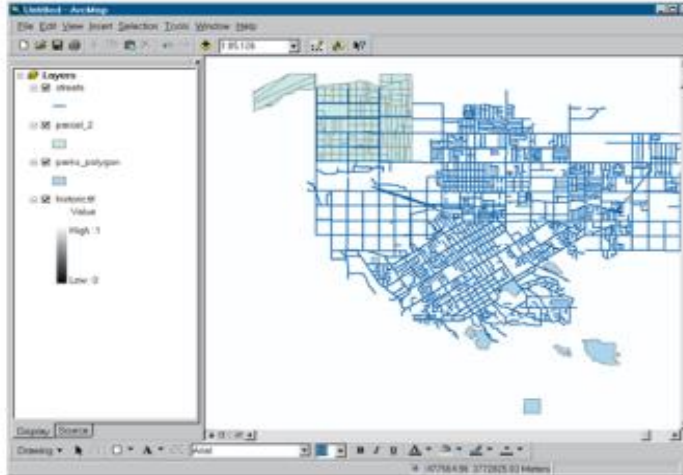
2. In ArcCatalog, navigate to the WaterProject geodatabase under the project folder connection and open it by double-clicking it or clicking the plus sign next to it, if necessary.
3. Click and drag parks_polygon onto the map in ArcMap.
4. Add the parcel_2 coverage to the map by opening the City_share\land folder in ArcCatalog, clicking parcel_2, and dragging it onto the map.

The parks_polygon and parcel_2 layers are displayed on the map.

5. Click the Full Extent button on the Tools toolbar to see all of both layers.



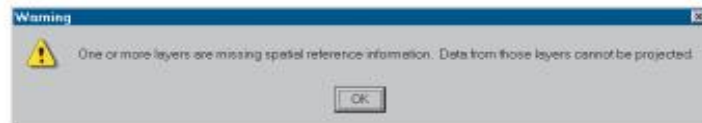
6. Add the streets layer to the map by opening the City_layers folder, clicking streets, and dragging it onto the map.



7. Now open the City_share\image folder and click and drag historic onto the map.

You get a warning that the layer is missing spatial reference information—its coordinate system is undefined.

That's OK because you'll be registering the image interactively to place it in the correct geographic space. Click OK to close the warning message.



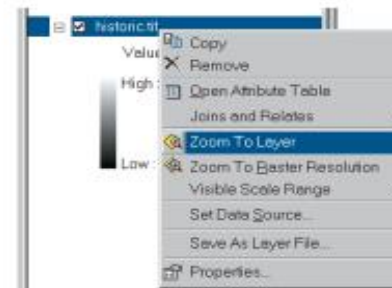
You'll notice that the image is not displayed even though it has been added to the map. That's because it's in scanner units (inches) rather than in geographic coordinates.

8. Click the Full Extent button on the Tools toolbar.

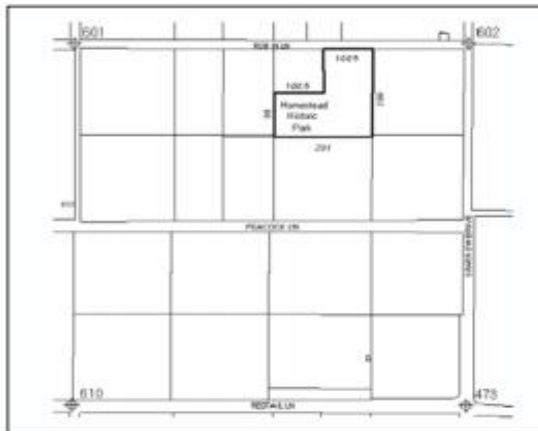
When the map redraws, you can see the city data layers as a small dot in the upper center of the view. The scanned image is actually drawn in the lower center, but it's too small to even see. You saw a similar situation in Chapter 5, 'Assembling the database', when you first added the lowland shapefile to the map.

The extent of the image, which is in inches, is 0 to about 13 in both the x and y directions. The extent of the other data, which is actual geographic space represented in UTM meters, is from about 478,000 to about 490,000 in the x direction and about 3,765,000 to 3,772,000 in the y direction. ArcMap attempts to draw all the data on the same page, so the page extent ranges from values of 0,0 in the lower left of the page to values of more than 490,000 in the x direction and more than 3,772,000 in the y direction. The image and the data are drawn in their respective parts of the page and end up being very small. You need to register the image so it is in the same geographic space as the streets, parcels, and parks.

9. Right-click historic.tif in the ArcMap table of contents and click Zoom To Layer.



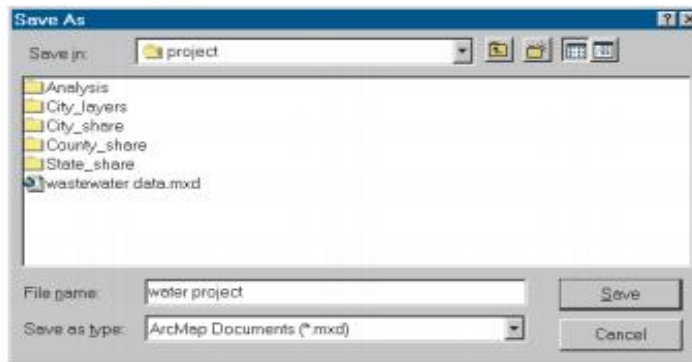
Now you can see the image.



Before registering the image, save the map in case you need to stop or take a break during the process.

10. Click File and click Save.

11. Navigate to the project folder. Type “water project” to name the map and click Save.



You’ll use this map for the rest of the project.

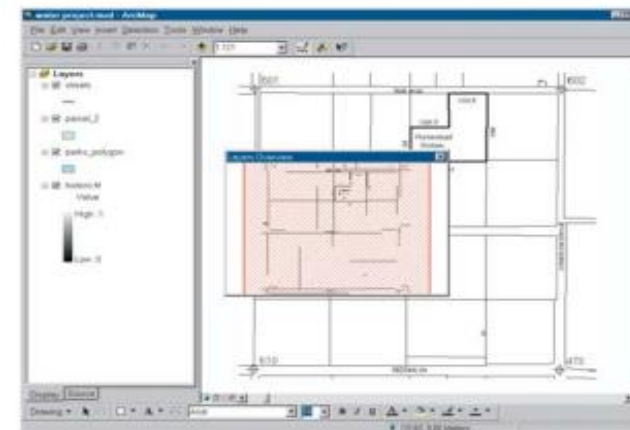
Finding the park area on the streets layer

The Parks Department added several registration marks to the sketch at street intersections. You’ll register the image to the streets by interactively adding links between the image and the streets layer—first pointing at a registration mark on the image, then at the corresponding intersection on the streets layer. You’ll need to find the area on the streets layer corresponding to the area covered by the image. To make it easier to do this, you’ll first open an overview window, so you’ll be able to see the image and the streets at the same time.

1. Click Window and click Overview.



A small window appears showing the image.

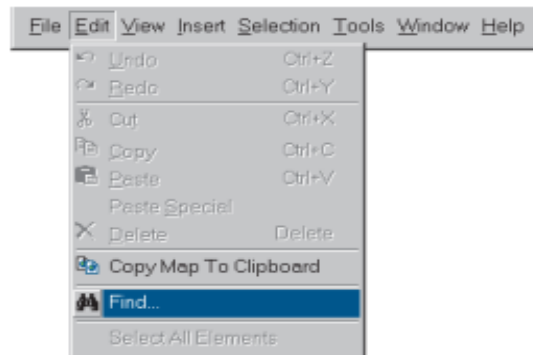


The overview window displays whichever layers are displayed in the main window at the time you open it, although you can modify this once the window is created. By default, it also shades the area visible on the main screen. Since the main window and overview window show the same area at this point, the shading covers the entire image in the overview window. When you zoom to the streets, the overview window will continue to display the image, so you'll be able to see both.

Now you can find the park area on the streets layer and zoom to it.

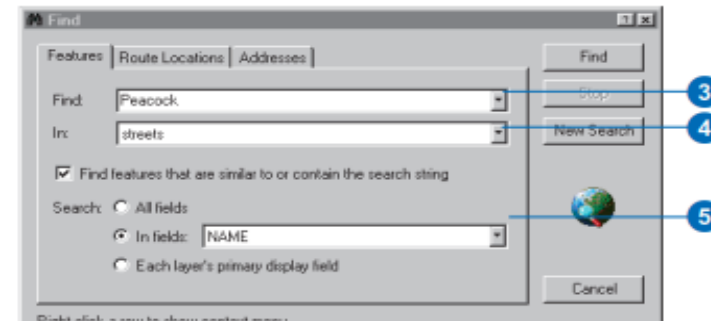
The image has several streets marked on it in the vicinity of the park including Robin Lane, Peacock Lane, and Sparrow Drive. You can search for one of these on the streets layer to find the area the park is in.

2. Click the Edit menu and click Find.



3. In the Find text box, type "Peacock".

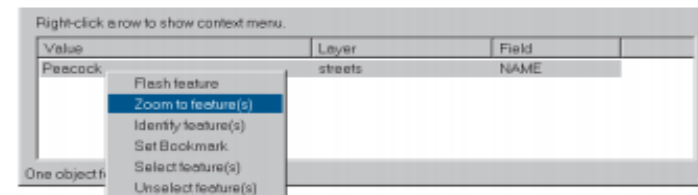
4. Click the In dropdown arrow, scroll down, and click streets.
5. Click In fields, click the dropdown arrow, and click NAME.



6. Click Find.

Peacock appears in the list of features that have been found.

7. Right-click Peacock and click Zoom to feature(s).



The map displays the area that includes Peacock Lane. The overview window still displays the image. You may want to enlarge the overview window so it's easier to see the image—simply click and drag one of the corners of the window. You may also want to move the overview window to make it easier to see the streets.

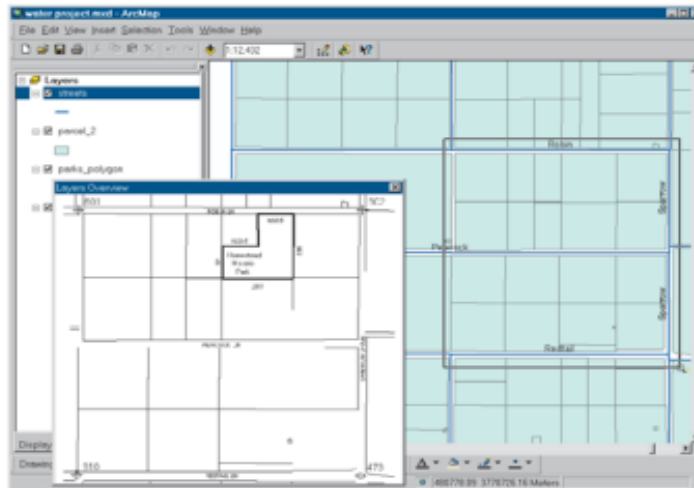
8. Click Cancel to close the Find dialog box.

To make sure you're in the right area, label the streets.

9. In the table of contents, right-click streets and click Label Features.

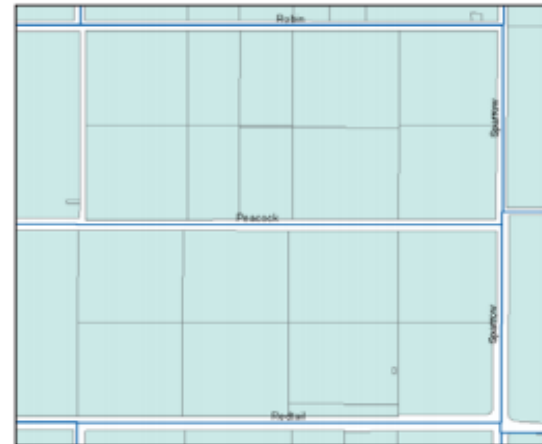
You can see that you're in the area that includes the park.

10. Use the Zoom In tool on the Tools toolbar to draw a box around the four street intersections that correspond to the control points on the scanned image. Use the image displayed in the overview window to orient yourself.

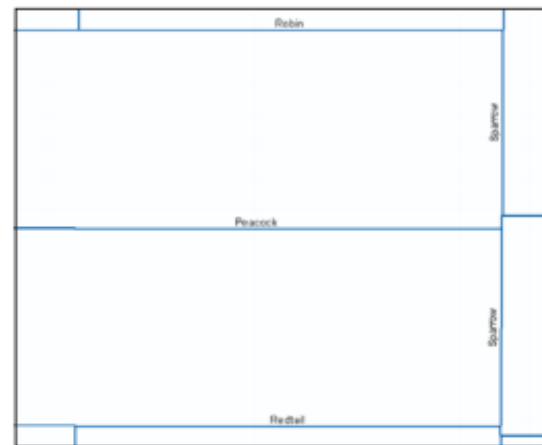


11. Close the overview window.

Now the display is zoomed to the area corresponding to the image.



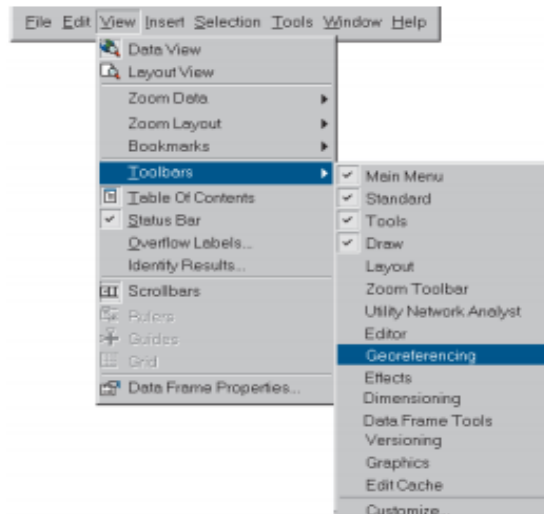
12. You won't need to display parcel_2 for the next set of steps, so uncheck the layer to make it easier to see the streets.



Registering the scanned image

Now you're ready to register the image to the streets layer. You'll do this by adding links between the control points on the image and the corresponding street intersections on the streets layer. This is known as georeferencing. ArcMap requires a minimum of three links to transform the image—rotating, scaling, and warping it as needed to fully register it to the streets.

1. Click the View menu, point to Toolbars, and click Georeferencing.

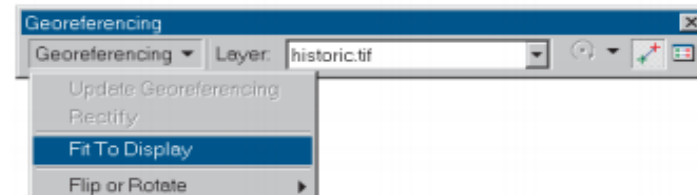


The Georeferencing toolbar appears.

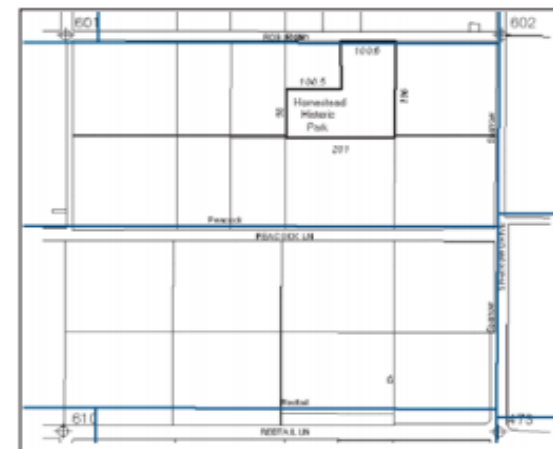
2. Click the Layer dropdown arrow and click historic.tif.



3. Click the Georeferencing dropdown arrow and click Fit To Display.



ArcMap scales the image to fit in the current window.

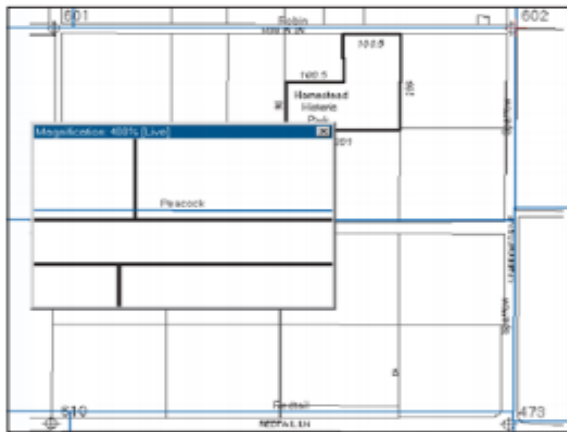


Since the window is currently zoomed to the four street intersections that match the registration marks on the image, the streets and the image are displayed at approximately the same scale. You can see, though, that the control points aren't located exactly at the intersections. You'll add three links to register the image. To make it easier, you'll use a magnifier window. You can add control points within the magnifier window.

- Click Window and click Magnifier.



A small window appears with a default magnification of 400 percent.



When you drag the window and release the mouse button, it magnifies the portion of the display it is currently on top of by 400 percent.

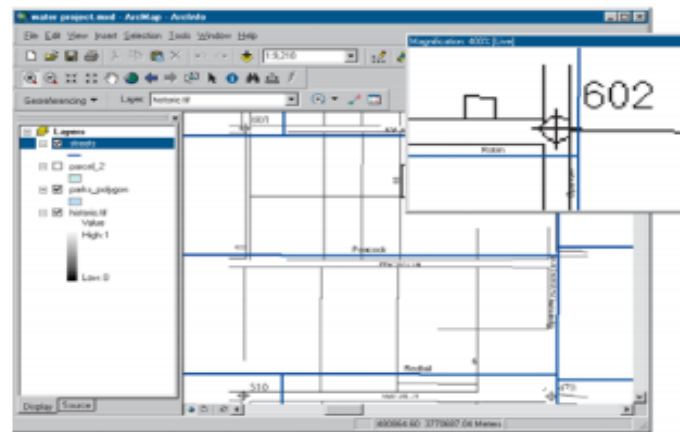
- Click the Add Control Points button on the Georeferencing toolbar.



Add Control Points

The mouse pointer turns into a crosshair when it is anywhere on the map.

- Drag and center the magnifier window over the registration mark in the upper right, labeled 602, and release the mouse button. If necessary, reposition the window so you can see both the registration mark and the corresponding street intersection—Robin and Sparrow—within the window.



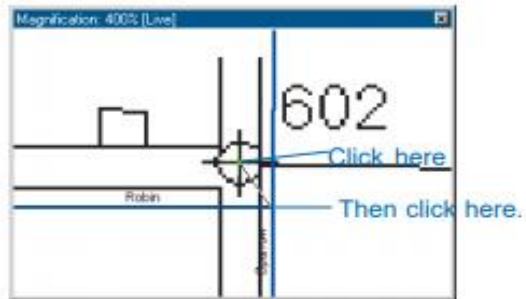
Note that the registration mark and intersection may be in slightly different positions on your map.

- Center the crosshair over the registration mark and click.

A green control point is added to the image. Move the mouse pointer away from the control point but don't click again.

A line stretches from the control point as you move the mouse pointer. This is the link—you'll connect the other end of it to the corresponding street intersection.

8. Center the mouse pointer over the intersection of Robin and Sparrow on the streets layer—you can see the link stretch as you do this—and click.



You've added the other end of the link. The second control point is shown as a red crosshair. The image is now shifted so the upper-right corner of the image is in the correct location—at the corner of Robin and Sparrow. However, not all registration marks are located exactly at the intersections. You'll add a couple more links to achieve better registration.

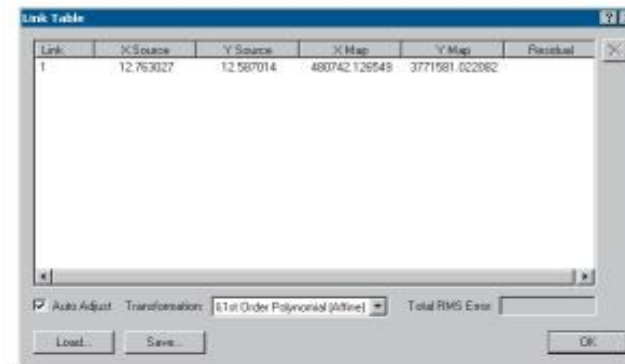
Before you add the next link, look at the link table.

9. Click the View Link Table button on the Georeferencing toolbar.



For each link, the table lists the x and y coordinates for the source—the scanned image—and the corresponding coordinates for the map—the streets layer.

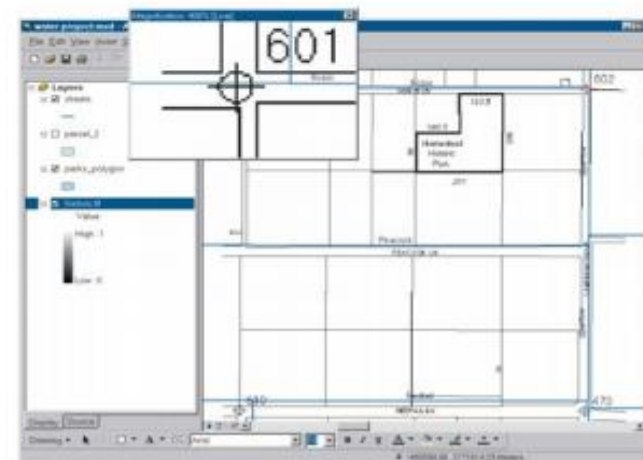
If you make a mistake and need to delete a link, select it and click the Delete button, which looks like the letter X.



10. Click OK to close the Link Table.

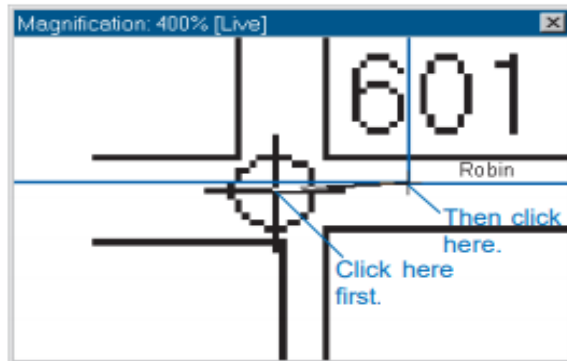
Now you'll add the other two links.

11. Drag and center the magnifier window over the registration mark in the upper left, labeled 601, and release the mouse button.



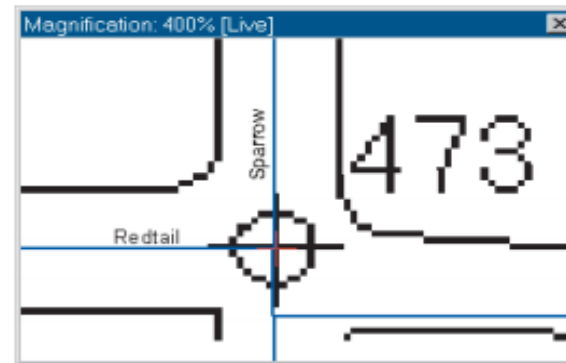
If necessary, reposition the window so you can see both the registration mark on the image and the corresponding street intersection.

12. Center the crosshair over the registration mark and click.
13. Center the crosshair over the intersection and click to add the second control point.



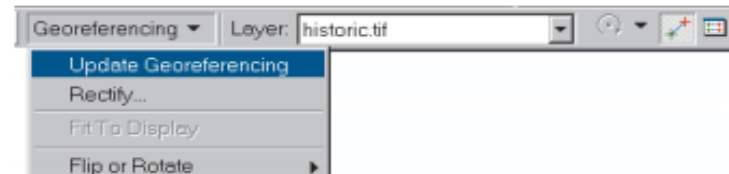
The image adjusts slightly. Now add the third link in the same manner.

14. Drag the magnifier window over the registration mark in the lower right, labeled 473.
15. Click the registration mark, then click the intersection.
The image shifts again.



Now the control points match closely with the intersections. You could add a fourth link, but at this point the registration is acceptable for your purposes.

16. Click the Georeferencing dropdown arrow and click Update Georeferencing to save the new registration.



You don't need the control points anymore.

17. Click the Georeferencing dropdown arrow and click Delete Control Points. Then close the Georeferencing toolbar.

Keep the magnifier window open since you may want to use it when digitizing the park boundary.

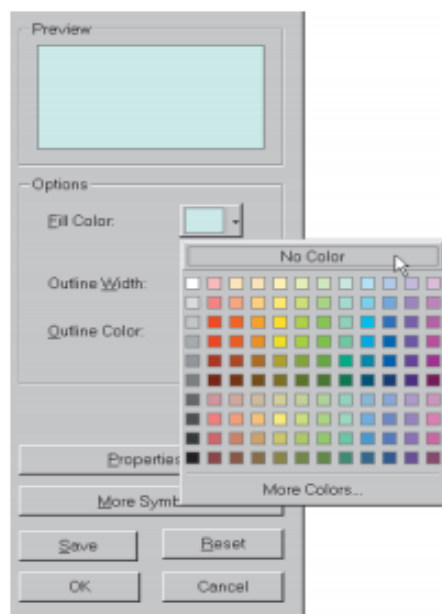
Displaying the park boundary and the parcels

You need to be able to see the image underneath the parcels when digitizing, so you'll draw the parcel outlines.

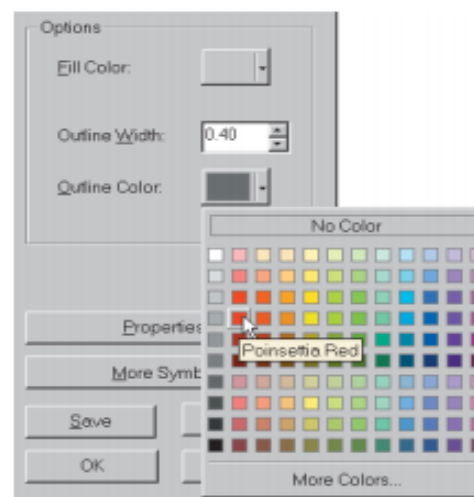
1. Click the legend symbol under parcel_2 in the table of contents.



2. In the Options panel on the Symbol Selector dialog box, click the Fill Color dropdown arrow and click No Color.



3. Click the Outline Color dropdown arrow and set the color to red.

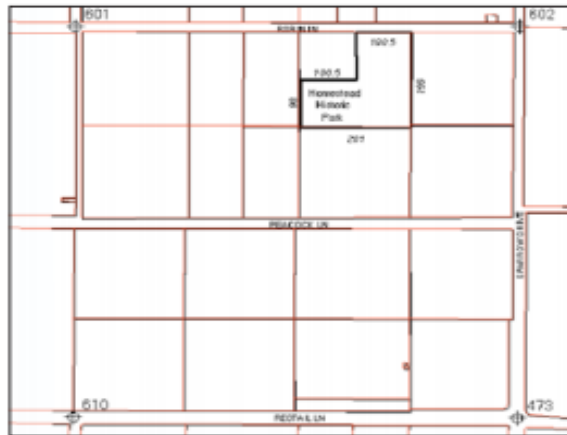


4. Click OK.
5. Check the box next to the parcel_2 layer to draw the parcels.

You don't need to display the streets or the street names at this point, but you'll keep the layer on the map for use in the analysis phase of the project.

6. Right-click streets in the table of contents and click Label Features—it's currently checked—to turn off the street name labels.
7. Uncheck the streets layer so the streets are no longer displayed.
8. Right-click the historic.tif layer and click Zoom To Layer.

Now your display should show only the parcel boundaries in red on top of the image.



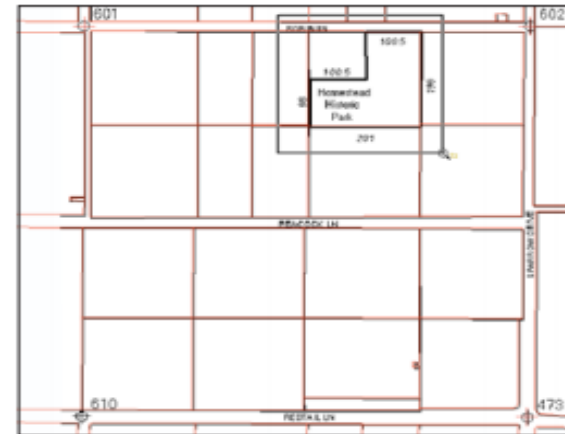
9. Click File and click Save to save your map.

You can see that the parcel boundaries in the parcel_2 layer match well—but not exactly—with the parcel boundaries on the image. Since you'll be snapping the boundary to the parcel_2 layer and using the image merely as a guide for digitizing the park boundary, this registration is acceptable. If you were digitizing solely by tracing from the image, you would want to make sure the image was as closely registered to the streets as possible. To do this, you could add more links. In any case, the registration might never be exact because of such factors as distortion on the scanned image, the placement of registration marks on the image, and slight differences in the location of the streets on the image—created from a paper map—and in the GIS database.

Preparing to digitize the park boundary

You'll align the park boundary exactly with the surveyed parcel boundaries by snapping to the parcel_2 layer. First you need to set up the digitizing environment.

1. Zoom in to the park by using the Zoom In tool on the Tools toolbar to draw a box around the park boundary.



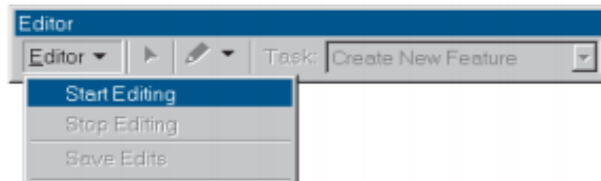
While you're here, add a bookmark to use when you start digitizing the boundary.

2. Click the View menu, point to Bookmarks, and click Create. Name the bookmark Park Boundary and click OK.
3. Click the Editor Toolbar button.



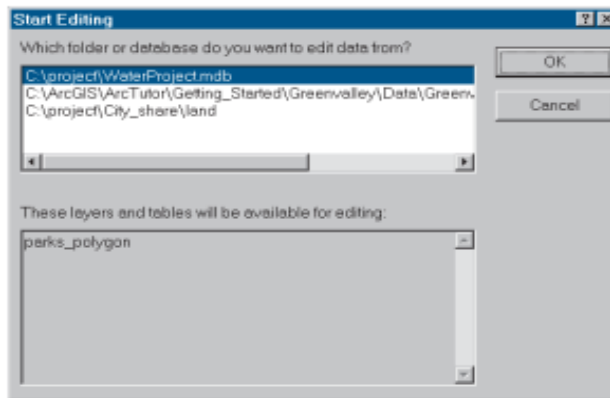
Editor
Toolbar

- Click Editor and click Start Editing.



The Start Editing dialog box appears. You'll be adding a feature to the `parcs_polygon` feature class you copied to the `WaterProject` geodatabase, so select it as the database to edit data from.

- Click `project\WaterProject.mdb`, then click OK.

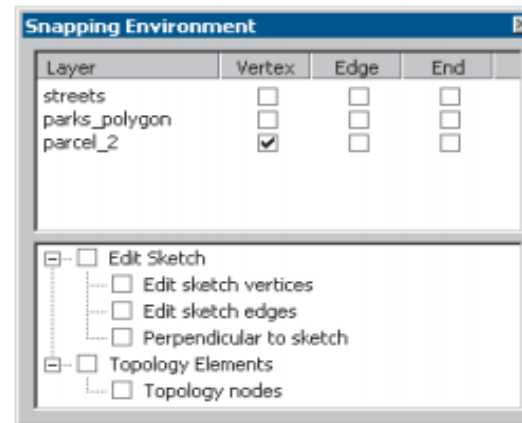


The Editor toolbar shows that the target layer—the one you are editing—is `parcs_polygon` and the current editing task is `Create New Feature`.



Now set the snapping environment so the new park boundary will align exactly with the existing parcel boundaries.

- Click Editor, then click Snapping.
- Check the box in the Vertex column for the `parcel_2` layer.



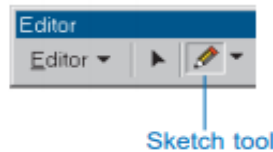
This will snap the editing mouse pointer to the vertices of the parcels.

- Close the Snapping Environment dialog box.

The snapping tolerance defines how close the mouse pointer must be to an object before it snaps to that object. You can change the snapping tolerance by choosing `Options` from the Editor menu. For this exercise you don't need to change the snapping tolerance.

Starting to digitize the boundary

1. Click the Sketch tool.



It may help if you zoom in to the northeast corner of the park—you can use the Pan and Zoom tools while you are digitizing. Just click the Zoom tool, drag a rectangle around the area you want to see, and click the Create New Feature tool again to resume digitizing. Then use the bookmark you created to display the full park boundary again. Or, use the magnifier window. You can move the window—and move the mouse pointer in and out of the window—while digitizing.

If you make a mistake while digitizing, click the Undo button on the ArcMap Standard toolbar.



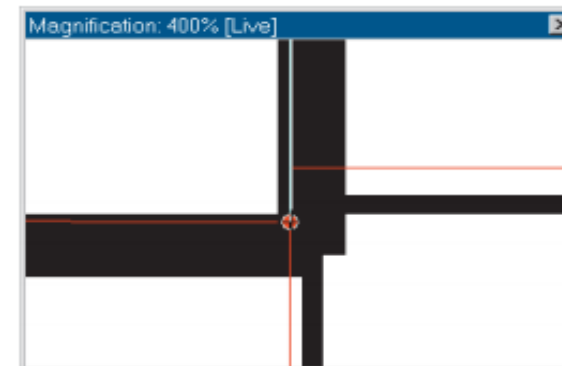
2. Move the editing mouse pointer over the northeast corner of the Homestead Historic Park boundary.

The existing parcel boundaries are drawn with red lines, and the park boundary is drawn with a heavy black line. You'll snap to the existing parcel boundary. The digitizing mouse pointer is shown as a blue dot with a crosshair. When the mouse pointer gets within the snapping tolerance of the parcel corner, the blue dot snaps to the vertex.

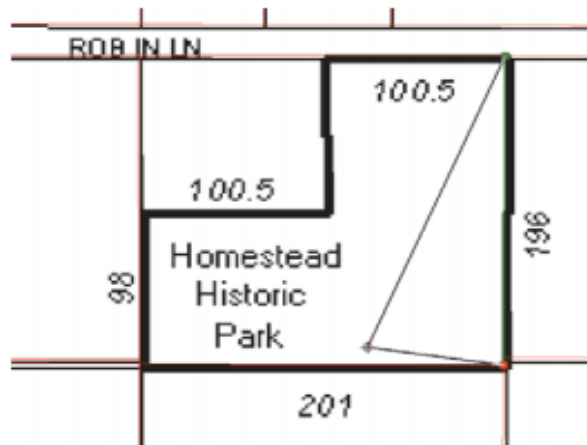
3. Click the northeast corner of the park to start your edit sketch.



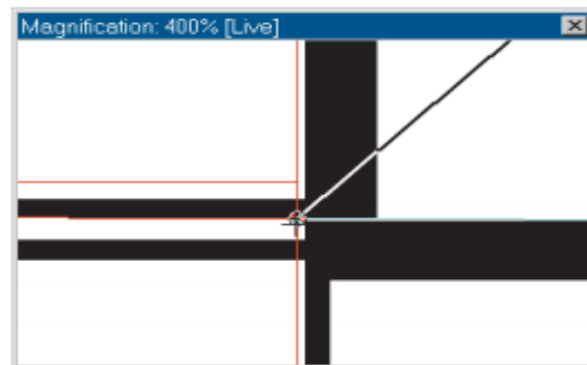
4. Move the mouse pointer to the southeast corner of the park. There are two vertices here. Make sure that the mouse pointer snaps to the southernmost vertex. Click the vertex.



After you add the second point, a line is drawn back to the first point in your sketch to create a polygon that stretches as you move the mouse pointer.



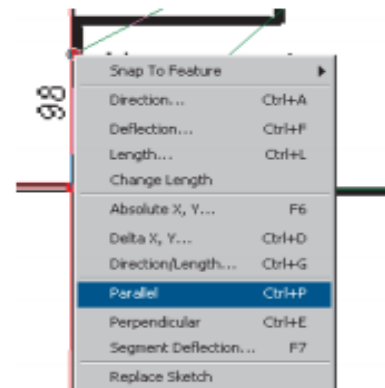
5. Move the mouse pointer to the southwest corner of the park. There are two vertices here. Click the southernmost vertex.



Placing a vertex by angle and distance

The next segment of the park boundary is only half as long as the parcel boundary. The scanned image includes dimensions for each segment. You'll use the dimensions to place the next two vertices using angle and distance.

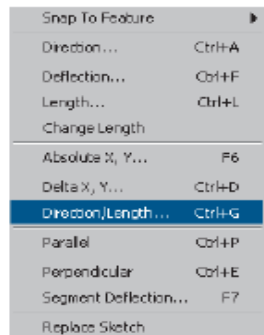
1. Place the mouse pointer near the parcel boundary line at the corner of the park. Right-click and click Parallel.



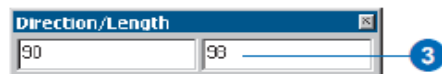
Now the mouse pointer is constrained to be parallel to the parcel boundary.

2. Right-click again and click Direction/Length.

The Direction/Length dialog box appears.

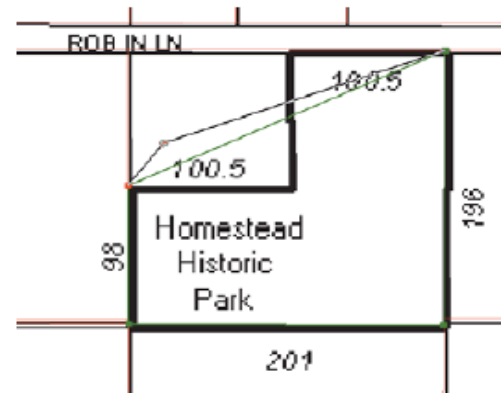


3. Click in the Direction text box and type "90", then click in the Length text box and type "98". Press Enter.

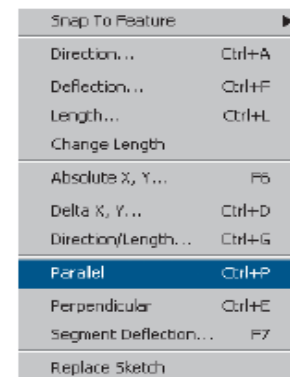


The length of this segment of the park boundary as shown on the image is 98 meters.

A vertex is placed on the line coinciding with the parcel boundary 98 meters from the previous vertex you added at the corner of the parcel.



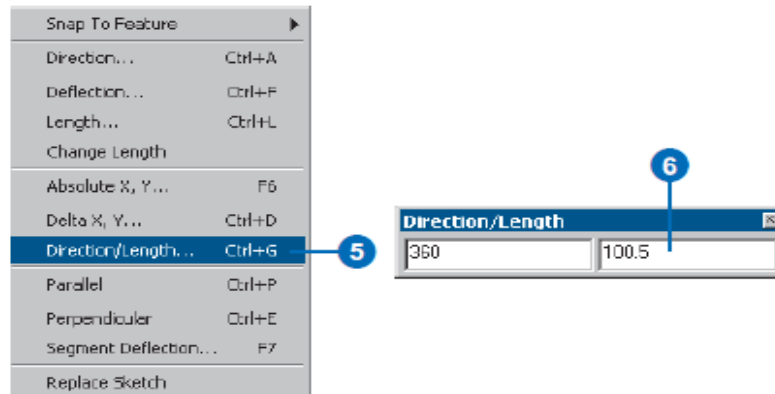
4. Move the editing pointer near the midpoint of the north boundary of the parcel. Right-click and click Parallel.



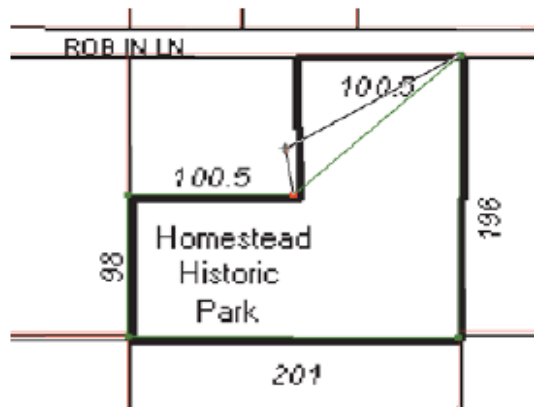
Now the next segment you add will be parallel to the north boundary of the parcel.

5. Right-click again and click Direction/Length.

- Click in the Direction text box and type “360”, then click in the Length text box, type “100.5”, and press Enter.



The new segment is added to the edit sketch; it is 100.5 meters long and parallel to the north boundary of the parcel.



Adding a perpendicular line

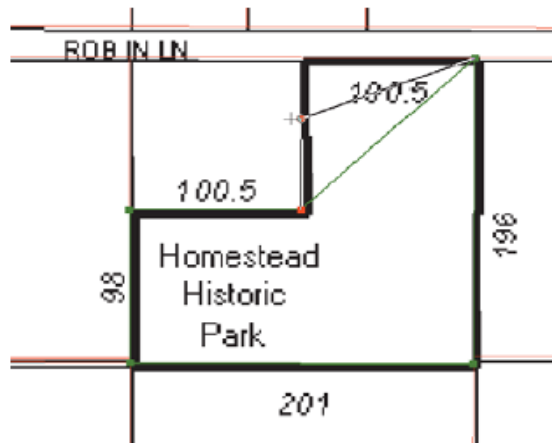
The next segment is perpendicular to the segment you just added.

