PDHonline Course L145 (5 PDH)

GIS – Introduction and Sample Uses

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2020

PDH Online | PDH Center

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Welcome to:

FEMAs GIS Tutorial Series (Tutorials I, II and III)

Screen-captures of FEMA's well-thought-out and carefully presented tutorial on:

GIS

(Geographic Information Systems)

TUTORIAL 3 OF 3

The tutorial series presents an introduction to GIS illustrated with FEMA's application of GIS in their MAP MODERNIZATION OBJECTIVES

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IMPORTANT:

The **yellow-text** links in the course material and the **GLOSSARY** entries accessed through the pull-down menu provide significant benefits to those studying the "live," on-line tutorial.

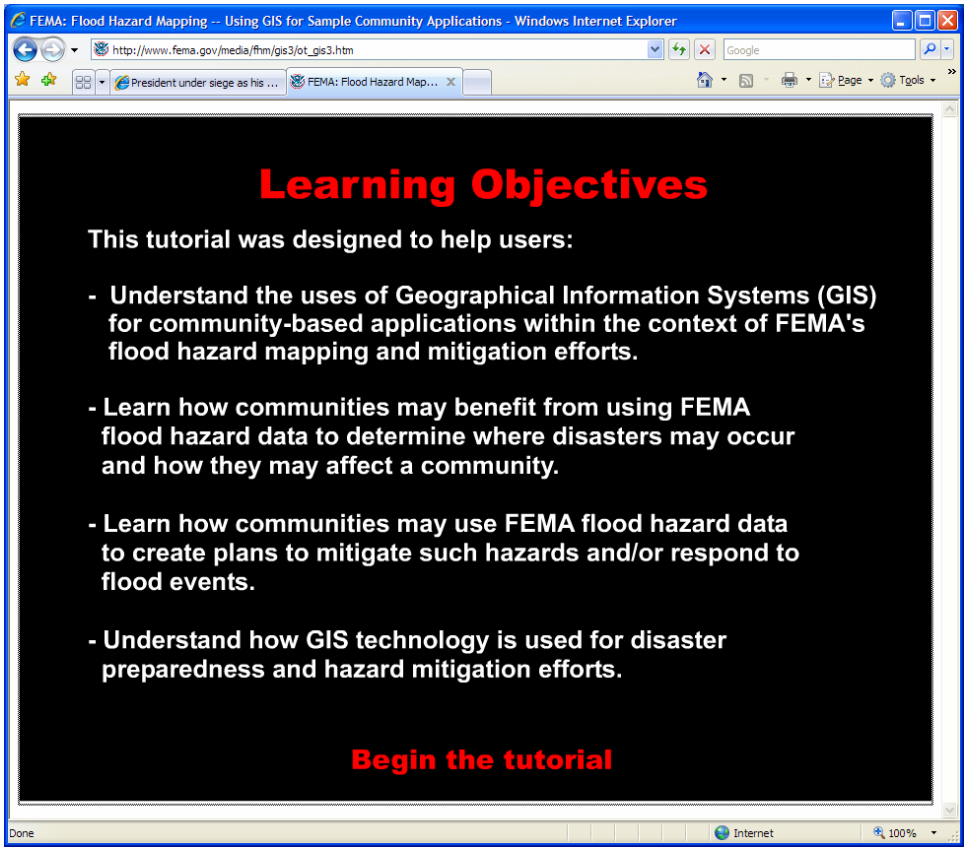
For this reason, it is suggested that those using this hard-copy version of FEMA's GIS tutorial series make frequent reference to the GLOSSARY section at the end of each portion of the tutorial.

For your convenience and ease of study, each of these three hard-copy files (a separate file covering each session of FEMA's 3-part GIS tutorial series) contains GLOSSARY entries from all three "live" tutorials.

Both the course material and the quiz rely on frequent reference to these GLOSSARY entries.

