4

GIS AND GPS TOOLS

Maps and Geographic Systems

Starting Point

Go to www.wiley.com/college/Pine to assess your knowledge of GIS and GPS tools.

Determine where you need to concentrate your effort.

What You'll Learn in This Chapter

- Benefits and challenges of using GIS, including the investment needed in computer hardware and software, geographic data, procedures, and training staff and technical support
- Benefits and challenges of using GPS to aid in location, navigation, tracking, mapping, and timing
- How to interpret different types of data
- Advantages image maps have over feature-based layer maps
- The uses of geocoding in emergency management
- Types of data available to emergency managers

After Studying This Chapter, You'll Be Able To

- Define GIS as a system and what investment is needed to implement a GIS system
- Use GIS to identify populations and areas at risk to certain hazards
- Assess how GPS can be used to create accurate maps
- Interpret vector and raster data
- Select appropriate data types for your goals
- Evaluate geocoding and its uses in emergency management activities

Goals and Outcomes

- Assess GIS capabilities and the best way to use them in emergency planning and response
- Evaluate the role of GPS in emergency management
- Choose data that pinpoints special facilities during disasters
- Use flood zone maps for hazard mitigation
- Compare and contrast feature-based maps and image-based maps
- Evaluate TIGER files and how they can be used in planning and recovery
- Evaluate map resources on the Internet

INTRODUCTION

When Hurricane Katrina flooded New Orleans, the Coast Guard went in to rescue people from the roofs of their flooded homes. Calls from stranded people came in nonstop. The members of the Coast Guard were not familiar with the area. The street signs were down. Street addresses were not useful. The Coast Guard, with support from United States Geological Survey (USGS), solved the problem by **geocoding** the addresses from 911 calls. Geocoding is the graphic representation usually in the form of a point on a map of information in a database that includes street addresses or other location information. The street addresses were converted to longitude and latitude coordinates that allowed the Coast Guard to locate those who were stranded. This is just one of the ways an emergency manager can use technology to save lives.

In this chapter, you will learn other ways geographic/information technology tools can save lives. You will assess the investment needed to implement a GIS system. You will assess how to develop a GIS system. You will compare and contrast different map data types and how the data can help you in all phases of emergency management. All of these tools, like the geocoding, can help you in preparedness, mitigation, response, and recovery.

4.1 Geographic Information System: A Review of the Technology

Organizing information so it can be accessed by pointing to a region or a specific location on a map is used in a variety of applications. Systems that support this task are called **geographic information systems (GIS).** The information available is data that relates to specific locations. For example, it could be a map of your neighborhood that shows the precise locations of where all the violent crimes occurred in the past year. The data includes the physical identifier location along with the information associated with it. This information is geographic in that it is related and referenced by a system of coordinates. Objects, the data associated with them, and their locations are the building blocks of the GIS. A GIS is an organized collection of computer hardware and software designed to create, manipulate, analyze, and display all types of geographic data. A GIS allows complex spatial operations that are difficult to do otherwise. The GIS can assist in emergency rescue operations by identifying where help is needed and helping to direct resources in an efficient manner. GIS is also referred to as a "smart map" tool. It allows users to search, analyze, and edit data. For example, the New York City Emergency Management department uses a language map created by their GIS team. This map shows the breakdown of languages spoken in the neighborhoods of Brooklyn. The map also highlights areas where English is not understood. This information would

be used during an evacuation. Emergency managers would issue evacuation orders in languages the residents would understand (see Figure 4-1).

A geographic information system (GIS) is one of the most important tools that you have. You can use GIS's and their programs, data, maps, charts, and tables to make valuable decisions. From planning decisions on the locations of shelters to decisions in a response concerning the best evacuation route to examining floodplains, GIS is a tool for providing needed information for decision making.

A GIS is an information system but one in which the data is geographically referenced. A GIS, for example, could create and edit lists of schools, hospitals, nursing homes, or shelters, but they also have the capability to display records in the tables in a graphic or map format.

Map data comes in three forms, including **lines** (road or rail features), **points** (school, hospital, or shelter locations), and **polygons** (areas such as political districts, or areas reflecting specific base flood zones). Lines, points, and polygons are used in a vector format (a coordinate-based map). A second type of format is image oriented (raster data). The image may be a high-resolution photo from an aircraft or U.S. Geological Survey (USGS) digital elevation data that has quantitative attributes referring to cells in a rectangular grid that reflect elevation.

A GIS is a system. A GIS system includes data, graphics, and a program to manipulate both the data and the graphics. A GIS stores, retrieves, manipulates, analyzes, and displays these data according to user-defined specifications. Ideally the GIS is used as a decision support system involving the integration of spatial data in a problem-solving environment. As a system, GIS includes the basic characteristics of all systems. As we discussed in Chapter 2, a system consists of input, transformation, and output. Let's look at how the GIS works.