- Move the mouse pointer along the vertical line, partway to the north boundary of the parcel, right-click, and click Perpendicular.



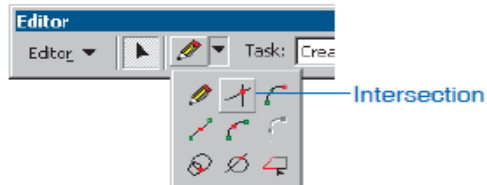
Now the mouse pointer is constrained to be perpendicular to the previous segment.

- Click to add a vertex partway to the north boundary.



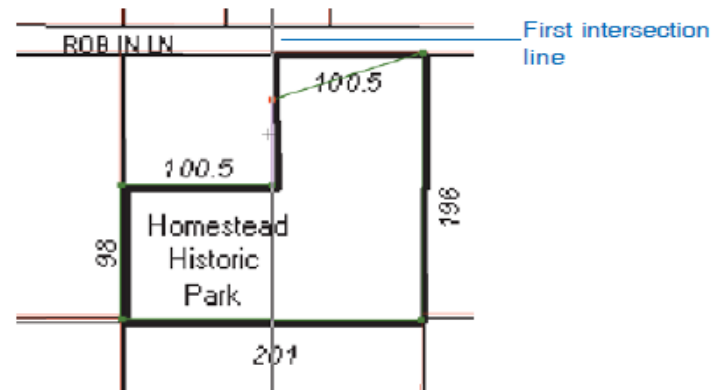
Adding a point at the intersection of lines

- Click the Create New Feature tool dropdown arrow and click the Intersection tool.

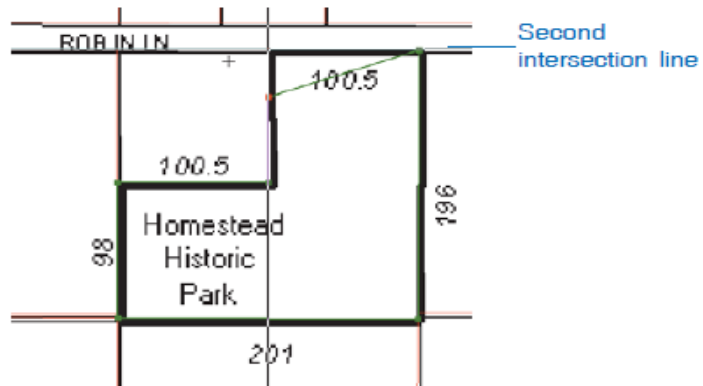


The Intersection tool lets you place the next point in your edit sketch at the intersection of two lines.

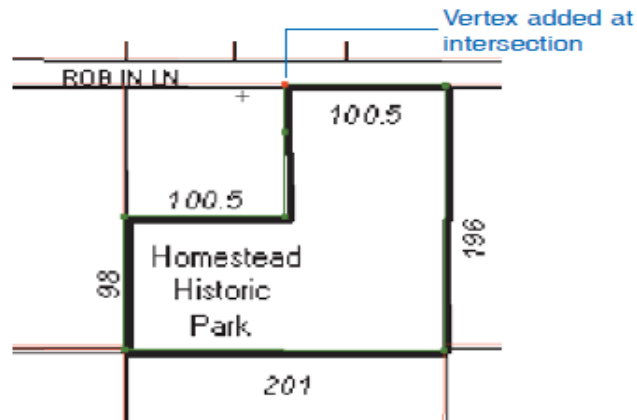
- Place the mouse pointer near the segment you just created. A temporary line extends along the segment. You will make this the first intersection line. Click to set the intersection line.



- Place the mouse pointer near the north boundary of the parcel. You will make this the second intersection line. Click to set the intersection line.

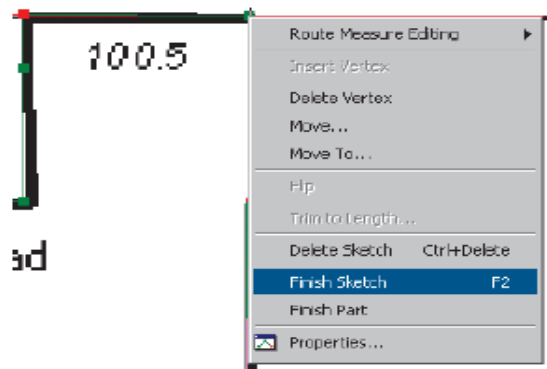


The new vertex appears at the intersection of the two lines at the corner of the boundary.

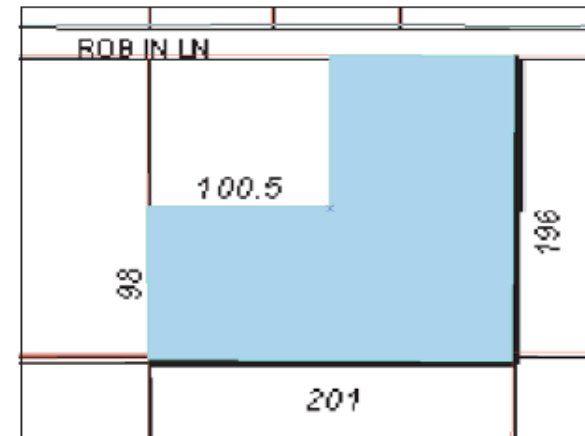


Finishing digitizing

1. Click the northeast corner of the park, right-click, then click Finish Sketch.



The new park polygon is finished. Its boundary turns light blue to indicate that it is selected, and it takes on the color of the other park polygons.



2. Close the magnifier window if it's still open.

Editing the feature attributes

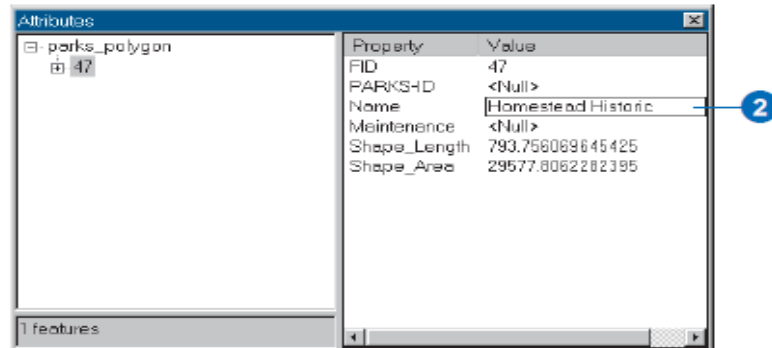
Now that you've finished digitizing the park, you can update the new feature's attributes in the database.

1. Click the Attributes button on the Editor toolbar.



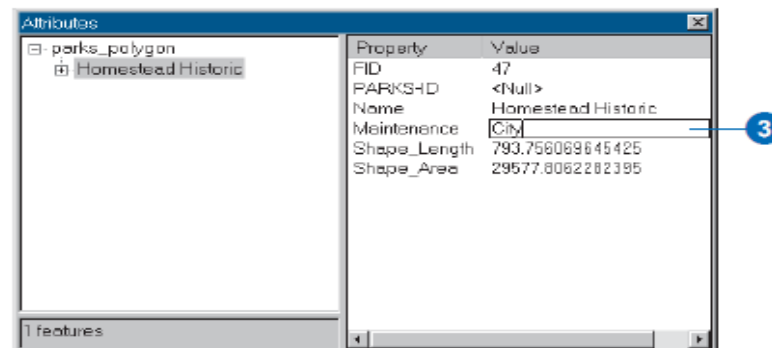
Attributes

- Click next to Name in the Value column and type "Homestead Historic".

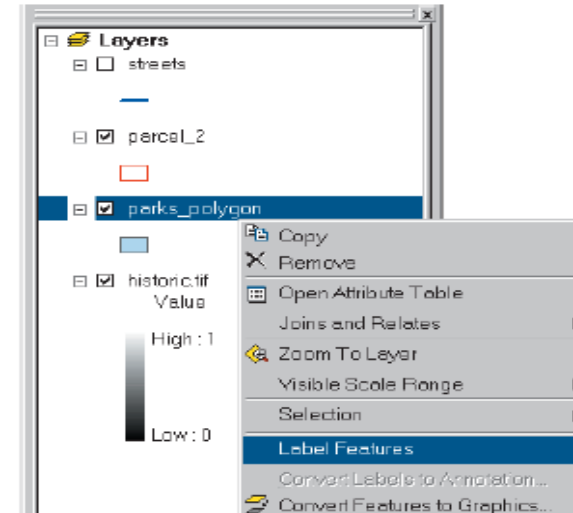


The park will be maintained by the city, so you will update the maintenance field as well.

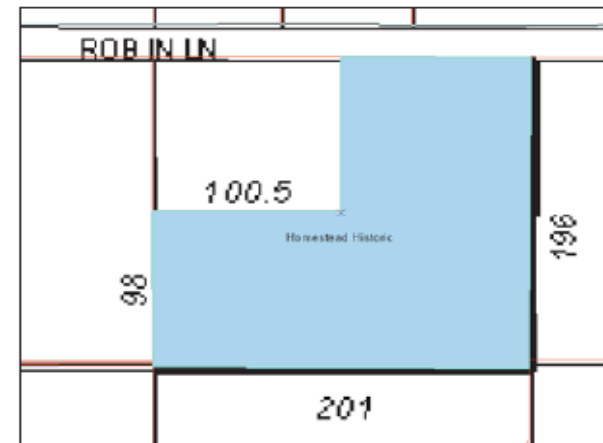
- Type "City" as the value for the Maintenance field and press Enter. Close the Attributes dialog box.



- Right-click parks_polygon in the table of contents and click Label Features.



The new park is labeled with its name.



Saving your edits

Now save your changes to the park feature class in the database.

1. Click Editor, then click Save Edits.

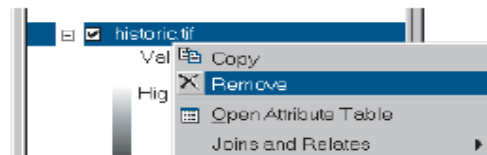


2. Click Editor, then click Stop Editing.

Although this was a simple example, you saw how the Editor provides a variety of tools for constructing features.

Before continuing, clean up the table of contents. You don't need the historic.tif layer anymore, so remove it from the map.

3. Right-click historic.tif in the table of contents and click Remove.



4. You don't need to display parks right now, so uncheck them.

5. Click File and click Save to save your map at this point.

The last task before you start the analysis is to merge the two parcel layers.

Merging the parcel layers

Sometimes data that you need is in two or more adjacent datasets, either because of the way the data was created or the way it is stored. For example, multiple datasets might be created by digitizing from adjacent map sheets into separate shapefiles. In some cases, data for large areas is stored as sets of separate tiles to make it easier to manage and update the features.

The parcel data that you will use in the analysis is stored as tiles of adjacent shapefiles. You have two tiles that you will merge into a single layer, so you'll be able to more easily select the suitable parcels during the analysis.

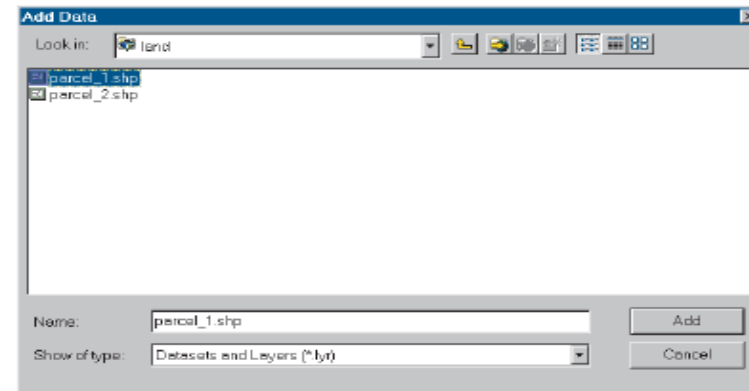
In order to merge the two adjacent layers, you will create a new feature class in the WaterProject geodatabase, then load both existing parcel layers into the new feature class layer.

Creating the new feature class

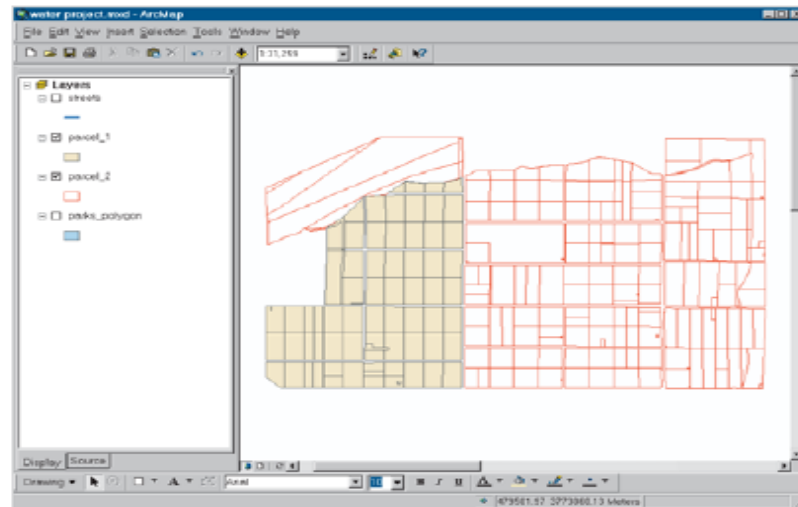
1. Right-click parcel_2 and click Zoom To Layer.

Now you'll add the other parcel layer to the map.

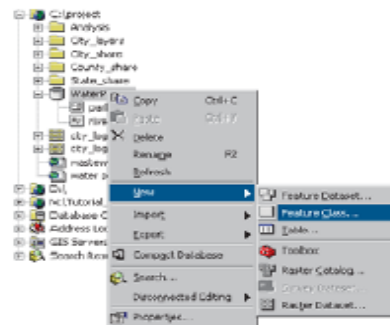
2. Click the Add Data button, navigate to the City_share\land folder under the project folder, click parcel_1, and click Add.



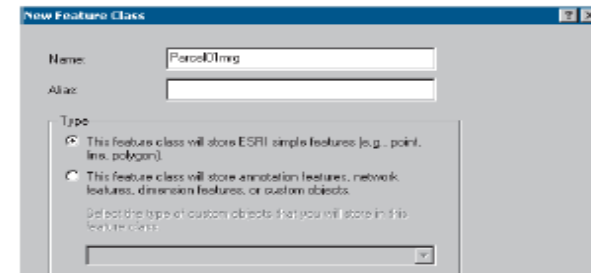
You can see the two adjacent parcel layers. Parcel_1 is drawn with a default solid fill color, while the parcel_2 boundaries are displayed in red.



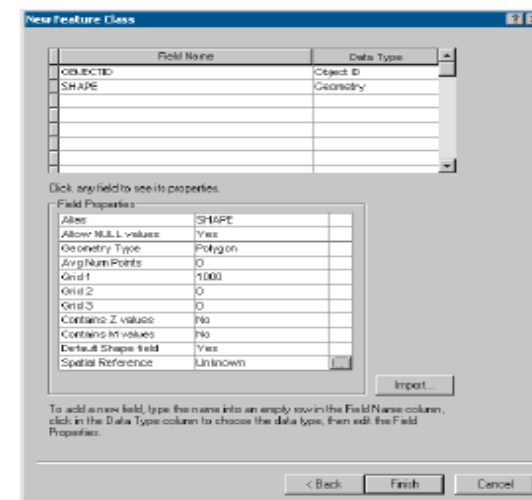
3. Make sure ArcCatalog is open, then right-click the WaterProject geodatabase in ArcCatalog, point to New, and click Feature Class.



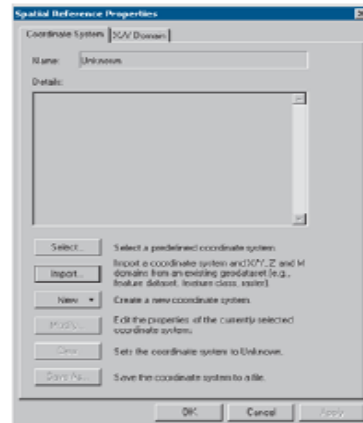
4. Type "parcel01mrg" as the name, click Next, then click Next again.



5. Click Geometry under Data Type and confirm that the Geometry data type under Field Properties is Polygon. If it isn't Polygon, click in the box, click the dropdown arrow that appears, and click Polygon.
6. Click the ellipsis (...) button next to the Spatial Reference text box.



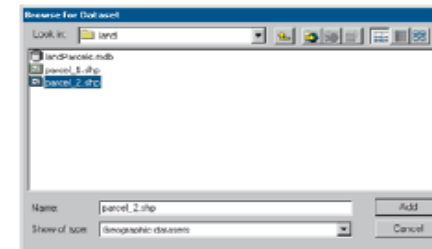
The Spatial Reference Properties dialog box appears.



7. Click **Import** on the Spatial Reference Properties dialog box to import a coordinate system from an existing geodatabase.

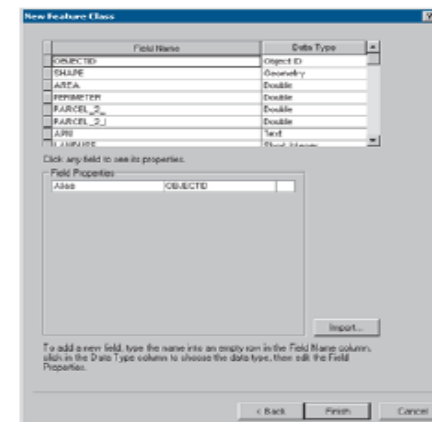
The spatial extent of the coordinate system imported to create the new feature class must include all data that will be loaded. Since the spatial extent of `parcel_2` encompasses `parcel_1`, `parcel_2` will be used as the input coordinate system reference for this new feature class.

8. Select `parcel_2` from the `City_share\land` folder, then click **Add**.



The Spatial Reference Properties dialog box displays with the coordinate system of `parcel_2`.

9. Click **Apply** and click **OK**.
10. Click the **Import** button on the New Feature Class dialog box. This imports the fields from an existing feature class.
11. Select `parcel_2` from the `City_share\land` project folder, click **Add**, then click **Finish**.

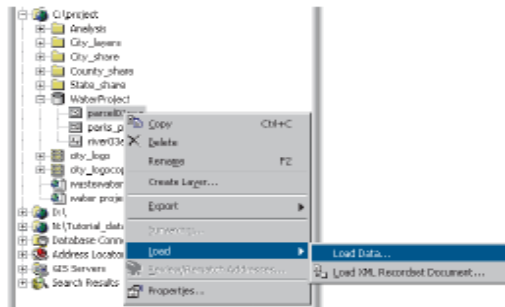


`Parcel01mrg` is added as a new Personal Geodatabase Feature Class.

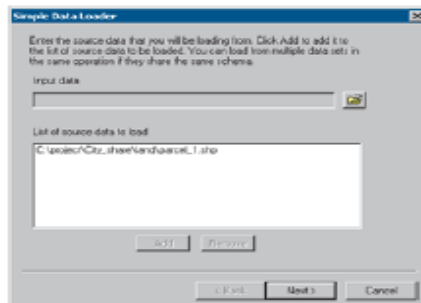
Loading parcel_1 data

The new feature class has now been created using the spatial extent and field names of parcel_2, but it's still empty. You need to load both the parcel_1 and parcel_2 shapefiles to create the final merged feature class.

1. Right-click parcel01.mrg in ArcCatalog, point to Load, and click Load Data.



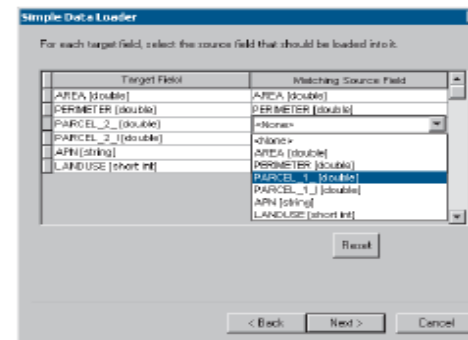
2. Click Next on the Simple Data Loader dialog box.
3. Click the Browse button next to the Input data field, select parcel_1 from the project\City_share\land folder, then click Open.



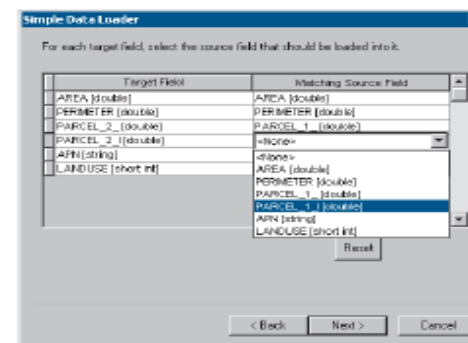
4. Click Add, click Next, then click Next again.

The data loader attempts to match the source field (parcel_1) to the target field (set by parcel_2). Since the field names for the new feature class were created based on parcel_2, you need to specify the fields in parcel_1 that represent the same data but have a different name.

5. Click the first box labeled None under the Matching Source Field. Click Parcel_1_[double] in the dropdown box that appears.



6. Click the box labeled None directly below, then click PARCEL_1_1[double] from the dropdown menu.

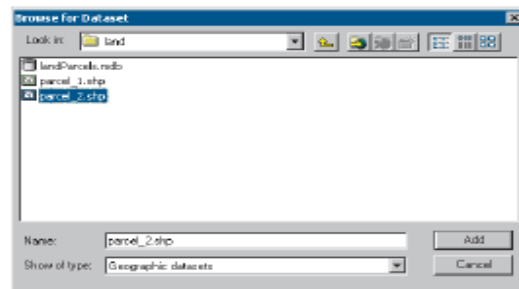


- Click Next, click Next again, then click Finish.

Next you will repeat this process to add parcel_2 to the parcel01mrg feature class.

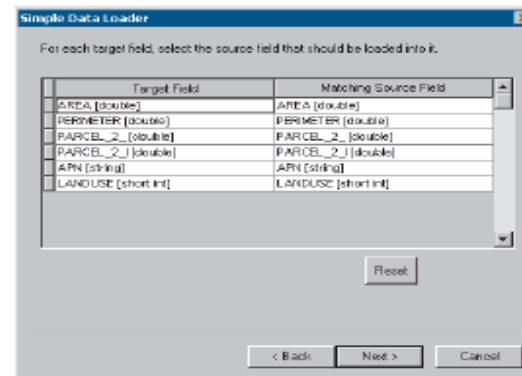
Loading parcel_2 data

- Right-click Parcel01mrg, point to Load, then click Load Data.
- Click Next on the Simple Data Loader dialog box.
- Click the Browse button next to the Input data field, click parcel_2 from the project\City_share\land folder, then click Open.



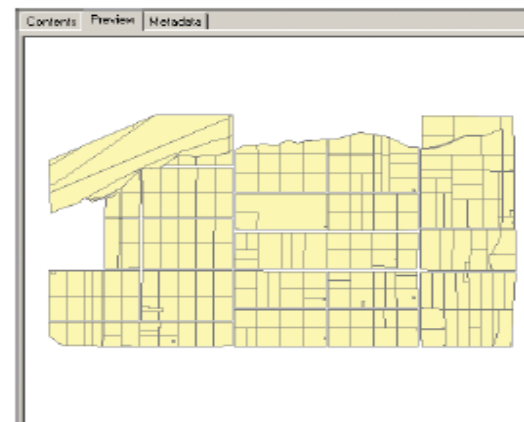
- Click Add, click Next, then click Next again.

This time, the Matching Source Field contents are already filled in because you used parcel_2 as the template for this feature class.



- Click Next, click Next again, then click Finish.

Click the Preview tab for the parcel01mrg feature class, and you will see that both parcels have been combined to form a single feature class.



6. Click and drag the new parcel01mrg feature class from ArcCatalog to the top of the table of contents in your map.
7. You don't need the parcel_1 and parcel_2 layers any longer, so remove them from the map by right-clicking them and clicking Remove.
8. Click File and click Save to save your map.

In this chapter you have prepared your data for the analysis and completed the project database. Preparing data—whether by converting it, changing its coordinate system, managing its attributes, or editing its features—is an important part of a GIS project. The quality of the analysis and map depends on the quality of the data. An organization's biggest investment in a GIS project, other than its staff, is usually in its data.

In the next chapter you'll perform the analysis to find parcels that meet the city's criteria as a site for the wastewater treatment plant.

Completing GIS-Analysis for Areal Management

In the AM Project's planning stage a user decided which data he would need in order to meet the criteria. You then assembled the data and prepared it for analysis.

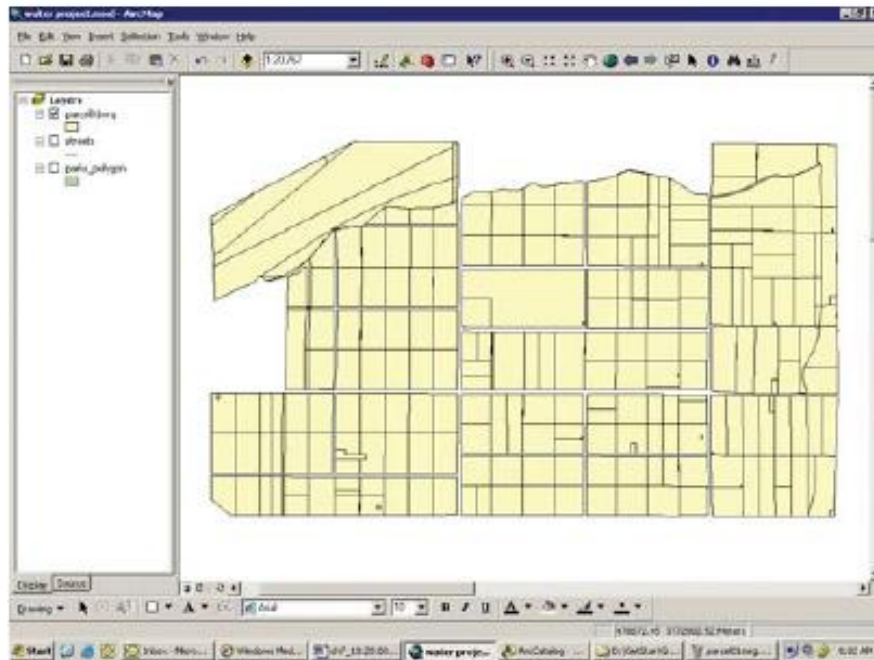
At this point a user is ready to perform the analysis. There are often several alternative methods a user can use to get to the end result.

The approach a user applies is partly dictated by the problem which is necessary to solve, partly by the data, and partly by personal preference of a user. In this analysis, the parcels suitable for a site for the wastewater treatment plant have to meet certain location criteria and also have to be vacant. The location criteria fall into two categories: features the plant should be away from or outside of—away from parks and residences, outside the flood zone—and features the plant should be near or inside of—near the river, inside the low elevation area. The areas delineated by these criteria become the unacceptable and acceptable areas for the plant, respectively.

A user will find the parcels that fall outside the unacceptable areas, then find the subset of these that fall inside the acceptable areas. Next, of the remaining parcels, a user will find the ones that are vacant. The city also prefers that the site be near a road and near the existing wastewater junction. A user will find and tag the parcels that are within 50 meters of a road. A user will also find and tag the parcels that are within 500 and 1,000 meters of the wastewater junction. Finally, a user will find parcels that are at least 150,000 square meters in size, large enough to build the plant on.

If you closed your ArcCatalog and ArcMap at the end of “Preparing data for AM Project chapter”, you will need to reopen them and reopen the water project map. Your map should currently include the **parks_polygon**, **streets**, and **parcel01mrg** layers, with the parcels displayed.

You'll be adding data from several locations during the analysis, so in the Catalog tree navigate to and open the project folder so you can see the **City_layers**, **City_share**, and **State_share** subfolders and the **WaterProject** geodatabase. Open each subfolder and the geodatabase so you can see the contents of each.





Now you're ready to start the analysis process. The general approach for this analysis was presented in the flowchart in a chapter, 'Planning a GIS project in Areal Management'. At this point, you need to develop the specific steps for each phase of the analysis. Detailed flowcharts for each section are presented at the beginning of the appropriate section in this chapter. You'll implement the analysis using ArcMap. Combining the river buffer and lowland layer and combining the park and residential buffers with the flood zone layer will reduce the number of selections you'll have to do to find the parcels that meet the criteria. It's easier to do the selections all at one time, so you'll first create the two layers that delineate the acceptable and unacceptable areas, then do all three selection steps.

Delineating the area the plant site should be within

In this phase of the analysis you'll buffer and combine features to delineate the areas the wastewater treatment plant should be within—areas within 1,000 meters of the river and lowland areas. You'll create a 1,000-meter buffer around the river, then combine the buffer with the lowland layer. Here are the steps:

- Create a 1,000-meter buffer around the river.
- Overlay the river buffer and the lowland layer.

Here's a flowchart of the process using the layer names:



Buffering the river

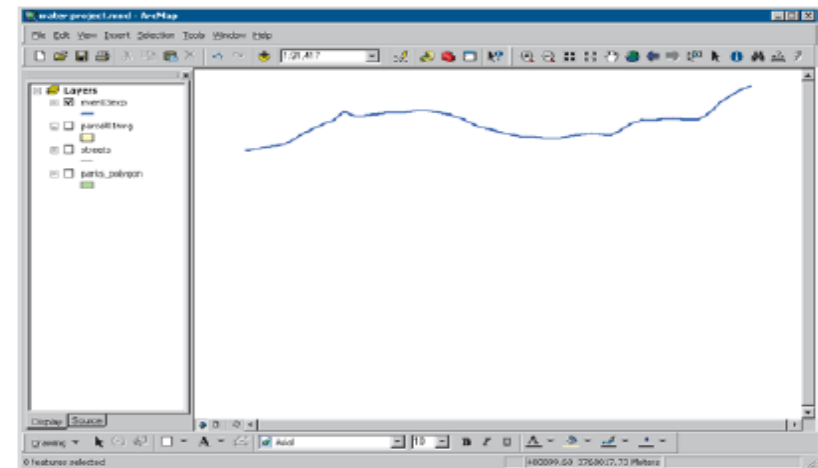
You'll use the Buffer tool in ArcToolbox to buffer river03exp to 1,000 m to create river04buf. The Buffer tool is one of many geoprocessing tools contained in ArcToolbox. Any of the geoprocessing tools can be run from ArcToolbox, from the command line, through the ModelBuilder™, or with a Script. These options will be described in more detail throughout this section. If you would like more information on geoprocessing methods after working through this tutorial, see *Geoprocessing in ArcGIS*.

1. Uncheck the parcel01mrg layer since you won't need to display it until later.

2. In the Catalog tree, click river03exp in the WaterProject geodatabase and drag it onto the map in ArcMap.



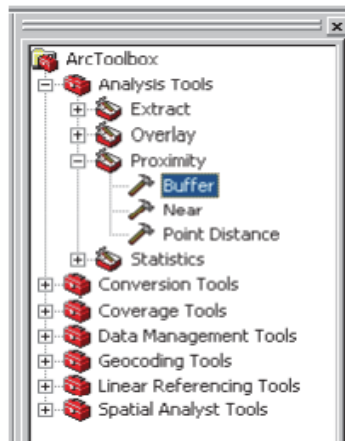
3. Click the Full Extent button on the Tools toolbar to see the river.



- Click the Show/Hide ArcToolbox button on the toolbar.



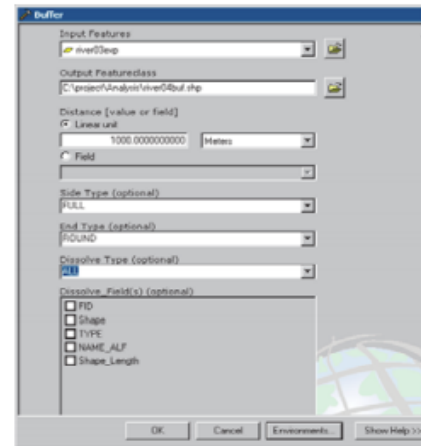
- Double-click Analysis Tools in the ArcToolbox tree, double-click Proximity, then double-click the Buffer tool.



The Buffer dialog box appears.

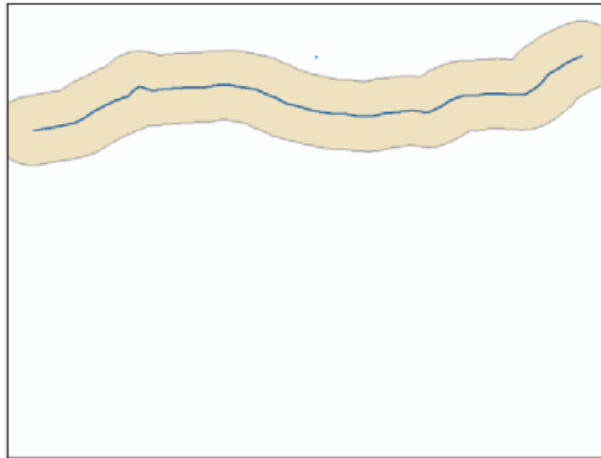
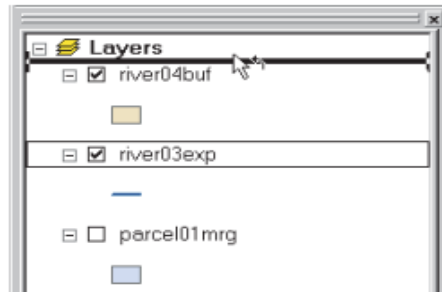
- Click the Input Features browse button, navigate to and double-click WaterProject.mdb in the project folder, click river03exp, and click Add.
- In the Output Feature class box type the path to the Analysis folder, and type “river04buf.shp” as the layer name.

For the rest of the analysis, the output layers you create will be shapefiles in the Analysis folder.



- Type “1000” in the Linear unit field and click the dropdown menu to change from Unknown units to Meters to create a buffer of 1,000 meters around the river.
- Click the dropdown arrow for Dissolve Type and choose ALL; the river is actually composed of five line segments, each of which will be buffered, so dissolving the barriers will create a single buffer around the river. Leave the default settings for Side Type and End Type.
- Click OK.
The Buffer window appears automatically, and the buffer is created.
- Close the Buffer window.
The river04buf layer appears on your map.

12. Drag the river03exp layer above the river04buf layer in the table of contents to display it on top.



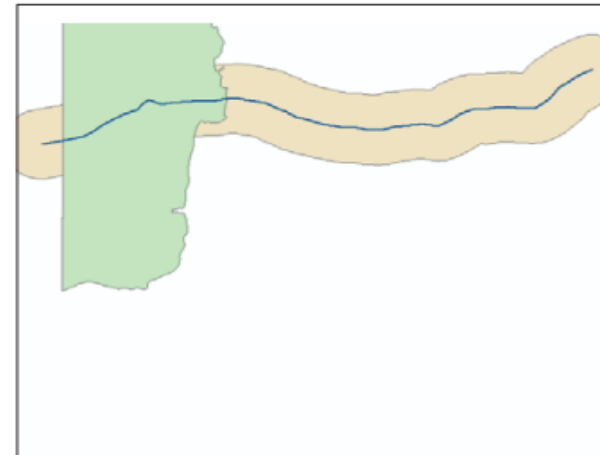
Overlaying the river buffer and the lowland area

Next you'll use the Intersect tool to combine the lowland layer and the river buffer to create low_river, which delineates the area the plant site needs to be within.

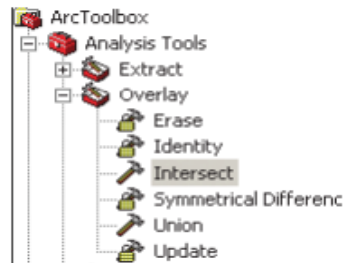
1. Add the lowland shapefile to the map by dragging it from the State_share folder in the Catalog tree.



ArcMap warns you that the lowland shapefile is in a different coordinate system than the other data on the map. That's okay—since you've defined the coordinate system for lowland (in Chapter 6, 'Preparing data for analysis'), it will overlay correctly with the other data. Click OK to close the Warning message box.

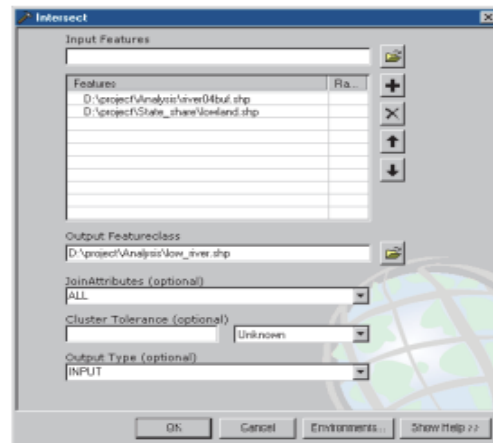


2. Double-click the Intersect tool under Overlay in the Analysis Tools.



The Intersect dialog box opens.

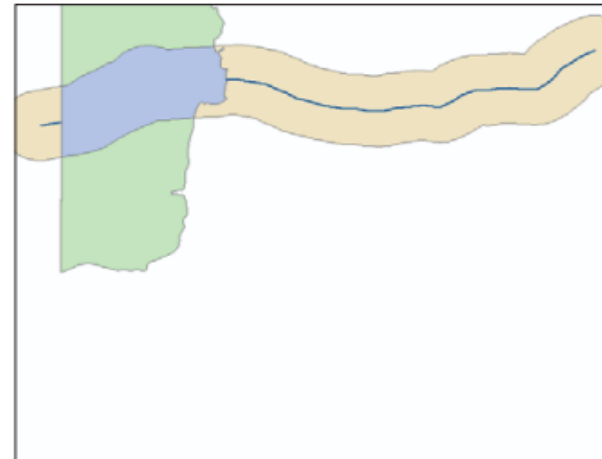
3. Click the Browse button on the Input Features box, navigate to lowland, and click Add. Do the same for river04buf.shp.



4. In the Output Featureclass box, ensure the path to the Analysis folder is displayed and type “low_river” as the layer name. If the path to the Analysis folder is not displayed, type it in or use the Browse button to navigate to it, then type the name of the new layer.

5. Click the JoinAttributes dropdown arrow and click ALL.
6. Leave the remaining fields as default and click OK.
7. When the intersect is complete, close the Intersect window. Drag low_river from the Analysis folder to the top of the map's table of contents.

The new layer is displayed. It contains only the area covered by both the river buffer and the lowland layer. You can see the lowland and river buffer layers underneath and that the new layer, low_river, represents the intersection of the two.



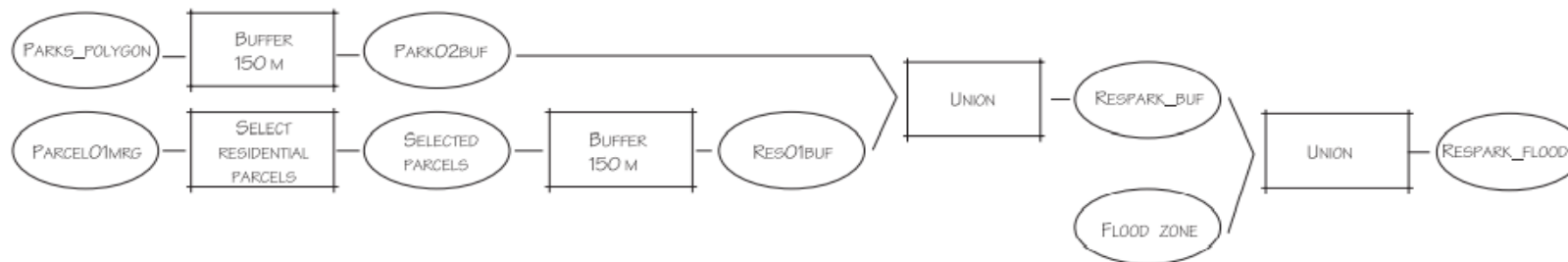
8. Uncheck low_river, river03exp, lowland, and river04buf since you don't need to display them for the next step. Keep them on the map, though, since you may want to use them later to verify the results of your analysis.
9. Click File and click Save to save your map.

Delineating the areas the plant site should be outside of

Now you'll find the areas the plant should be outside of—areas within 150 meters of parks and residential parcels and within the flood zone. You'll create a 150-meter buffer around parks, then select the residential parcels from the parcel layer and create a 150-meter buffer around them. You'll then combine the two buffer layers and combine the result with the flood zone layer. The resulting layer will delineate the areas the plant site should not be within. Here's a flowchart of the process:

Here are the steps:

- Buffer the parks to 150 meters.
- Select the residential parcels.
- Buffer the residential parcels to 150 meters.
- Overlay the parks and residential buffers.
- Overlay the combined park and residential buffer layer with the flood zone layer.