FEMA's GIS TUTORIAL SERIES – III

On-line at: http://www.fema.gov/media/fhm/gis3/ot_gis3.htm



FEMA's on-line tutorial provides links to terms and information in **yellow text** as seen above.

This information is available in the **GLOSSARY** included at the end of this course material.


FEMA: Flood Hazard Mapping -- Using GIS for Sample Community Applications - Windows Internet Explorer
http://www.fema.gov/media/fhm/gis3/ot_gis3.htm
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Introduction
Included in this tutorial are examples that show how the data may be layered to create the maps required to accomplish this task. A GIS also allows FEMA to quickly create visual aids that enhance the understanding of any event. For instance, in the case of a major flood, GIS data may be used to determine the impact of flooding on citizens of an affected area. The GIS can accurately display critically damaged areas, potential transportation and evacuation problems, and estimate the number of people affected.
Using GIS maps, FEMA may also determine the population density in each affected area, how many people have applied for assistance, and the resources needed. These analyses also help FEMA anticipate potential problems.
The GIS is an invaluable tool in all stages of a disaster event. It provides broad and precise geographical views of the magnitude and consequences of any event.
Next, you'll learn how FEMA creates these types of maps. Click on the forward arrow to continue.
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Internet
100%


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Step 1: Laying the Foundation
As stated previously, FEMA uses GIS technology to analyze data and quickly create visuals to enhance the understanding of any event.
To illustrate how GIS technology may be applied in the event of a flood disaster, we will walk you through the creation of a map for a medium-sized city in the United States that incorporates DFIRM and other data. This example focuses on the community's population density and areas subject to inundation by the base (1-percent-annual-chance) flood. The 100-year flood zones are also known as Special Flood Hazard Areas (SFHAs), the areas subject to inundation by the base (1-percent-annual chance) flood.