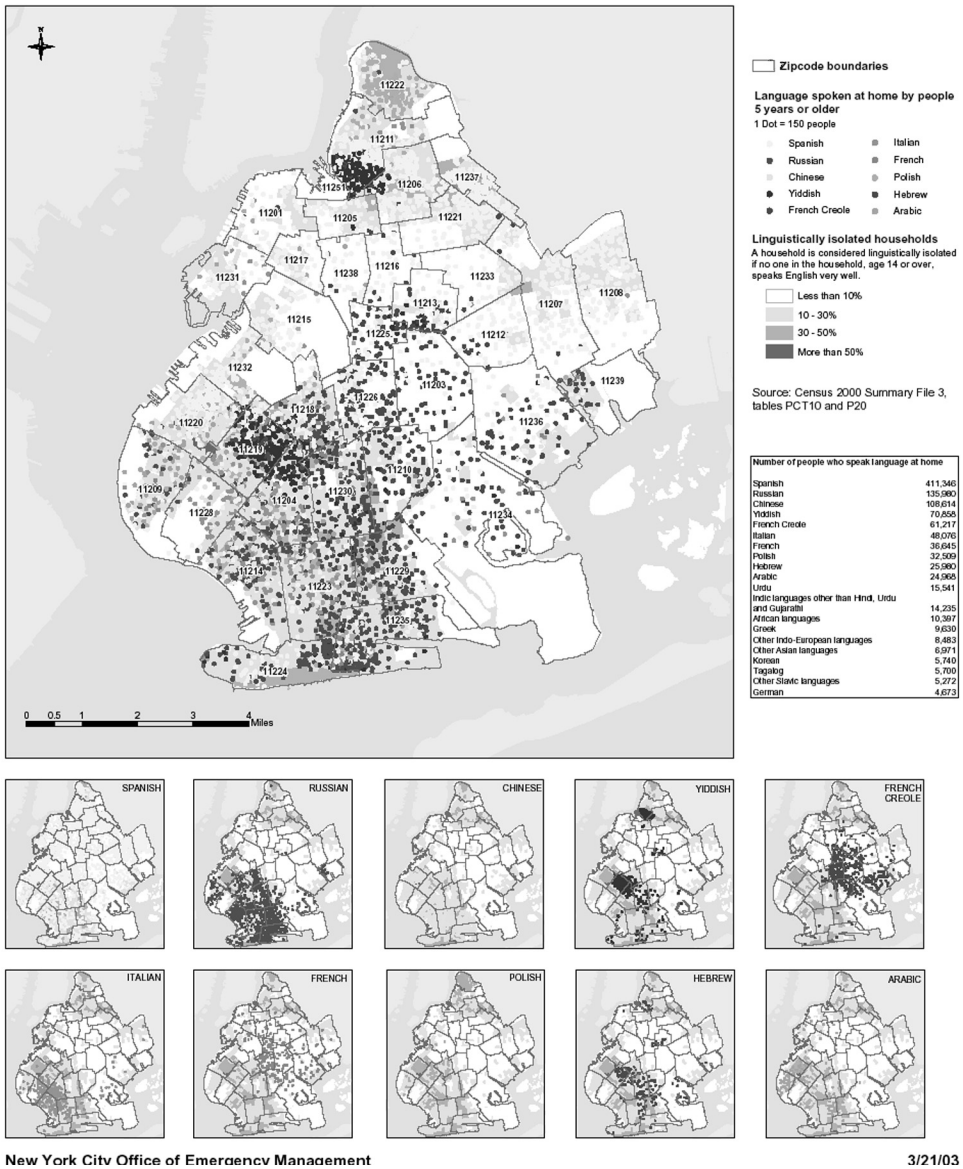
FOR EXAMPLE

Predicting Hurricane Damage

Emergency managers aren't the only ones using GIS to predict potential losses from hurricanes. Insurance agencies use GIS systems as well. For example, the Florida Farm Bureau Insurance Agency uses a GIS system where they can access information on all their policyholders. Each type of policy is color coded, as is the geographic area they live in. Florida Farm Bureau overlays event information such as hurricane track and wind speed against its policyholder points on a map. This way the insurance company can quickly determine which policyholders will have claims, how extensive the claims might be, and what homes to send adjustors to right away.

Figure 4-1

Distribution of Languages Spoken in Brooklyn



A map of Brooklyn that shows what languages are spoken in each neighborhood.

- **Input:** Input in a GIS system could include collection of phone listings or census information by geographic area.
- **Transformation:** Transformation in a GIS system includes the storage and retrieval of data and analysis.
- **Output:** The output in a GIS system is maps and tables. These maps could include risk zones, vulnerable populations, or tables of phone listings in vulnerable areas.

As with every system, GIS is prone to user error during input. The data input must be exact and accurate.

SELF-CHECK

- Define **geocoding.**
- How is GIS a system?
- Name the three forms of map data.

4.2 GIS in Emergency Management

Maps provide a very visual representation of an event, phenomena, or idea. For emergency managers, being able to see the area affected by a disaster supports communication and decision making. The output of a GIS system can be used during all four phases of emergency management. The key is to understand the types of data that could be used and how they contribute to disaster preparedness, response, recovery, and mitigation.

- **Disaster preparedness:** You can use the GIS to identify populations and areas at risk to certain hazards. For example, you can identify areas at risk to hazardous spills by matching potential storage facilities for hazardous materials in populated areas by matching the site addresses to census data. You can also view the areas that are in a floodplain as well as identify appropriate evacuation routes and shelters. Individuals with special needs can be identified by address and assistance with evacuation can be organized.
- **Response:** You can use the GIS to help you to respond to an emergency. An area affected by a flood or a chemical spill can be shown on a map. Other information will be shown as well. This information

FOR EXAMPLE

Red Cross and GIS

Private organizations, such as the Red Cross, are using GIS as well. The Red Cross used mapping software along with population data to be able to respond quickly to the specific needs of Hurricane Katrina and Rita victims. "Using GIS technology, the Red Cross was able to better plan prior to hurricanes Katrina and Rita as well as respond with greater flexibility and precision after the events occurred," says Eric Maier, ESRI commercial account manager. "ESRI deployed resources to help generate maps and data on wind fields, damaged areas, populations, city infrastructure, streets, and more. This information was provided to Red Cross managers, directors, and senior leadership who make decisions and carry out strategic planning" (www.gisuser.com/content/view/7077).

includes the location of critical facilities, including schools, hospitals, nursing homes, parks, shopping areas, business areas, manufacturing areas, and transportation routes. Seeing the location of critical facilities in an area affected by an emergency could help emergency managers determine appropriate evacuation routes or shelter locations. Having the precise location of a school, hospital, park, or business is useful, but other information associated with these sites enables you to make better decisions. Knowing the school enrollment, the number of beds at a hospital by type, or the type of patients in a nursing home could provide you with timely information for use in making evacuation decisions.

- **Recovery:** Information from GIS is also essential to recovery. In the example of a hurricane, the GIS will show you what areas were destroyed and need rebuilding, including the age of housing, and the GIS can show you where utility lines are, including those where service needs to be restored.
- **Mitigation:** Risk analysis occurs both before and after the event. Similar to disaster preparedness, the GIS information can be used to first identify the community's vulnerability to hazards. This information can be used for mitigation campaigns. In addition, information such as languages spoken by citizens in specific neighborhoods (see Figure 4-1) can be used to help prepare hazard awareness campaigns. By knowing what languages are common in geographic areas, you can tailor your media messages to that audience by placing the messages in the language they speak and understand. Further, some homes could be to be elevated or moved.

SELF-CHECK

- How is GIS used in preparedness?
- How is GIS used in response?
- How is GIS used in mitigation?

4.3 Developing and Implementing a GIS

A GIS is a type of computer system that requires building large databases before it is useful. Using a GIS isn't like using other microcomputer applications. With most microcomputer applications, you can use it immediately after the purchase of the hardware and software. A GIS is different. Using a GIS requires that large spatial databases be created, appropriate hardware and software be purchased, applications be developed, and all components be installed, integrated, and tested before you can begin to use the GIS. Developing a GIS involves investment in five areas: computer hardware, computer software, geographic data, procedures, and trained staff.