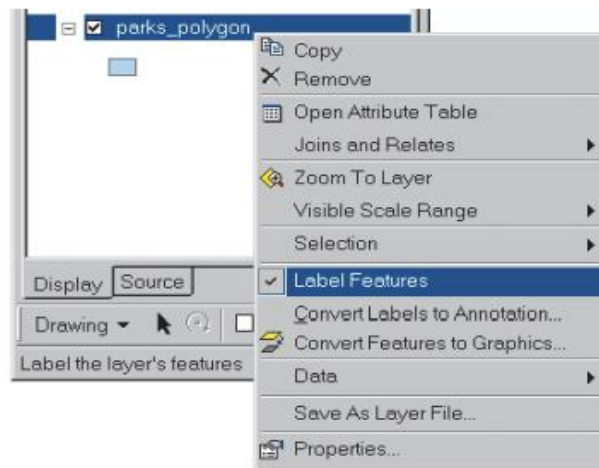
Buffering the parks

First you'll create a 150-meter buffer around parks.

1. Check parks_polygon in the table of contents to display the parks.

The parks are labeled with their names.

2. Right-click parks_polygon and click Label Features, which is currently checked on, to turn off the labels.



You will use the Command Line to buffer the parks in this section.

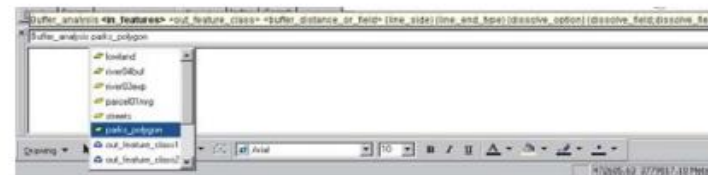
3. Click the Show/Hide Command Line button on the toolbar in ArcMap if the Command Line window isn't already open.



4. The Command Line window appears in the ArcMap document. Click and drag the bar at the top of the Command Line window to the bottom of the document so it's displayed horizontally.



5. Click in the top of the Command Line window and type "Buffer". Buffer is highlighted. Since this is what you want, press the spacebar. The command line usage for Buffer appears.
6. Begin typing "parks_polygon" and it will be automatically selected from the dropdown list. Press the spacebar, and parks_polygon will be added to the command line.



You must next specify the out_feature_class, the name, and directory of the new file you are creating.

7. Type "c:\project\Analysis\park02buf" and press the spacebar. If your project folder is on a drive other than C, type the drive where your project is located.
8. Type "150" for the buffer distance and press the spacebar.

- Specify FULL for line_side, ROUND for line_end_type, and ALL for dissolve_option, pressing the spacebar to move between each command.



You don't need to specify the dissolve field at this time.

- Press Enter to run the command.

The park buffers are automatically added to the map document.

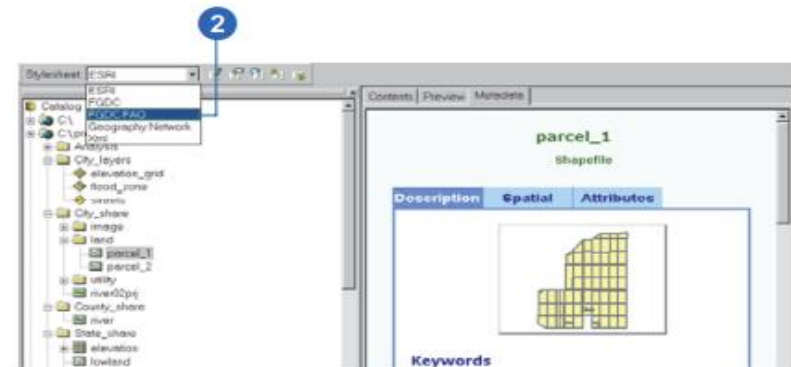
- Close the Command Line window.
- Drag the parks_polygon layer above the park02buf layer in the table of contents to display it.



Selecting the residential parcels

Previously, you created buffers for a layer with a single feature (the river) and a layer with many features (parks). This time you'll buffer selected features in a layer—only the residential parcels from the parcel01mrg layer. You need to know the land use code for residential parcels so you can select them. You can get the code from the metadata.

- In ArcCatalog, click parcel_1 in the City_share\land folder and click the Metadata tab.
- Click the Stylesheet dropdown arrow and click FGDC FAQ.



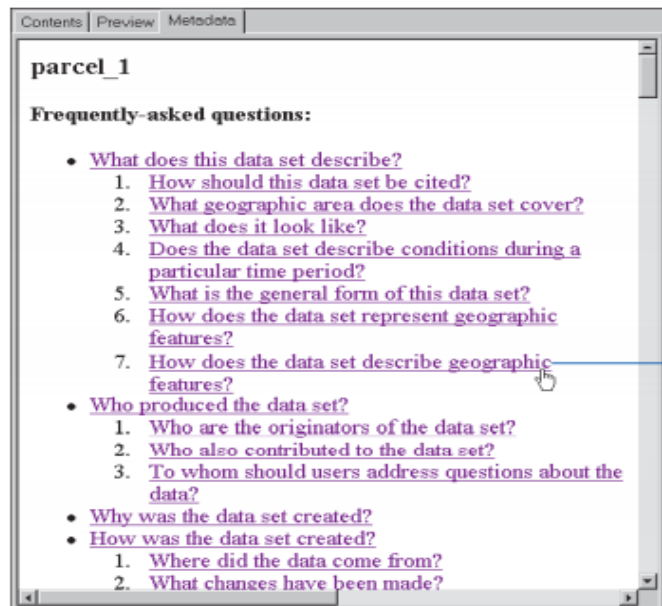
The format of the metadata changes.

The metadata that you see displayed in Catalog is controlled by the stylesheet that you use to display it. The stylesheets are similar to database queries—they basically define what information is pulled out of the metadata and how it can be formatted.

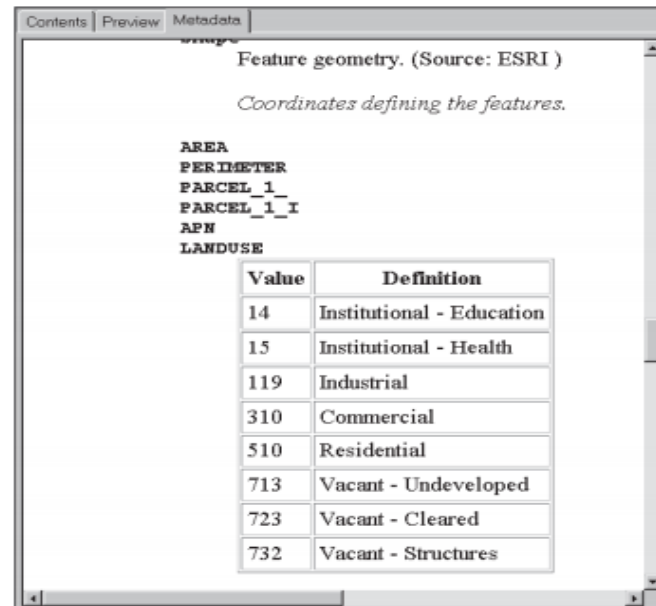
ArcGIS provides several predefined stylesheets—the default is the ESRI stylesheet, which you used earlier. You can also create your own stylesheets.

The FGDC FAQ stylesheet was developed by the Federal Geographic Data Committee to present the metadata in the form of a set of frequently asked questions. This format lets you see the values for each attribute in a layer (as long as they've been defined in the metadata).

3. Click “7. How does the data set describe geographic features?” in the first section.

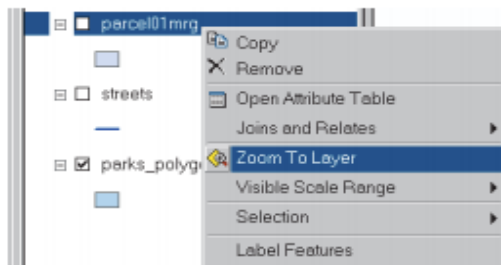


The value definitions for the land use attribute are listed (you may need to scroll down to see them). You can see that residential parcels have a value of 510. Note also that vacant parcels have values of 713, 723, and 732. You'll use these values later in the analysis.

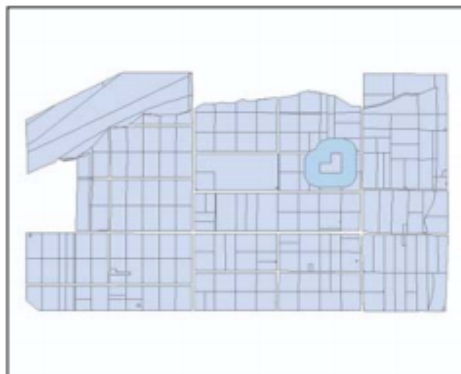


Before selecting the residential parcels, zoom in to the parcel layer.

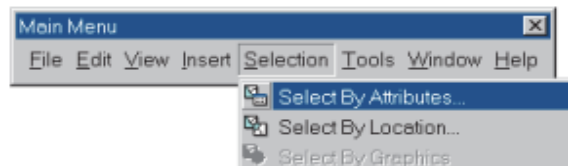
- Right-click parcel01mrg in the ArcMap table of contents and click Zoom To Layer, then check the layer to display the parcels.



You can also see the buffer around the historic park.



- Click the Selection menu and click Select By Attributes.

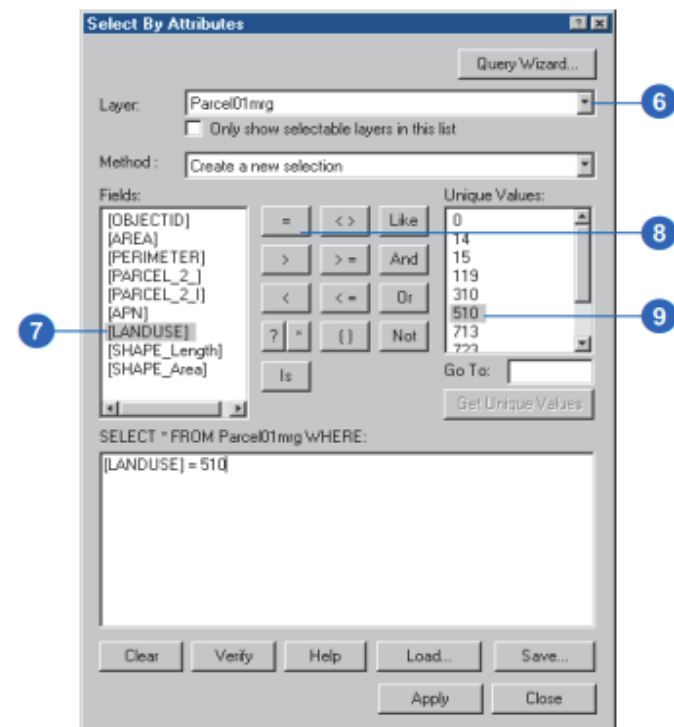


- In the Select By Attributes dialog box, click the dropdown arrow next to the Layer box and click Parcel01mrg as the layer to select from.

The default method is to Create a new selection, which is what you want.

You'll use the query builder to create a simple query expression.

- Double-click LANDUSE in the Fields list.
- Click the equals sign (=) button.
- Click Get Unique Values and double-click 510 (the code for residential) in the Unique Values list.



You can see the query expression you've built in the text box. It should look like this:

[LANDUSE] = 510

10. Click Apply. The residential parcels are highlighted with a blue line. Close the Select By Attributes dialog box.



Now you'll be able to create buffers around the parcels to keep the plant from being sited too close to a residence.

Buffering the selected parcels

To complete the buffer of the selected parcels and overlay of the park and residential buffers, you will create a graphical model in ModelBuilder, another option for geoprocessing in ArcGIS.

Models automate the process of performing a sequence of geoprocessing tasks on your data. You can run a model over and over with a single click, so you can quickly change parameter values to experiment with different outcomes.

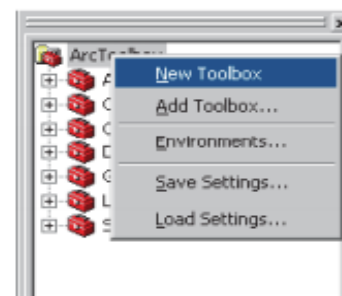
You can also export a model you have created to a script, enabling you to easily create new scripts that you can then modify.

Although models can be built with several operations, then run at the end, you will create the model in several steps, running each process individually, enabling you to examine the results of each processing step.

1. Make sure the ArcToolbox window is open in your map document. If not, click the Show/Hide ArcToolbox button on the toolbar.

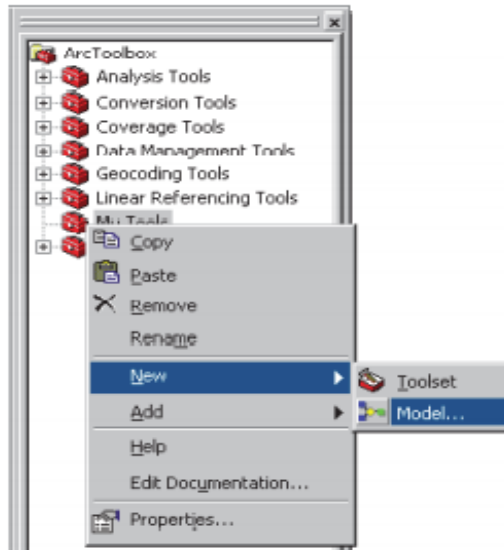


2. Right-click the ArcToolbox folder and click New Toolbox.

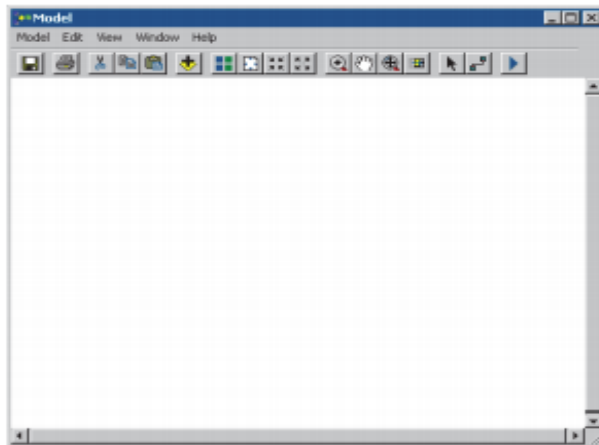


3. Right-click the new toolbox that is added and click Rename. Type "My Tools" as the new toolbox name and press Enter.

4. Right-click My Tools, point to New, and click Model.



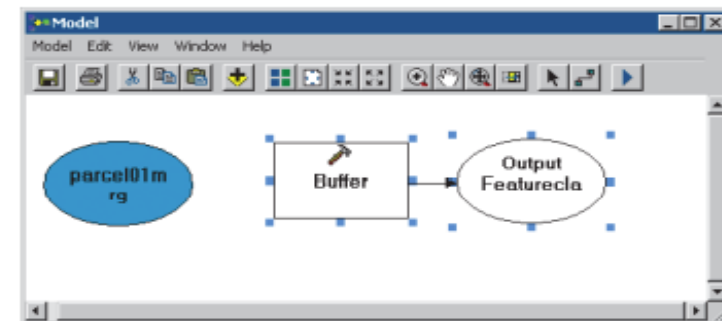
A new ModelBuilder window opens, allowing you to start building your model.



The toolbar gives you quick access to much of the available functionality in the ModelBuilder menus and more.

There are multiple ways to add data and tools to a model. Click the Add Data or Tools button and add data, or drag input data from the ArcCatalog tree or layers from the table of contents of any ArcGIS Desktop application having a display. Alternatively, supply the input data parameter values inside the tool's dialog box.

5. Click and drag parcel01mrg from the table of contents and drop in the ModelBuilder window. Parcel01mrg is automatically displayed as a blue oval, indicating that it is an input variable. Drag the oval to the left side of the window.
6. Double-click Analysis Tools in ArcToolbox, double-click Proximity, and drag and drop the Buffer tool in the ModelBuilder window.

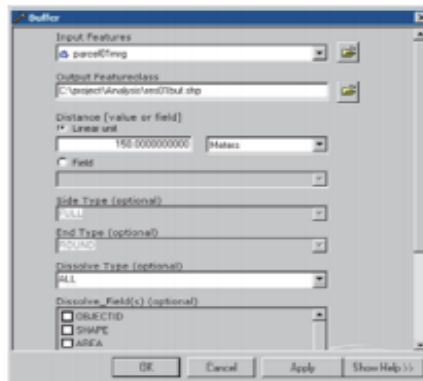


When you add the Buffer tool, it automatically creates a derived data element—in this case the Output Featureclass. Both the tool and derived data elements stay white, indicating that the tool is in a not-ready-to-run state until it is connected to input data.

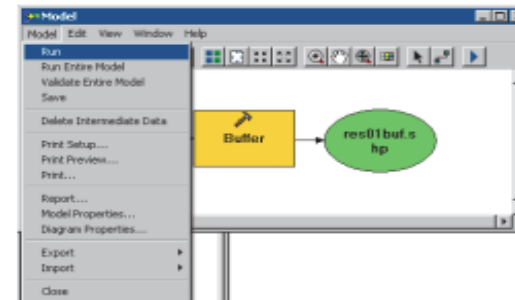
7. Click the Add Connection button on the Model toolbar.



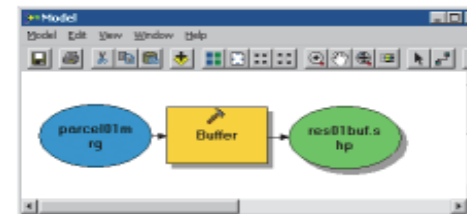
8. Click and drag a line from parcel01mrg to the Buffer tool. All model elements should now be shown in color. The input element is displayed in a blue oval, the tool is displayed in a yellow rectangle, and the output element is displayed in a green oval.
9. Double-click the Buffer tool in the model. The Buffer tool dialog box appears. The Input Features dialog box is already filled in for you.
10. In the Output Featureclass text box, type or browse to the path to the Analysis folder and type “res01buf.shp” as the layer name.
11. Type “150” in the Linear unit field and click the units dropdown menu to change from Unknown to Meters.
12. Click the dropdown arrow for Dissolve Type and click ALL, then click OK.



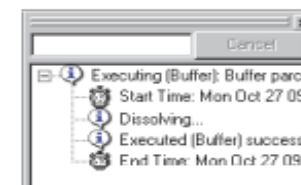
13. Click the Model dropdown menu on the toolbar and click Run.



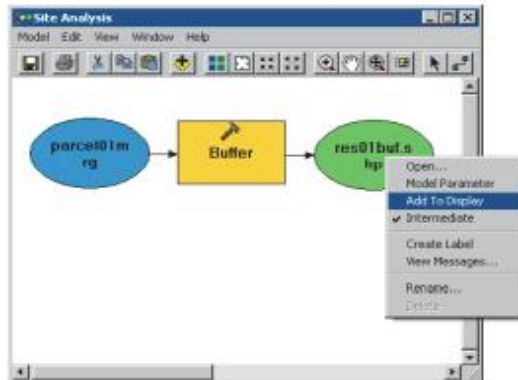
The Buffer tool will flash red while processing. The Buffer tool and res01buf.shp output element now have drop shadows, indicating that the process has run and the derived data has been generated.



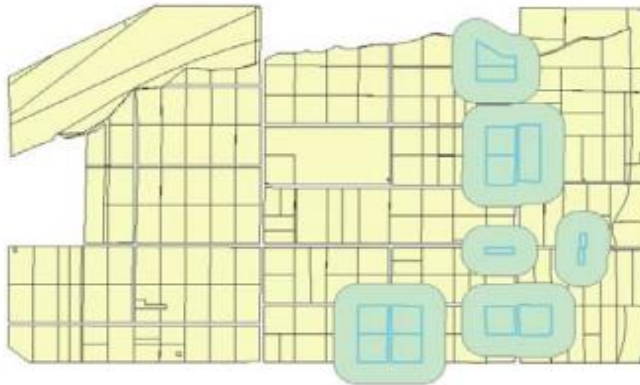
The geoprocessing window will appear automatically in ArcMap and display a log of the processes that have been run. Close it when it's finished.



14. Right-click the res01buf.shp data element and click Add To Display.

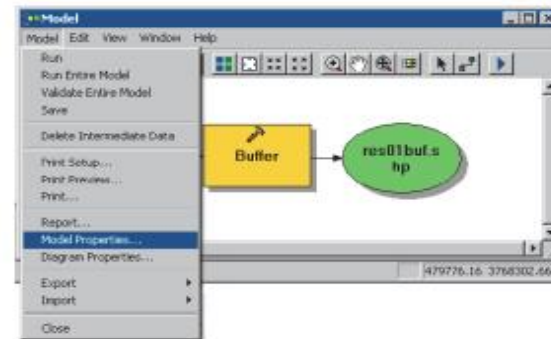


The selected parcels and their buffers are displayed.



Now that you have built the first part of your model, it is a good idea to rename it to reflect its contents. It is also good practice to save the model as you are building it.

15. Click the Model menu and click Model Properties.



The Model Properties dialog box opens.

16. Click the General tab and type "Site_Analysis" in the Name text box and "Site Analysis" in the Label text box, then click OK.

The screenshot shows the 'Model Properties' dialog box with the 'General' tab selected. The fields are: Name: Site_Analysis, Label: Site Analysis, Description: (empty), and Stylesheet: (empty). There is a checkbox for 'Store relative path names (instead of absolute paths)' which is unchecked. The buttons 'OK', 'Cancel', and 'Apply' are at the bottom.

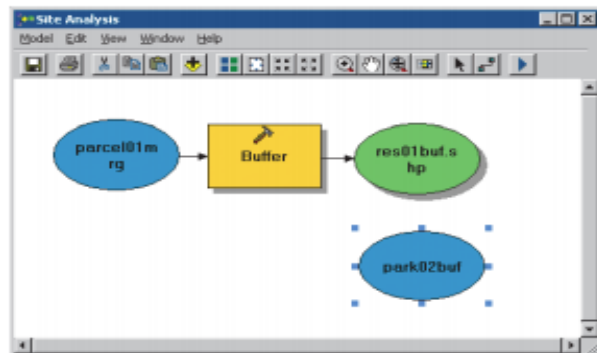
17. Click the Model menu and click Save.

Site Analysis is now saved as the name of the model in My Tools and as the label for the ModelBuilder window.

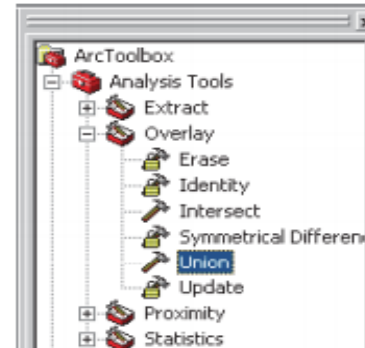
Overlaying the park and residential buffers

Now you'll combine the park and residential buffers to delineate the areas within 150 meters of a park or residence. To do this, you will add to your existing Site Analysis model using the Union tool.

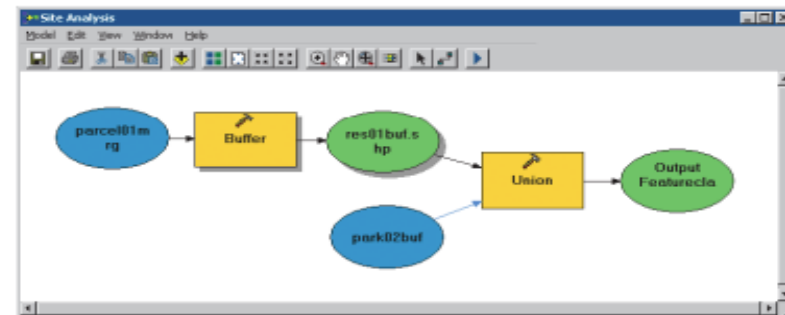
1. Click and drag park02buf from the table of contents to the ModelBuilder window and place directly below the res01buf.shp data element. Expand your ModelBuilder window as necessary.



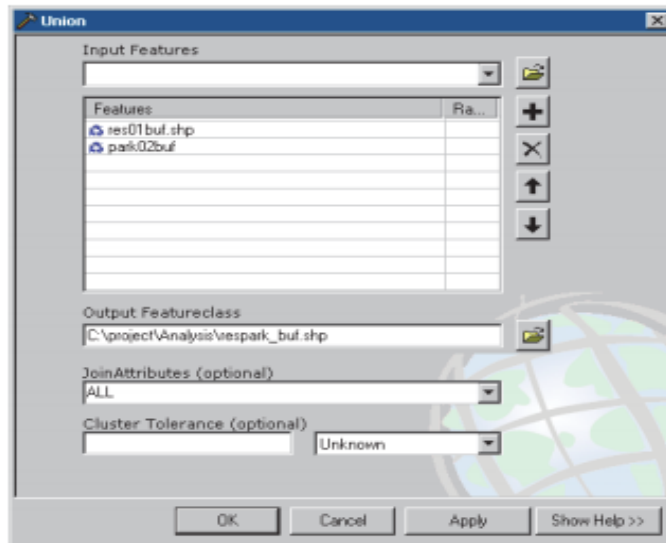
2. Double-click the Overlay Tools under the Analysis Tools Toolbox. Click and drag the Union tool from the Toolbox to the ModelBuilder window.



3. Click the Add Connection button on the toolbar to draw a connection from park02buf to the Union tool and from res01buf to the Union tool.



- Double-click the Union tool. The Union dialog box appears; the features have already been filled in for you.



- Ensure the path to your Analysis folder is specified for the Output Featureclass and specify “respark_buf” as the output layer name.
- Click OK.

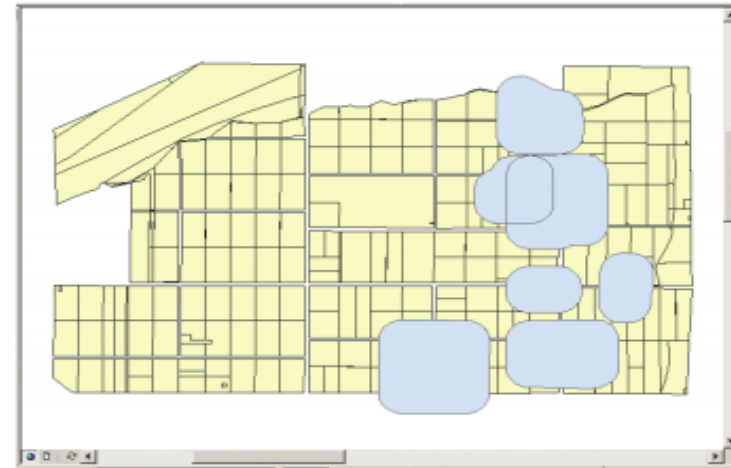
Another way to run a model process is to click the Run button on the ModelBuilder toolbar.

- Click the Run button on the toolbar.



Notice that the model will only run processes that have not yet been run. When completed, close the Site Analysis dialog box.

- Right-click the respark_buf.shp data element, then click Add To Display.



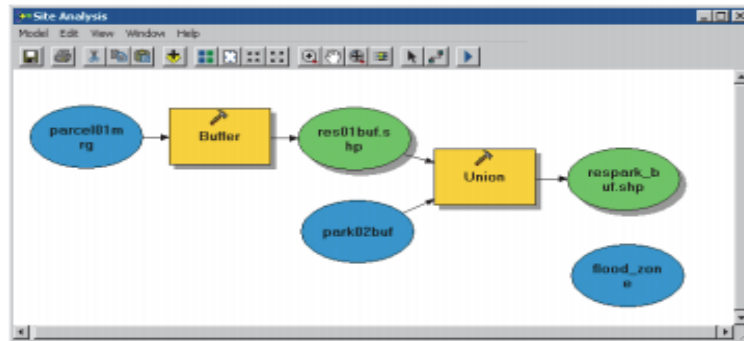
- Save your model.

You have now buffered the selected residential parcels and overlaid those parcels with the buffered parks using the Union tool. Next you will overlay the result of the buffered parcel and park union with the flood zone to delineate all the areas the wastewater treatment plant should be outside of.

Overlaying the residential/park buffers and flood zone

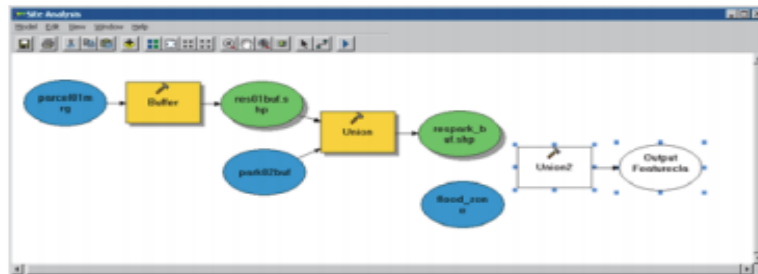
- Click and drag the flood_zone layer, located in the City_layers folder, from the Catalog tree onto the map.
- Click and drag the flood_zone layer from the table of contents to your Site Analysis model and place it directly

below the respark_buf data element, expanding your ModelBuilder window as necessary.

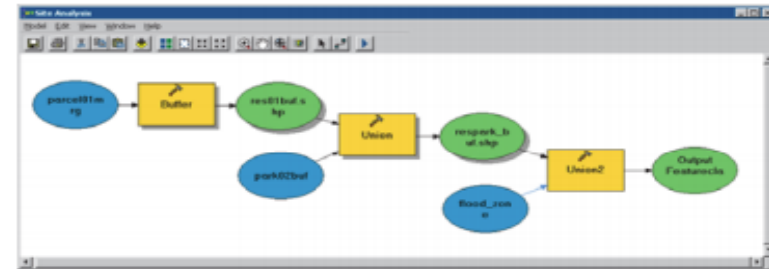


You'll use the Union tool again since you want to create a layer of areas inside either the residential and park buffers, the flood zone, or both.

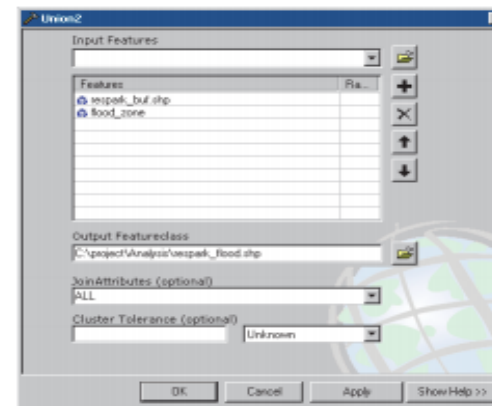
3. Click and drag the Union tool from ArcToolbox to your model. The new tool will be called Union2 since there is already a Union tool in the model.



4. Click the Add Connection tool and draw a connection from respark_buf and flood_zone to the Union2 tool.



5. Double-click the Union2 tool. The Union dialog box appears; the features have been filled in for you.



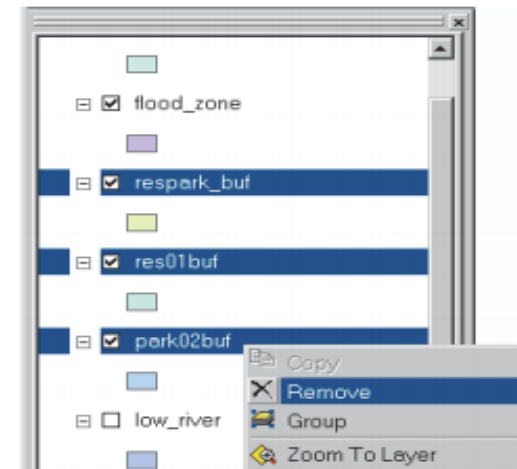
6. Ensure the path to the Analysis folder is displayed and type "respark_flood" as the output layer name.
7. Click OK.
8. Click the Run button on the toolbar.
9. Close the Site Analysis dialog box.
10. Click the Model menu and click Save.

11. Right-click the `respark_flood` element in the model and click Add To Display.
12. Turn off all the layers except `respark_flood` by unchecking them in the map's table of contents.



So far you've performed a series of buffers and overlays to create the two layers delineating the acceptable and unacceptable areas for the wastewater treatment plant site based on the city's criteria. You can see that even a fairly simple GIS analysis consists of stringing together a set of individual operations, often with the same operation repeated on different datasets. The operations build on the previous ones to achieve a resulting layer or layers. In the process, interim layers are created. You'll want to keep some of these layers to help verify the final results of your analysis. Others you can remove from the map.

13. Click `respark_buf` in the table of contents to select it, press the Ctrl key, and click `res01buf` and `park02buf` so all three layers are selected.
14. Right-click one of the selected layers and click Remove.



Before continuing, save your map.

15. Click File and click Save.

In many instances, the geoprocessing work that must be done is repetitive. Scripts are an efficient and effective way to automate your geoprocessing tasks.

If you are new to scripting languages, you do not need to be an expert programmer to create and use scripts. You can build a model in a ModelBuilder window and export the model to a script that you can then run or modify.

The following section will guide you through the steps to create a script from the Site Analysis model you have just created.

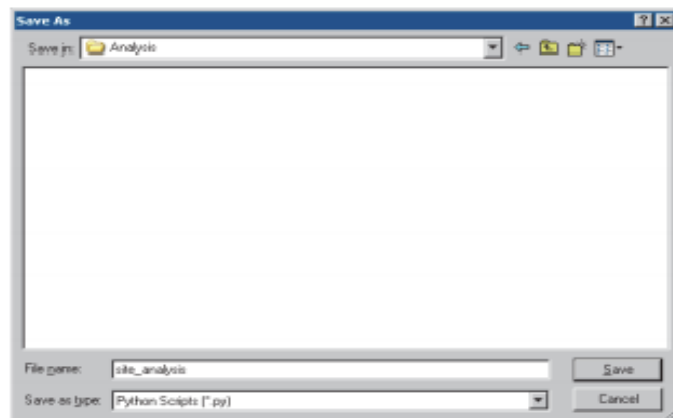
Generating a script from a model

1. Click the Model dropdown menu, point to Export, point to To Script, then select your preferred scripting language—for example, Python.



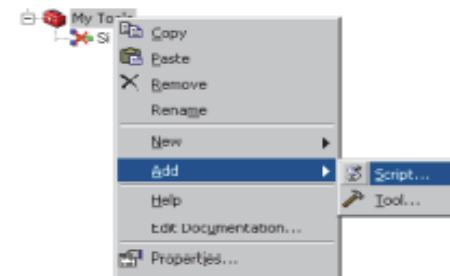
The Save As dialog box appears.

2. Click the Save in dropdown arrow and navigate to your analysis folder, then type “site_analysis” as the name for the script and click Save.



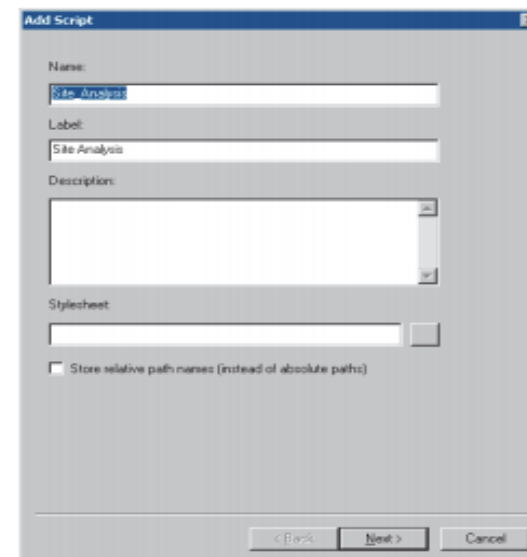
Now you will add the script you have just exported to your My Tools toolbox.

3. Right-click My Tools, point to Add, then click Script.

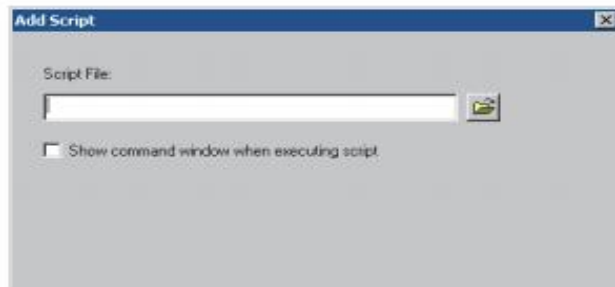


The Add Script dialog box appears.

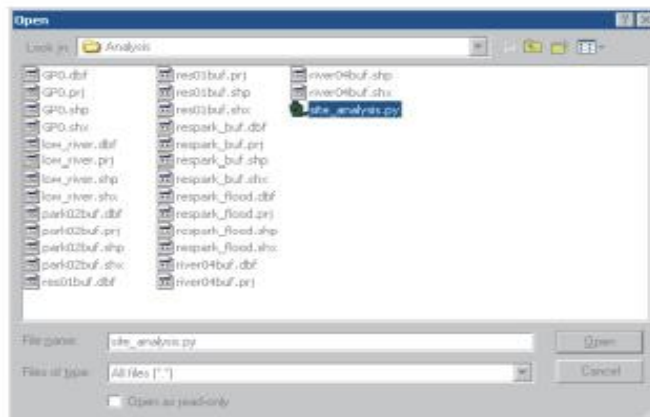
4. Type “Site_Analysis” in the name box and “Site Analysis” in the label box, then click Next.



5. Click the **Browse** button to select a Script File.

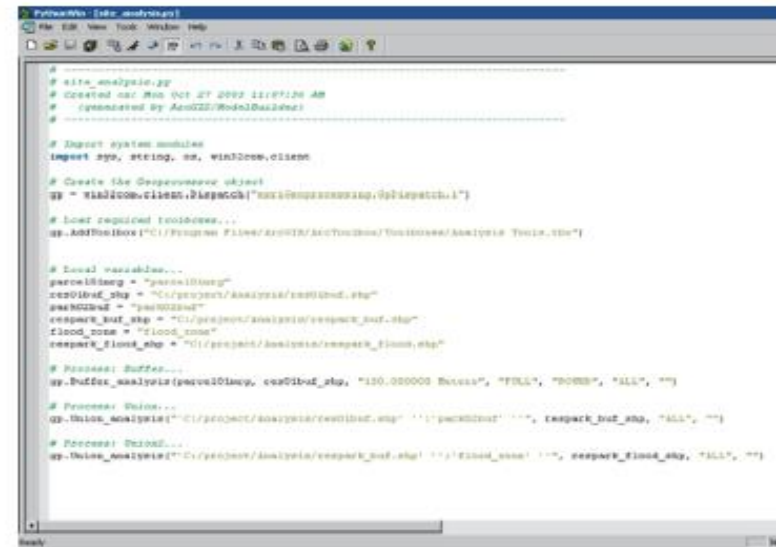


6. Navigate to your Analysis folder, click `site_analysis.py`, and click Open.



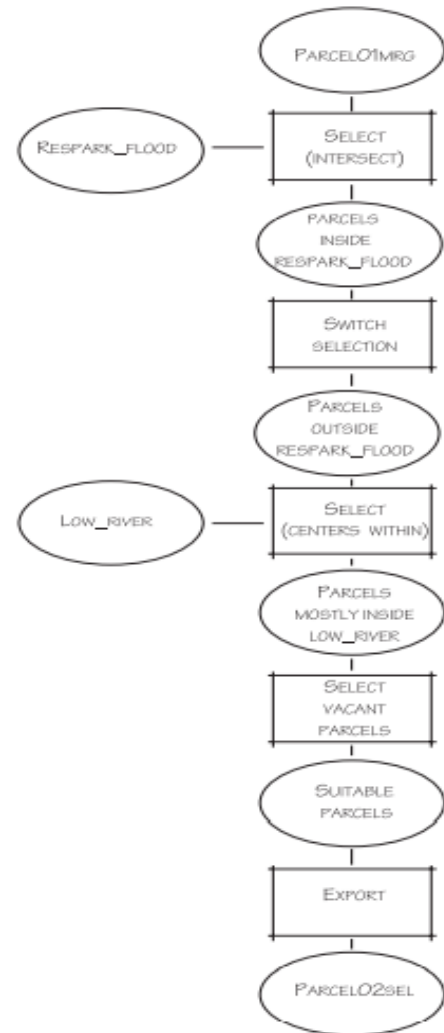
- Click Next, then click Finish. The script is now added to your My Tools toolbox.
- Right-click the Site Analysis script and click Edit.

This opens the Python script in the PythonWin application so you can view or modify the contents of the script.



9. Close the Site_Analysis script and PythonWin application.
10. Your Site Analysis model is now complete, and you have successfully exported it to a script, so save your model and close it.

In the next two sections, you'll use the interim layers (low_river and respark_flood) in a series of selections to eliminate the unsuitable parcels, creating a final layer of suitable parcels. Here's the flowchart for this process:



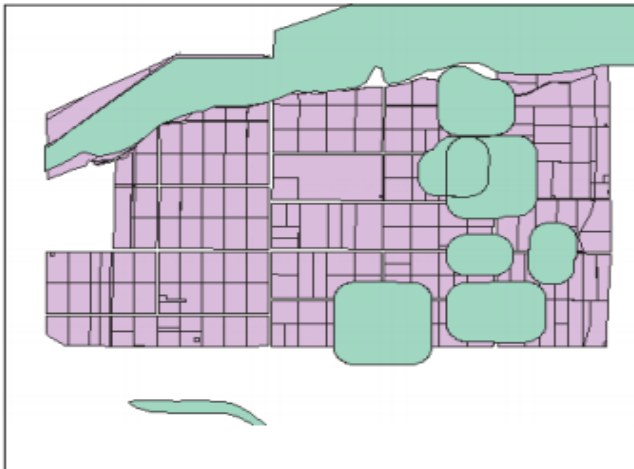
Finding the parcels that meet the location criteria

At this point you have two layers to use to select parcels meeting the criteria for the wastewater treatment plant site. First you'll select parcels falling outside the respark_flood polygons, then you'll select the subset of these that fall inside the low_river polygon.