Usually the starting point for a GIS project is a base map. Click on the forward arrow to learn more about base maps.
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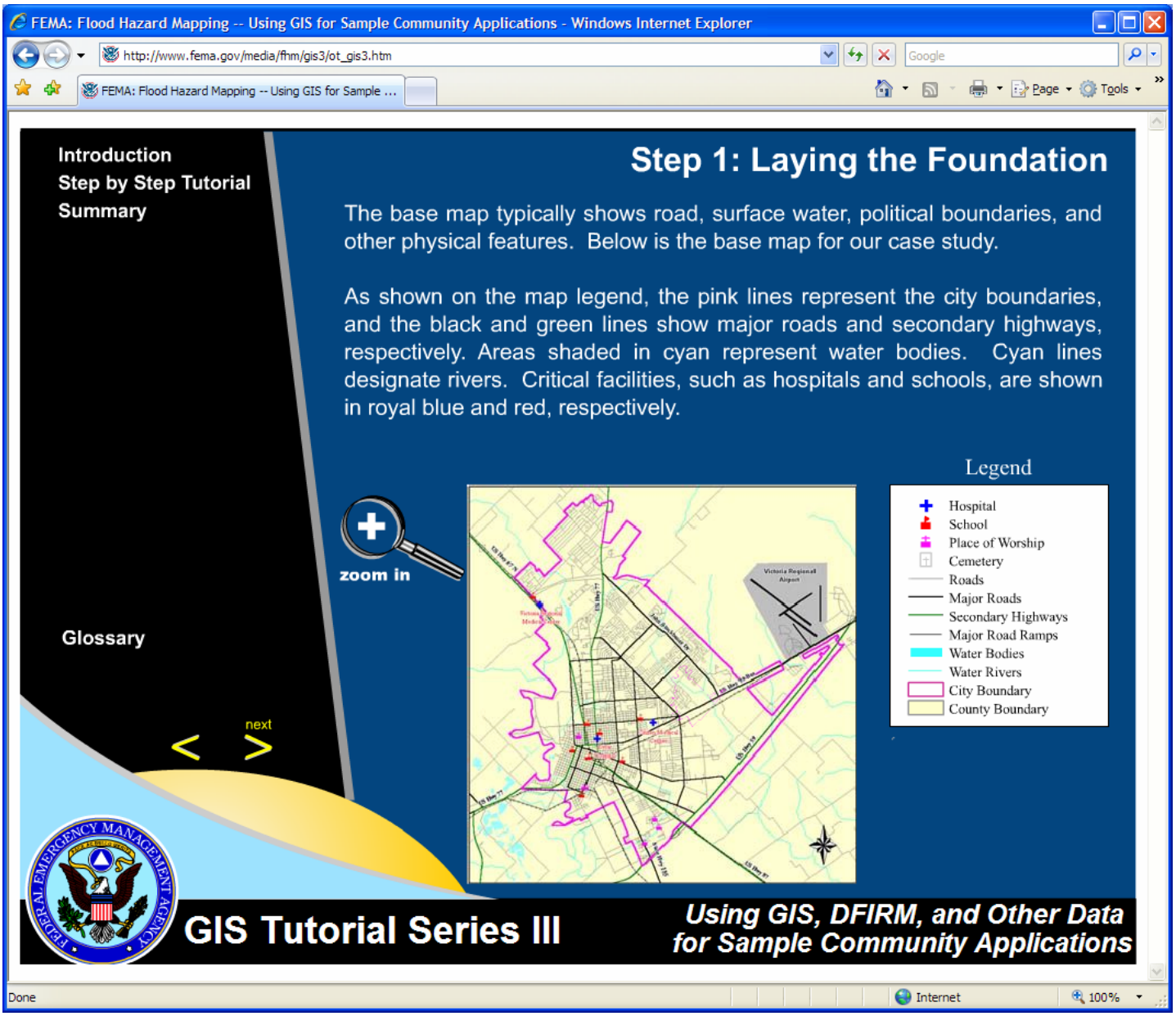
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Step 1: Laying the Foundation
The base map typically shows road, surface water, political boundaries, and other physical features. Below is the base map for our case study.
As shown on the map legend, the pink lines represent the city boundaries, and the black and green lines show major roads and secondary highways, respectively. Areas shaded in cyan represent water bodies. Cyan lines designate rivers. Critical facilities, such as hospitals and schools, are shown in royal blue and red, respectively.
zoom in
Legend
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
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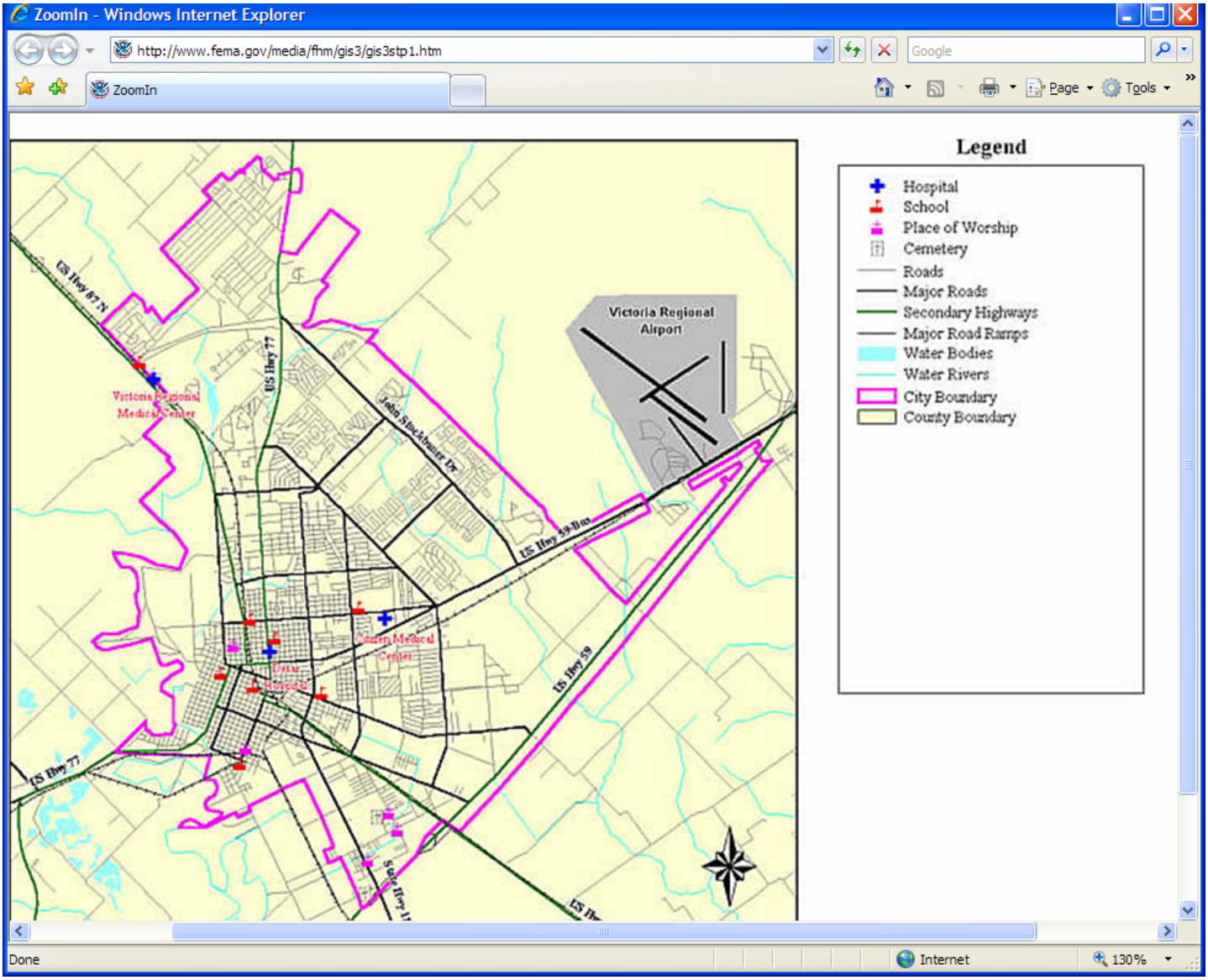