- **Computer hardware:** Desktop personal computers are increasing with dramatic speed with extensive RAM capabilities. To run GIS, you should purchase the fastest computer on the market, with extensive RAM and at least one (possibly two) large monitor (at least 17"). A color printer that is capable of printing 17 by 14 inches is essential. A plotter is useful for preparing large 36" wide maps. A scanner is useful for including photographs or maps in a GIS.
- **Computer software:** Several software companies are providing local and state governments excellent GIS programs. Commercial products include Intergraph's Geo-Media, ESRI products, and MapInfo all have reasonably priced powerful software. The Census Bureau in collaboration with EPA and NOAA distribute LandView software to read Census and other federal agency data. Each of the shell software is fully capable of enabling emergency management agencies in completing complex hazard analysis.
- **Geographic data:** Data includes relational databases that have street addresses that can be geocoded or geographic coordinates. The above software can either geocode the databases or create points from the coordinate fields. Census Bureau TIGER Street, highway, rail, and water features are available from distributors in common map projections. Feature image data (photos, satellite images, or USGS Quad sheets) are also

available from either federal or state agencies or commercial distributors in a format that is projected to display an image along with local street and other **vector data.** Vector data is a coordinate-based data layer in a GIS that represents features on a map in the form of a point, a line, or a polygon.

- **Procedures:** The manner in which data is stored, analysis performed, maps prepared, or files shared must be established.
- **Training staff and technical support:** Training and technical support are critical to efficient operations and effective program operations. The GIS technical staff person must understand file management, database formatting, and computer aided graphics drawing programs. If the staff member has these skills, the GIS program can be learned easily. In addition, skills in understanding computer networks will be helpful in ensuring that printers function, scanners work, and server files are available to the staff.

GIS development involves a technology that requires management attention. It should have active as opposed to passive management involvement in the project. Past failures of GIS did not result from technical difficulties. Instead, they resulted from a lack of realistic expectations of all parties associated with the project, including GIS technicians, potential users, managers, and officials. You must get involved in planning for the development of a GIS. You may be in a position to facilitate realistic expectations from technical staff, users, and other support staff who might assist in the development of GIS data.

The development of GIS layers must address the following concerns.

- What will be the source for each data layer (shelter locations, schools, hospitals, nursing homes, bridges, streams, or emergency management resources)?
- Who will own the data layer?
- How will the new GIS layer be integrated with existing data files (lists of schools, hospitals, nursing homes, etc.)?
- Who will be responsible for updates to the data?
- How will the cost of the data be allocated?
- Will access to the data be made available to the public? How? By whom?
- Who will be responsible for archiving and retention of the data layer?

GIS data layers need to be prepared as a team effort with other administrative agencies that are involved in the emergency management system and who may use these up to date data layers. Planning and input from a variety of public agencies is critical in facilitating realistic expectations of the GIS.

Problems often occur because

- the GIS is not integrated with other systems where interaction may be desired;
- staff do not fully understand the technology prior to extensive training;
- development time estimates differ from actual task time;
- GIS involves greater uncertainty about costs;
- a greater likelihood exists that programmatic changes (to other parts of the emergency management system) will be needed during the development phases.

Management needs to anticipate these problems and take appropriate action. Since the introduction of a GIS affects other elements of the emergency management process, it is an opportunity to introduce fundamental change into the way emergency management operates. You, therefore, must be involved in the adoption of this new technology and help plan, implement, and monitor the process.

A key factor in the success of a GIS is the creation of an "enterprise" or "corporate" database. This is a single, organization-wide data resource for GIS information. In this type of database, all users have access to up-to-date information, and the creation of the data is efficient. Since a GIS can affect an entire organization, its establishment is a question of policy, management cooperation, and coordination, rather than a technical issue.

GIS is therefore more than a technology issue. GIS requires data such as databases, images, pictures, and graphics that are fundamental to the entire state or local agencies. Know that other agencies will be interested in data layers, especially those that are maintained by the emergency management unit (shelters, special populations, resources, etc.). You will need to seek out other local or state units that are interested in jointly developing a GIS. These departments could include the departments of planning, public works, public safety, and education.

4.3.1 LandView and MARPLOT Software

Federal agencies have prepared and used spacial data sets for many years. The Census Bureau in collaboration with EPA and NOAA distribute mapping software (MARPLOT) and data sets (LandView). The latest data sets for the U.S. are available from U.S. Census Bureau or the EPA for less than $200. Go to either of their Web sites and search for "LandView". LandView for specific states is also available at no cost from http://atlas.lsu.edu.

LandView has its roots in the CAMEO (Computer-Aided Management of Emergency Operations) software. CAMEO was developed by the EPA and the NOAA to facilitate the implementation of the Emergency Planning and Community Right-to-Know Act. This law requires communities to develop emergency response plans addressing chemical hazards and to make available to the public information on chemical hazards in the community.

FOR EXAMPLE

Government Resources

The federal government has a wealth of hazard information on the Web available to emergency managers and to private citizens. For example, the National Geophysical Data Center (NGDC) has a collection of databases and data on natural hazards. To view the information, go to www.ngdc.noaa.gov/

The LandView database and MARPLOT map system allows users to retrieve and map Census 2000 demographic and housing data; EPA facility air, water, and hazardous waste data; and USGS mapping information. The mapping data comes from the Geographic Names Information System (GNIS), which contains over 1.2 million records that reflect landmarks such as schools, churches, cemeteries, government sites, and many other landmarks that are places, features, and areas on USGS maps. As with other GIS programs, you can use LandView to create thematic maps of census data. You can use LandView as with other GIS programs to locate a street address or intersection on a map based on TIGER road features and address ranges.

The LandView allows users to identify and map Census legal and statistical areas, EPA sites, and USGS GNIS features. You can customize the maps, vary the scale, and search for objects on the map (landmarks, roads, water features, cities etc.). You can also add information to the maps with MARPLOT. For more information on both products, visit www.census.gov/geo.

SELF-CHECK

- Define **vector data.**
- To develop a GIS, you need to invest in what areas?
- What concerns accompany the GIS layers?
- How is LandView and MARPLOT software used?

4.4 Data Representation

GIS represents objects such as roads, land use, and elevation with digital data. These objects can be divided into discrete objects such as homes and roads and continuous fields such as rainfall or elevation. There are two methods used to store data in a GIS for both types of objects: vector and raster.

Both vector and raster data layers use longitude and latitude lines.

- **Longitude:** Used to describe the east-west position of a point. The position is reported as the number of degrees east (to −180.0 degrees) or west (to +180.0 degrees) of the prime meridian (0 degrees). It is represented by vertical lines running from the north to south poles. Lines of longitude are farthest apart at the equator and intersect at both poles; therefore they are not parallel.
- **Latitude:** Used to describe the north-south position of a point as measured usually in degrees or decimal degrees above or below the equator. Latitude lines are the horizontal lines on a map that increase from 0 degrees at the equator to 90 degrees at both the north (+90.0 degrees) and south (−90.0 degrees) poles.