Selecting the parcels outside the residential/park buffer and flood zone areas

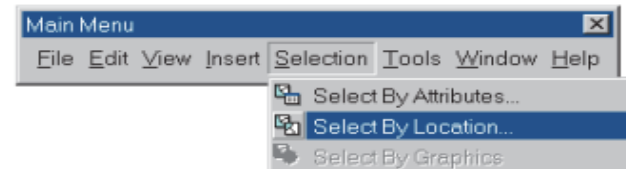
You'll use Select By Location to select parcels that intersect the respark_flood layer. The selected parcels will lie fully or partially within the flood zone or within a residential or park buffer. You'll then switch the selected set to select the parcels that lie outside those areas. The selected parcels will be outside the flood zone and more than 150 meters from a park or residence.

1. Click the check box next to the parcel01mrg layer to display it.



You can see that some parcels fall within the respark_flood area.

2. Click Selection and click Select By Location.

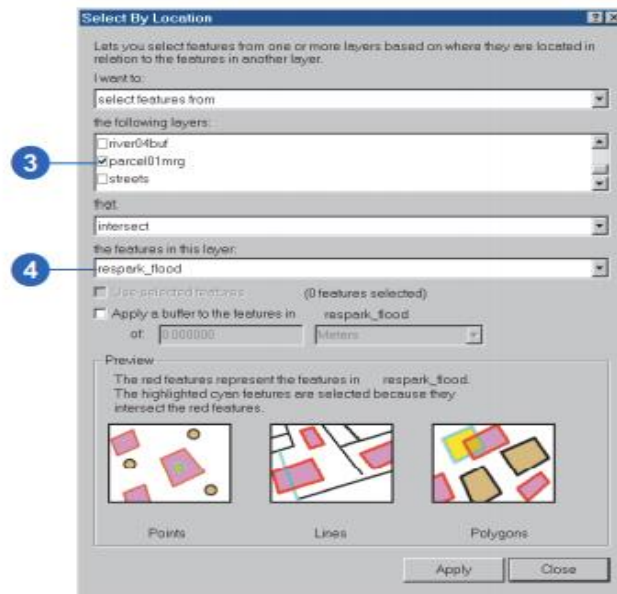


The Select By Location dialog box appears. This dialog box lets you compose a wide variety of queries to select features in one layer based on their location relative to features in another layer. In the top box you specify the type of selection. The default is to create a new selected set (select features from), which is what you want. In the next box you choose the layer to select from.

3. Scroll down and click the check box next to parcel01mrg.

Next, you will specify the relationship between the layers. The default is intersect—features that fall fully or partially within the features of the selection layer will be selected. This is the option you want, so accept the default. Finally, you specify the selection layer.

4. Click the dropdown arrow and click respark_flood.



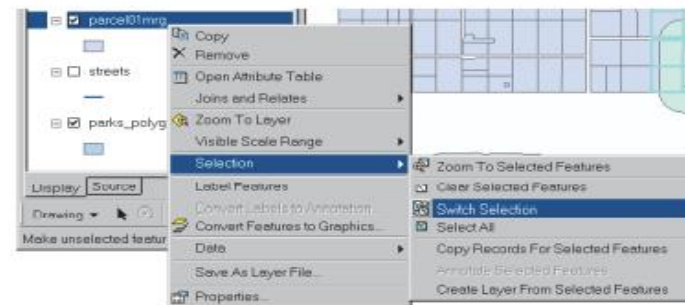
5. Click Apply at the bottom of the dialog box, then click Close to close the Select By Location dialog box.

ArcMap selects the parcels that are completely or partially within the respark_flood polygons and highlights them on the map.

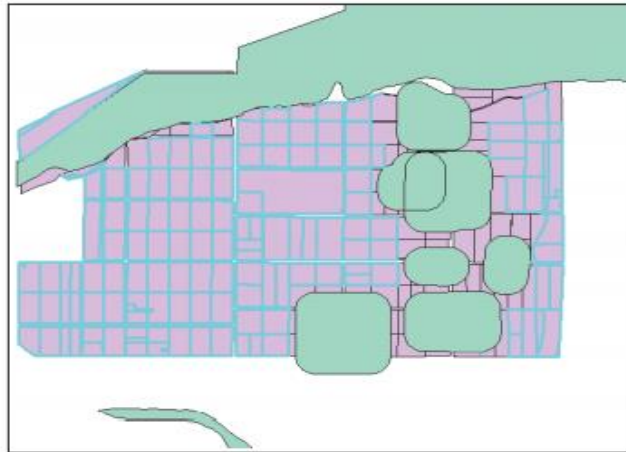


You actually want the parcels that are outside the respark_flood polygons, not inside, so you'll switch the selected set of parcels.

6. Right-click parcel01mrg in the table of contents, point to Selection, and click Switch Selection.



Now the parcels outside the flood zone and more than 150 meters from a park or residence are selected.

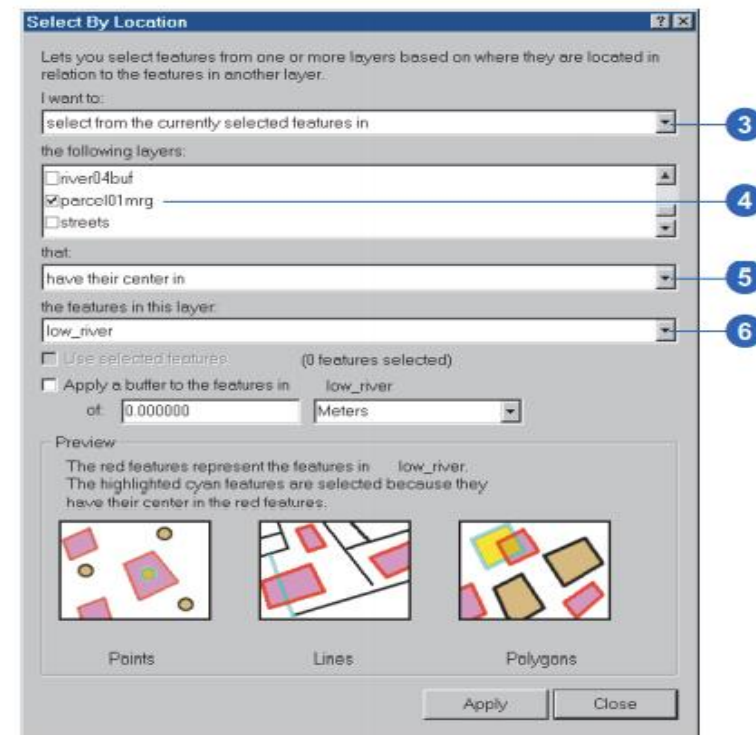


Selecting those parcels within the combined river buffer and lowland area

The next step is to select from the currently selected parcels those that are within the lowland area and within 1,000 meters of the river. You'll use Select By Location again, this time to select from the currently selected set of parcels.

1. Click the check box next to the low_river layer to display it.
2. Click Selection and click Select By Location.
3. Click the dropdown arrow for the top box and click the 'select from the currently selected features in' option.
4. Check the box to select features from parcel01mrg, if it's not already checked.

5. Click the dropdown arrow to choose a relationship type and click 'have their center in'.
- That will select the parcels that have at least half their area within the low_river polygon.
6. Click the dropdown arrow, scroll down, and click low_river as the selection layer.



7. Click Apply and click Close to close the Select By Location dialog box.

ArcMap selects those parcels that are mostly within the low_river polygon. You can see that the selected parcels are outside the respark_flood area and inside the low_river area.



So far you've narrowed down the set of possibly suitable parcels from all the parcels in the study area to those outside the flood zone and more than 150 meters from a park or residence. You then narrowed the set further to those parcels with at least half their area inside the lowland area (elevation 365 meters or less) and within 1,000 meters of the river. The next step is to find the vacant parcels from among these.

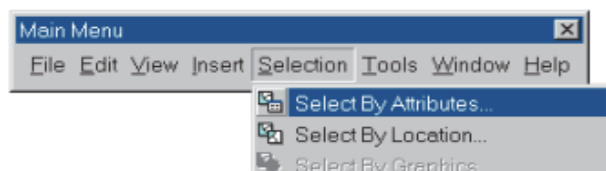
Finding the vacant parcels

To find which parcels meet all the city's requirements as a location for the wastewater treatment plant, you'll select the vacant parcels from among the currently selected ones.

Selecting vacant parcels using the land use code

In the last two selections, you selected parcels based on their location. This time, you'll select based on an attribute, specifically, the parcel land use code. As you recall from the metadata in the assessor's database, vacant land is coded with values in the 700s. You'll create a query expression to select the parcels that have a land use code greater than or equal to 700 and less than or equal to 799.

1. Click Selection and click Select By Attributes.



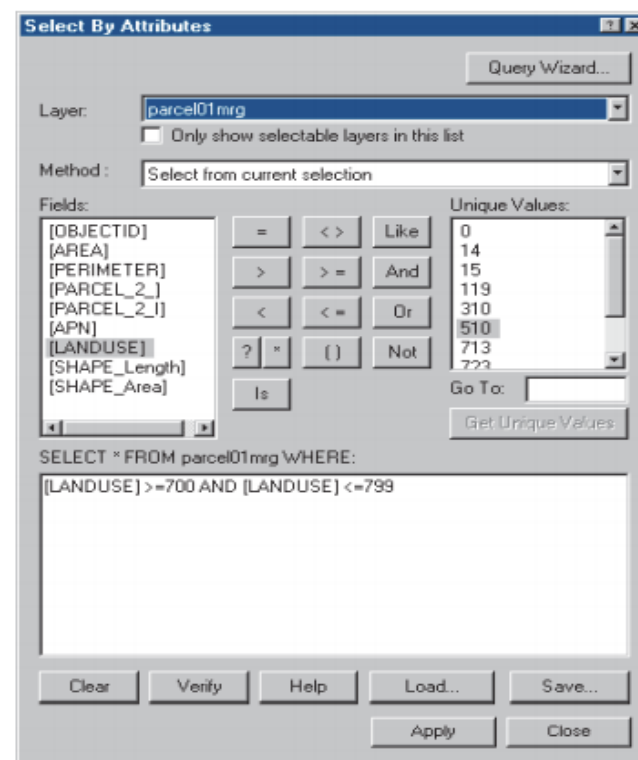
The Select By Attributes dialog box appears.

2. Click the Layer dropdown arrow and click parcel01mrg.
3. Click the Method dropdown arrow and click Select from current selection.

Now you'll create the query expression.

4. Double-click "LANDUSE" in the Fields list.

5. Click the greater than or equal to ($\geq$) sign and type "700".
6. Click And.
7. Double-click LANDUSE in the Fields list.
8. Click the less than or equal to ($\leq$) sign and type "799".

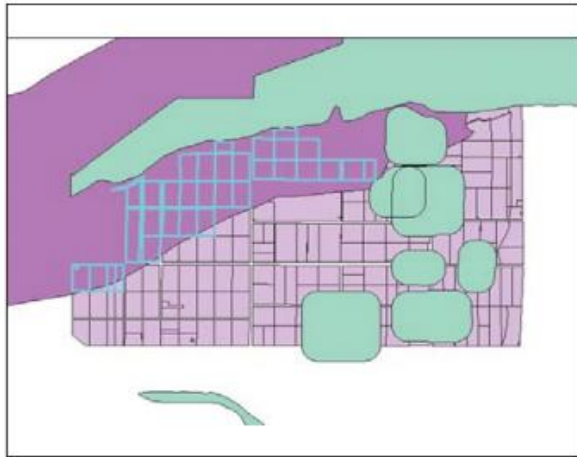


Your query expression should look like this:

[LANDUSE] $\geq$ 700 AND [LANDUSE] $\leq$ 799

9. Click Apply.

ArcMap selects the parcels that have land use codes in the 700s (the vacant parcels) and highlights them.



10. Close the Select By Attributes dialog box.

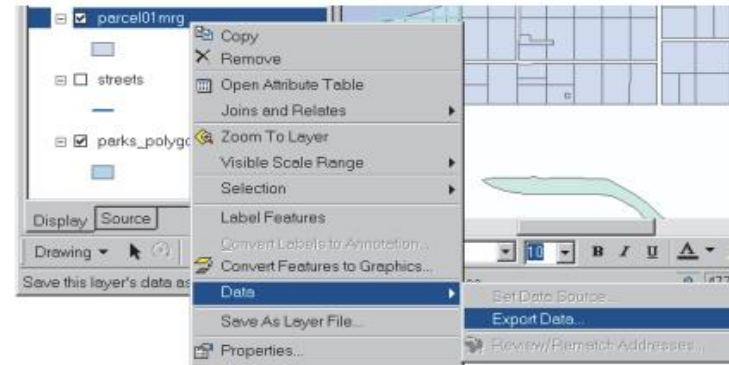
The selected set of parcels contains only the ones that meet the city's required criteria:

- Outside the flood zone
- At least 150 meters from parks and residences
- Elevation of 365 meters or less
- Within 1,000 meters of the river
- Vacant

Exporting the selected parcels to a new shapefile

To make it easier to work with only the suitable parcels, you'll export the selected parcels to a new shapefile.

1. Right-click parcel01.mrg in the table of contents, point to Data, and click Export Data.

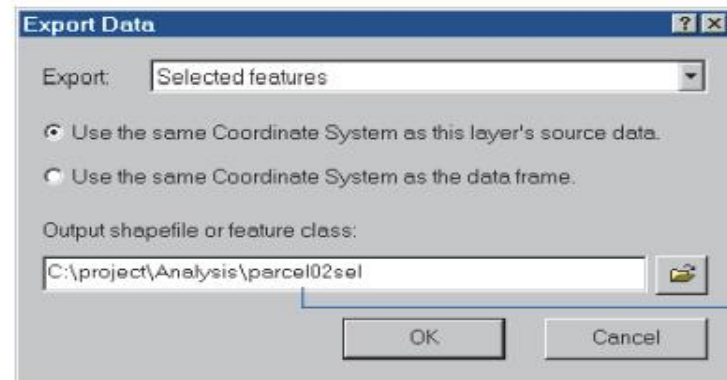


The Export Data dialog box appears. Since there are features currently selected in the parcel01mrg layer, the dialog box defaults to Selected features.

2. Make sure the path to the Analysis folder is displayed in the output feature class box.

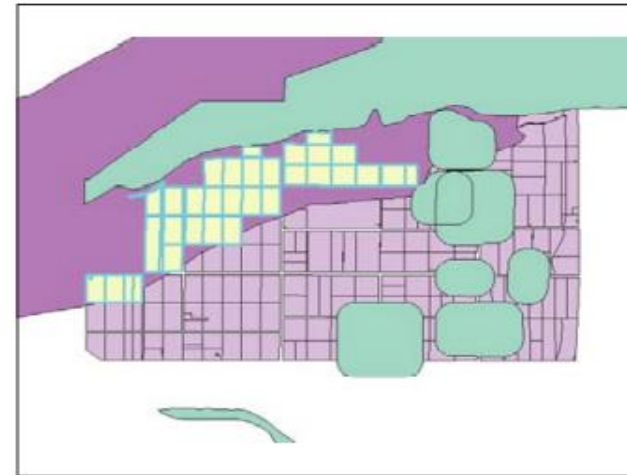
The dialog box defaults the name of the new shapefile to be Export_Output.shp.

3. Highlight the text and type “parcel02sel” to rename the feature class.

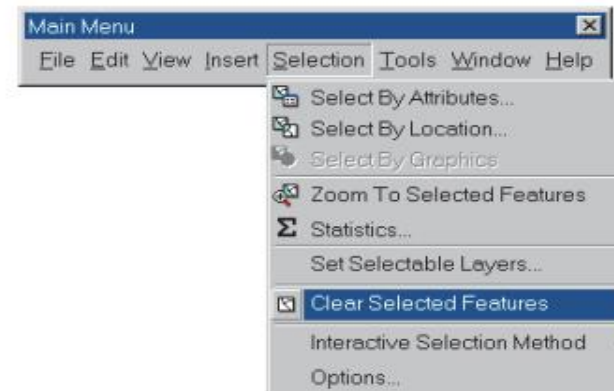


4. Click OK and click Yes when prompted to add the exported data to the map.

The new layer contains only the suitable parcels.



5. Click Selection and click Clear Selected Features to deselect the parcels in the parcel01mrg layer.



6. Click File and click Save.

Finding suitable parcels near roads and near the wastewater junction

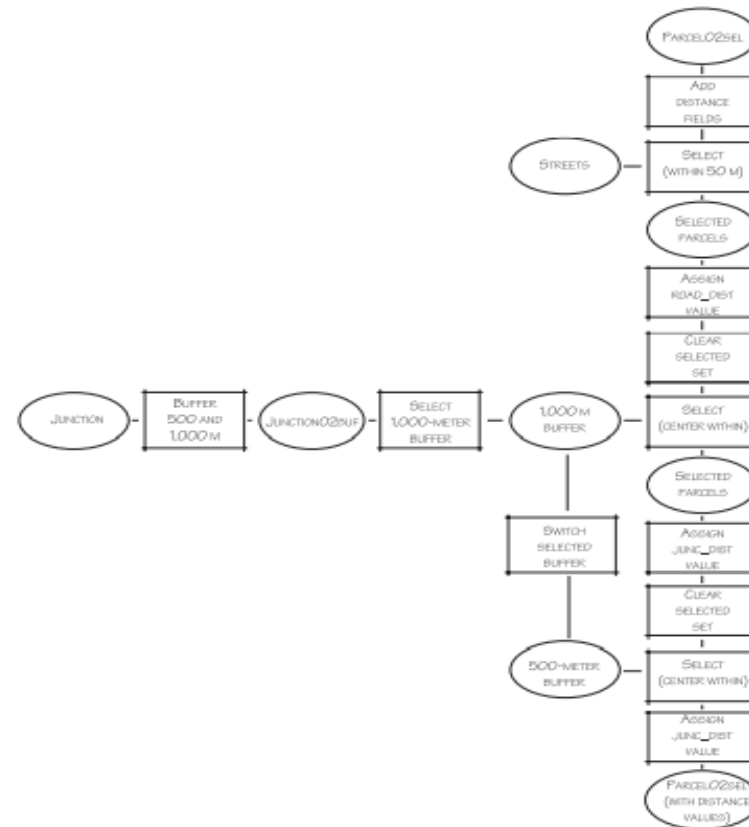
To continue with the decision-making process of the location of the wastewater treatment plant, the city council wants to know which suitable parcels are within 50 meters of a road and within 500 and 1,000 meters of the main wastewater junction. These will be considered the highly suitable parcels.

You'll select the parcels near these features and tag them with a code. That way you can display them color coded on your final map.

Here are the steps you'll perform:

1. Add two fields to the parcel02sel attribute table to hold the distance values: ROAD_DIST and JUNC_DIST.
2. Assign distance from roads.
 - Select the parcels within 50 meters of a road.
 - Assign a value, "50", to the ROAD_DIST field for the selected parcels in the parcel02sel attribute table.
3. Assign distance from the wastewater junction.
 - Buffer the junction to 500 and 1,000 meters.
 - Select the 1,000-meter buffer and use it to select the parcels within 1,000 meters of the junction.
 - Assign a value of 1,000 to the JUNC_DIST field for the selected parcels in the parcel02sel attribute table.
 - Select the 500-meter buffer and use it to select the parcels that fall within 500 meters of the junction.
 - Assign a value of 500 to the JUNC_DIST field for the selected parcels.

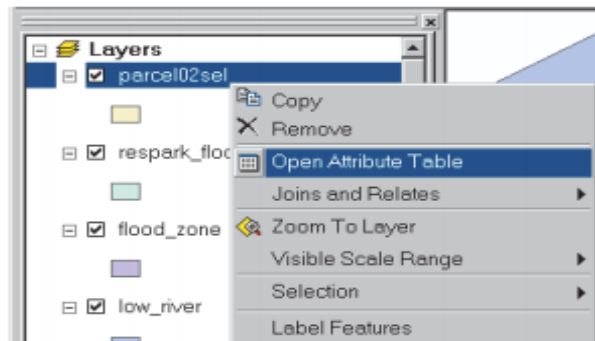
Here's the flowchart of the process:



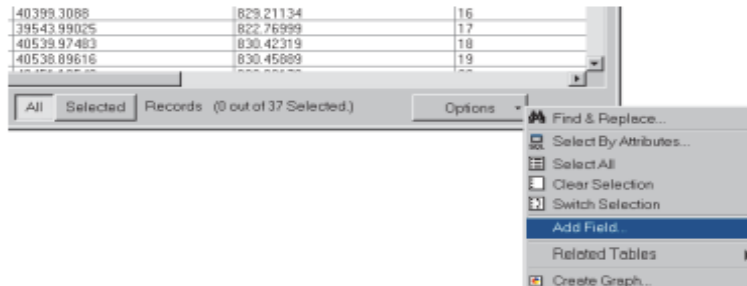
Adding fields to the parcels layer

Before you find the parcels near roads and the wastewater junction, you'll add two fields to the parcel02sel attribute table to contain the distance values you'll assign.

1. Right-click parcel02sel and click Open Attribute Table.

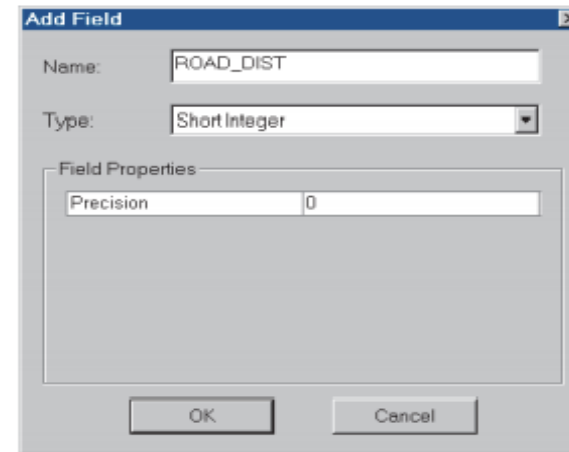


2. Click the Options button on the table and click Add Field.
The Add Field dialog box appears.



3. Type "ROAD_DIST" as the field name.

You can accept the default type of short integer.



The short integer type stores values up to 32,768, which is sufficient for the ROAD_DIST field—the values in this field will be either 50 or 0.

4. Click OK.

Now add the JUNC_DIST field in the same way.

5. Click Options and click Add Field.

6. Type "JUNC_DIST" as the field name and click OK.

7. Scroll all the way to the right of the Attributes dialog box to see the new fields.

Currently, the two columns have no values in them or contain zeros, since you just added the fields. In the next few steps you'll select the parcels near roads and the wastewater junction and enter values for the selected parcels.

APN	LANDUSE	ROAD DIST	JUNC DIST
029204402	732	0	0
029204408	732	0	0
029204407	732	0	0
029204406	732	0	0
029204409	732	0	0
029204410	732	0	0
029204411	732	0	0
029204412	732	0	0

8. Close the attribute table for now by clicking the Close button.

Finding parcels within 50 meters of a road

The city would prefer that the parcel for the new plant be within 50 meters of an existing road. You'll use the streets layer to select the parcels within 50 meters of a road and assign a value of 50 to the ROAD_DIST field.

1. Before continuing, uncheck the check boxes for all layers except parcel02sel in the table of contents so that only the suitable parcels are displayed.
2. Check the streets layer to display it.
3. Click the Selection menu and click Select By Location.

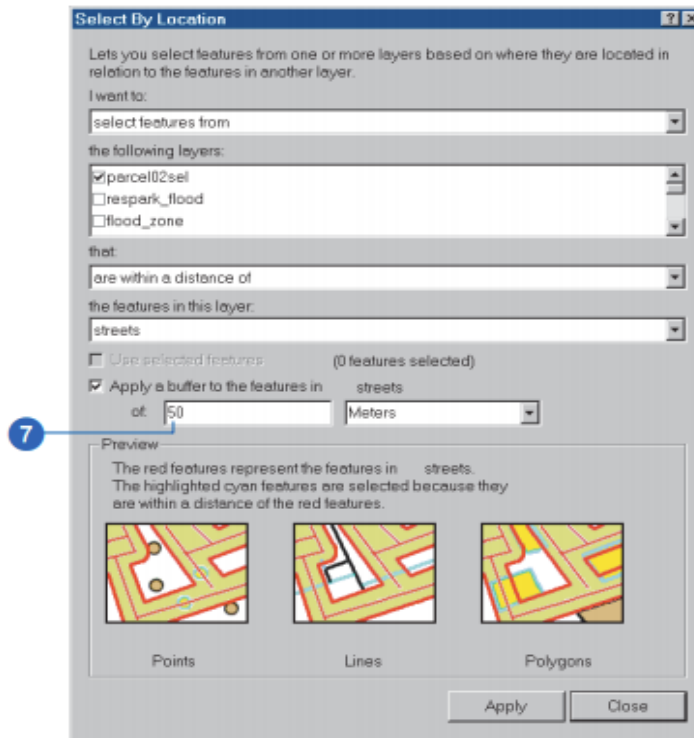
You've seen this dialog box before. This time, you'll select features on one layer (parcels) within a distance of features on another layer (streets).



4. Click the 'I want to' dropdown menu and click 'select features from'.
5. Check the check box for parcel02sel.
6. Click the dropdown arrows for the next two text boxes and click 'are within a distance of' and 'streets'.

The option to Apply a buffer to the features in streets is automatically checked.

7. Type “50” in the text box and click the dropdown arrow and select Meters to select parcels using a buffer of 50 meters.



8. Click Apply.

The parcels within 50 meters of streets are selected.



Using a buffer when selecting features is an easy way of finding features within a certain distance of other features. This method is quicker than using the Buffer tool—as you did with rivers, parks, and residential parcels—when you don’t need to create a separate buffer layer to combine with other layers.

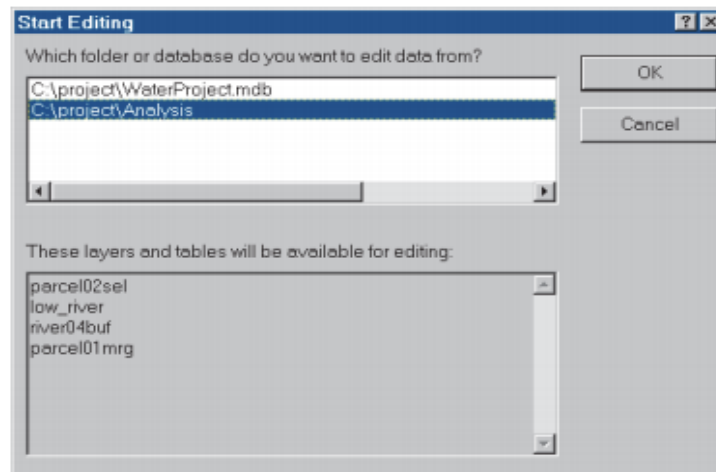
9. Click Close to close the Select By Location dialog box.

Now you can assign a value to the ROAD_DIST field for the selected parcels to tag them as being within 50 meters of a road.

Assigning a value to the ROAD_DIST field

To assign or update values in a layer’s attribute table, you need to open the layer for editing. You can edit the attributes either by using the Attributes button on the Editor toolbar, as you did for the historic park, or by editing directly in the attribute table, as you’ll do here. To assign values in the attribute table, you create a calculation expression. The values are assigned to the selected parcels or to all the parcels if none are selected.

1. On the Editor toolbar, click the Editor dropdown arrow and click Start Editing; click the Editor Toolbar button, if necessary, to open the toolbar.
2. Click the Analysis folder as the folder to edit data from and click OK. Click Start Editing to close the message stating that you are starting to edit in a different coordinate system.



3. Click the Target dropdown arrow and click parcel02sel as the layer to edit.



4. Right-click parcel02sel in the table of contents and click Open Attribute Table.
The selected parcels—those within 50 meters of a road—are highlighted.

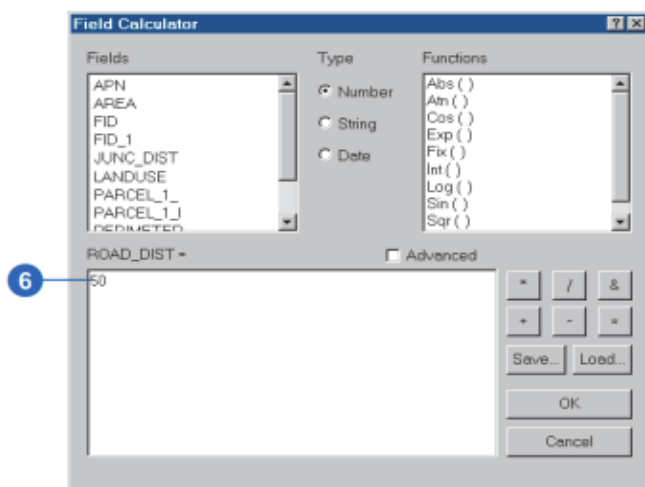
FID	Shape	FID	AREA	PERIMETER	PARCEL_1
0	Polygon	28	18743.94634	596.86787	0
1	Polygon	31	36233.8468	782.65661	0
2	Polygon	32	40484.28696	804.84396	0
3	Polygon	33	49834.54098	898.30515	0
4	Polygon	53	36221.4449	781.30885	0
5	Polygon	54	38340.25769	783.39497	0
6	Polygon	55	38504.58681	785.11244	0
7	Polygon	56	36993.79842	769.80311	0
8	Polygon	58	18802.62068	679.52129	0
9	Polygon	60	36864.35396	768.91386	0
10	Polygon	77	1467.35632	639.44957	0
11	Polygon	137	15820.18382	615.86548	0
12	Polygon	138	40819.3688	832.83885	7
13	Polygon	139	40273.55258	828.56194	8
14	Polygon	200	39802.64727	826.30124	9
15	Polygon	201	40447.63171	828.67385	10
16	Polygon	204	10565.63966	614.54883	13
17	Polygon	205	26459.63556	718.87443	14
18	Polygon	208	39573.91857	822.81252	15
19	Polygon	207	40399.3088	829.21134	16
20	Polygon	208	39543.98625	822.78899	17
21	Polygon	209	49579.97483	930.42319	18
22	Polygon	210	49538.88616	930.45885	19

5. Scroll to the right in the Attributes window, right-click the ROAD_DIST field—the mouse pointer changes to a down arrow when it's over the field name—and click Calculate Values.

LANDUSE	ROAD_DIST	WATER_DIST
732	0	
732	0	
732	0	
732	0	
732	0	
732	0	
732	0	
732	0	
732	0	
732	0	

The Field Calculator dialog box appears. Since you clicked the ROAD_DIST field, ArcMap starts the calculation expression for you by displaying ROAD_DIST =.

- Click in the expression box and type “50” to complete the expression.

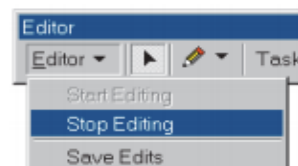


- Click OK.

ArcMap assigns a value of 50 to the ROAD_DIST field for the selected parcels—the ones within 50 meters of a road. All other parcels have a value of 0 for ROAD_DIST. You’ll use these values along with the JUNC_DIST values to color code the highly suitable parcels on your final map.

APN	LANDUSE	ROAD_DIST	JUNC_DIST
029204402	732	0	0
029204408	732	50	0
029204407	732	0	0
029204406	732	0	0
029204409	732	50	0
029204410	732	50	0
029204411	732	50	0
029204412	732	50	0
029204118	732	50	0
029204119	732	50	0

- Click the Editor dropdown arrow on the Editor toolbar and click Stop Editing. Click Yes when prompted to save your edits.



When you save your edits, ArcMap clears the selected set of features, so you’ll be able to start with the full set of suitable parcels to find the ones near the wastewater junction in the next step.

Keep the parcel02sel attribute table open since you’ll need it in the next step, but you may want to move, resize, or minimize it so you can see the map.

Measuring and assigning the wastewater junction distance

The city would prefer that the plant site be within 1,000 meters of the point where the plant will connect to the existing wastewater system. The council is willing to accept parcels that extend beyond the 1,000-meter buffer as long as most of the parcel is within the buffer. Parcels within 500 meters are even more desirable.

You need to find the parcels within 500 meters and 1,000 meters of the main wastewater junction and tag them with the distance. For this task you’ll use a number of the tools you used previously: buffer, selection, and attribute editing. Rather than give you step-by-step instructions, we’ve listed the major steps to give you a chance to work through the task yourself. You can review the previous sections if you need help with the specific steps.

Add the wastewater junction coverage to the map (it's located in the utility folder under the City_share folder). The junction coverage contains the main wastewater junction point where the new plant will connect to the existing system.

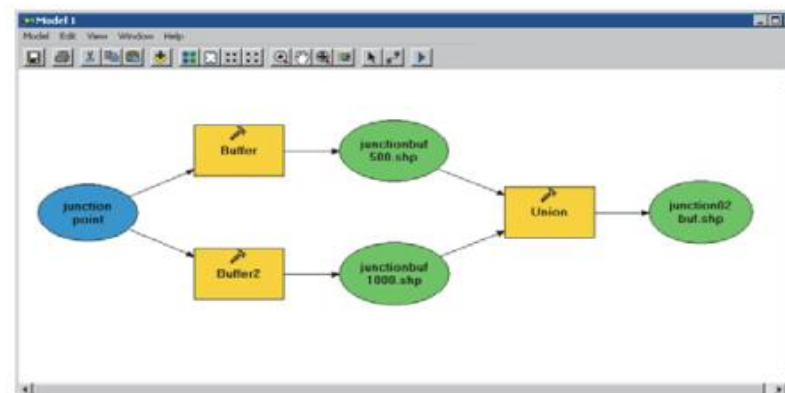
You will create a new model to buffer the wastewater junction point. First, create a new toolbox named My Tools if you haven't done so already. Create a new model in the My Tools toolbox.

Add the junction layer to the model. Add the Buffer tool to the model and add a new connection from the junction layer to the buffer. Set the Buffer parameters to buffer 500 meters. Confirm the path to your Analysis folder is set and name the Output feature class junctionbuf500. Set dissolve type to ALL.

Next, add another Buffer tool and add a new connection from the junction layer to that tool. Set the Buffer2 parameters to buffer 1000 meters. Confirm the path to your Analysis folder is set and name the Output feature class of Buffer2 junctionbuf1000. Again, set the dissolve type to ALL.

Click and drag the Union tool from ArcToolbox to the model. Add a connection from junctionbuf500 and junctionbuf1000 to the Union tool. Confirm the path to your Analysis folder is set and name the Union Output feature class junction02buf.

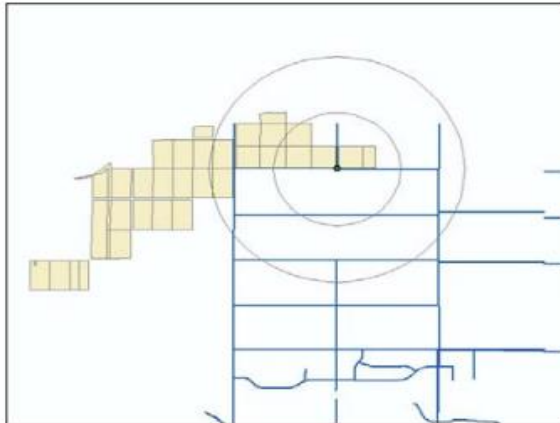
Run the model and add junction02buf to your map.



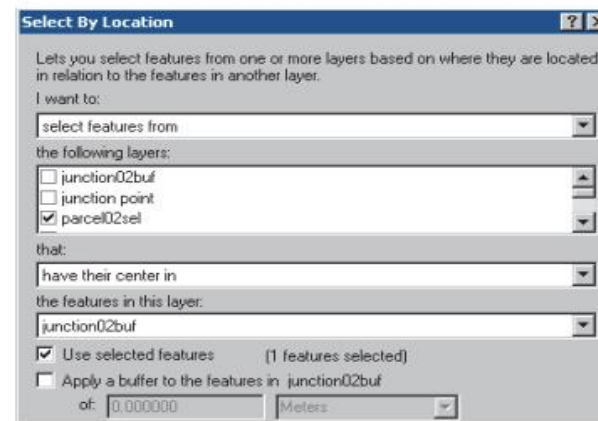
Name and save your model as Junction Buffer, then close.

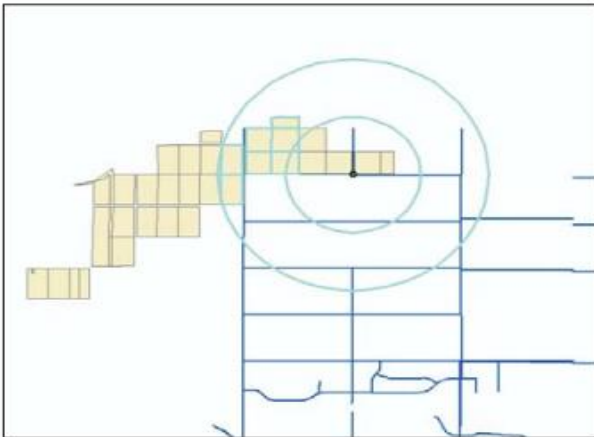
The buffers draw on the map but obscure the junction and the parcels. Change the symbology of the junction02buf layer so the buffers are drawn with no shading (use "no color" as the fill color).

Now you can see which parcels are within 0 to 500 meters and within 500 to 1,000 meters of the junction. Next, you'll select each set of parcels and tag them with the respective distance.



Use the Select Features tool to select the 500- to 1,000-meter buffer by pointing at it and clicking. Then use Select By Location to select the parcels in parcel02sel that have their center in the selected features of junction02buf. This will select all the parcels between 500 and 1,000 meters from the junction. Close the Select By Location dialog box when you're done.

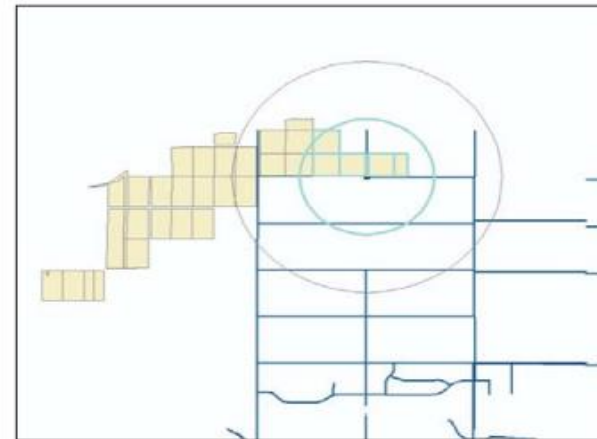




Use the Editor toolbar to start editing parcel02sel; ensure parcel02sel is the target layer. Open the attribute table for parcel02sel—click the Restore button if you minimized it before—and assign the value 1000 to the JUNC_DIST field for the selected parcels. Save your edits, but don't stop editing yet. You'll notice that some of the suitable parcels are both within 50 meters of a road and 1,000 meters of the junction, a few are more than 50 meters from a road but within 1,000 meters of the junction, and quite a few are not near either; both fields have values of 0.

APN	LANDUSE	ROAD DIST	JUNC DIST
029204402	732	0	1000
029204408	732	50	1000
029204407	732	0	1000
029204406	732	0	0
029204409	732	50	1000
029204410	732	50	1000
029204411	732	50	0
029204412	732	50	0
029204118	732	50	0
029204119	732	50	0

Now switch the selected features for junction02buf so the 0- to 500-meter buffer is selected, or simply use the Select Features tool to select the inner buffer. Then select by location to select the parcels that have their center in the selected features of junction02buf (i.e., the 0- to 500-meter buffer). Now you'll have only those parcels within 500 meters of the junction.



Assign the value 500 to the JUNC_DIST field for the selected parcels.

APN	LANDUSE	ROAD DIST	JUNC DIST
029204402	732	0	1000
029204408	732	50	1000
029204407	732	0	1000
029204406	732	0	500
029204409	732	50	1000
029204410	732	50	1000
029204411	732	50	500
029204412	732	50	500
029204118	732	50	500
029204119	732	50	500

Stop editing and save your edits. Then save your map.

Now you've assigned the distance from the wastewater junction to those parcels within 500 and 1,000 meters. On your final map, you'll color code the parcels based on their distance to roads and the wastewater junction so the city council and the public can see which are the highly suitable parcels.

Another way of selecting the parcels near the junction would have been to use Select By Location with a buffer distance, but by creating the junction02buf layer you'll be able to display the rings on the map to make it easier for the city council and public to visualize the distance from the wastewater junction.

Finding suitable parcels meeting the required total area

The final step in the analysis is to find suitable parcels that are large enough on which to construct the wastewater treatment plant. The minimum required area for constructing the plant is 150,000 square meters. You'll check the parcel02sel attribute table to see which parcels are at least this large.

Sorting the parcels by AREA

The parcel02sel attribute table should still be displayed.