ZoomIn - Windows Internet Explorer
http://www.fema.gov/media/fhm/gis3/gis3stp1.htm
ZoomIn
Legend
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
Victoria Regional Airport
Victoria Regional Medical Center
John Stockbauer Dr
US Hwy 77
US Hwy 59
US Hwy 59 Bus
Citizens Medical Center
Done
Internet
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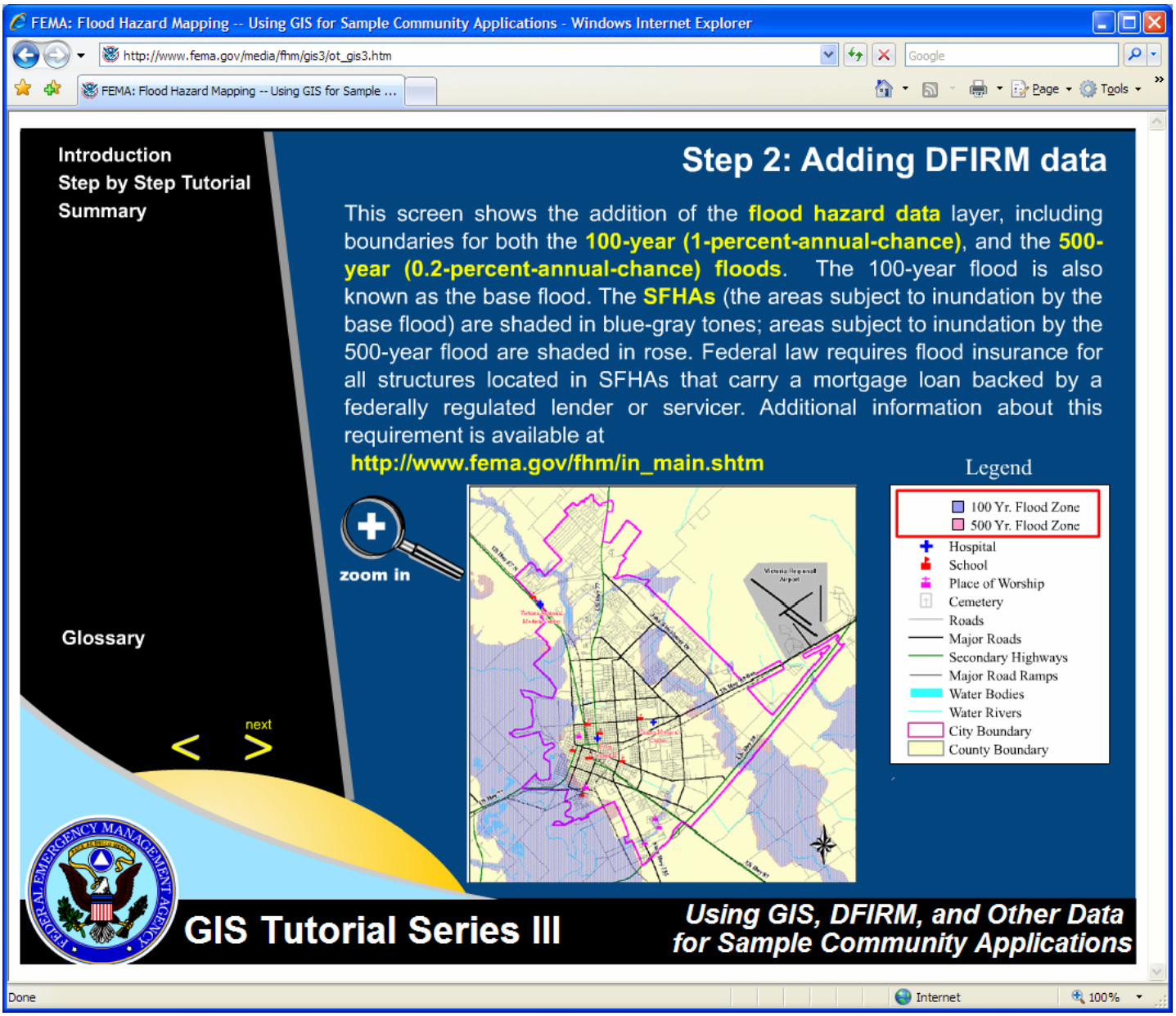
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Step 2: Adding DFIRM data
This screen shows the addition of the flood hazard data layer, including boundaries for both the 100-year (1-percent-annual-chance), and the 500-year (0.2-percent-annual-chance) floods. The 100-year flood is also known as the base flood. The SFHAs (the areas subject to inundation by the base flood) are shaded in blue-gray tones; areas subject to inundation by the 500-year flood are shaded in rose. Federal law requires flood insurance for all structures located in SFHAs that carry a mortgage loan backed by a federally regulated lender or servicer. Additional information about this requirement is available at