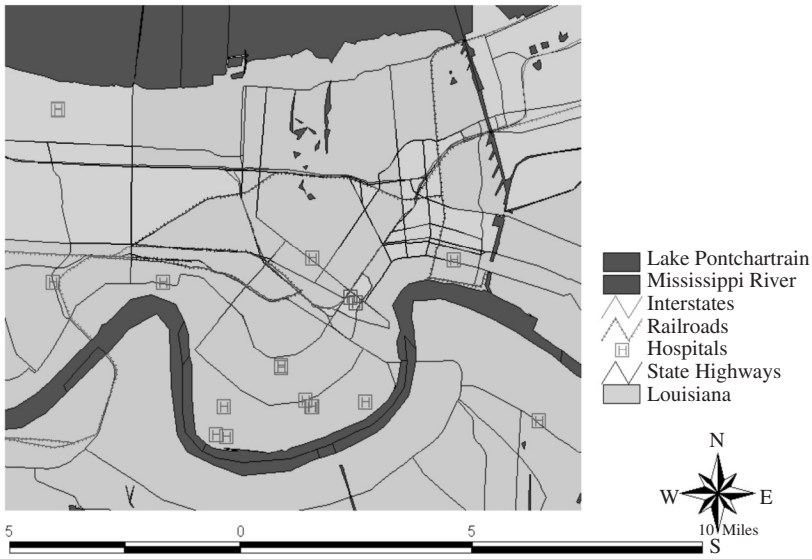
4.4.1 Vector Data

GIS include graphics that illustrate the information about an area. Vector data layers use geometric shapes such as points, lines (series of point coordinates), or polygons, also called *areas* (shapes bounded by lines), to represent objects.

A vector data layer is a coordinate-based data structure commonly used to represent map features. Each object is represented as a list of sequential

Figure 4-2

Vector Displays



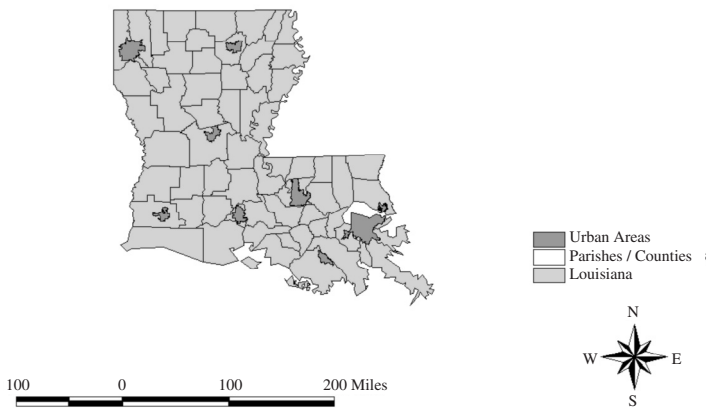
A vector display of the New Orleans area.

x,y coordinates. Attributes may be associated with the objects. Figure 4-2 includes lines such as streets or roads, the interstate, railroads, and water features. Hospitals illustrate points on the map. The polygons include the boundaries of the City of New Orleans, Orleans Parish, Lake Pontchartrain, and the Mississippi River.

- **Polygon (area, parcel):** A polygon is an area feature whose perimeter is defined by a series of enclosing segments and nodes. It is a simple bounded region—simple in the sense that it does not consist of more than one polygon (where a boundary can consist of more than one polygon). Examples of a polygon include the boundaries of a state, urban area, or county (parish). Information about the urban area, county, or state may be attached to the data file that is associated with the graphic image.
- **Point:** A point is an object on the map that represents a specific location for information. The map object is defined by a single *x,y* coordinate pair. Each point object is represented by a symbol style (e.g., circle, square, triangle, etc.). Figure 4-4 shows the location of cities in Louisiana. The cities would be points on the map. Examples of point data that could be used in emergency management include the location of special populations, resources, residents, hazard sites, churches, schools, and shelters.
- **Line:** The line is a map object defined by a set of sequential coordinates that represents the shape of a geographic feature. For example, a line may represent street centerlines, railroads, cables, streams, or rivers. Lines join

Figure 4-3

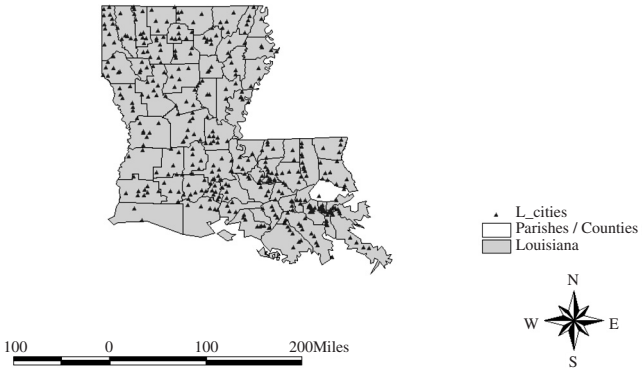
Polygon Displays



Map of Louisiana: counties (parishes) and major urban areas.

Figure 4-4

Polygon and Point Displays

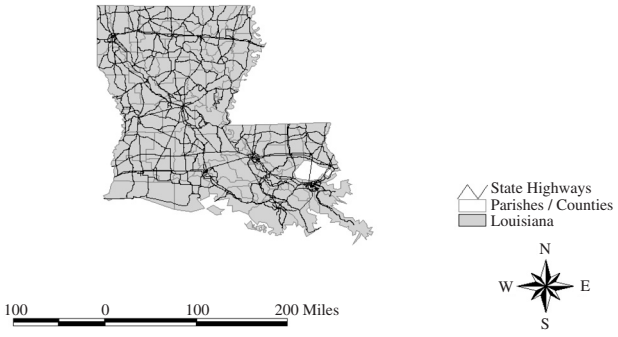


A map of Louisiana: counties and cities.

two points. A street map is a collection of thousands of line object segments joined together to provide a visual representation of a community transportation network. Figure 4-5 shows segments of the Louisiana State Highway system. Data that is graphically displayed as lines could include the location of water features by type, including rivers, streams, drainage ditches, or canals.

Figure 4-5

Polygon and Line Displays



highways.

A map of Louisiana: counties with primary and secondary state highways. The highways are shown as line objects.

4.4.2 Raster Data

Raster data consists of rows and columns of cells. Each cell stores a single value. Usually, raster data are images. An image is a graphic representation or description of an object that is typically produced by an optical or electronic device. Some common examples of image data include remotely sensed data, such as satellite data, scanned data, and photographs. Image data such as a photo is also referred to as *raster data.* The raster image is displayed in a series of grid cells, or pixels; each has a certain value depending on how the image was captured and what it represents. For example, if the image is a remotely sensed satellite image, each pixel represents light energy reflected from a portion of the Earth's surface. If, however, the image is a scanned document, each pixel represents a brightness value associated with a particular point on the document. A photo or satellite image is a raster image. It is a type of computerized picture consisting of row after row of tiny dots (pixels). Raster images are sometimes known as *bitmaps.* Aerial photographs, scanned pictures, and satellite images are common types of raster data found in GIS. Figure 4-6 shows an air photo of New Orleans

Figure 4-6

USGS Digital Orthophoto Quad: raster image of New Orleans, January 2004.

in January 2004. USGS Digital Orthophoto Quarter-quads were merged to create this image of New Orleans.