1. Scroll to the left, if necessary, to see the AREA field.
2. Right-click AREA and click Sort Descending.

AREA	PERIMETER
18743.94634	
38233.8468	
40484.20606	
40834.56088	
36221.4449	
38340.25769	
38504.58681	
36959.79042	
18802.67008	
36864.35396	
1467.35622	288.44957

The largest parcels are listed at the top.

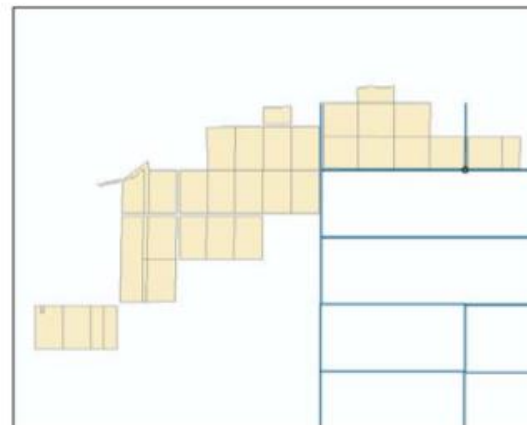
AREA	PERIMETER
61280.49249	1274.63154
41476.83105	837.99145
41162.43451	839.65045
40834.56088	808.30515
40819.3698	832.83905
40766.12503	831.8554
40539.97483	830.42319
40538.89616	830.45889

None of the suitable parcels is anywhere near 150,000 square meters in size. In fact, the largest one is only a little more than 60,000 square meters (you may need to scroll to the top of the table to see it). It looks like the city is going to have to assemble the plant site from several parcels or else relax its criteria to include more parcels as possible sites. You'll check to see if there are several adjacent suitable parcels that total 150,000 meters.

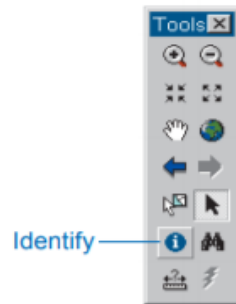
Checking for adjacent parcels totaling 150,000 square meters

You'll first identify several parcels to see how large they are, then select a group of them to see if they total 150,000 square meters in area.

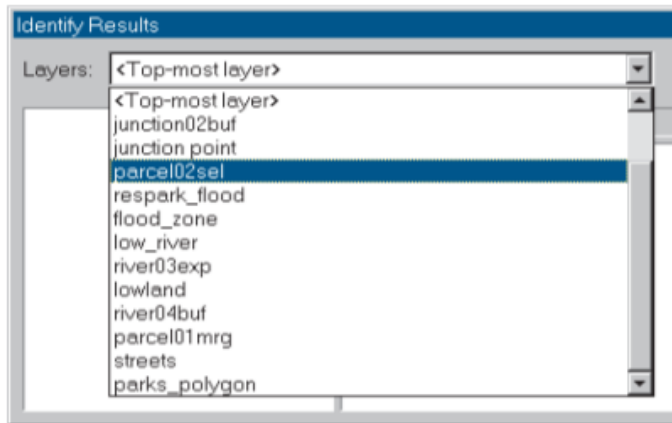
1. Right-click parcel02sel in the table of contents and click Zoom To Layer, then uncheck junction02buf so it's no longer displayed. Move the attribute table to better see the parcels, if necessary.



2. Click the Identify Tool.

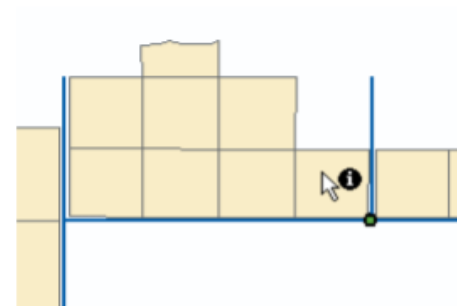


3. Click the Layers dropdown arrow in the Identify Results dialog box and click parcel02sel.

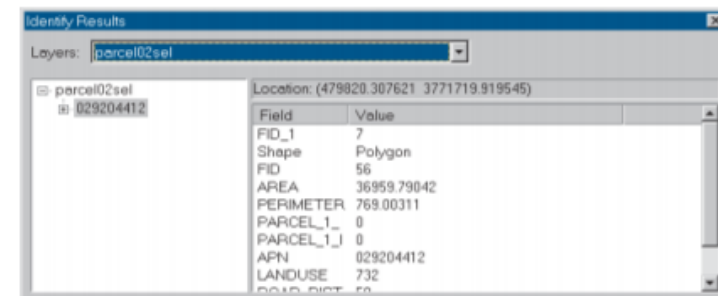


That sets parcel02sel as the layer in which to identify features. Leave the Identify Results dialog box open.

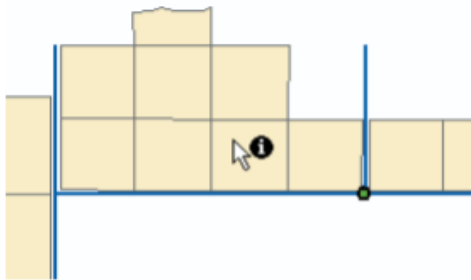
4. Click the parcel adjacent and just to the west of the wastewater junction.



You can see that this parcel is just under 37,000 square meters in area.

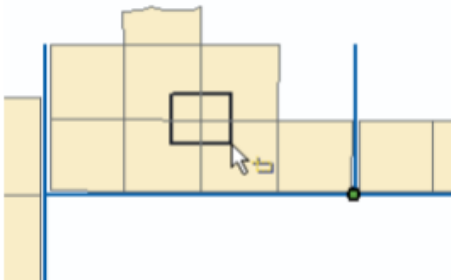


- Click the parcel to the left of the previous one.

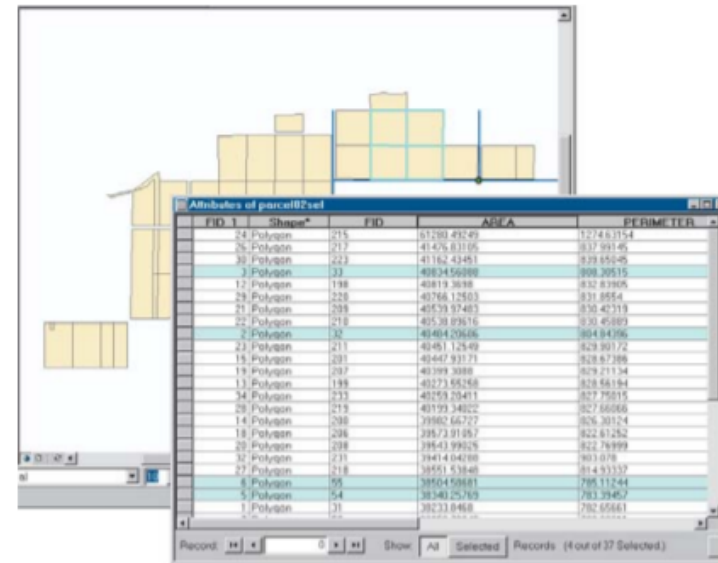


This parcel is about 38,500 square meters. You can see that most of the suitable parcels near the junction are about the same size. It looks like four contiguous parcels together will total about 150,000 square meters. Close the Identify Results box.

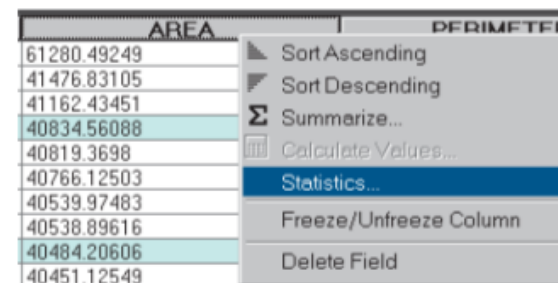
- Click the Select Features button.
- Click and drag a box around the intersection of four contiguous parcels.



The parcels are highlighted on the map and in the attribute table.

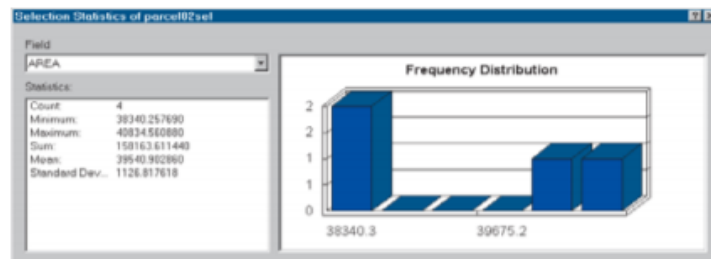


- Right-click AREA in the table and click Statistics.



The Selection Statistics dialog box appears.

ArcMap calculates summary statistics about the selected parcels and presents a graph of the distribution of values. You're not interested in the distribution of values in this case, but the statistics are useful. You can see the number of parcels selected (count), the size of the smallest and largest parcels, the total area, and the mean size of the four parcels.



The sum of the areas of these four parcels is slightly more than 158,000 square meters. There is enough room for the plant here. Further examination shows that there are a number of combinations of adjacent suitable parcels that will provide enough room for the plant. You can use the Select Features tool to draw a box around different groups of parcels, or select a parcel by clicking on it and clicking additional parcels while pressing the Shift key to add them to the selected set. Then recalculate the statistics to see the total area.

9. Close the Selection Statistics dialog box and the attribute table when you're done selecting parcels.
10. Click Selection and click Clear Selected Features.

So it looks like the city will be able to piece together a site for the plant. You decide to set up an interactive session at the city council meeting using a big screen so you can query different combinations of parcels on request from the council members.

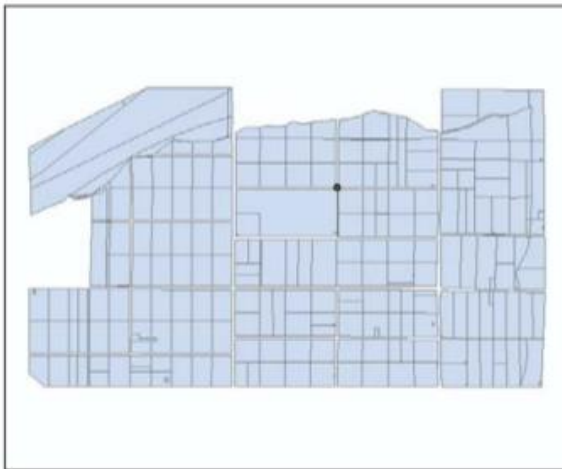
Reviewing the analysis results

Anticipating one question the city council is likely to ask, you decide to see if there are any parcels in the study area at least 150,000 square meters in size and, if so, why they didn't make the final cut.

You'll use select by attribute to find any parcels greater than 150,000 square meters, then display them with the analysis layers to see which criteria they do or don't meet.

Finding any parcels at least 150,000 square meters in size

1. Uncheck parcel02sel and streets and check parcel01mrg so you can see all the parcels in the study area.
2. Right-click parcel01mrg in the table of contents and click Zoom To Layer.

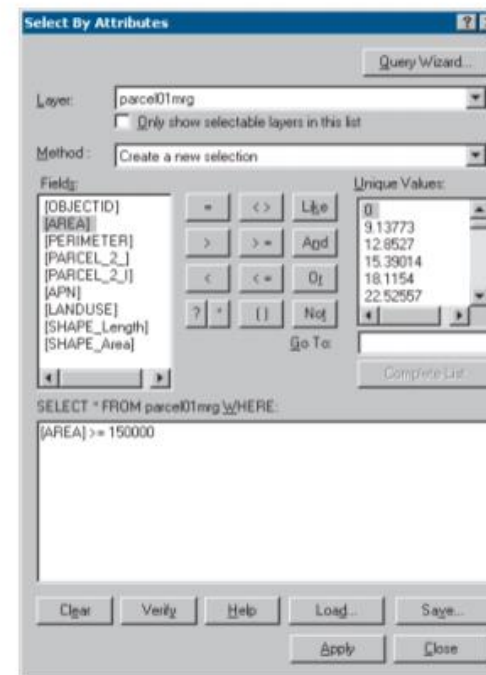


3. Click Selection and click Select By Attributes.
4. Click the Layer dropdown arrow and click parcel01mrg. Use the default method (Create a new selection).
5. Double-click [AREA] in the Fields list, click the greater than or equal to sign ($\geq$), and type "150000" to create the query expression.

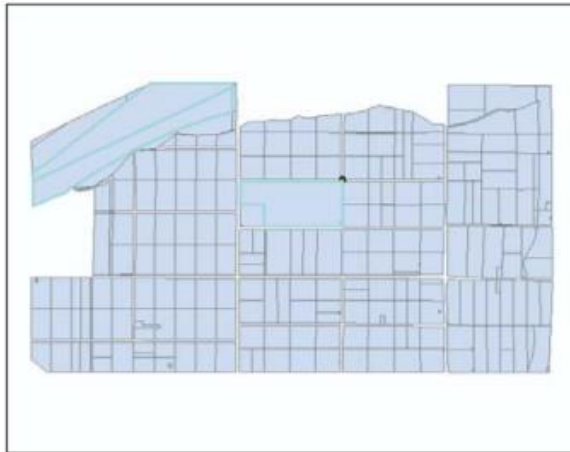
The expression should look like this:

[AREA] $\geq$ 150000

6. Click Apply, then click Close to close the dialog box.



There are three parcels of at least 150,000 square meters.



First check to see if the parcels are vacant.

7. Right-click parcel01.mrg in the table of contents and click Open Attribute Table.
8. Click Selected at the bottom of the table window to show just the selected parcels.

374.35753	0
2977.36348	0
756.46672	0
535.97827	0

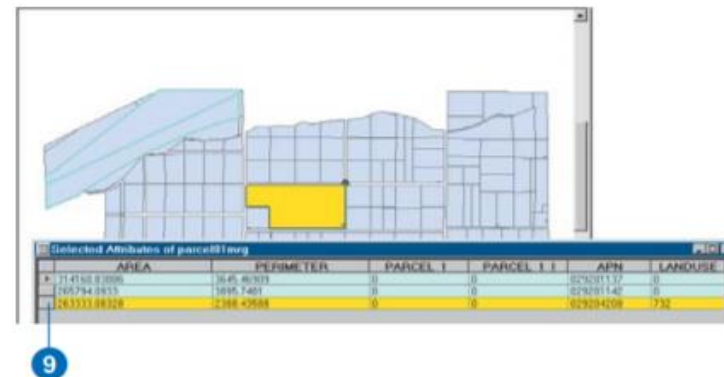
Show: Records (3 out of 280 Selected.)

8

Two of the parcels have no land use code, but the other has a code of 732, which is vacant (you may need to scroll to the right to see the LANDUSE field).

PARCEL 1 I	APN	LANDUSE
0	029201137	0
0	029201142	0
0	029204208	732

9. Click the box next to the vacant parcel to highlight it. If necessary, minimize or move the table so you can see the highlighted parcel on the map.

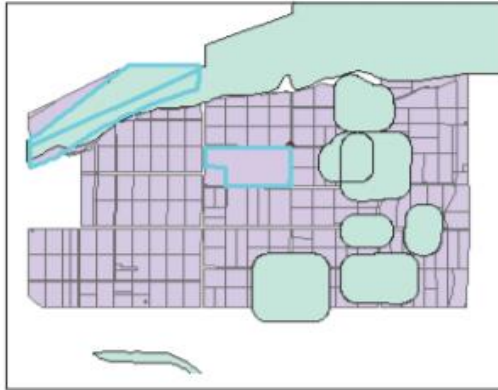


So the two parcels in the upper left of the study area were rejected because they weren't classified as vacant land. You'll have to check with the City Assessor to find out the actual land use for the parcels—it might be that they're vacant but were never assigned land use codes in the database. In the meantime, though, you'll check to see why the third parcel was rejected.

10. Close the attribute table.

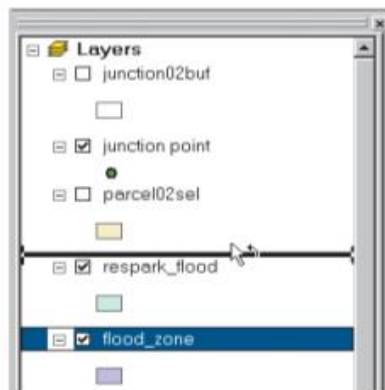
Displaying the selected parcels with the criteria layers

1. Check the respark_flood layer to display it.



You can see that the two parcels in the upper left are mostly within this layer, which includes the flood zone and buffers around parks and residential areas.

2. Check the flood_zone layer, then click and drag it above respark_flood in the table of contents.



Now it's clear that the two parcels are outside the residential and park buffers but are within the flood zone. So even if these parcels are vacant, they'd be rejected for being inside the flood zone. The third parcel, though, is outside the flood zone and the park and residential buffers.



3. Uncheck respark_flood and flood_zone and check low_river.



The city required that suitable parcels be completely or mostly within this area. More than half of this parcel is outside the area.

4. Check the lowland layer, then uncheck low_river.



The parcel is fully within the lowland layer, so it must be the river buffer that it's mostly outside of; that is, most of the parcel is more than 1,000 meters from the river.

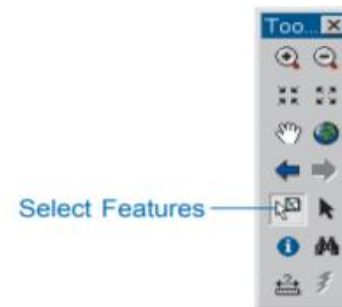
5. Uncheck lowland and check the river04buf layer.



Yes—that's why it was rejected. Still, a portion of the parcel is within the buffer, and the parcel is also adjacent to the wastewater junction, a big plus. You decide to highlight it on the final map to call it to the city's attention as a possible alternate site. Any additional construction costs may be offset by the cheaper land costs involved in buying a single parcel rather than four separate ones.

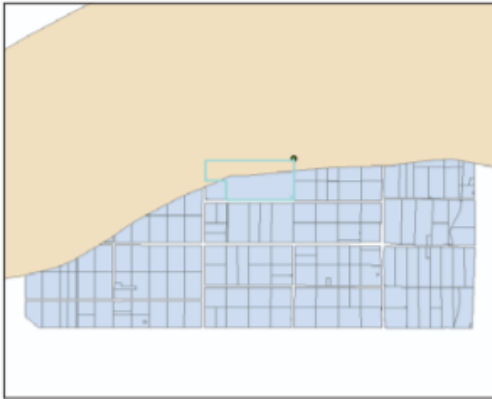
Creating a layer containing the alternate site

1. Click the Select Features tool.

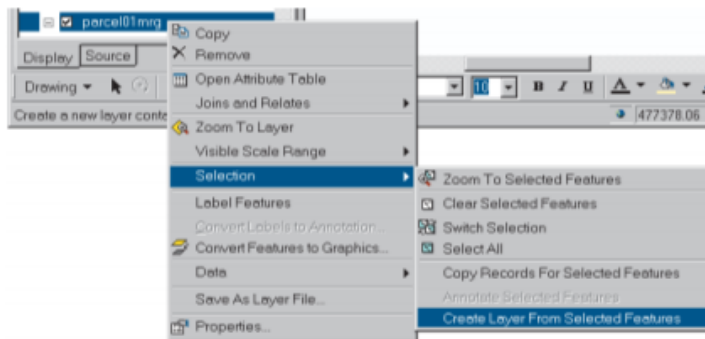


2. Click inside the alternate site, but outside the river buffer, so it is the only parcel selected.

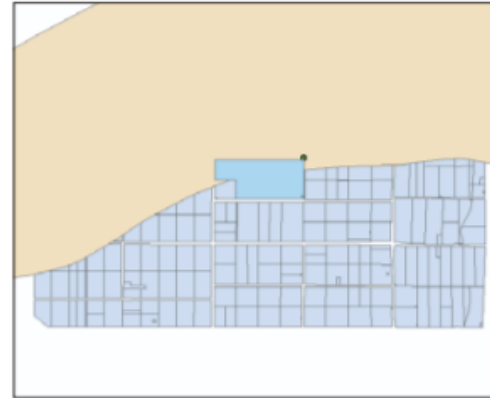




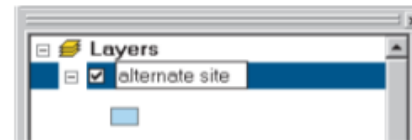
3. Right-click parcel01mrg in the table of contents, point to Selection, and click Create Layer From Selected Features.



ArcMap adds the layer containing the single parcel to the map.



4. Click the layer name (parcel01mrg selection) to select it, then click again to highlight the name.
5. Type “alternate site” as the new layer name and press Enter.

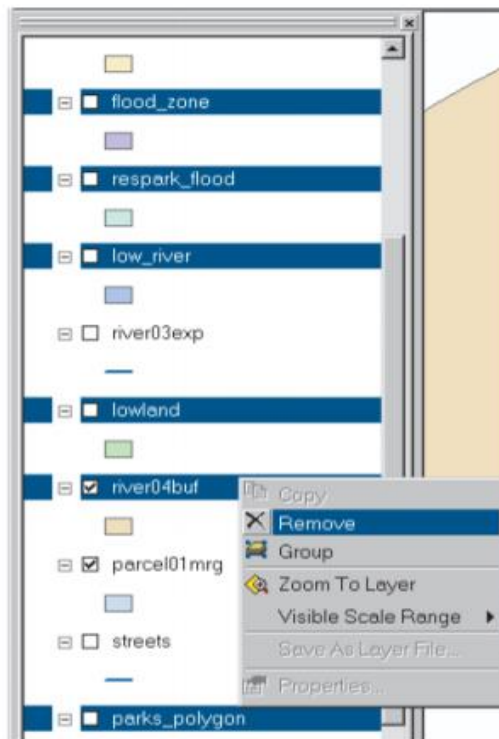


This is a temporary layer for this map—it is not stored as a separate layer file. In the next chapter you’ll change its symbology and add it to the final map.

Cleaning up the table of contents

You won't be using several of the analysis layers on your final map, so you can remove them at this point.

1. Click `flood_zone`, then press the Ctrl key and click `respark_flood`, `low_river`, `lowland`, `river04buf`, and `parks_polygon` so they're all selected.
2. Right-click one of the selected layers and click Remove.



At this point, your map should only include the following layers:

- alternate site
- junction02buf
- junction point
- parcel02sel
- river03exp
- parcel01mrg
- streets

If any other layers are still on your map, go ahead and remove them.

3. Click File and click Save to save your map.

The analysis phase of the project is finished, at least for now. GIS makes it easy to modify your criteria and rerun the analysis, if necessary.

There are many questions that GIS analysis can help you answer as well as many different approaches. This analysis showed one approach to solving a particular problem using several of the most common GIS analysis tools: buffer, overlay, and selection. You'll combine these tools and others in various ways when performing your own analyses.

In the next chapter you'll make a map to present the results of your analysis to the city council and the public.

Presenting the Project Results

In this Project description's chapter students will create a poster-sized map to present the results of the performed analysis. The poster will contain three maps. One map will show the geographic relationship of the suitable parcels to the rest of the city. Another map will show all of the suitable parcels. The third map will show the highly suitable parcels symbolized according to their proximity to the main wastewater junction and to roads. Students will label these parcels with their parcel identification numbers. Students will also create a report showing parcel identification numbers, area, and distance from the junction for the highly suitable parcels. The map will also include explanatory text, a North arrow, legends, scalebars, and a title.

Designing the map

You'll want to give some thought to the map design before you start laying out the map. The design should reflect how the map will be used and who the audience for the map is. In this case, your map will be displayed at a city council meeting. The council members are probably familiar with the issues involved in siting the wastewater treatment plant, but the members of the public attending the meeting may not be. Both groups will want to see the location of the suitable parcels in relation to the rest of the city. They'll also want to see all the suitable parcels, as well as the most likely candidates for the plant site, with additional information about the highly suitable parcels.

You'll first want to decide what elements will be on the map and list them. Then decide how the elements will be arranged on the page.

In this case, you'll create three maps on one poster-size page for display at the city council meeting.

1. An overview map of the city showing the location of the study area and including the following layers:
 - Streets (streets.lyr)
 - The river (river03exp)
 - The elevation grid (elevation_grid.lyr)
 - The study area extent (graphic rectangle)

2. A map of the study area showing all suitable parcels and including the following layers:
 - Suitable parcels in one color (parcel02sel)
 - Other parcels in a different color (parcel01mrg)
 - The alternative site shaded using diagonal hatching (alternate site)
 - The wastewater junction (junction point)
 - The 500- and 1,000-meter buffers around the junction (junction02buf)
 - The river (river03exp)
3. A map of the highly suitable parcels including the following layers:
 - Highly suitable parcels color coded by distance from roads and from the wastewater junction and labeled with their parcel numbers (parcel02sel)
 - All other suitable parcels in a neutral color (parcel02sel)
 - The alternate site shaded using diagonal hatching and labeled with its parcel number and area (alternate site)

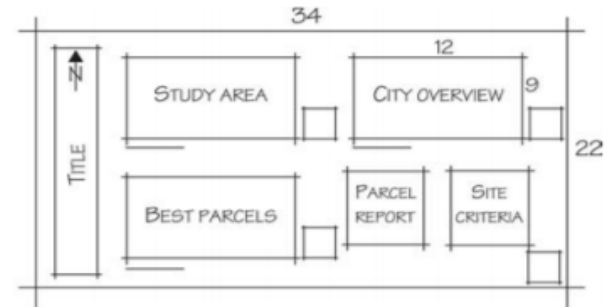
You'll also want to include other map elements and explanatory text to make the map easier to understand and more attractive.

The additional map elements are as follows:

- Report listing the highly suitable parcels
- Text block listing the site selection criteria
- Map title
- Scalebar for each data frame
- Legend for each data frame
- North arrow
- City logo
- Map reference information
- Graphic rectangles to complete the map composition

Once you've decided on what the maps should show and what other elements to include, you'll want to decide how the elements will be arranged on the page. While it's easy in ArcMap to move and resize the individual maps and other elements on the page, you may want to make a sketch on paper to use as a guide. The sketch should show at least the approximate position of the maps and map elements and contain notes about the page size and map sizes. You can reposition and resize the elements interactively as you create the map.

Here's a sketch for the map you'll create:



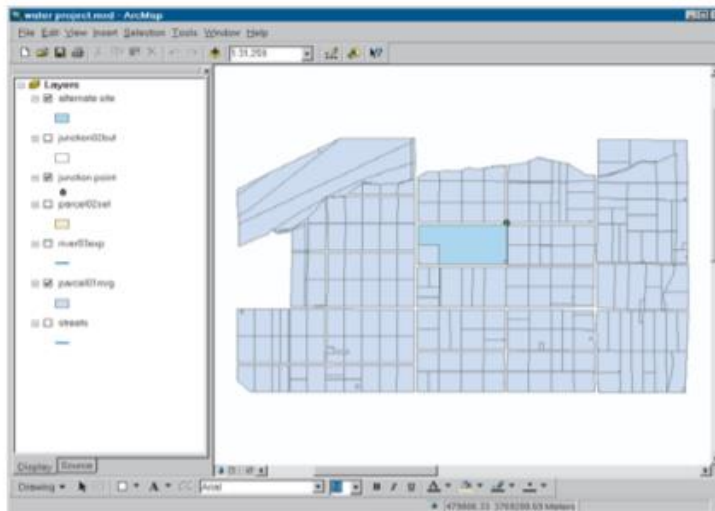
Here are the major steps you'll complete to create the map:

- Create the three data frames.
- Modify the data frames to show the required layers and geographic extent.
- Create and add the parcel report.
- Add the text block listing the site criteria.
- Add the legends and scalebars for each data frame.
- Add the other map and graphic elements (North arrow, title, logo, map reference information, graphic rectangles).

Setting up the map page

You'll be creating a poster-sized map with three data frames, one for each map. You'll work in both Data view and Layout view to create the map.

If necessary, start ArcMap and open the water project.mxd map (located in the project folder). The map should currently have the alternate site, junction point, and parcel01 mrg layers displayed.



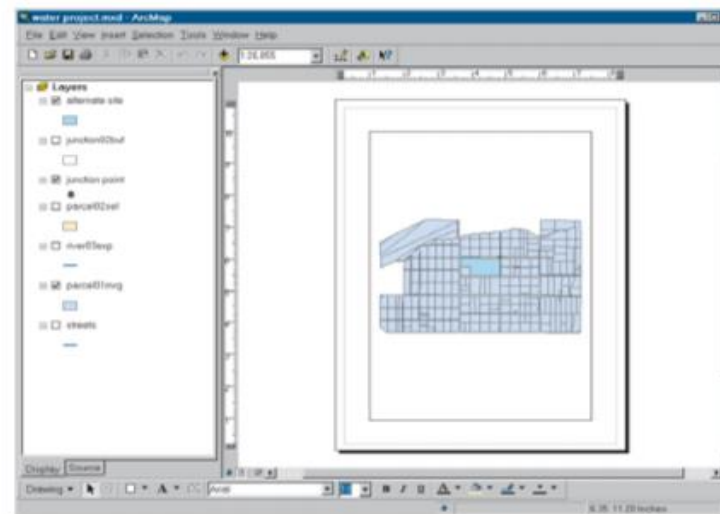
Switching to Layout view

First you'll switch from Data view to Layout view.

1. Click View and click Layout View.



The map switches to Layout view and displays the map page filled by a data frame containing the currently displayed layers. The Layout toolbar also appears.



Layout view lets you view several data frames on a single page and interactively work with the map elements. A data frame is a way of organizing layers together on a map page. Currently there is only one data frame on the page, indicated by the rectangle.

The Layout toolbar contains tools for zooming and panning on the page itself. The tools on the Tools toolbar let you work with the data inside the data frame, just as you do in Data view.

Zoom in on map page



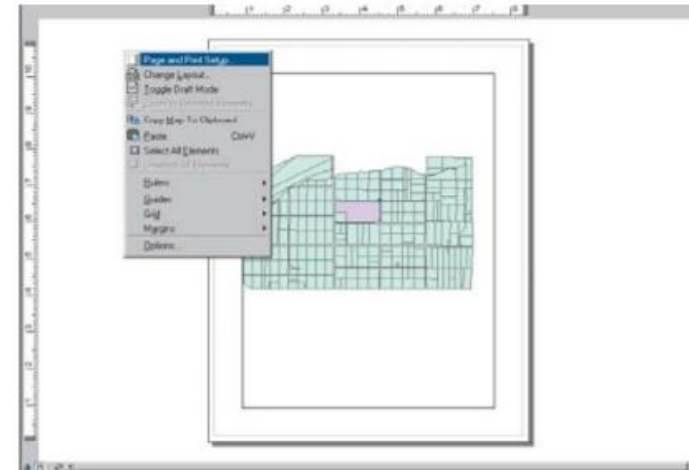
Zoom in on data in data frame



Changing the page size

You'll set the page size to accommodate the final printed map.

1. Right-click on the page, outside the data frame, and click Page and Print Setup (if you right-click inside the data frame, you open the Data Frame Properties dialog box).



The Page and Print Setup dialog box appears. The Use Printer Paper Settings box is checked, indicating that ArcMap will automatically detect the printer's page size.

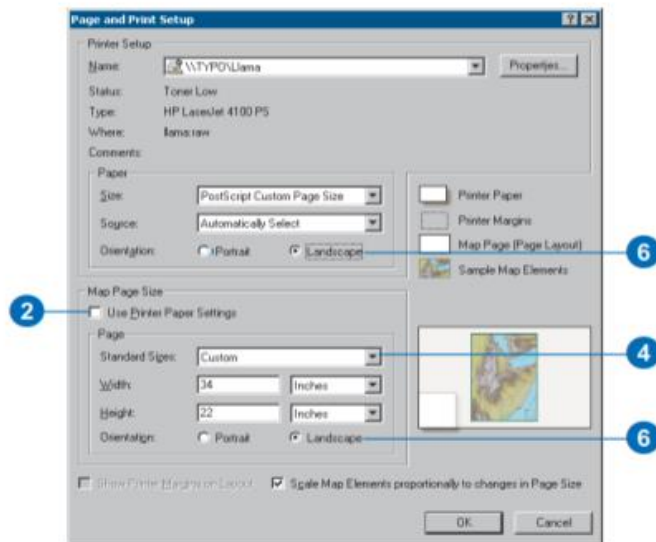
The city has another printer that is capable of printing D size (22 x 34 inch) pages, so you don't want the page size to be the same as the default printer.

2. Uncheck Use Printer Paper Settings.
3. Click Size and click PostScript Custom Page Size.
4. Click the Standard Sizes dropdown arrow and click Custom.
5. Type “34” in the Width text box and type “22” in the Height text box. Make sure the units for each are set to inches.

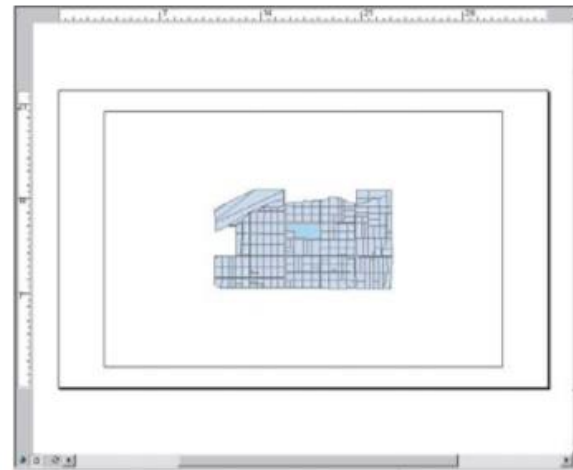
Now the virtual page for the map will be 22 x 34 inches—D size.

You want the map poster to be wider than it is high, so change the page orientation.

6. Click Landscape in both the Paper and Page panels, then click OK.



ArcMap adjusts the size and orientation of the page.

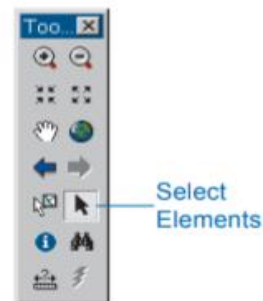


You'll use the existing data frame to display the suitable parcels. In the next steps you'll resize the data frame and make a copy of it to display the city overview map.

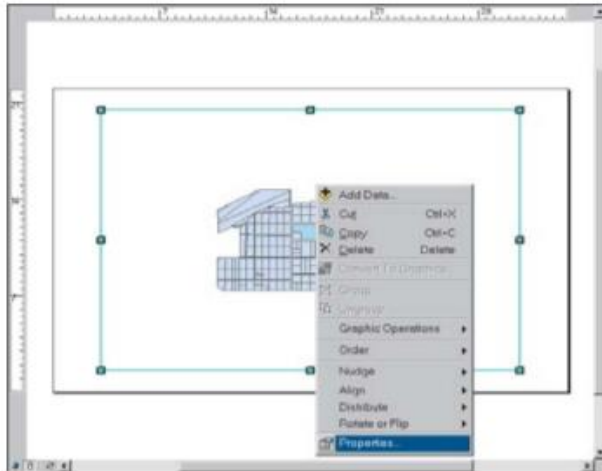
Resizing the data frame

First you will make this data frame smaller.

1. Click the Select Elements button.



2. Right-click near the middle of the data frame and click Properties.



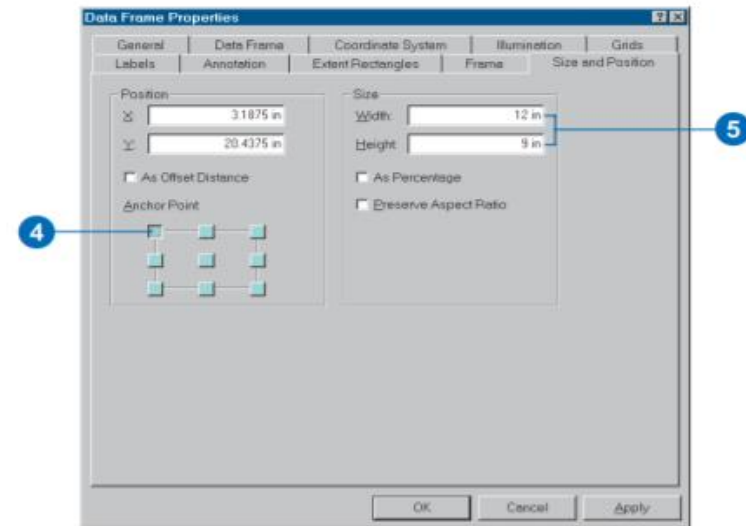
The frame is highlighted, selection handles appear at the corners and sides of the frame, and the Data Frame Properties dialog box appears.

3. Click the Size and Position tab.

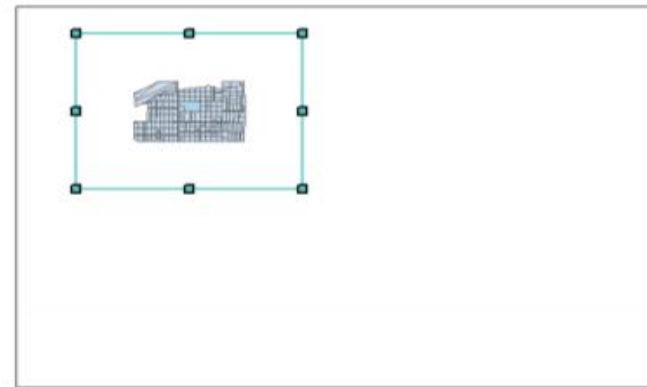
You can move and resize elements on the page by clicking and dragging the whole element or one of its selection handles, or you can set the position and size by typing the values in page units in the Data Frame Properties dialog box. You'll set the size and position of the first data frame explicitly by typing the values.

You want the upper-left corner of the data frame to remain where it is, but resize the data frame to be 12 by 9 inches.

4. Click the upper-left anchor point in the Position panel.
5. In the Size panel, type "12 in" in the Width box and "9 in" in the Height box. Click OK.



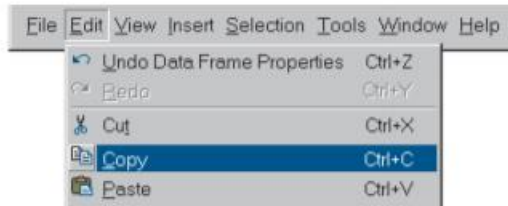
The data frame is resized, and the layers are scaled down to fit inside.



Copying the data frame

Now you'll make a copy of the data frame to contain the city overview map.

1. Click Edit and click Copy.

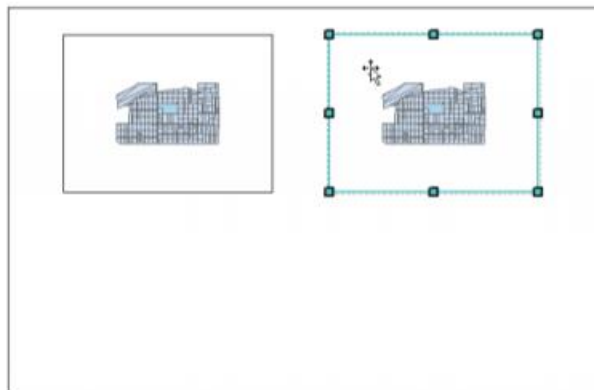


2. Click Edit and click Paste.

The copy of the data frame is pasted onto the map on top of the original data frame.

3. Click on the data frame and drag the copy to the right of the original.

Both data frames display the same layers.



You'll use the new data frame to show the position of the project area with respect to the rest of the city and the original one to show all of the suitable parcels. You'll add a third data frame to show the highly suitable parcels, but first rename the other two.

Renaming the selected data frame

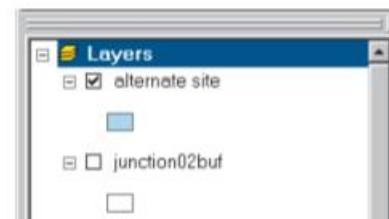
The table of contents is divided into sections by data frame. Both data frames in the table of contents have the same title—Layers (the default)—because you copied one to create the other.

The data frame that you have just pasted onto the map is still selected—you can see its selection handles in the Layout view.

1. Scroll through the table of contents until you see the Layers heading in bold type.

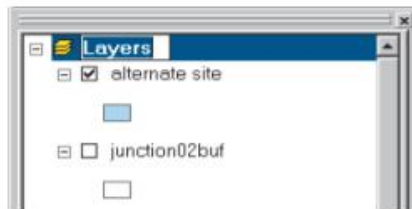
This is the data frame you just added. The bold type identifies this data frame as the selected data frame.

2. Click the bold Layers heading in the table of contents to select it.



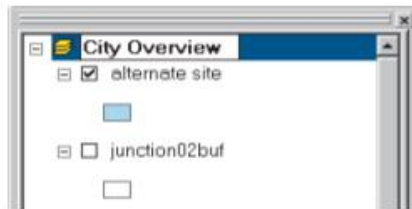
3. Click Layers again to highlight the name.

If you click twice rapidly—a double-click—on the name of a data frame, you will open the Data Frame Properties dialog box. You do not need to change any properties of the data frame at the moment, so if you get this dialog box, just click Cancel and try again.



You can now type a new name for the data frame.