Figure 4-7 shows an infrared satellite photo image of New Orleans after Hurricane Katrina. The red color of the image highlights flooded and nonflooded areas of the city. Polygons of flooded areas of the city were made by a GIS team from Louisiana State University and used with Lidar elevation contours to determine the depth and extent of flooding. The image in Figure 4-8 is Lidar and is discussed in the following section of this chapter.

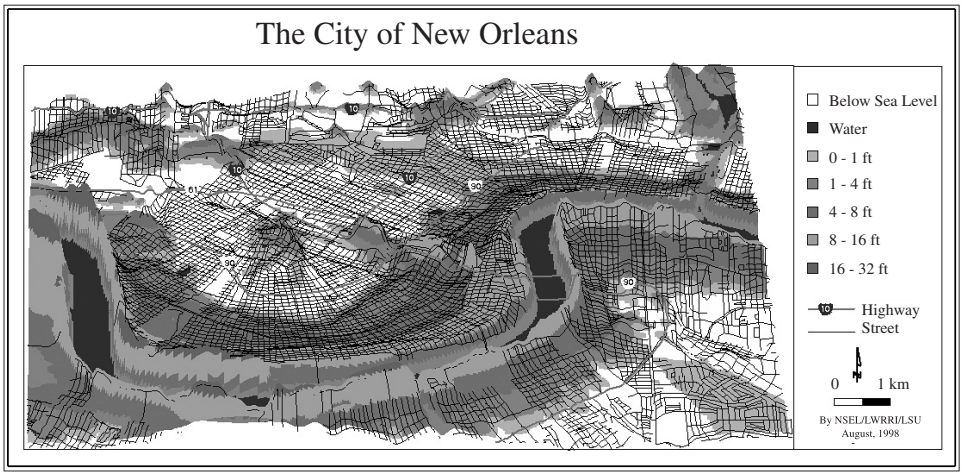
Figure 4-8 is an image of New Orleans created from Lidar data and shows land elevations. Note that high ground shown in greens and browns follows the Mississippi River (in blue). Major highways are displayed in red over the digital raster elevation image. The highways provide landmarks to better understand the high and low areas of the city.

There are limitations to image data. The main limitation with image data is that images do not contain attribute information about the features they show. A United States Geological Survey Quad Sheet is a common map used by emergency managers. These maps appear to be similar to a state transportation road map available from state transportation or tourist agencies. The Quad Sheet

Figure 4-7

Post-Hurricane Katrina satellite infrared image of New Orleans, September 2, 2005.

Figure 4-8



Lidar raster image of New Orleans (prepared by the Center for Public Health Impacts of Hurricanes at Louisiana State University).

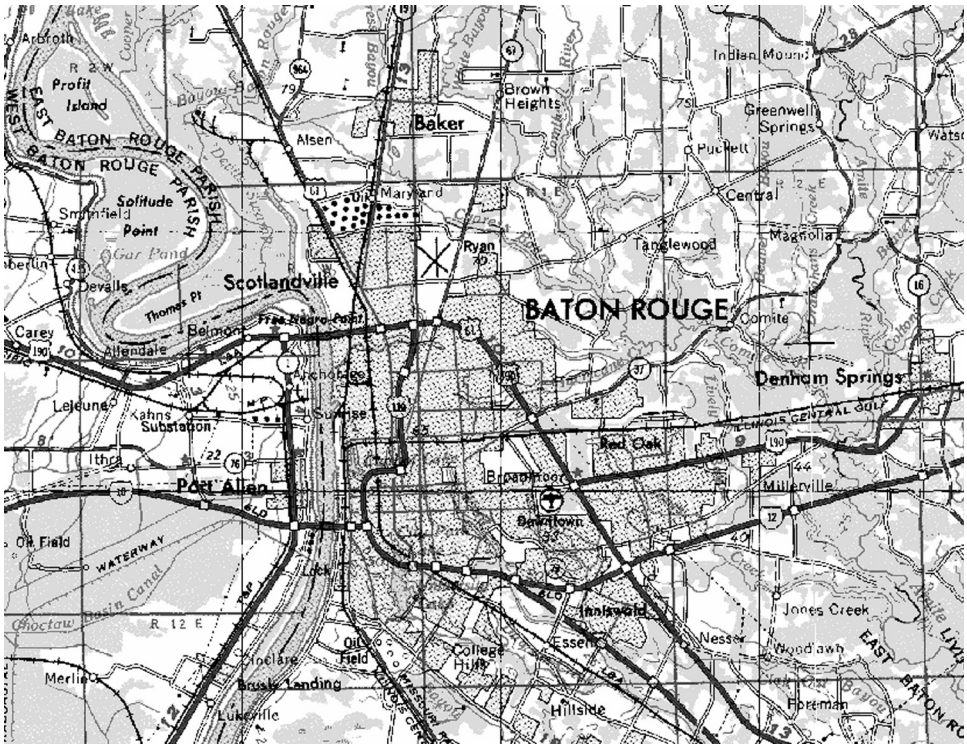
Maps produced by the U.S. Geological Survey provide additional data beyond roads and waterways, such as wetland areas. The details of local areas are available on a national basis from the U.S. Geological Survey as well as from many local surveying, mapping, or blueprint vendors. Figure 4-9 is a portion of a 1:100,000 scale USGS Quad Sheet.

Image data can be organized in a number of ways depending upon the particular image format. An image file such as an air photo can contain georeference information so that roads, water features, or schools can be placed at the appropriate location over the image.

4.4.3 TIGER Files

TIGER files are some of the best data layers available for GIS applications in emergency management. They were developed by the U.S. Department of Commerce Census Bureau to assist in the census. Street and water layers were taken from USGS maps and edited to include street and water feature names. The street files also include address ranges. These files thus have been enhanced to allow for geocoding of data files that include street addresses. The TIGER files are the only national source of street files that include address ranges. Although many commercial vendors suggest that their maps are better than the TIGER files, in reality their maps were drawn from the Census Bureau TIGER files. Few commercial vendors have really enhanced these files. If the TIGER files have been enhanced, it has been done by local communities that know the street names and have spent great effort to correct street names, delete streets that are private

Figure 4-9



A portion of Baton Rouge, Louisiana, on a USGS Quad sheet.

roads, and add street names to "unnamed street" files. The editing of the TIGER files must be done in collaboration with local officials.

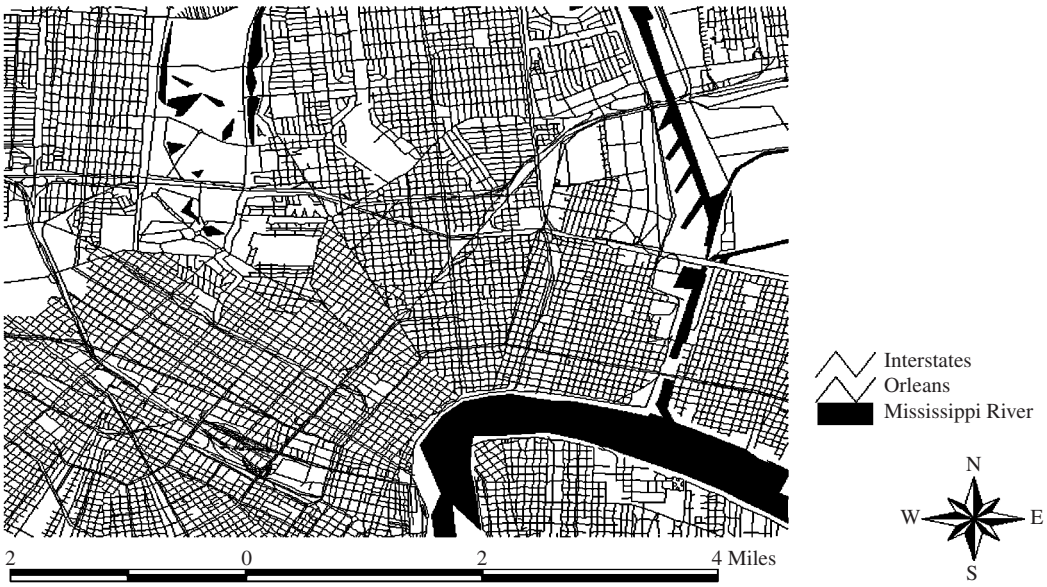
The Bureau of the Census developed TIGER (Topologically Integrated Geographic Encoding and Referencing System). It is based on the USGS DLG-3 hydrographic and transportation data. Attribute data tied to the topology include feature names; political and statistical geographic area reference codes per county; incorporated places, census tract, and block numbers; and potential address ranges and ZIP codes. These files are at a scale of 1:100,000 as compared to more accurate mapping in the USGS. For more information on the USGS files see http://www.usgs.gov.

You will need to determine how accurate a specific piece of data is before using it in emergency management. Maps such as the USGS/Department of Commerce TIGER Files are approximate files and good for broad views of a local area. They are not suitable for engineering purposes.

With a GIS, you can display image data and feature-based spatial data together. The TIGER street network (feature-based data) can be placed over an

Figure 4-10

TIGER Files



Road map of New Orleans: source of road files from TIGER.

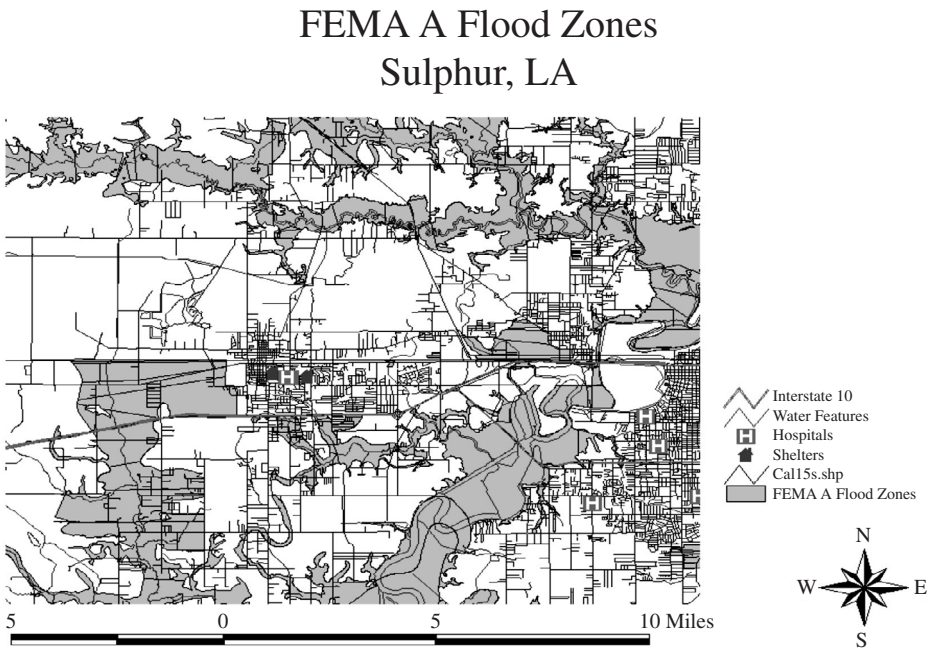
image (photograph). Combining these types of data is very useful to the emergency manager.

Application: Using Flood Zone Maps

Let's take a moment to look at a map and think about how you could use it. You are the emergency manager for Sulphur, Louisiana, and you know a hurricane is coming. You want to determine what the possible damage could be. You look at the map in Figure 4-11 and see the flood zones displayed on the map. How could you use this information in emergency planning or response?

You could use this type of display in emergency planning or response in several ways. You can determine the potential damage from a flood and easily see who will be affected. A GIS allows the user to select features in a layer (residents) that intersects with another layer (a flood zone). A list of residents from the flood zone could be created using the GIS. You can then communicate directly with residents in the flood zone in a pending flood. You can see the interstates and plan evacuation routes. You can also attain a list of critical facilities from looking at this map, and you could make special arrangements to evacuate those residents. For example, there was much outrage in the aftermath of

Figure 4-11



Flood zones of Sulpher, Louisiana.

Hurricane Katrina when it was discovered that some nursing home residents were abandoned by their nurses and caregivers. Evacuation plans of critical facilities must be one of your priorities during a city-wide evacuation. From this map you can also see the location of the shelters.

This type of information can be part of a geographic information system and is available to you. Let's once again look at three additional examples of the information that you can receive from a GIS:

FOR EXAMPLE

Flood Maps

There are several online resources for maps for your use. One of the best resources is FEMA. FEMA's Map Service Center (MSC) provides online access to National Flood Insurance Program (NFIP) Map Products. The MSC Web site is designed to provide the latest information and support services to users on flood related data. The Web site address is www.fema.gov/msc/.

- A GIS can provide regular maps of the local community and of areas of special interest to emergency management.
- A GIS can conduct spatial queries and display the results. Such queries could include, Which households are within a 100-year flood zone? Which schools or nursing homes are within 300 yards of a rail line or major state highway? How many people live within a 100-year flood zone?
- A GIS can provide a basis for conducting complex spatial analyses such as the area, residents, and businesses that would be vulnerable from a chemical release from a fixed facility or an intersection.