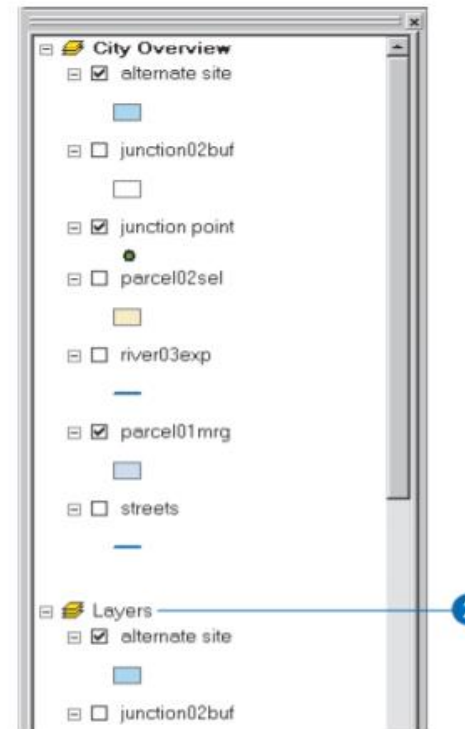
4. Type “City Overview” and press Enter.



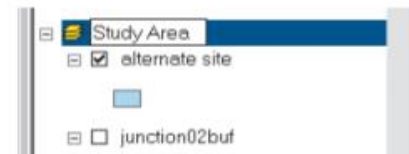
Renaming the original data frame

Now you’ll rename the other data frame.

1. Scroll through the ArcMap table of contents until you see the Layers heading.
2. Click Layers to select the data frame, then click it again to highlight the name.



3. Type “Study Area” and press Enter.



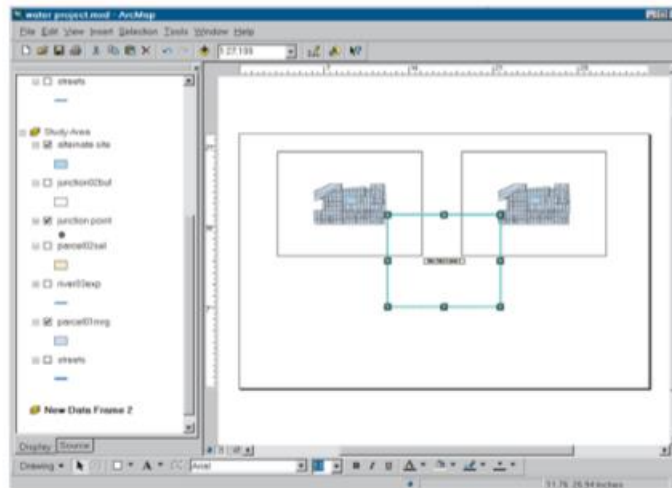
Inserting a new data frame

Now add the third data frame, which will show the highly suitable parcels. You'll do this by inserting a new data frame rather than copying an existing one.

1. Click Insert and click Data Frame.



The new data frame appears as the selected data frame in the center of the map and is listed at the bottom of the table of contents, named New Data Frame 2.

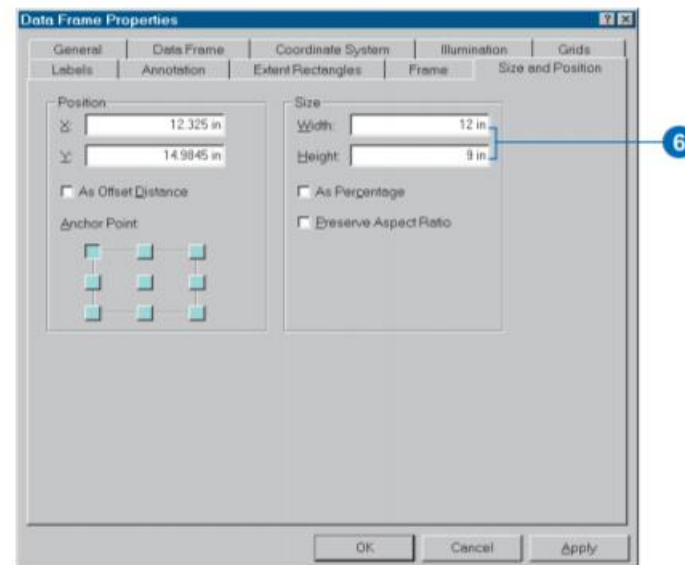


2. Click New Data Frame 2 in the table of contents to select it, then click again to highlight the name.

3. Rename the data frame by typing "Best Parcels", then press Enter.

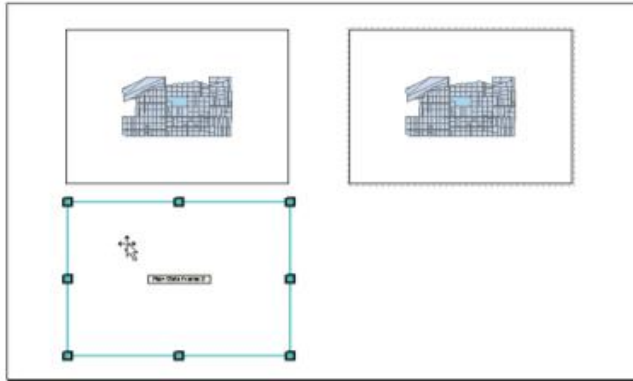
You want the new data frame to be the same size as the others (12 by 9 inches) and positioned below the Suitable Parcels data frame, so you'll resize and move it.

4. Right-click inside the new data frame on the map and click Properties.
5. Click the Size and Position tab.
6. Double-click in the Width text box and type "12 in", then double-click in the Height text box and type "9 in". Click OK.



The data frame is now the same size as the others.

7. Click and drag the data frame so it is positioned below the Study Area data frame. It's OK if it's not lined up exactly—you'll align the data frames later.



The data frame is currently empty. You'll copy the layers you need from the Study Area data frame later, after you've changed their symbology.

8. Click File and click Save to save your map so far.

Through the rest of the chapter, you'll want to periodically save your map in case you need to stop or take a break and come back to it. We'll remind you at the end of each section, but you may want to save more often.

At this point, you've added the three data frames to create the basic structure of the map. Now you'll modify each data frame to display the necessary layers. In the next step you'll change the contents of the city Overview data frame to show the location of the suitable parcels with respect to the rest of Greenvally.

Creating the overview map

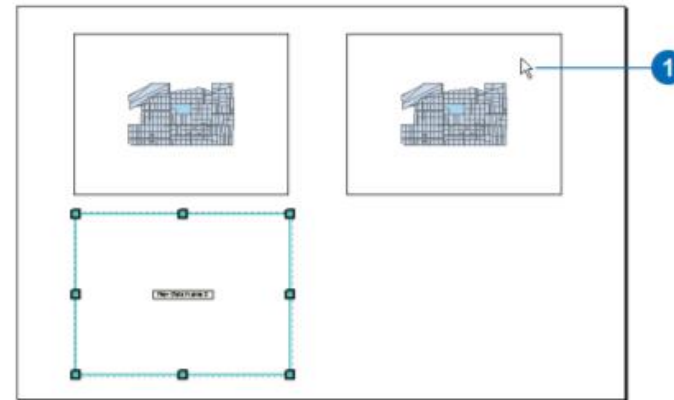
You want the City Overview data frame to show where the suitable parcels are relative to the rest of Greenvally. Because most Greenvally residents are familiar with the major streets of Greenvally, you can use the streets to orient the map readers. You'll also display the river and the elevation grid so people can see that the study area containing the parcels is near the river and in the low-lying area. Later you'll add a rectangle showing the location of the study area.

To create the map, you'll remove the unnecessary layers from the City Overview data frame, change the extent of the area displayed in the data frame, and change the way the streets are displayed. Then you'll change the way the river is displayed and, finally, add the elevation grid layer underneath.

Removing unnecessary layers from the data frame

It is often easier to work with the data in a given data frame in Data view, particularly when the layout contains several data frames.

1. Click inside the City Overview data frame on the map page to select it.



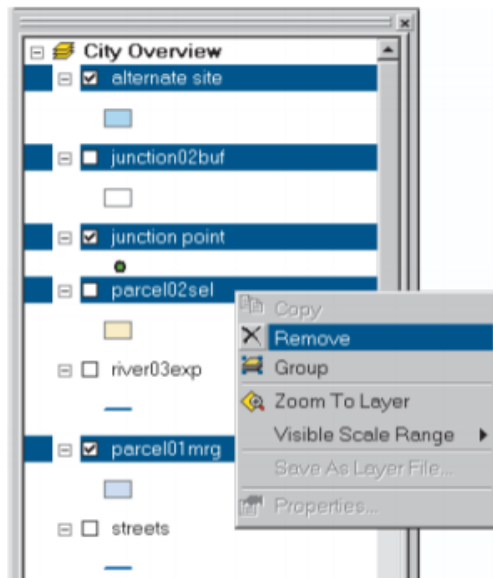
2. Click View and click Data View.



On a map with multiple data frames, switching to Data view shows you the data for the currently selected data frame. In this case, the selected data frame is City Overview.

3. Scroll to the City Overview data frame in the table of contents, if necessary.
4. Click alternate site under the data frame heading in the table of contents to select it.

5. Press the Ctrl key and click the following layers to select them as well:
 - junction02buf
 - junction point
 - parcel02sel
 - parcel01mrg
6. With the layers selected, point to one of the highlighted layers, right-click, and click Remove.

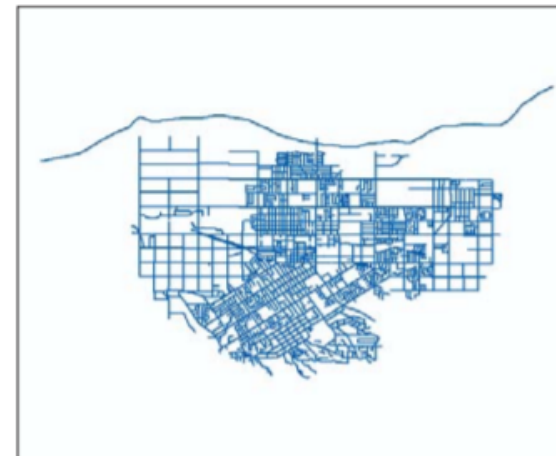


The layers are removed from the map. You could have left the layers in the data frame and just not displayed them, but it's easier to work with the data frame without the layers in the table of contents.

You should now have only streets and river03exp in the data frame. Neither are currently displayed. If any additional layers remain, remove them as well.

7. Click the check boxes next to river03exp and streets to display them.
8. Click the Full Extent button on the Tools toolbar.

This zooms to the full extent of the remaining layers.



Showing the major streets

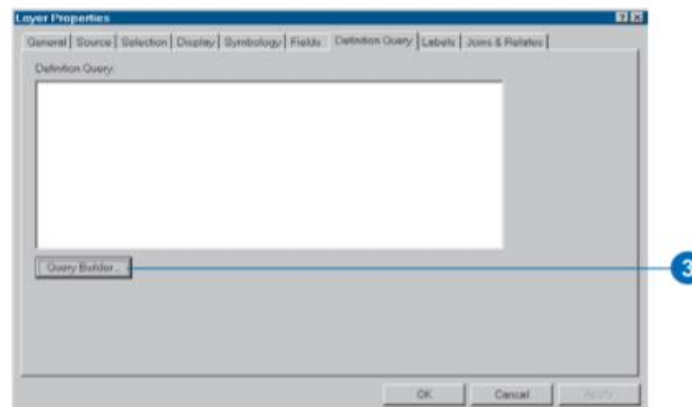
The streets layer shows all of the streets of Greenvally. Displaying only the major streets will be sufficient for showing the location of the suitable parcels and, in fact, will make the map easier to read. You'll modify the properties of this layer to simplify the representation of the streets.

1. Double-click streets under the City Overview data frame in the table of contents.



Double-clicking a layer is a quick way to get to its Layer Properties dialog box.

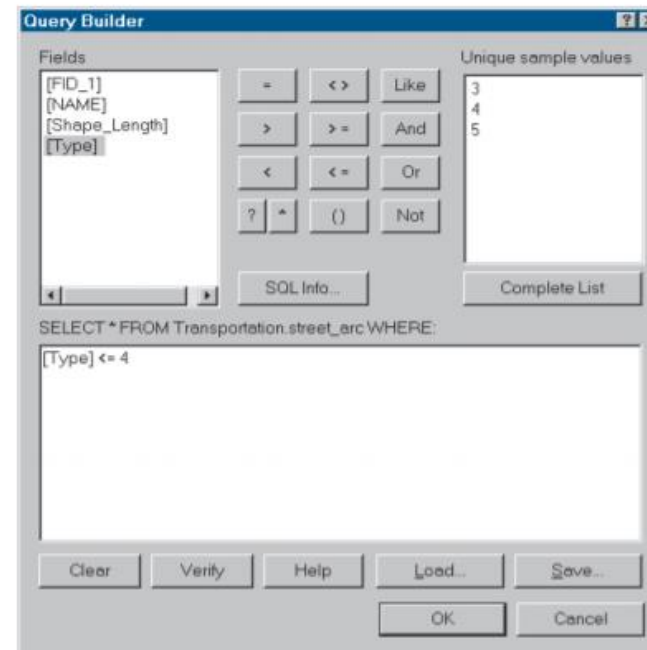
2. Click the Definition Query tab.
3. Click the Query Builder button.



The Query Builder dialog box appears. It's similar to the other query dialog boxes you've already seen.

The Greenvalley streets in this database belong to three classes. Classes 3 and 4 are major streets; class 5 streets are smaller streets. You will select the major streets.

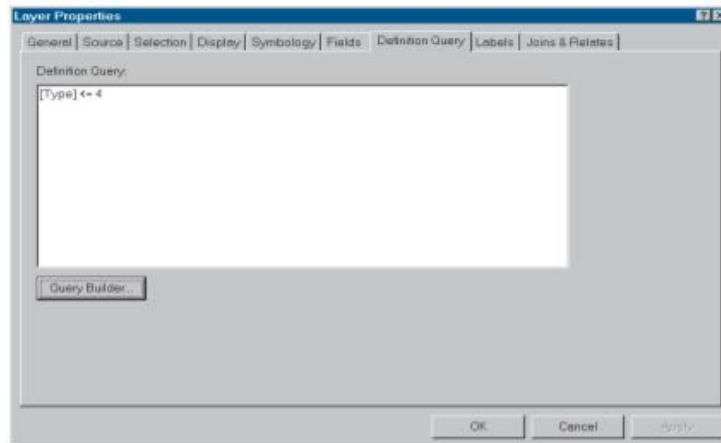
4. Double-click [Type].
5. Click the less than or equal to button ($\leq$).
6. Type "4", review the query expression, then click OK.



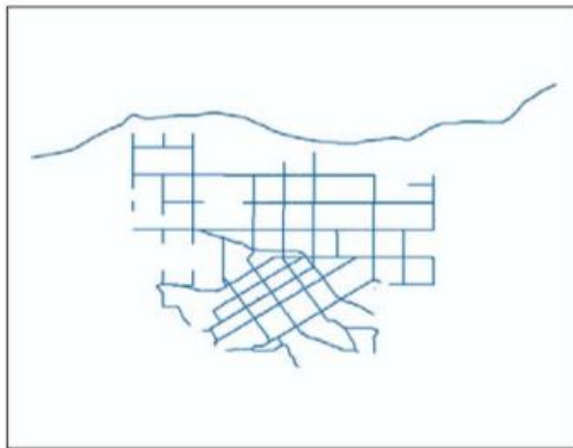
The query expression is added to the Definition Query tab of the Layer Properties dialog box. It should look like this:

[Type] $\leq$ 4

7. Click OK on the Layer Properties dialog box.



Only the major streets are displayed—the smaller streets are left off the map. Using Definition Query is a quick way of showing only certain features in a layer without selecting them and creating a separate layer.



Now you can zoom to the area covered by the major streets.

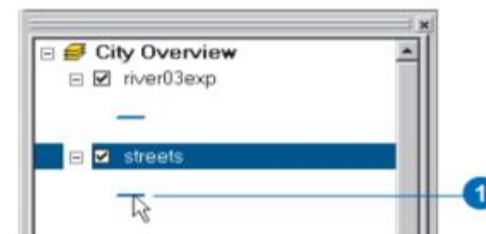
8. Right-click streets in the table of contents and click Zoom To Layer.

Changing the street symbol

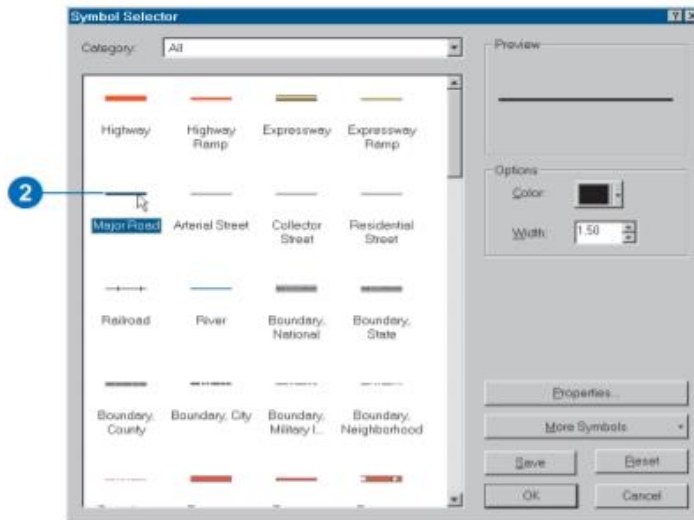
Because you have not yet specified a symbol for the streets, they are drawn in a randomly selected color. You want the streets to be drawn with a simple black line.

1. In the table of contents, click the line symbol below the streets layer (you may need to scroll through the table of contents to locate it).

Note that streets are also in the Study Area data frame—make sure you're working with the layers under the City Overview data frame.



2. Click the Major Road symbol and click OK.

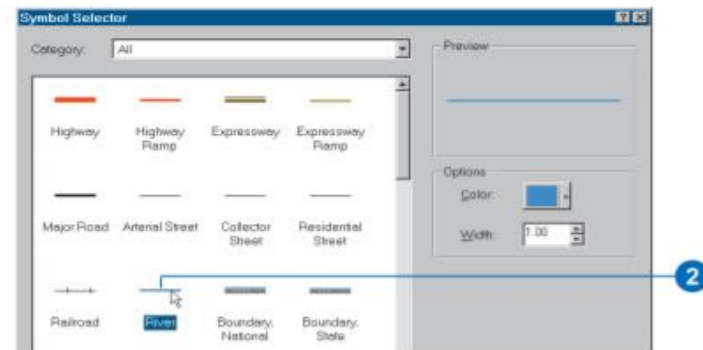


The major streets of Greenvally are now drawn on the map with a black line.

Displaying the river and elevation layers

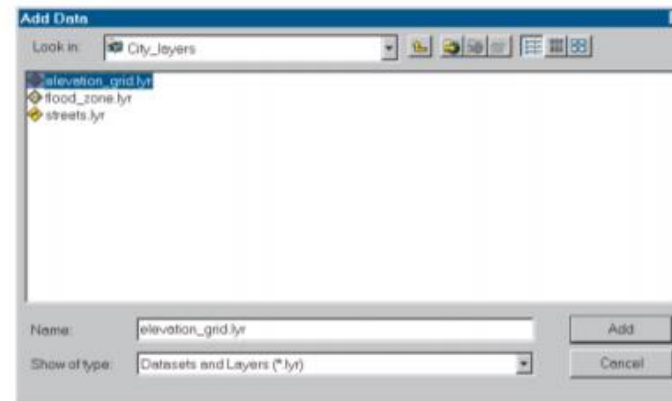
You also want to display the river and elevation grid so the city council and public can see that the study area was chosen based on its proximity to the river and its location in a low-lying area.

1. Click the line symbol beneath the river03exp layer name.
2. Click the River symbol and click OK.



The river is now drawn with a blue line.

3. Click the Add Data button, navigate to the City_layers folder, and click elevation_grid.lyr. Click Add.



If you get a warning message about the coordinate system for the layer, click OK.

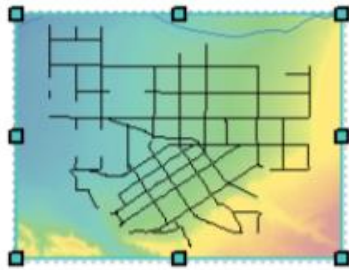
The elevation grid is added to the data frame and is displayed using the colors you specified when you created the layer.

The City Overview should now display the following layers, listed in this order in the table of contents:

- river03exp
- streets
- elevation

4. Click View and click Layout View.

The City Overview data frame on the map now shows the major streets, the river, and the elevation grid. ArcMap attempts to center the layers in the data frame. Since the river is along the top edge, it is only partially visible.



5. Click the Pan tool on the Tools toolbar.



6. Click in the data frame and drag the layers down so the river is visible near the top of the data frame.



The data frame is finished for now.



Later in the chapter you'll add a rectangle to this frame to show the location of the study area.

7. Click File and click Save to save your map.

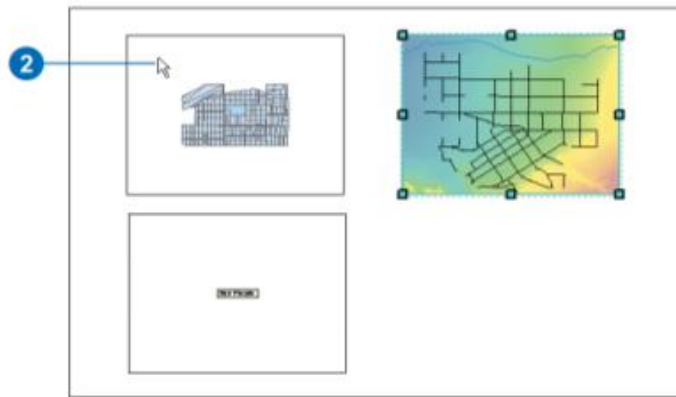
In the next step, you'll make the necessary changes to the Study Area data frame to show the suitable parcels.

Creating the map of suitable parcels

This map will show suitable parcels shaded in one color and all other parcels in another color. It will also show the location of the wastewater junction, along with the 500- and 1,000-meter buffers around the junction. The map will also include the alternate site, shaded using a diagonal hatched pattern, and will display the river to help orient map readers to the location of the parcels.

Setting the display environment

1. Click the Select Elements tool on the Tools toolbar.
2. Click the Study Area data frame on the page—the one in the upper left.



The data frame is selected and highlighted on the map, and the data frame name is shown in bold type in the table of contents. To make it easier to see the data you're working with, switch to Data view.

3. Click View and click Data View.

You'll be displaying all the listed layers in this data frame, except streets, so remove the streets layer.

4. Right-click streets in the table of contents and click Remove.

The data frame should now contain the following layers, listed in this order in the table of contents:

- alternate site
- junction02buf
- junction point
- parcel02sel
- river03exp
- parcel01mrg

If the data frame contains any other layers, you can remove them.

Currently, alternate site, junction point, and parcel01mrg should be displayed.

Changing the symbol for the parcels

You'll use the parcel01mrg layer as a background layer. This layer contains all the parcels in the study area. The foreground data in this data frame will be the layer containing only the suitable parcels (parcel02sel). It will display on top of the parcel01mrg layer.

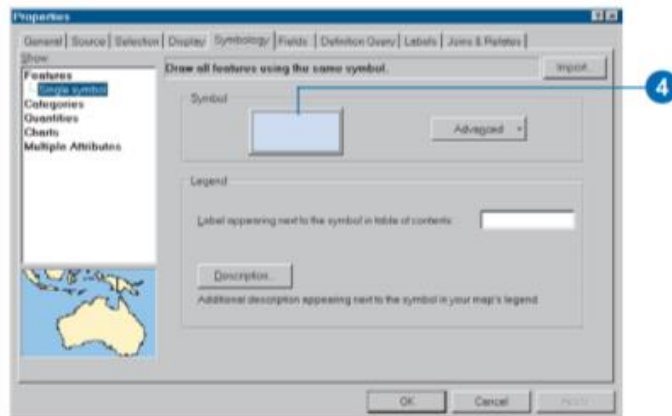
1. Right-click parcel01mrg in the table of contents and click Zoom To Layer.

The parcels fill the data frame.

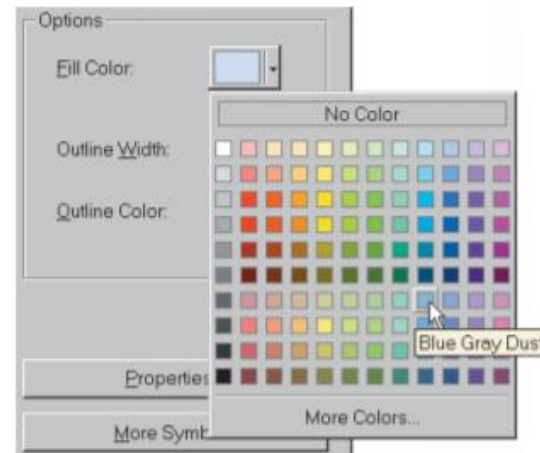


You want to emphasize the suitable parcels when you draw them on top, so change the color for the parcels in this layer to a light shade.

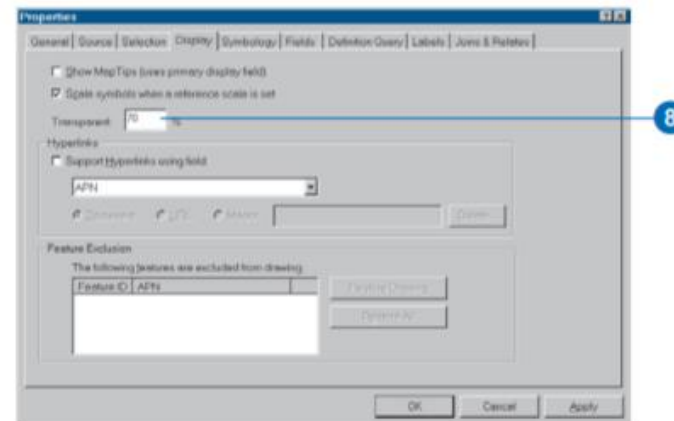
2. Right-click the parcel01mrg layer in the table of contents and click Properties.
3. Click the Symbology tab.
4. Click the Symbol button.



5. Click the Fill Color dropdown arrow and click Blue Gray Dust.



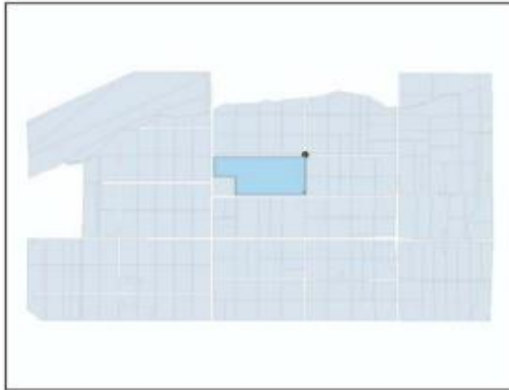
6. Click OK.
7. Click the Display tab on the Properties dialog box.
8. In the Transparent text box, type "70".



That will set the parcel fill color to be a lighter shade of the Blue Gray Dust color.

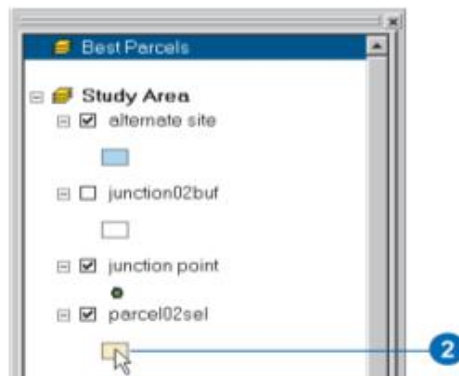
9. Click OK.

The parcels are now drawn in a light blue-gray.



Displaying the suitable parcels

1. Check the box next to the parcel02sel layer to display it.
2. Click the symbol box beneath parcel02sel.

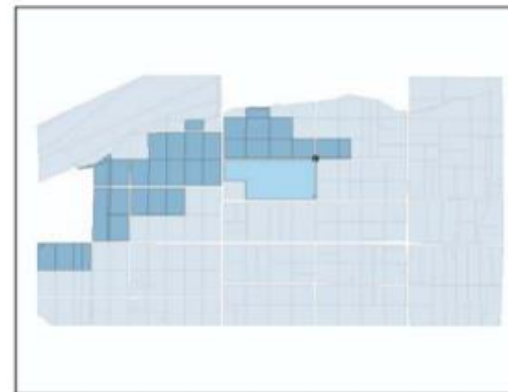


3. Click the Fill Color dropdown arrow and click Blue Gray Dust.



4. Click OK on the Symbol Selector dialog box.

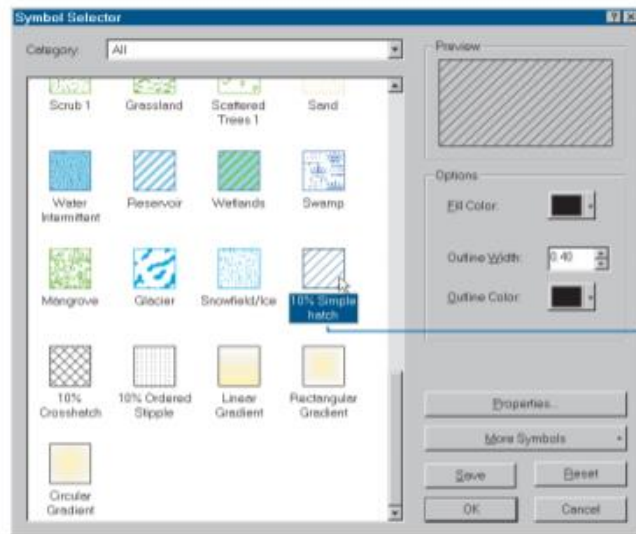
Now the suitable parcels are drawn using a medium blue-gray, a darker shade of the color the rest of the parcels are drawn with.



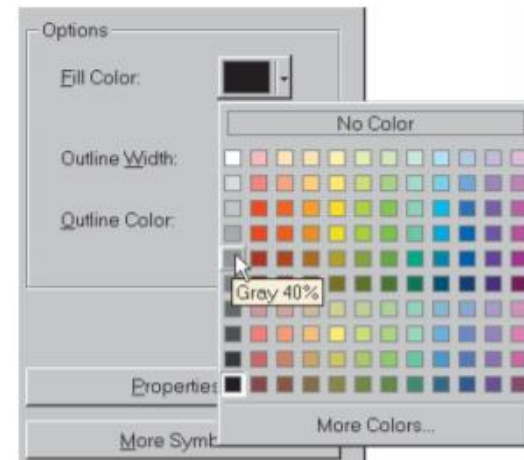
Changing the symbol for the alternate site

Right now the alternate site is drawn using the default color ArcMap selected when you created the layer. You'll draw it using gray diagonal hatching so it is visible but doesn't detract from the suitable parcels.

1. Click the symbol box beneath the alternate site layer to display the Symbol Selector dialog box.
2. Scroll to the bottom and click 10% Simple hatch.

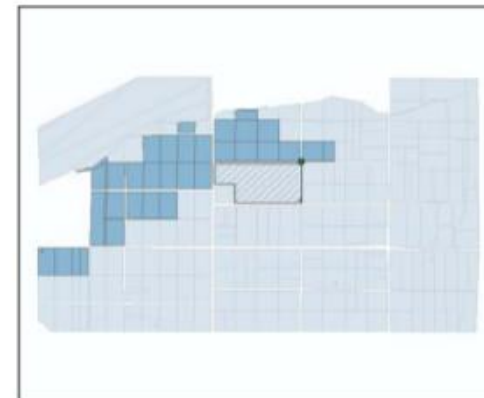


3. Click the Fill Color dropdown arrow and click Gray 40%.



4. Click OK.

The picture redraws with the gray diagonal hatching.

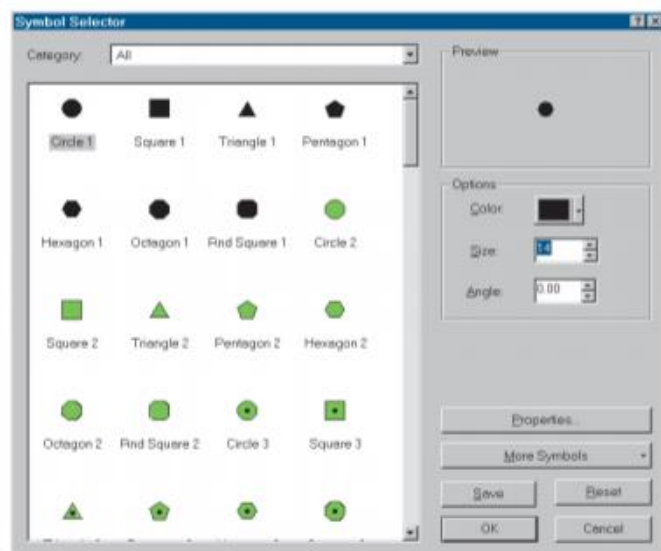


Displaying the river and the wastewater junction

You'll also want to display the river and wastewater junction to show where the suitable parcels are in relation to these features. You know how to change the symbology for a layer at this point, so we'll just give you the major steps. If you need help, review the specific steps in the previous sections.

Display the river03exp layer and draw it using the same symbol you used for the river in the City Overview data frame.

The wastewater junction should already be displayed. Click the point symbol underneath the layer to display the Symbol Selector dialog box. Click a symbol of your choosing. You can use the Color dropdown arrow to change the color if you like. Use the arrows in the Size text box to set the size to 14 (points).



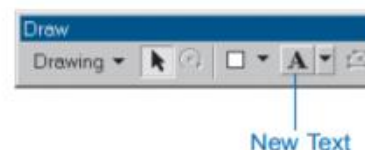
Displaying and labeling the junction buffers

Finally for this map, you'll want to display and label the 500- and 1,000-meter buffers around the wastewater junction.

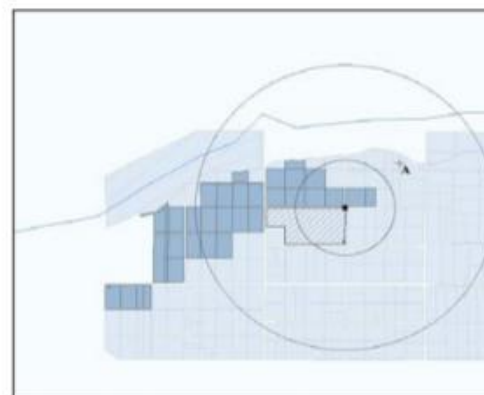
1. Click the check box next to the junction02buf layer to display it.

Now you'll label the two buffers by adding text to the data frame. You can also label features using a value stored in the attribute table. You'll do that later, on the map of highly suitable parcels.

2. Click the New Text button on the Draw toolbar.



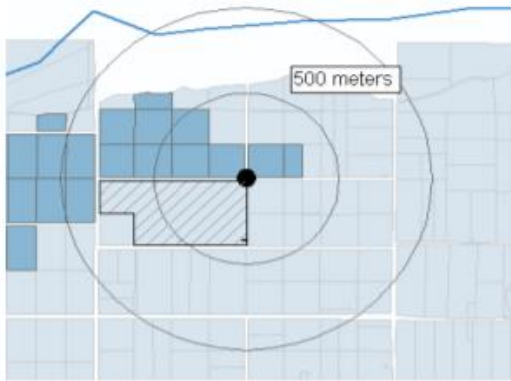
The cursor changes to a crosshair and an A.



3. Move the cursor next to the upper-right edge of the inner buffer circle and click.

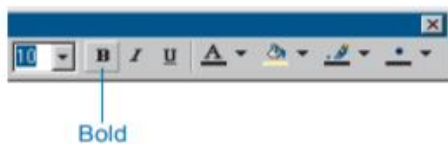
A text box appears.

4. Type "500 meters" and press Enter.



The text box is still active and highlighted with a box.

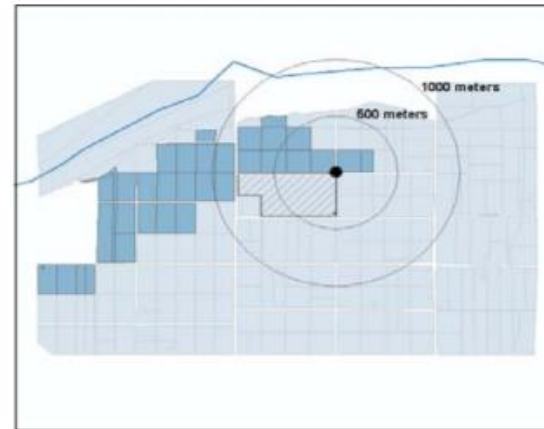
5. Click the Bold button on the Draw toolbar to make the text appear in bold type.



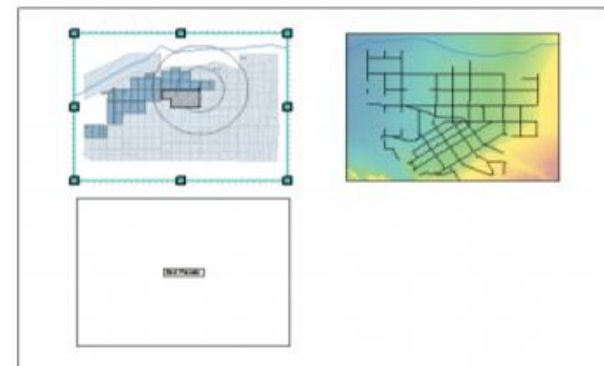
If you make a mistake, simply click the text to select it, press the Delete key on the keyboard, and start over.

6. With the text still selected, click and drag it to reposition it away from the outer buffer circle, if necessary.

7. Add the second label, 1000 meters, in the same manner.



8. Click View and click Layout to switch back to layout view and display your map at this point.



9. Click File and click Save to save your map.

You've completed two of the maps. In the next section you'll create the map of the highly suitable parcels.

Creating the map of highly suitable parcels

The third map will focus on the highly suitable parcels, color coding them by their distance from roads and the wastewater junction. You'll also label each parcel with its assessor's parcel number (APN) so people can associate the parcels on the map with the parcel report you'll create. Finally, you'll label the alternate site with its area.

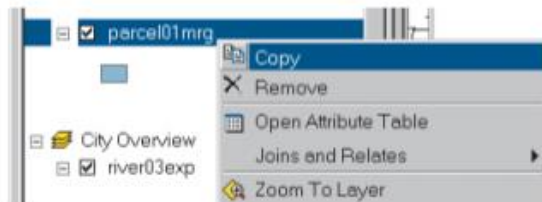
You've already changed the symbols in the Study Area data frame for several of the layers, so you'll copy the layers you need from that data frame into the Best Parcels data frame. Then all you'll need to do is change the color coding for the highly suitable parcels and label them.

Copying layers from the Study Area data frame

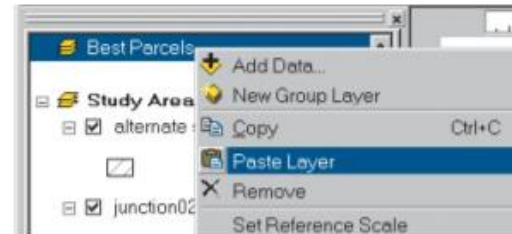
Now you can copy the layers you need into the empty data frame. Since the changes you need to make to the layers are minimal, you can continue to work in Layout view. The map will be updated as you make the changes.

The order in which you add the layers to the data frame determines the order in which they are drawn, with the most recently added drawn on top. To maintain the correct order, copy them in the reverse order to the order that they appear in the table of contents.

1. Right-click the parcel01mrg layer under the Study Area data frame in the table of contents and click Copy.



2. Right-click the Best Parcels data frame in the table of contents and click Paste Layer.



The parcel01mrg layer is added to the Best Parcels data frame and appears on the map.

Now copy the rest of the layers you need, in this order:

- parcel02sel
- junction point
- alternate site

The Best Parcels data frame should now display these layers listed in the following order in the table of contents:

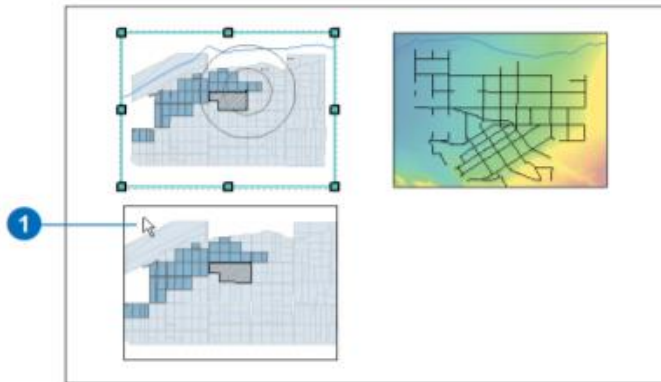
- alternate site
- junction point
- parcel02sel
- parcel01mrg

Creating the layer of the highly suitable parcels

To make it easier to display and label the highly suitable parcels, you'll select them and create a new layer in the data frame. You'll do this by creating a selection expression. In Layout view, queries are performed on the selected data frame. You have been adding layers to the

Best Parcels data frame, but it is not the selected data frame—Study Area is selected. Before you can query the parcels layer, you have to select the Best Parcels data frame.