SELF-CHECK

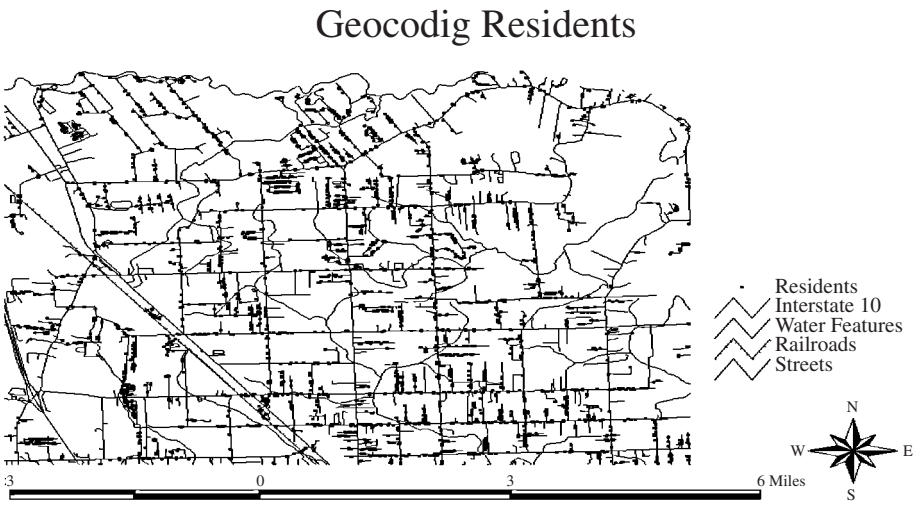
- Define **longitude** and **latitude.**
- How are TIGER files used in emergency management?
- What types of vector data are used in emergency management?
- What are the uses of raster data in emergency management?

4.5 Geocoding

Many organizations maintain large databases of events by address, such as accident and crime reports, customer records, and tax and parcel records. Addresses are, in fact, the most common form of storing geographic data. With geocoding, you can display the tabular information in a computerized database containing addresses as points on a map and easily find their locations on a map. Address geocoding can allow you to locate fire stations by entering their addresses, show where all the students live in relation to the schools they attend, or locate customers and thereby site facilities where the customers are concentrated. As mentioned earlier in this chapter, geocoding was used during Hurricane Katrina to help the Coast Guard rescue stranded flood victims. In this example, street addresses were of no use to the Coast Guard. This is because the Coast Guard was not familiar with New Orleans, and all the street signs had been destroyed. Longitude and latitude coordinates were the only way the Coast Guard could locate those who called in for help.

An address specifies a location in the same way that a geographic coordinate does. But since an address is merely a text string containing the information of house number, street name, direction, and/or zip codes, an address needs a

Figure 4-12



Geocoding of residents along a street network.

mechanism to calculate the geographic coordinate for the address and then display the location on a map based on the assigned coordinate. To do so, addresses stored in tabular data files must first be associated with a geographic feature, usually in a street network. The coordinates of a data source can be used to calculate and assign coordinates to addresses if the data source features also have addresses. Geocoding is the mechanism that allows you to use addresses to identify locations on a map.

There are a variety of planning, administrative, and operational activities that use geographic data in the form of addresses. Geocoding enables you to do the following:

- ▲ Create pin maps to show locations of various events by addresses
- ▲ Query and find geographic features using addresses

FOR EXAMPLE

Evacuating Students

Geocoding is one tool that can be used in evacuating schools. With geocoding, you can match student addresses against a street map of a city. Once the homes of students are located, school assignments and busing plans can be created and analyzed.

- Identify and list addresses in a flood zone or within a specific distance of a facility with hazardous chemicals
- Analyze crimes by address. These locations can be mapped and analyzed with other demographic data
- Identify potential impacts of storage facilities for hazardous materials in populated areas by matching the site addresses to a theme containing census data

SELF-CHECK

- What local organizations could provide accurate residential and business addresses for geocoding?
- Give two examples of how geocoding can be used in emergency management.

4.6 Global Positioning Systems

A **global positioning system (GPS)** is a system to identify and record a geospatial reference point on the Earth's surface using a set of satellites orbiting Earth. This system of 24 Navstar satellites circle Earth every 12 hours at an altitude of 12,000 miles above Earth, constantly transmitting the precise time and their position in space. The system created a huge commercial market for handheld GPS receivers and was used by emergency response personnel, including agencies such as police, fire, emergency, medical, and public works. The unit measures the location to within 30 meters. Drawing its power from flashlight batteries and a small antenna, the unit takes about 10 seconds to find and lock onto radio transmission from at least three Navstar satellites.

GPS uses the triangulation of signals from the satellites to determine locations on Earth. GPS satellites know their location in space, and receivers can determine their distance from a satellite using the travel time of a radio message from the satellite to the receiver. Commercial GPS units vary in price and quality and thus may not provide the accuracy required by a user. Cheaper models may not be able to determine the precise ground position of the GPS unit. GPS products have been developed for use for many commercial applications. They include surveying and mapping, aviation and marine navigation, vehicle tracking systems, and mobile computer and cellular platforms. Following Hurricanes Katrina and Rita, survey teams were dispatched to New Orleans to use

GPS to record the extent of flooding at street intersections or in open areas. In addition, the precise locations of residential and commercial buildings in New Orleans were identified using GPS units. High water marks were then measured on these structures so as to verify water depths throughout the city. GPS technology was essential in accurately recording the extent of flooding and the location of high water marks.

GPS technology has many applications. These applications can be broken down into five broad categories:

- **Location:** GPS technology determines precise locations. For example, there are now emergency personal locator beacons widely available for less than $1000.00. These pocket-sized beacons can be used by anyone. The beacon is capable of pinpointing someone's exact position. The beacon can also send a distress signal to the Air Force which then routes the information to the state police. A hiker, for example, may want to use it when navigating dangerous terrain. If the hiker gets lost, he or she could send a distress signal and his or her position would be given to the state police. The state police could then send in some rescue personnel to find the hiker. GPS beacons are now in many cars. If you had an accident in one of these cars, you could send a distress signal and an ambulance would come to your aid.

FOR EXAMPLE

GPS at Ground Zero

The terrorist attacks in New York on September 11, 2001, gave many challenges to emergency managers in the recovery period. One of the challenges was how to remove so much debris quickly and efficiently. The collapse of the World Trade Center left 1.8 million tons of debris. New York City decided to use a GPS tracking system on the trucks that hauled debris away. The GPS-based system enabled staff to locate each truck as it loaded materials at the site. The trucks could be located at all times: during the loading, when they were on the transportation routes, and when they were transferring loads to barges for shipment to the Staten Island disposal site, or to metal recyclers in the area. The Web-based system provided information in near real time, permitting quick correction of any problems. Complete available truck status included time in, time out, loaded or unloaded, type of load, destination, vehicle speed, name of driver, whether the trailer had been disconnected from the tractor at any time, and similar information.(http://www.gpsworld.com/gpsworld/article/articleDetail.jsp?id=30686&pageID=1&sk=&date=)

- **Navigation:** GPS technology enables you to easily travel from one location to another. For example, many cars now have interactive maps on the dash that use GPS technology. Using this program, you can enter in your destination into the computer and the computer will display the best route. Airplanes, ships, and other vehicles have this capability as well.
- **Tracking:** GPS systems can be placed on vehicles and cargo, and their movements can be tracked over the Web. For example, emergency managers can track the locations of fire trucks and ambulances over the Web if they are equipped with GPS beacons.
- **Mapping:** GPS can be used to survey an area and create maps. State transportation agencies have used GPS to record, in a GIS format, accurate highway elevation centerline data sets. GPS has been used to record the route, distance, and time for school bus routes. GPS has been used by damage assessment teams following a disaster. They record the location of residential and business structures and can be combined linked to a damage assessment form.
- **Timing:** GPS satellites carry atomic clocks and beam back precise time measurements to our receivers here in the United States. Many public safety and utility vehicles are equipted with GPS to provide time and location information to dispatchers. Emergency personnel can thus be directed to deal with emergency situations.

SELF-CHECK

- Define **global positioning system (GPS).**
- How does GPS work?
- How does a GPS help in emergency preparedness and response activities?

SUMMARY

A thorough understanding of maps and geographic systems is essential to your job as an emergency manager. In this chapter, you learned how to interpret maps. You can use maps in preparing for a disaster and mitigating losses. A GIS is a spatially referenced information system that can support decision making in emergency planning, response, recovery, and mitigation activities. You can use GPS technology to identify the specific location of a point or area, navigate to a specific location, track vehicles, and locate map areas. In this chapter, you

evaluated different GIS and GPS tools and their benefits in emergency management. These tools will help you in every phase of emergency management.

KEY TERMS

Geocoding	A graphic representation usually in the form of a point on a map of information in a database that includes street addresses or other location information.
Geographic information systems (GIS)	A computer-based information system that provides a means for the capture, storage, manipulation, analysis, and display of geographical reference information for solving complex problems.
Global positioning system (GPS)	A system to identify and record a geospatial reference point on Earth's surface using a set of satellites orbiting Earth.
Latitude	Used to describe the north-south position of a point as measured usually in degrees or decimal degrees above or below the equator.
Line	A map object that is defined by a set of sequential coordinates that represents the shape of a geographic feature.
Longitude	Used to describe the east-west position of a point.
Point	An object on a map in a GIS that represents information for a specific location.
Polygon	An area vector data feature in a GIS that defines a perimeter by a series of enclosing segments.
Raster data	A graphic representation of a geographic area from an optical or electronic device in the form of an aerial photograph, scanned picture, land classification, or ground contours. The image is represented by rows and columns of cells that may have data values.
Vector data	A coordinate-based data layer in a GIS that represents features on a map in the form of a point, line, or polygon.

ASSESS YOUR UNDERSTANDING

Go to www.wiley.com/college/Pine to evaluate your knowledge on GIS and GPS tools.
Measure your learning by comparing pretest and posttest results.

Summary Questions

1. The primary purpose of developing a GIS is to support decision making. True or false?
2. Developing a GIS involves investment in the following areas:
   (a) Geographic data
   (b) Procedures
   (c) Trained staff
   (d) All of the above
3. Which of the following is not an element of a vector data set?
   (a) Point
   (b) Line
   (c) Polygon
   (d) Cell
4. All vector point objects use longitude and latitude references. True or false?
5. An example of a GIS output would be a map showing address locations in a risk zone. True or false? .
6. Which of the following would be an example of using GIS in an emergency response?
   (a) Show an area flooded
   (b) Identify homes or businesses damaged
   (c) Pinpoint closed bridges or streets
   (d) All of the above
7. Emergency managers have found that staff training and technical support are not necessary for effective use of GIS. True or false?
8. GIS is more than a technology issue. This is true except for which of the following?
   (a) GIS requires the use of databases and tables.
   (b) GIS may utilize images and other graphics.
   (c) GIS requires a knowledge of how to store files.

(d) GIS only is used by a central mapping unit and never by other agency personnel.

9. Point data on a map can represent locations such as schools, shelters, businesses, parks, or hazard sites. True or false?
10. A raster file may include a satellite photo of Earth as well as a scanned image. True or false?
11. A GIS can display hazard areas, including an area vulnerable to a wildfire. True or false?

Review Questions

1. How can data be used in a GIS system for emergency response and long-term recovery?
2. Why is GIS used in emergency management?
3. What are the key elements of GIS, and how are they integrated for decision support?
4. What are the challenges in effectively implementing GIS?
5. What is geocoding, and how can it contribute to emergency planning?
6. How is geocoding related to GIS?
7. What is GPS, and how does it enhance emergency response?
8. What is the most important element in effectively using GIS: people, process, or technology?

Applying This Chapter

1. You are the local emergency manager for a town that was just devastated by a hurricane. You now are in the rescue mode as people need to be taken from their homes to safety. What geographic information system tools can you use to aid in the rescues?
2. You are the local emergency manager of a city that is the target of a terrorist attack. The terrorists plan to release hazardous chemicals in the subway system. Given access to GIS, what types of maps could be created and how would they be used?
3. You are the local emergency manager of a coastal town that is always vulnerable to hurricanes. How would GIS information be used to predict hurricane damage and plan the recovery?
4. You are the local emergency manager for a town that is home to three chemical companies that work with hazardous chemicals. How does

geocoding assist in identifying potential impacts of disasters to hazardous materials storage facilities in populated areas?

5. You are the local emergency manager for an agency that just installed a GIS system. What challenges do you anticipate in implementing the new system, and how do you plan to overcome those challenges?
6. You are the local emergency manager for a town that was hit by an earthquake. What types of maps do you need and why?

YOU TRY IT

Preparing for an Evacuation

You were just hired as an emergency manager for Newark, New Jersey. One of your concerns is the amount of hazardous waste that the industrial facilities in Newark produce. You want to plan an evacuation of certain areas of the city. How can a GIS help you plan this evacuation?

Creating a Hazard-Awareness Campaign

You are an emergency manager for Los Angeles, California. One of your goals is to educate the residents about earthquakes and how they can build homes that are not vulnerable to earthquakes. You also want to educate the residents on what to do if an earthquake does occur. How can a GIS system help you plan your public-awareness campaign?

Managing Relief Supplies

You are the head of FEMA, and Florida has been hit with a hurricane. You are receiving constant calls from the local emergency managers wanting to know where the relief supplies are. They are out of food and water. You can answer their questions because you are using a GPS system. How does the GPS system help you answer their questions?