1. Click the Best Parcels data frame on the virtual page to select it.



Now you can select the highly suitable parcels—those within 50 meters of a road and/or 1,000 meters of the wastewater junction. These parcels have values greater than 0 for either or both the ROAD_DIST and JUNC_DIST fields.

2. Click Selection and click Select By Attributes.



The Select By Attributes dialog box appears.

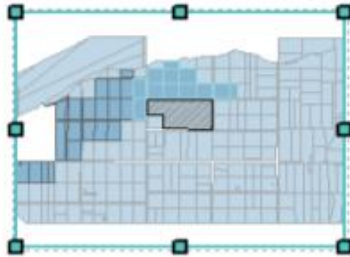
3. Click the Layer dropdown arrow and click parcel02sel.
4. Double-click ROAD_DIST in the Fields list.
5. Click the greater than button (>).
6. Type "0".
7. Click Or.
8. Double-click JUNC_DIST.
9. Click the greater than button (>).
10. Type "0".



The selection expression should look like this:

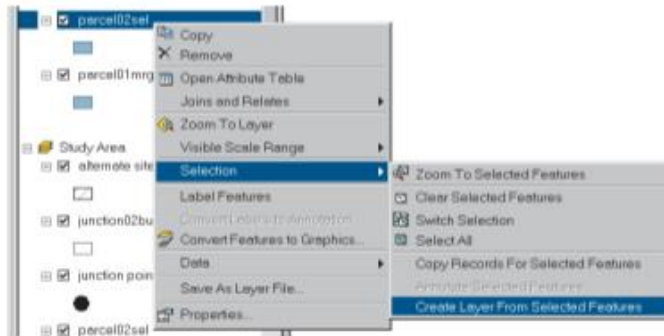
“ROAD_DIST” > 0 OR “JUNC_DIST” > 0

11. Click Apply, then click Close.



Now the highly suitable parcels are selected, and you can create a separate layer containing them.

12. Right-click parcel02sel in the table of contents—under the Best Parcels data frame—point to Selection, and click Create Layer From Selected Features.



ArcMap creates a new layer in the Best Parcels data frame that contains the selected features. The default name is parcel02sel selection. You will rename it to “highly suitable”.

13. Click parcel02sel selection in the table of contents to select it, then click again to highlight the name.

14. Type “highly suitable” and press Enter.



The layer is renamed in the table of contents. Now you will change the way it is symbolized and add the parcel identification numbers as labels on the map.

Color coding the highly suitable parcels

You’ll color code the highly suitable parcels based on both their distance from roads and from the wastewater junction, using the ROAD_DIST and JUNC_DIST fields. There are five possible pairs of values:

- Less than 500 meters from the junction and less than 50 meters from a road (junc_dist = 500 and road_dist = 50)
- Less than 500 meters from the junction but more than 50 meters from a road (junc_dist = 500 and road_dist = 0)
- 500 to 1,000 meters from the junction and less than 50 meters from a road (junc_dist = 1000 and road_dist = 50)
- 500 to 1,000 meters from the junction but more than 50 meters from a road (junc_dist = 1000 and road_dist = 0)
- More than 1,000 meters from the junction but less than 50 meters from a road (junc_dist = 0 and road_dist = 50)

These distance values may play a part in the city council's decision of which parcels to buy for the plant site. The parcels closer to the junction and closer to a road are the most suitable, although other factors may come into play in the decision, such as engineering issues (the slope and soils on-site) and economic issues (the ownership and assessed value of each parcel).

You'll symbolize the highly suitable layer so that both distance values are communicated.

1. Double-click the highly suitable layer under the Best Parcels data frame in the table of contents.

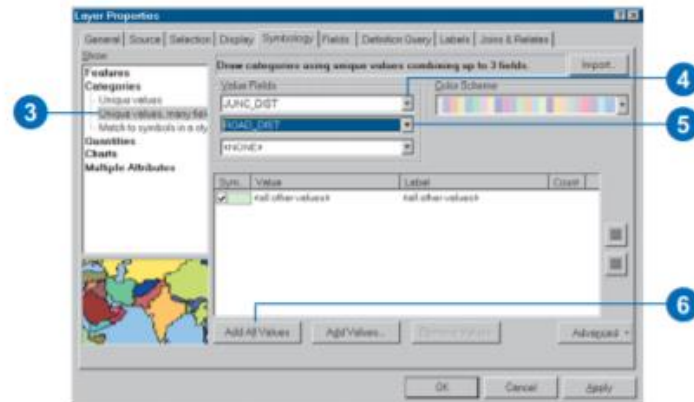
2. Click the Symbology tab.

Currently, all the parcels are drawn with a single default symbol.

3. Click Categories in the Show box and click Unique values, many fields.

The Unique values, many fields option lets you color code features based on combinations of values from up to three fields. You need only two: JUNC_DIST and ROAD_DIST.

4. Click the top dropdown arrow in the Value Fields section and click JUNC_DIST.
5. Click the second dropdown arrow in the Value Fields section and click ROAD_DIST.
6. Click Add All Values.



Only four pairs of values are listed. Apparently there are no parcels in the fifth category (more than 1,000 meters from the junction, but less than 50 meters from a road).

The pairs appear in this order:

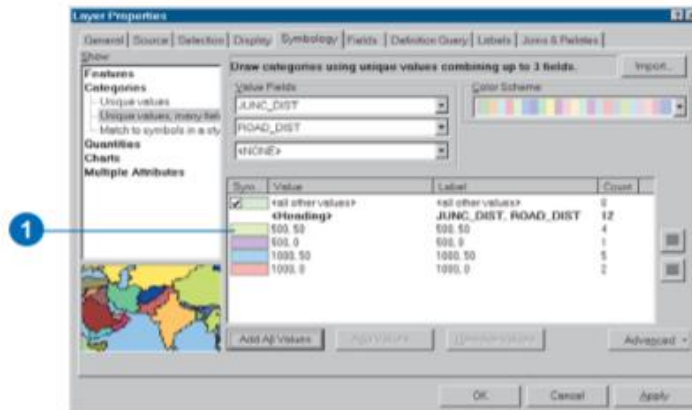
- 500, 50
- 500, 0
- 1000, 50
- 1000, 0

The four pairs of values will be shown on the map with unique symbols. You'll draw the parcels within 500 meters of the junction in two shades of green—parcels near a road in a dark shade and parcels far from a road in a lighter shade—and the parcels between 500 and 1,000 meters from the junction in two shades of yellow. The remaining parcels—those meeting all the city's criteria but more than 50 meters from a road and more than 1,000 meters from the junction—will be shaded using the same blue-gray you used in the Study Area data frame.

Changing the symbol colors

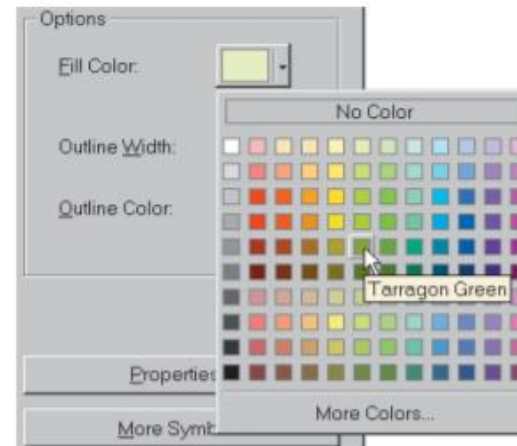
ArcMap uses default colors for the value combinations. You want to use two shades of green for the parcels within 500 meters of the junction and two shades of yellow for parcels between 500 and 1,000 meters of the junction.

1. Double-click the symbol box next to 500, 50.

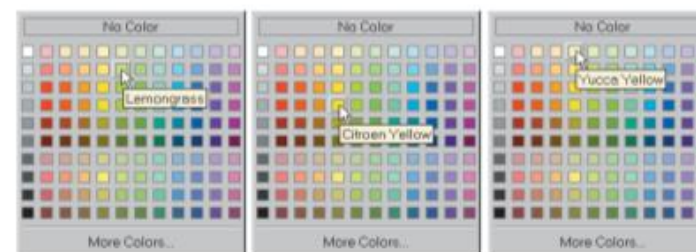


The Symbol Selector dialog box appears.

2. Click the Fill Color dropdown arrow and click Tarragon Green.



3. Click OK.
 4. Now select the colors for the other values in the same manner. Use the following colors:
- | | |
|----------|----------------|
| 500, 0 | Lemongrass |
| 1000, 50 | Citroen Yellow |
| 1000, 0 | Yucca Yellow |



There are no other values in this case, so you can turn off the symbol for other values.

- Click the check box next to <all other values> to uncheck it.

5

Sym...	Value	Label	Count
☐	<all other values>	<all other values>	0
☒	<Heading>	JUNC_DIST, ROAD_DIST	12
	500, 50	500, 50	4
	500, 0	500, 0	1
	1000, 50	1000, 50	5
	1000, 0	1000, 0	2

You also want to change the legend labels, so keep the dialog box open.

Changing the heading and value labels

Now you'll change the labels that appear in the table of contents to make them easier to understand. These labels will also appear in the map legend when you create it.

- Click the label field for the Heading and type "Distance to: Junction, Road". Rather than pressing Enter, which will close the dialog box, just click in the next label field to change the label.

Sym...	Value	Label	Count
☐	<all other values>	<all other values>	0
☒	<Heading>	Distance to: Junction, Road	12
	500, 50	500, 50	4
	500, 0	500, 0	1
	1000, 50	1000, 50	5
	1000, 0	1000, 0	2

- Click the label field for 500, 50 and type "<500m; <50m".

Sym...	Value	Label	Count
☐	<all other values>	<all other values>	0
☒	<Heading>	Distance to: Junction, Road	12
	500, 50	<500m; <50m	4
	500, 0	500, 0	1
	1000, 50	1000, 50	5
	1000, 0	1000, 0	2

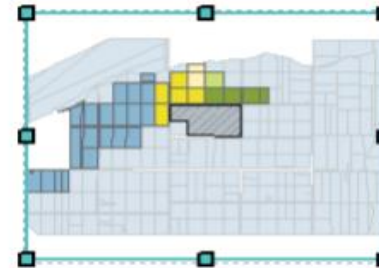
- Change the labels for the remaining three symbols.

For 500, 0 type "<500m; >50m".

For 1000, 50 type "500–1000m; <50m".

For 1000, 0 type "500–1000m; >50m".

- Click OK.



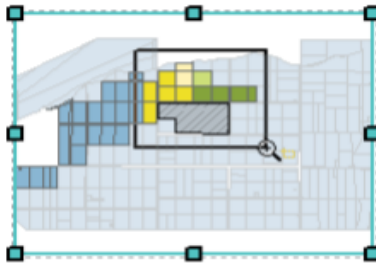
Now the highly suitable parcels have unique symbols based on distance from roads and the wastewater junction. The parcels shaded green are within 500 meters of the junction, and the parcels shaded yellow are between 500 and 1,000 meters from the junction. The dark-shaded parcels—both green and yellow—are within 50 meters of a road, while the lighter shaded parcels are more than 50 meters from a road.

Labeling the highly suitable parcels

Next, you'll label the highly suitable parcels with their APN so they can be identified in the parcel report. First, zoom to the highly suitable parcels to emphasize them on the map.

1. Click the Zoom In tool on the Tools toolbar and click and drag a rectangle around the highly suitable parcels and the alternate site.

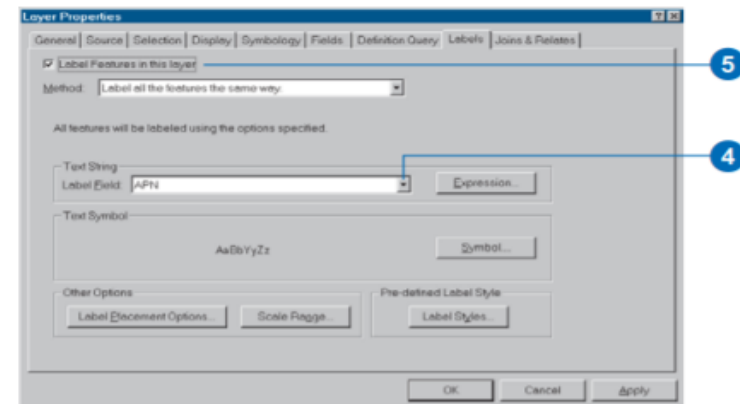
Since you're zooming in on the data—not the map page—make sure you're not using the Zoom In tool on the Layout toolbar.



Before you add the labels, you will make sure that the correct field is used for labeling.

2. Double-click highly suitable.
3. Click the Labels tab of the Layer Properties dialog box.
4. Click the dropdown arrow to select the label field and click APN.
5. Check Label Features in this layer in the upper-left corner of the dialog box and click OK.

Each highly suitable parcel is now labeled with its APN.



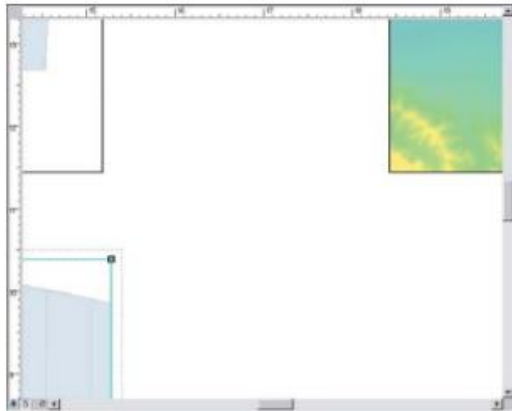
It's hard to see how the labels will look since the map is currently scaled down to fit the screen. You can display the map at the actual size to see how it will look when printed.

6. Click the Zoom to 100% button on the Layout toolbar.



Zoom to 100%

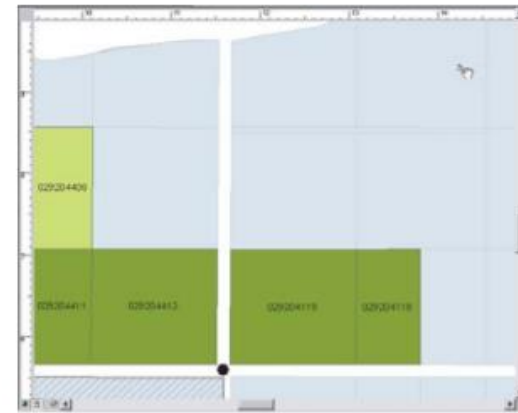
The map is now displayed in the ArcMap window at the printed size, but you're looking at the center of the map.



7. Click the Pan tool on the Layout toolbar and drag the map to the upper right until you can see the highly suitable parcels with their labels.

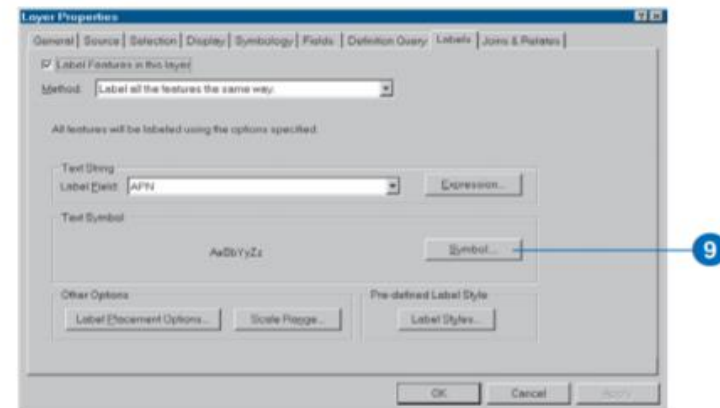


The Pan and Zoom tools on the Layout toolbar let you move around the map page, whereas Pan and Zoom on the Tools toolbar let you change the geographic extent of the data displayed in the currently selected data frame.



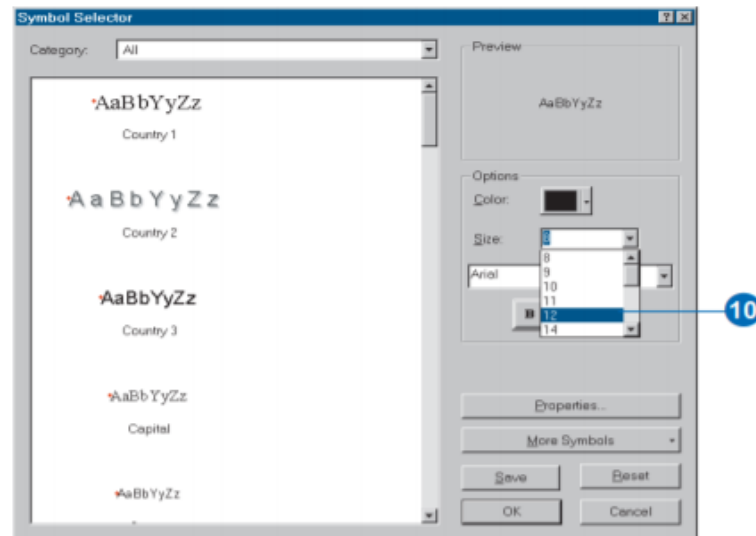
The labels look pretty good, but they could be a little larger.

8. Double-click the highly suitable layer in the table of contents to display the Layer Properties dialog box and click the Labels tab.
9. Click Symbol.



The Symbol Selector dialog box appears. The labels are currently displayed using 8 point type.

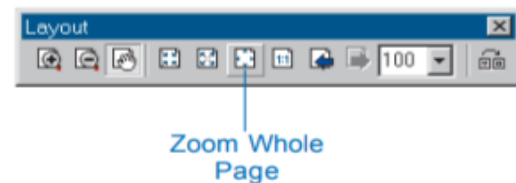
10. Click the Size dropdown arrow and click 12 to make the labels 12 point. Click OK.



11. Click OK on the Layer Properties dialog box.

The labels are now larger and easier to read.

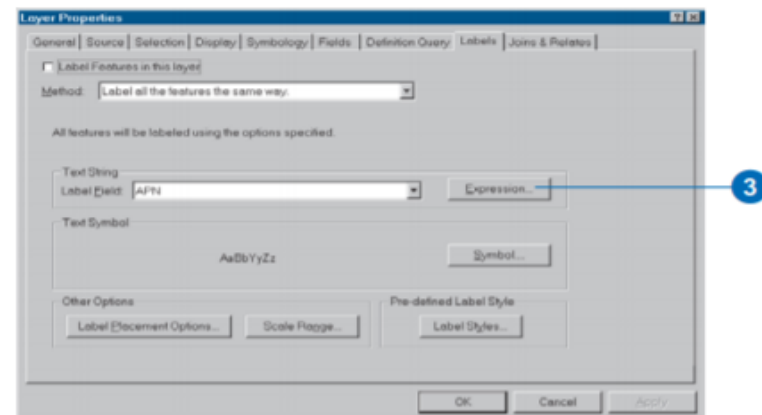
12. Click the Zoom Whole Page button on the Layout toolbar to see the entire map again.



Creating the label for the alternate site

The alternate site won't be in the parcel report since it doesn't meet all the city's current criteria for a site for the wastewater treatment plant. However, you want to display its area. You'll label the parcel with its AREA field using the Layer Properties dialog box to set the properties before displaying the label.

1. Double-click alternate site in the table of contents to display the Layer Properties dialog box.
2. Click the Labels tab.
3. Click Expression.



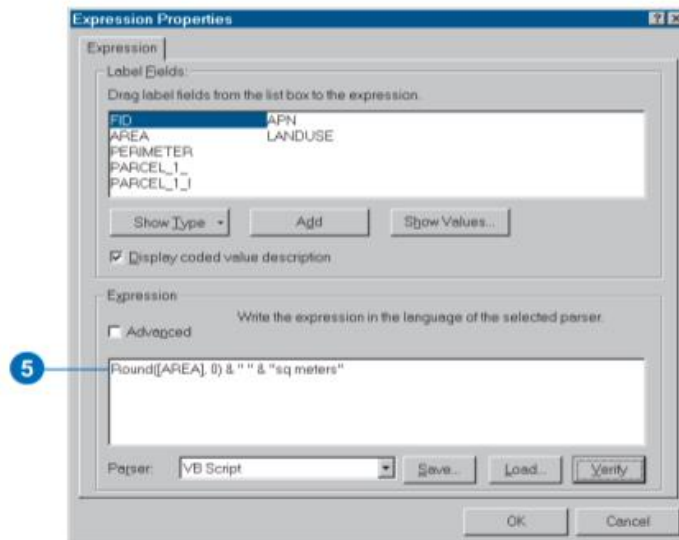
The Expression Properties dialog box appears. You can create a Visual Basic or Java™ script to customize the way labels are displayed. You'll create a simple VB script to display the area value with a suffix of "sq meters". The area value is stored in the database using several decimal places, which you don't need to

display, so you'll round the value to no decimal places. You will need to create an expression that looks like this:

Round([AREA], 0) & " " & "sq meters"

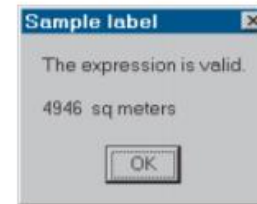
4. Click in the Expression box.
5. Type the expression in full or type all the characters except the field name, which you can drag from the Label Fields box.

The VB Round command has two arguments, enclosed in parentheses—the name of the field, AREA in this case, and the number of decimal places to round to, 0 in this case. You enclose in double quotes any text you want to display as part of the label, in this case "sq meters". The double quotes with two spaces inside will ensure there is space between the area value and the suffix when the label is displayed. You use an ampersand (&) to connect the elements of the script.



6. Click the Verify button to make sure you entered the expression correctly.

The Sample label box appears and tells you the expression is valid. It also shows you a sample of how the label will look. Note that the value displayed in the Sample label box is not the actual value of the parcel. If you get an error message when you click Verify, just check that you entered the expression correctly, make any changes, and click Verify again.



7. Click OK to close the Sample label dialog box and click OK to close the Expression Properties dialog box.

Now you've specified what will be in the label. Next you'll want to change the way the label is displayed.

Changing the label properties and displaying the label

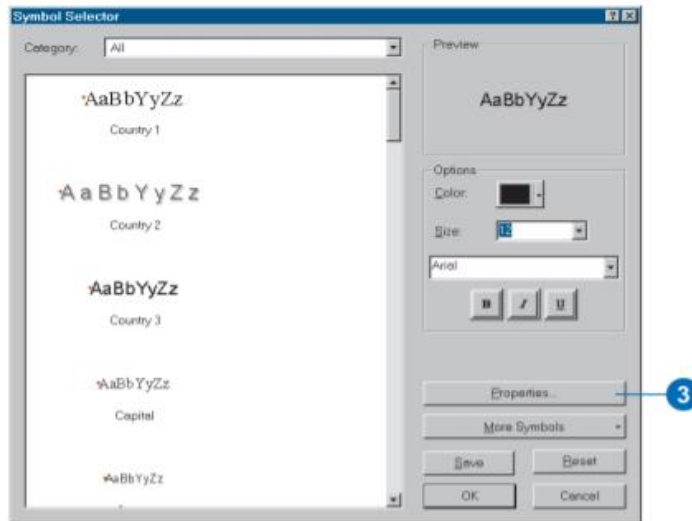
1. Click Symbol on the Labels tab.

The Symbol Selector dialog box appears.

2. Click the Size dropdown arrow and click 12 to make the label 12 point text.

Now the label will be large enough, but it will be drawn on top of the diagonal hatching and might still be difficult to read. You'll add a mask around the text so it appears on a solid background.

3. Click Properties.



The Editor dialog box appears to let you edit the text properties. You can see that the size is shown as 12, as you just specified.

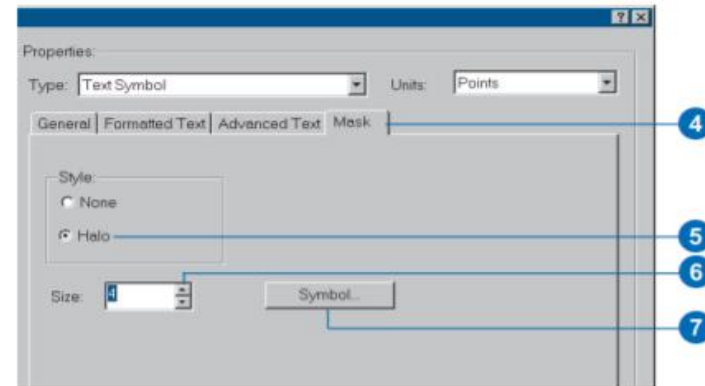
4. Click the Mask tab.
5. Click Halo in the Style panel.

The Preview panel shows you how the text will look. You want the mask to be wider to block out the hatching in the alternate site parcel.

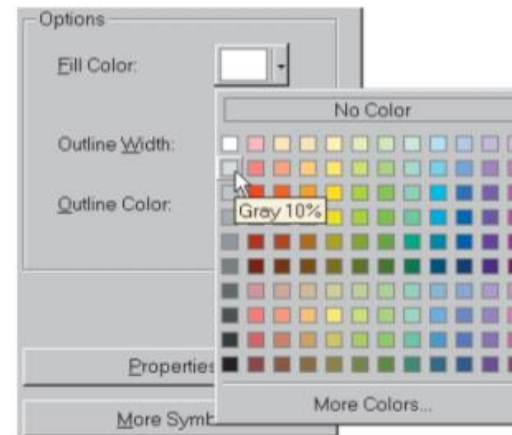
6. Click the up arrow in the Size text box to increase the mask width to 4 points.

You also want the mask to be light gray so it's easy to read the text.

7. Click Symbol to display the mask Symbol Selector dialog box.



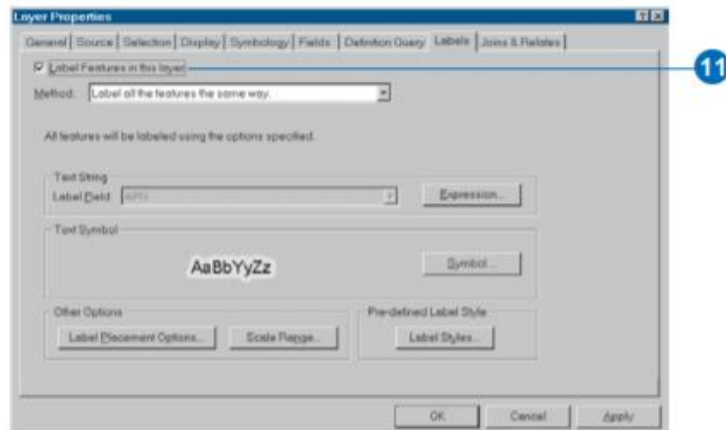
8. Click the Fill Color dropdown arrow and click Gray 10%.



9. Click OK to close the mask Symbol Selector.

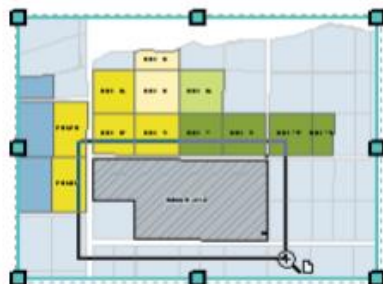
The Preview panel shows that the mask is light gray.

10. Click OK to close the Editor dialog box and click OK again to close the text Symbol Selector dialog box.
11. Check Label Features in this layer in the upper-left corner of the dialog box and click OK.



The alternate site is labeled with its area.

12. Click the Zoom In tool on the Layout toolbar and click and drag a rectangle around the alternate site.



You can see the label with its mask.



13. When you're done reviewing the label, click the Zoom Whole Page button on the Layout toolbar to view the entire map again.
 14. Click File and click Save to save your map at this point.
- The third map is complete, and the geographic information you need to present is now displayed in each data frame. Next, you'll create a report for the highly suitable parcels, add it to the map, and finish laying out the map by adding the rest of the map elements.

Creating the parcel report

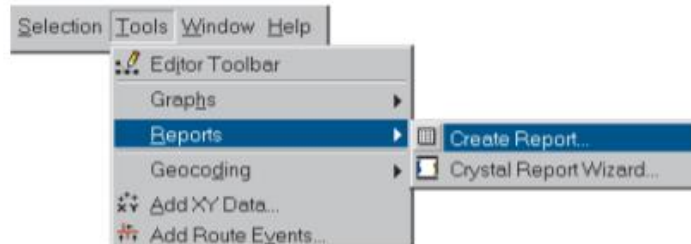
You'll create a tabular report of the highly suitable parcels to provide additional information about each. The report will list the assessor's parcel number, area, and distance from the junction for each parcel. You'll group the parcels by distance from the junction and sort them by size.

First you'll design the report—specifying what should be included—then you'll generate it and add it to the map.

Designing the report

You'll specify the fields you want in the report, then you'll specify how to group and sort the parcels.

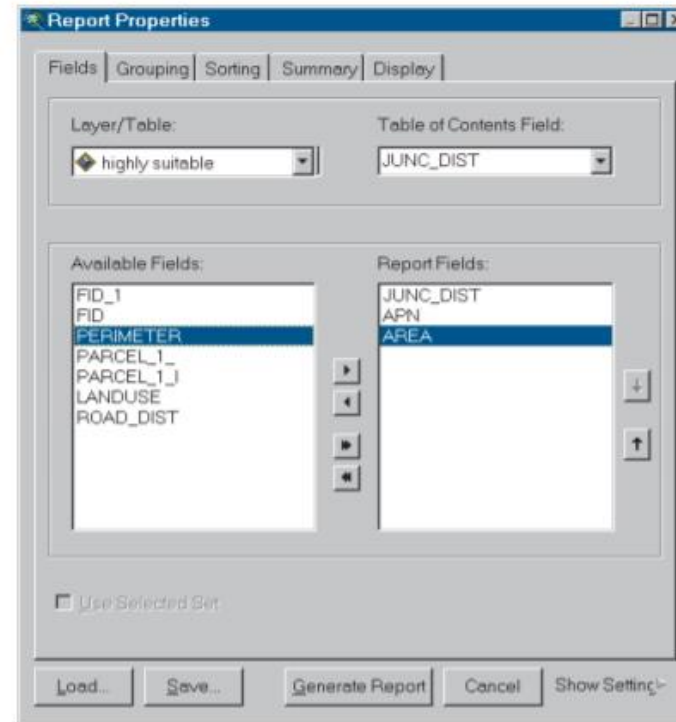
1. Click Tools, point to Reports, and click Create Report.



The Report Properties dialog box appears, and the Fields tab is selected. The other tabs are unavailable since you haven't yet specified any fields to include in the report.

2. Click the dropdown arrow in the Layer/Table text box and click highly suitable as the layer to create the report from.
3. Double-click JUNC_DIST to move it from the Available Fields to the Report Fields column.

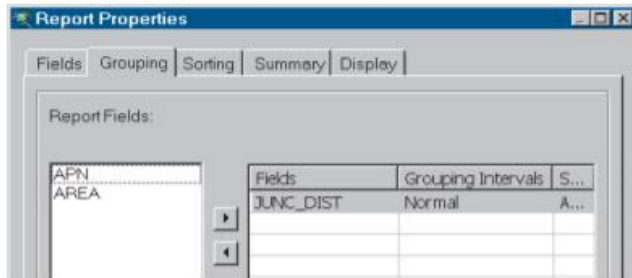
4. Double-click APN and AREA to add them to the Report Fields column as well.



Now the other tabs are available.

5. Click the Grouping tab.

- Double-click JUNC_DIST to specify this as the grouping field.

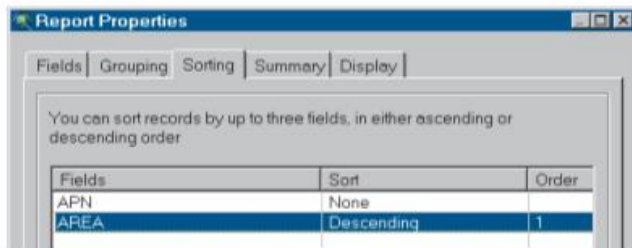


Parcels less than 500 meters from the wastewater junction will be in one section of the report, and the parcels between 500 and 1,000 meters from the junction will be in another.

- Click the Sorting tab.

Here you specify which fields to use to sort the records and how to sort them.

- Click in the Sort column for AREA and click Descending on the dropdown list that appears.

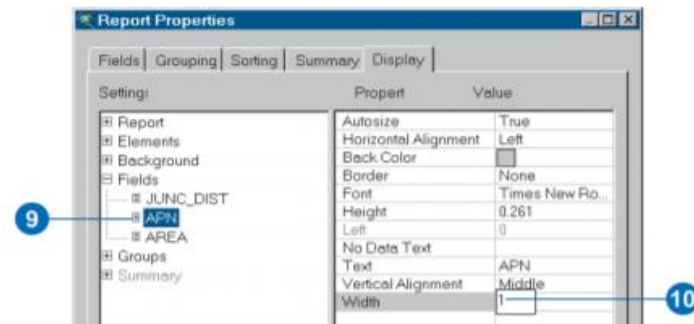


The largest parcel will be listed at the top for each group.

You'll need to change the width for the APN column to make it wide enough to display the full assessor's parcel number.

- Click the Display tab, click Fields, and click APN.

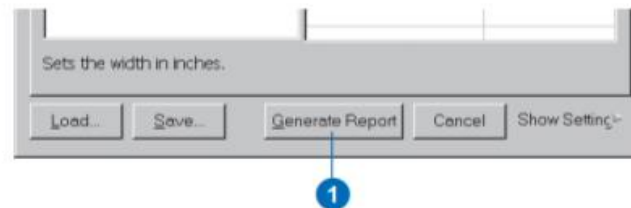
- Double-click in the box next to Width and type 1. Press Enter.



Generating the report

Now have ArcMap generate the report using the settings you have specified.

- Click Generate Report.

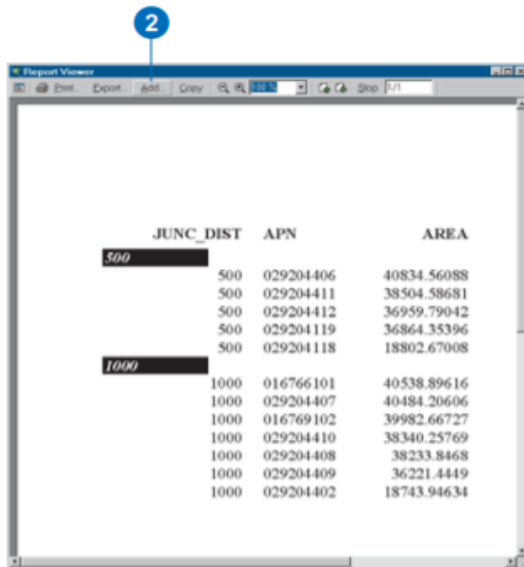


The Report Viewer appears. The viewer lets you preview the report.

The report looks good, so add it to the map.

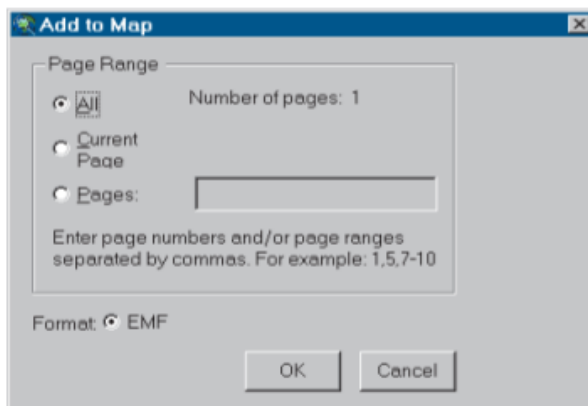
2. Click Add.

2



JUNC_DIST	APN	AREA
500		
500	029204406	40834.56088
500	029204411	38504.58681
500	029204412	36959.79042
500	029204119	36864.35396
500	029204118	18802.67008
1000		
1000	016766101	40538.89616
1000	029204407	40484.20606
1000	016769102	39982.66727
1000	029204410	38340.25769
1000	029204408	38233.8468
1000	029204409	36221.4449
1000	029204402	18743.94634

The Add to Map dialog box appears.



Add to Map

Page Range

☒ All Number of pages: 1

☐ Current Page

☐ Pages:

Enter page numbers and/or page ranges separated by commas. For example: 1,5,7-10

Format: ☒ EMF

OK Cancel

The report is only one page long, so you will accept the default settings.

3. Click OK.

The report appears on the map.

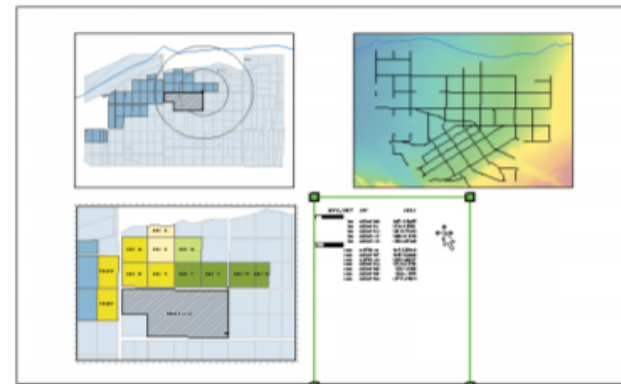
4. Click the X button to close the Report Viewer and click the Close button to close the Report Properties dialog box.

The Report tool asks if you want to save this report.

5. Click No.

6. Click the Select Elements tool, if necessary.

7. Click and drag the report into position beside the Best Parcels data frame.

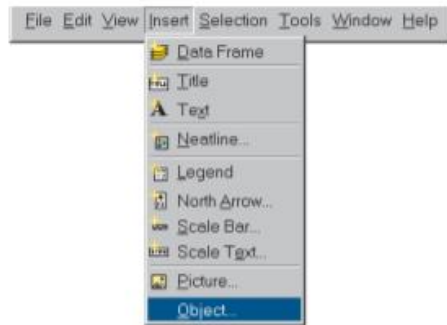


8. Click File and click Save to save your map.

Adding the list of site criteria to the map

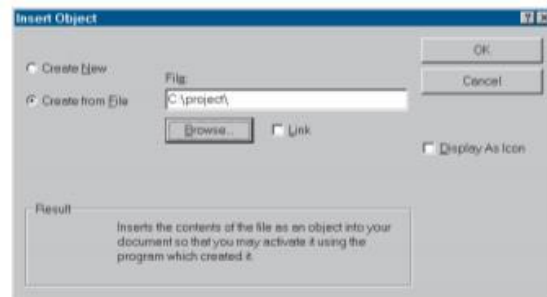
So that the public as well as the city council will be aware of the criteria used for finding a site for the plant, you'll add a text file listing the criteria. The city council staff e-mailed you a text file containing a copy of the criteria. The file is stored in the project folder.

1. Click Insert and click Object.

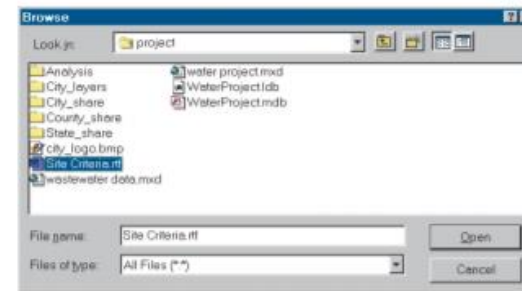


The Insert Object dialog box appears.

2. Click Create from File, then click the Browse button.



3. Navigate to the project folder, click Site Criteria.rtf, and click Open.

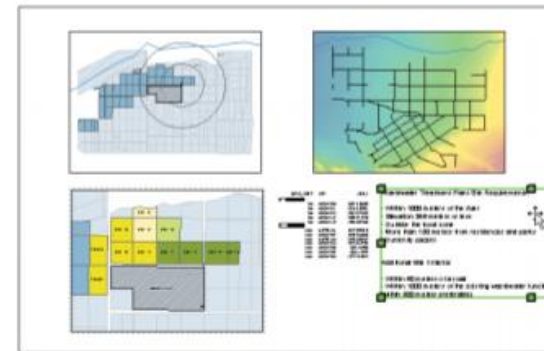


4. Click OK.

The text file is added to the map.

5. Click and drag the text to the right of the parcel report.

If you want, you can make the text smaller by using the green selection handles to resize the text block. Click the lower-left selection handle and drag it toward the upper-right selection handle. Holding the Ctrl key while you drag the handle will reduce the text proportionally. It's okay if the selection box extends beyond the map page since it won't be visible once the text block is no longer selected.



Adding the map elements

At this point you've added to the map the content you need to present to the city council. Now you'll add the map elements to make the map easier to read and more visually attractive.

Here are the elements you will add:

- An extent rectangle to show the location of the study area on the City Overview data frame
- Map legends
- Scalebars
- A North arrow
- The map title
- The city logo
- Map reference information
- Graphic rectangles to create a title bar and to enclose the map

Adding an extent rectangle to the City Overview map

You will add an extent rectangle to the City Overview data frame that will show the location of the suitable parcels relative to the rest of the city. Extent rectangles show the size, shape, and position of one data frame in another data frame.

First you'll need to select the City Overview data frame.

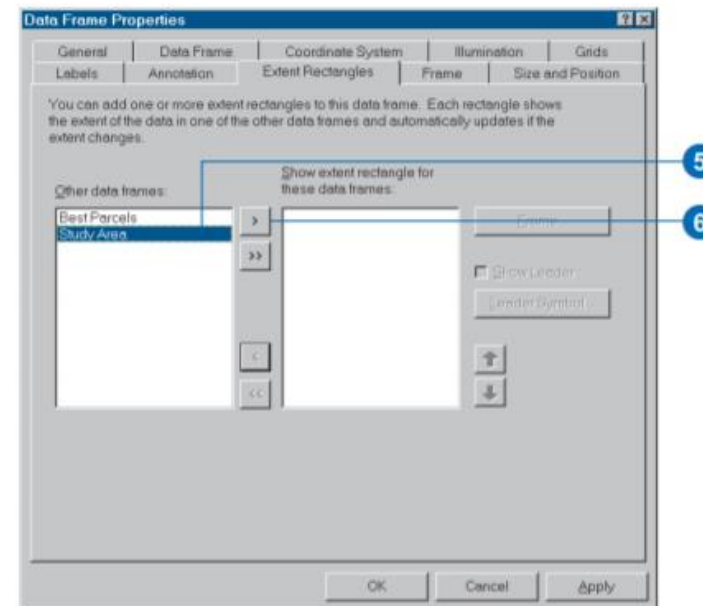
1. Click the Select Elements button, if necessary.
2. Click the City Overview data frame to select it.
3. Right-click the data frame and click Properties.

The Data Frame Properties dialog box appears.

4. Click the Extent Rectangles tab.

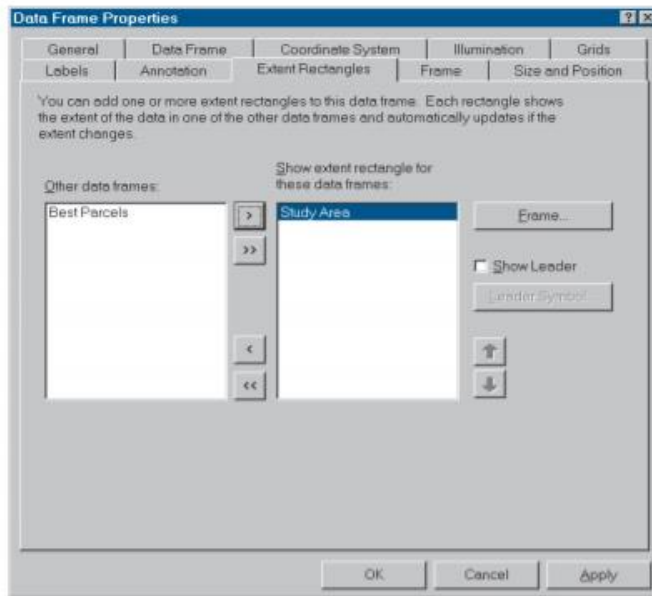
You will show the position of the Study Area data frame.

5. Click Study Area in the Other data frames list.
6. Click the top arrow button to move Study Area to the right list box.



ArcMap lets you choose a variety of symbols for the extent rectangle, but the default black line will work just fine. If you want to change the symbol, click the Frame button to display the Frame Properties dialog box.

7. Click OK on the Data Frame Properties dialog box.



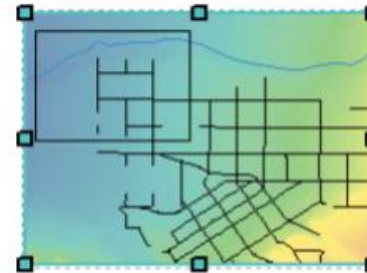
The extent rectangle appears in the City Overview data frame, showing the position and extent of the Study Area data frame, but it's clipped by the edge of the data frame.



8. Click the Pan tool on the Tools toolbar and drag the layers down and to the right until the entire extent rectangle is visible.



The city council and public will now be able to see the location of the suitable parcels relative to the major streets of Greentown.

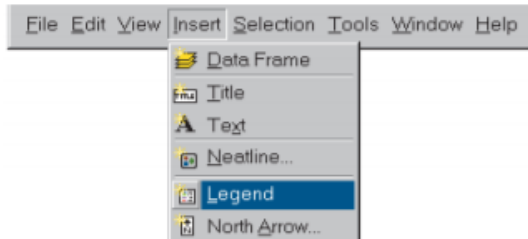


Adding the map legend for the City Overview map

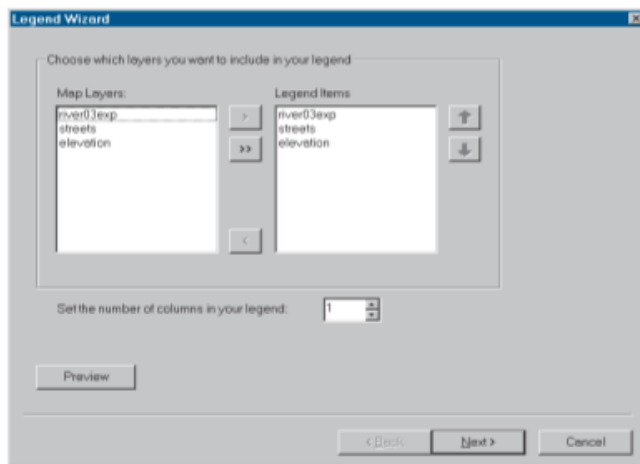
You'll want to add legends and scalebars for all three data frames. You'll select each data frame and create the legend and scalebar for each in turn. ArcMap automatically creates a legend based on the table of contents for each data frame. Once you've created the legend you can move, resize, and edit it.

The City Overview data frame should still be selected.

1. Click Insert and click Legend.



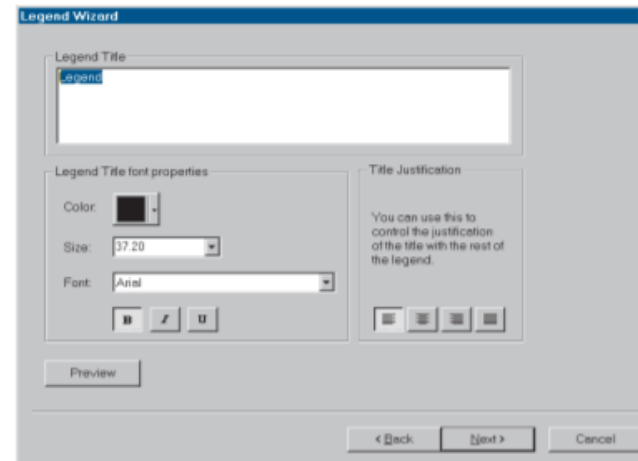
If the Legend Wizard dialog box appears, the ArcMap option to 'Use wizards when available' is turned on; if needed, this option is under Options on the Tools menu on the Applications tab. You can proceed with the following steps using the wizard. If the Legend Wizard doesn't appear and the legend is added immediately to the map, skip to step 5 below.



The wizard automatically lists all the layers in the data frame for inclusion in the legend. You want all the layers for this map.

2. Click Next.

You don't need a title for the legend, so double-click Legend and press the Backspace key to delete the text.

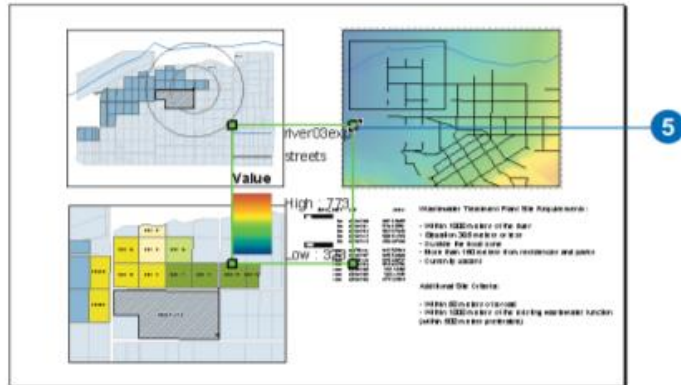


3. Click Preview.

The legend is displayed in the center of the map (you may have to move the wizard dialog box to see it). You'll use the default settings for the rest of the legend properties, so you can exit the wizard at this point.

4. Click Finish.

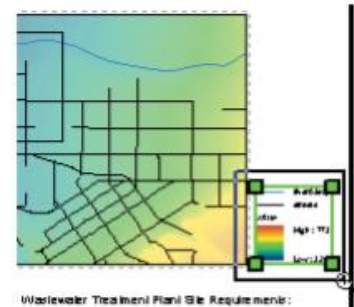
5. If necessary, click the selection handle in the upper-right corner of the legend box and drag it to the lower left until the legend will be small enough to fit on the page, to the right of the City Overview data frame.



6. Click and drag the legend to the right of the City Overview data frame.

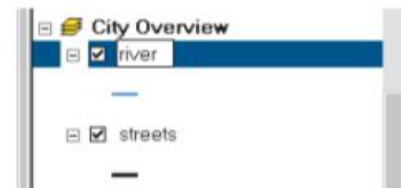


7. Click the Zoom In tool on the Layout toolbar and click and drag a rectangle around the legend so you can see it better.

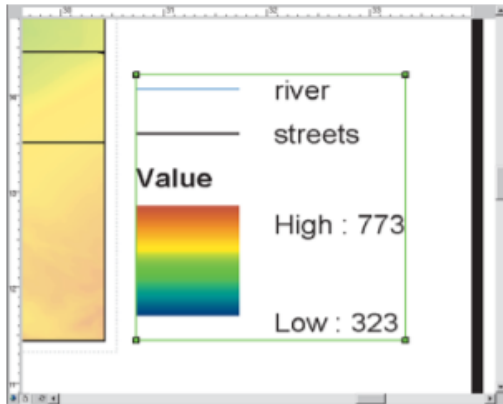


You'll notice that the text for the river symbol reads river03exp, and the label for the elevation layer is "Value". ArcMap takes the legend text directly from the table of contents. You want to use more explanatory text in the legend. This is easy to change.

8. Click river03exp under the City Overview data frame on the table of contents to select it. Click again to highlight the name.
9. Type "river" and press Enter.



The legend is updated with the new text.



Now change the text for the elevation layer.

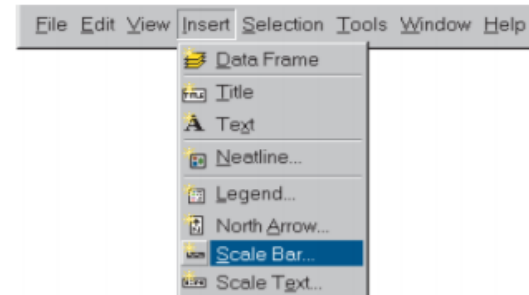
10. Click Value under the elevation layer to select it, then click again to highlight the name. Type “elevation” and press Enter.

11. Click the Zoom Whole Page button on the Layout toolbar to see the entire map again.

Adding a scalebar for the City Overview map

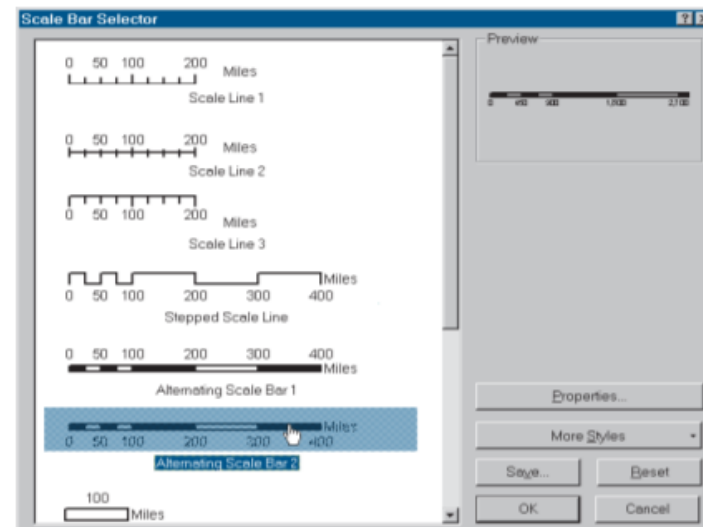
Each of the three data frames on the map is drawn at a different scale, so you’ll need to add a scalebar for each. You’ll add a scalebar for the City Overview data frame while it’s still selected.

1. Click Insert and click Scale Bar.



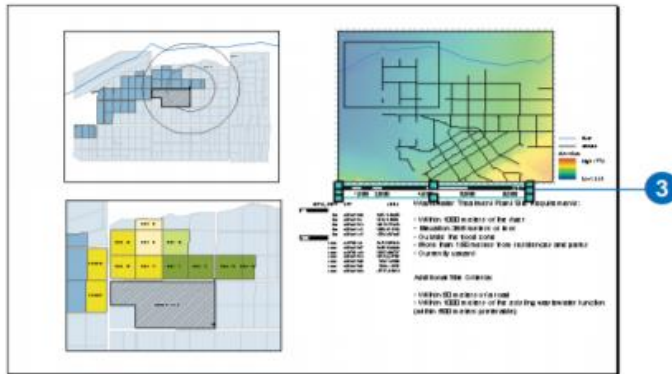
The Scale Bar Selector dialog box appears.

2. Click a scalebar that appeals to you and click OK.



The scalebar is added to the map.

- Click the scalebar and drag it below the City Overview data frame.



ArcMap knows the scale of each data frame and creates the scalebar accordingly.

Adding the other legends and scalebars

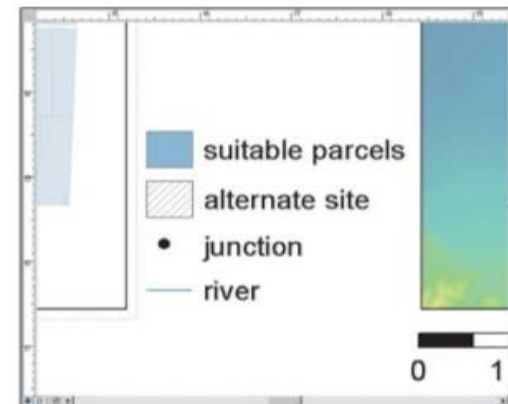
Now you know how to add legends and scalebars to your map. We'll give you the major steps for the other two data frames, and you can work through the tasks yourself. You can review the previous sections if you need help with the specific steps.

Select the Study Area data frame by clicking it. Insert a legend. You don't need to include the junction buffers or the parcel01mrg layers in the legend, so remove them from the Legend Items list in the wizard. Click each and click the < arrow at the bottom to move them off the list. You want the layers to appear in the following order in the legend: parcel02sel, alternate site, junction point, and river03exp.

Click parcel02sel in the list and click the up arrow twice to move it to the top. The layers should now be in the right order. The legend doesn't need a title, so remove it on the next screen in the wizard. Then preview the legend and click Finish to add it to the map. If you're not using the wizard, after the legend is added to the map right-click it and click Properties. Then click the Items tab to change the layers that are displayed and click the Legend tab to remove the title.

Click and drag the legend to the right of the Study Area data frame. Make the legend small enough to fit between the two data frames by clicking and dragging the upper-right selection handle, if necessary.

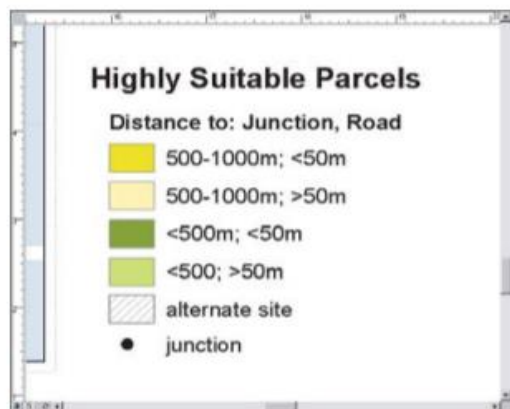
Change junction point to junction, river03exp to river, and parcel02sel to suitable parcels.



Insert a scalebar for the Study Area data frame. Use the same style you used for the City Overview and drag it under the Study Area data frame; you may want to zoom and pan on the page to position the scalebar.

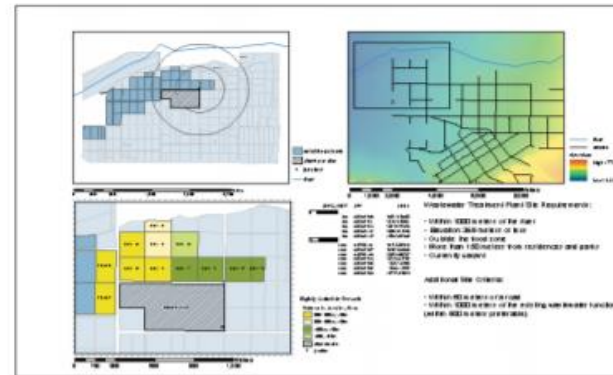
If you zoom in on the two scalebars you've added so far, you can see that the City Overview map is about half the scale of the Study Area map.

Select the Best Parcels data frame and insert a legend. You only need to include the highly suitable parcels, the alternate site, and the wastewater junction, in that order. This time include a title for the legend: Highly Suitable Parcels. Add the legend to the map; reduce its size, if necessary, by clicking and dragging one of the corner selection handles; and drag it to the right of the Best Parcels data frame, below the report.



Finally, add a scalebar for the Best Parcels data frame and position it below the frame.

Save your map at this point.

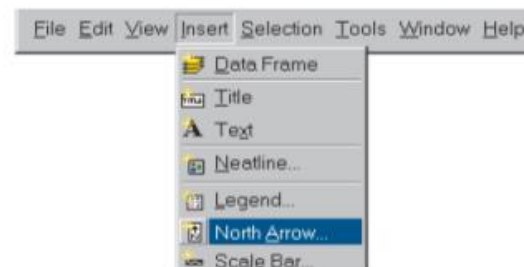


Now you are ready to add a few final map elements to finish the map. You'll include a North arrow, a map title, the city logo, and map reference information. You'll also add two graphic rectangles to tie the composition together.

Adding a North arrow

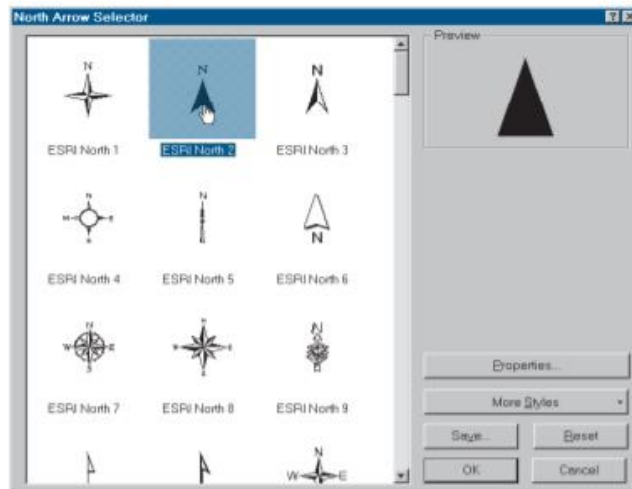
You'll place a North arrow in the upper-left corner to show the orientation of the whole map.

1. Click Insert and click North Arrow.



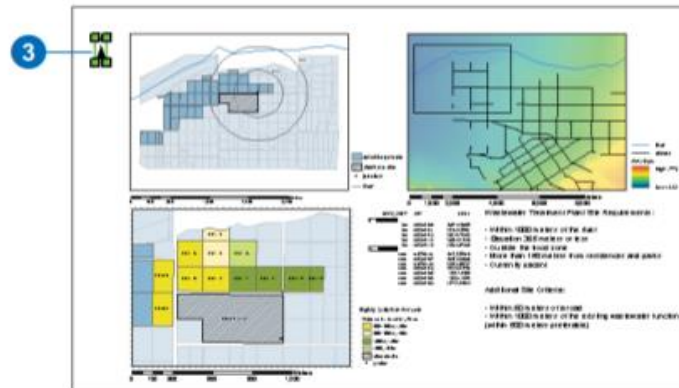
The North Arrow Selector dialog box appears.

- Click any of the North arrows, then click OK.



The North arrow appears on the map.

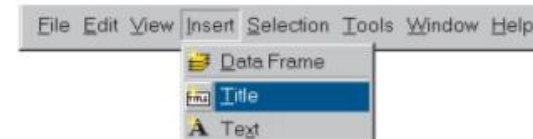
- Click the North arrow and drag it to the upper-left corner of the map so it is a little lower than the top of the Study Area data frame.



Adding a map title

Next you'll add a descriptive title to the map, placed vertically along the left side of the page.

- Click Insert and click Title.



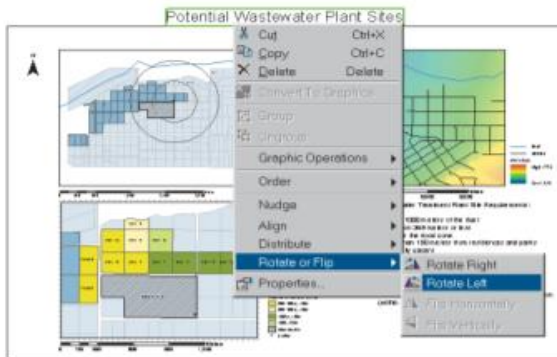
The text water project appears on the map. ArcMap uses the name of the map file as the default title.

- Type "Potential Wastewater Plant Sites".
- On the Draw toolbar, type "72" in the font size text box and press Enter.



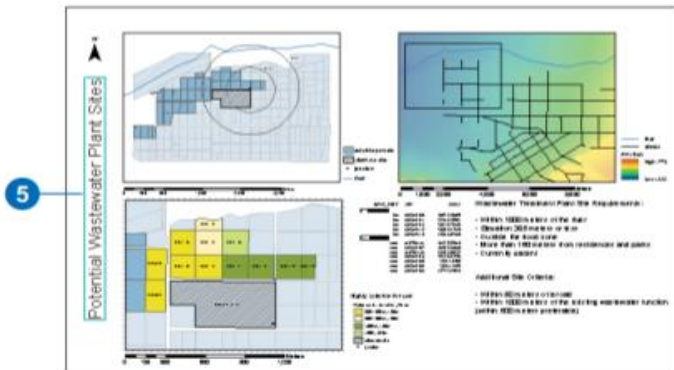
The map title is redrawn in 72 point type.

- Right-click the title, point to Rotate or Flip, and click Rotate Left.



The title is rotated. Now you can place it along the left edge of the map.

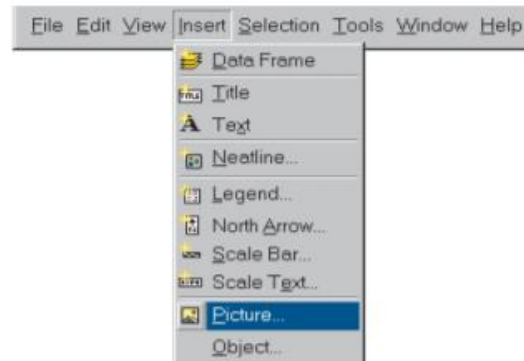
- Click on the title and drag it to the left edge of the map below the North arrow.



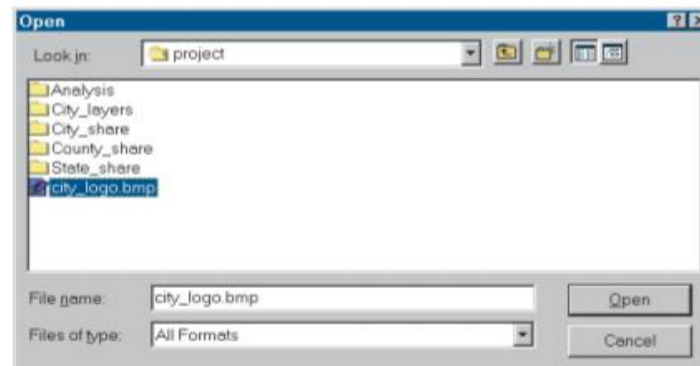
Adding the city logo

The map needs to have the city logo on it. You've got a bitmap version of the logo that you've used for previous projects stored in the project folder.

- Click Insert and click Picture.

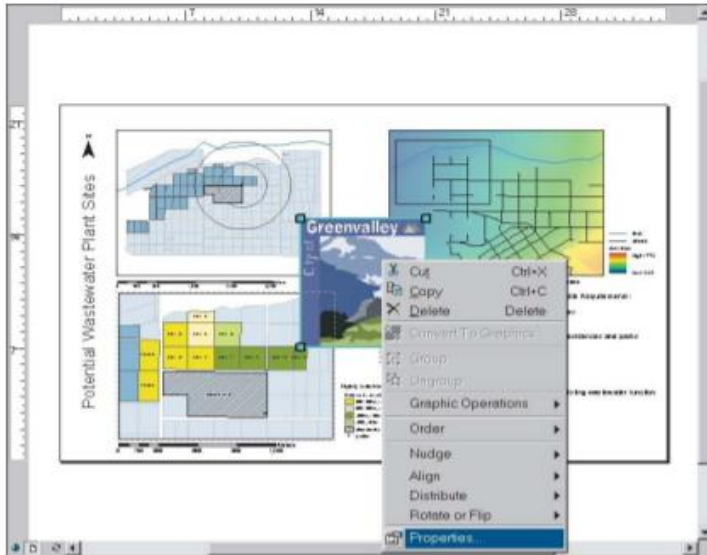


- Navigate to the project folder.
- Click city_logo.bmp and click Open.

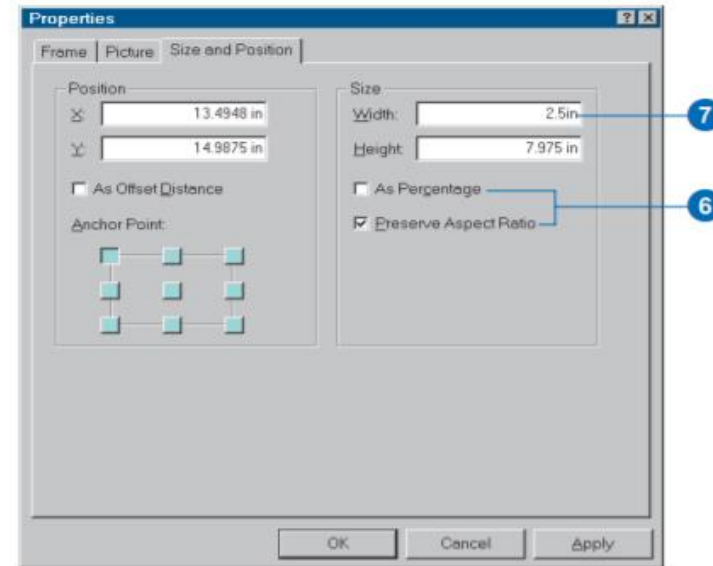


The logo is added to the map. You'll need to make it smaller and move it.

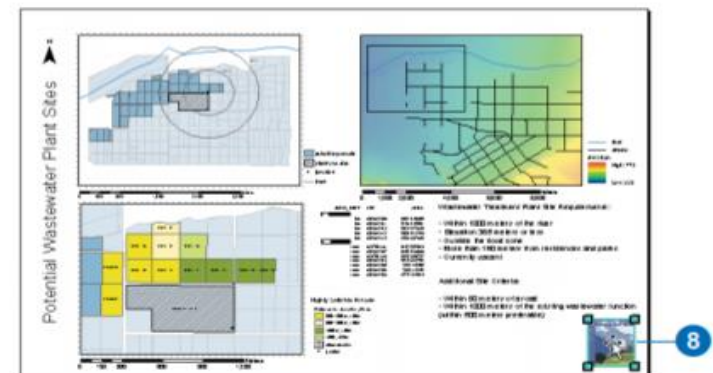
4. Right-click the logo and click Properties.



5. Click the Size and Position tab.
6. Uncheck the As Percentage box and check the Preserve Aspect Ratio box.
7. Click in the Width box and type "2.5in" to make the logo 2.5 inches wide. Click OK.



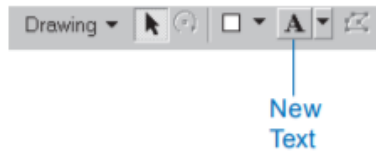
8. Click and drag the logo to the lower-right corner of the map.



Adding the map reference information

You'll want to add information about the map itself for reference. At a minimum, this should include the map projection information and the date. You can also include your name, as the author of the map, if you'd like.

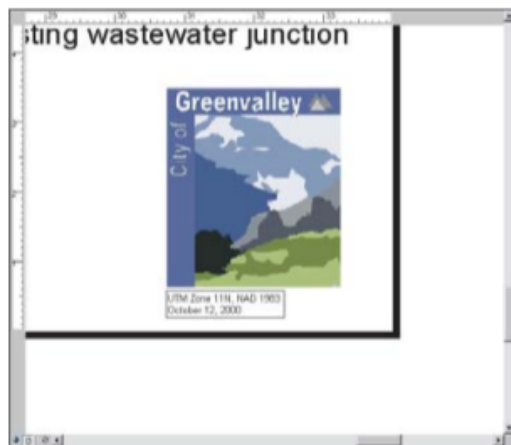
1. Click the New Text tool on the Draw toolbar.



2. Click beneath the logo.

In the text box, you'll type the map projection information on the first line and the date on the second line.

3. Type "UTM Zone 11N, NAD 1983".
4. Press the Ctrl key and press Enter to add a line break; if you press Enter without the Ctrl key, the text will be added to the map immediately.



5. Type today's date on the second line.
6. If you'd like, press Ctrl + Enter again and type your name.
7. Press Enter to add the text to the map.

The text box is still selected. You want to use 12 point type.

8. Click in the text size box on the Draw toolbar, type "12", and press Enter.

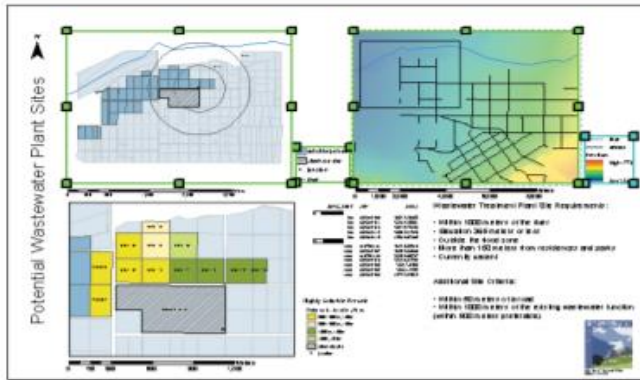
In an actual GIS project you might also include the sources of the data used on the map and the dates the data was collected, other contributors to the map, copyright information, and so on.

9. If necessary, click and drag the text to reposition it so it lines up with the left edge of the logo.
10. Click File and click Save to save your map.

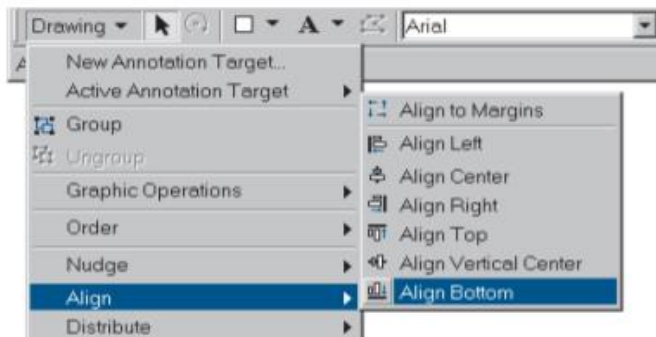
Aligning the map elements

So far, you've added all the elements to the map that you needed—the extent rectangle, legends, scalebars, North arrow, title, and logo—and arranged them on the page. Before adding the graphic rectangles to complete the map, you'll want to align the data frames and other map elements.

1. Click the Study Area data frame to select it.
2. Press and hold the Shift key and click the Study Area legend, the City Overview data frame, and the City Overview legend so that all four elements are selected.



3. Click the Drawing dropdown arrow on the Draw toolbar, point to Align, and click Align Bottom.



The bottom edges of the four elements now line up. You can align other combinations of map elements the same way.

Select the scalebars below the Study Area and City Overview data frames and use Align Vertical Center.

Select the Best Parcels data frame and its legend and use Align Bottom.

Select the Study Area data frame and scalebar and the Best Parcels data frame and scalebar and use Align Left.

Select the City Overview data frame and its scalebar and use Align Left.

Select the Study Area legend, parcel report, and Highly Suitable legend and use Align Left.

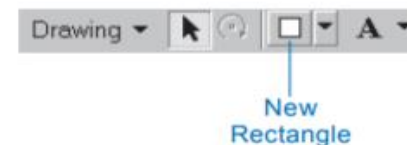
You may want to double check to make sure none of the map elements overlap (use the Pan and Zoom tools on the Layout toolbar) and move any elements accordingly.

Finally, you'll add two graphic rectangles to make your map look more polished. The first will frame the title and North arrow, and the second will tie the entire composition together.

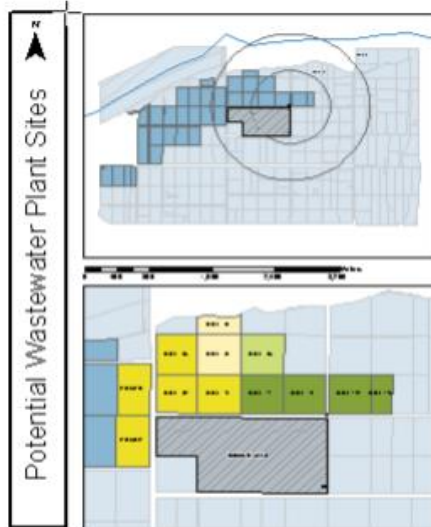
Adding graphic rectangles

First you'll place a graphic rectangle behind the title and North arrow.

1. Click the New Rectangle button on the Draw toolbar.

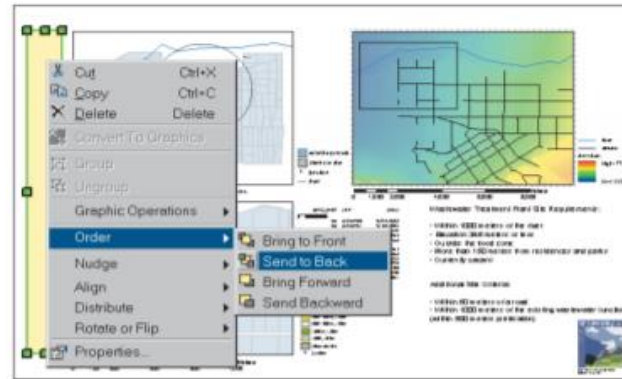


- Click below and to the left of the title, in line with the bottom of the Best Parcels data frame, and drag a rectangle around the title and the North arrow so the top of the rectangle is even with the top of the Study Area data frame.



The graphic rectangle appears on the map but covers the title and North arrow.

- Right-click the rectangle, point to Order, and click Send to Back.



The rectangle is now behind the title and North arrow.

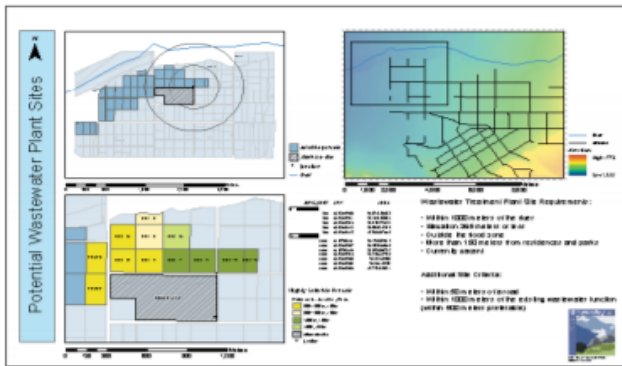
- Click the dropdown arrow beside the Fill Color button on the Draw toolbar.



- Click a light blue from the color menu.

The rectangle is drawn in light blue.

The rectangle should encompass the title and North arrow. If you need to resize the rectangle, just click one of its selection handles and drag. If you need to reposition the title or North arrow so they fit within the rectangle, just click and drag them.



Now you'll place a second graphic rectangle behind all of the elements on the page to frame the map and tie the composition together.

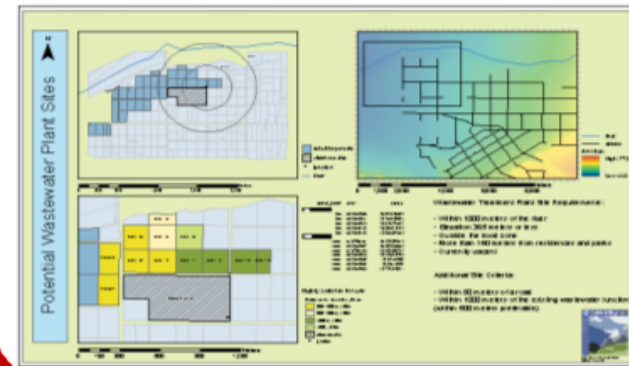
6. Click the Rectangle button on the Draw toolbar.
7. Click at the upper-left corner of the map and drag a rectangle to the lower-right corner of the map.
The second graphic rectangle appears on the map.
8. Right-click the rectangle, point to Order, and click Send to Back.
The rectangle is drawn behind the other map elements.
9. Click the dropdown arrow beside the Fill Color button on the Draw toolbar.

10. Click Olivine Yellow on the color menu.



Our final map

You have completed the postcard map for the city council meeting.

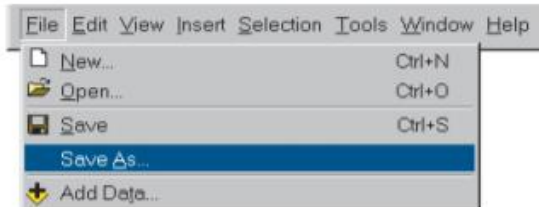


When you produce maps for publication, it is a good idea to check the final map for errors. This should include proofreading text, reviewing the symbology to make sure it is clear, and reviewing the map composition for balance. You should print the map to verify the colors—this will also make it easier to do other proofreading work.

Saving the map and printing it

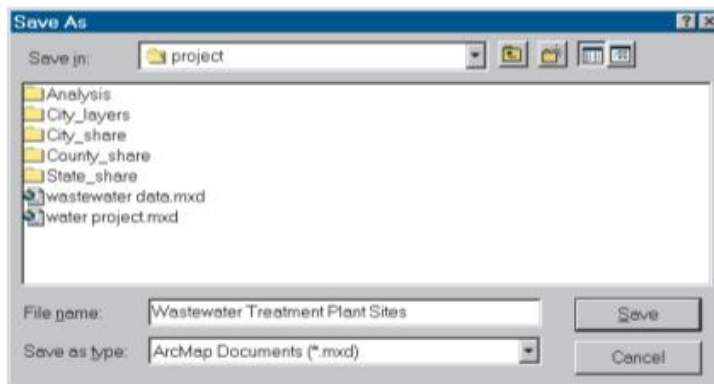
Now that you have finished laying out the map, you will save a copy of it. You'll still have the draft map if you need to make more changes.

1. Click File and click Save As.



The Save As dialog box appears.

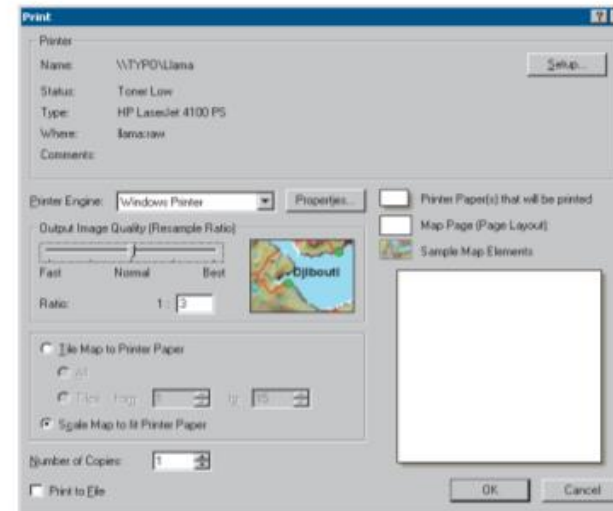
2. Navigate to the project folder.
3. Type "Wastewater Treatment Plant Sites" and click Save.



Later, when you need to view this map again, it will be available exactly as you have created it.

If you have a printer connected to your computer, you can print the map. You created the map as a D size map, so if your printer will print D size paper, you can print the map at full size; otherwise, you can scale the map down to fit your printer.

4. Click File and click Print.
5. If your printer doesn't print as large as D size, click Scale Map to fit Printer Paper. If it does print D size or larger, skip this step.



6. Click OK to print the map.

Now you have a map suitable for framing or presenting to the city council. There were a lot of steps in this fairly complex map, but as with the analysis phase, you actually used a small set of operations—in this case, assigning symbols to features, sizing and positioning map elements, and adding text and graphic elements. Understanding how to perform these basic tasks is the key to creating just about any type of map. Of course, ArcMap gives you many more options for creating highly customized maps.

The project is finished! The city council is likely to ask for additional analysis and a new map for their next meeting. Since the project database is complete, modifying the criteria and rerunning the GIS analysis should be relatively easy. And since you've saved a copy of your map, substituting the new analysis results will be straightforward.

You've completed a small, sample GIS project. While the scope was limited, the project process and many of the specific methods and tasks are ones that apply to a wide range of projects you'll encounter in your GIS work. The next section lists a few of the many resources that are available to you as you begin to explore the broad range of GIS applications and the specific functionality of ArcGIS.