http://www.fema.gov/fhm/in_main.shtm
zoom in
Legend
100 Yr. Flood Zone
500 Yr. Flood Zone
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
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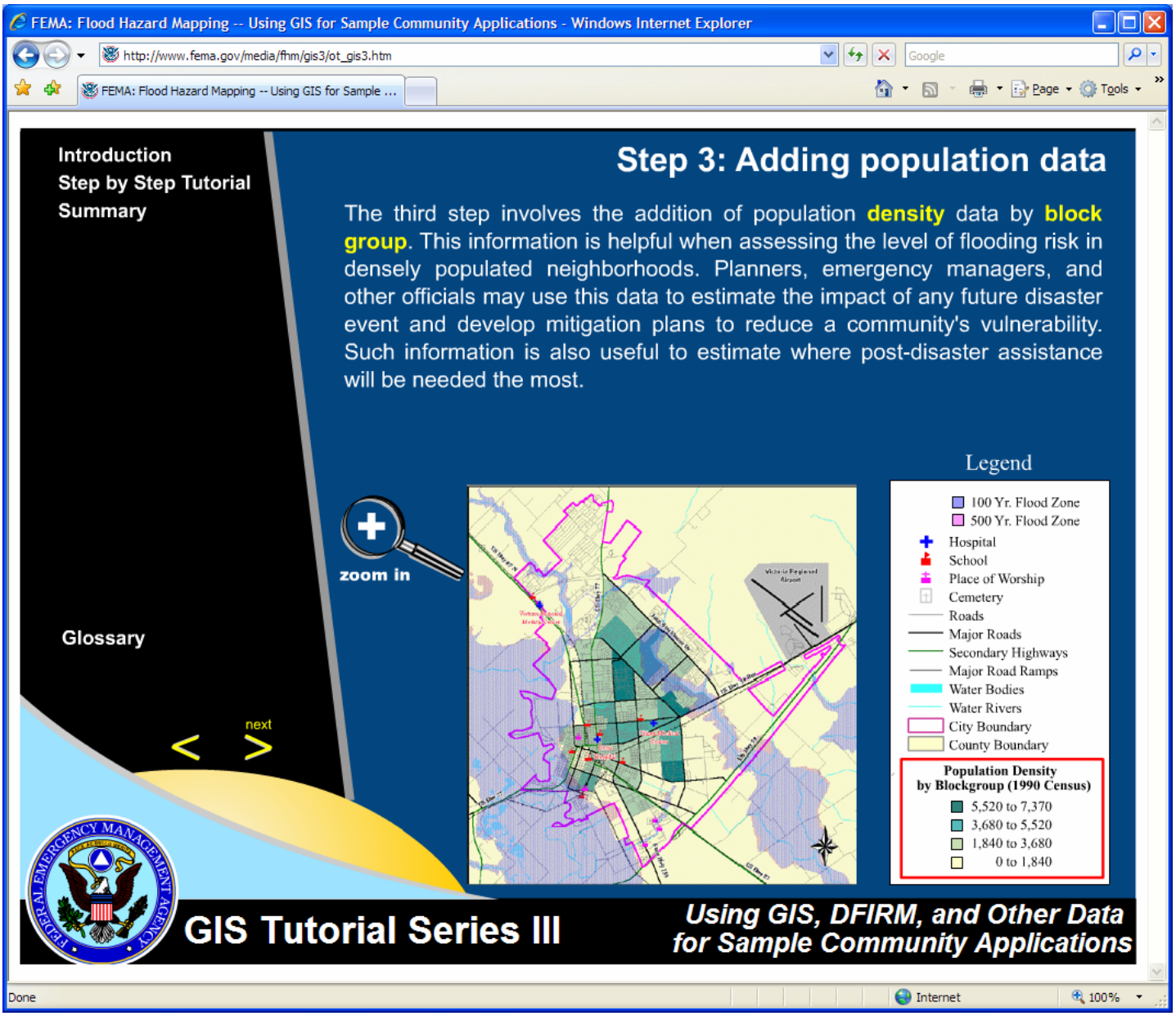
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Step 3: Adding population data
The third step involves the addition of population density data by block group. This information is helpful when assessing the level of flooding risk in densely populated neighborhoods. Planners, emergency managers, and other officials may use this data to estimate the impact of any future disaster event and develop mitigation plans to reduce a community's vulnerability. Such information is also useful to estimate where post-disaster assistance will be needed the most.
zoom in
Legend
100 Yr. Flood Zone
500 Yr. Flood Zone
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
Population Density by Blockgroup (1990 Census)
5,520 to 7,370
3,680 to 5,520
1,840 to 3,680
0 to 1,840
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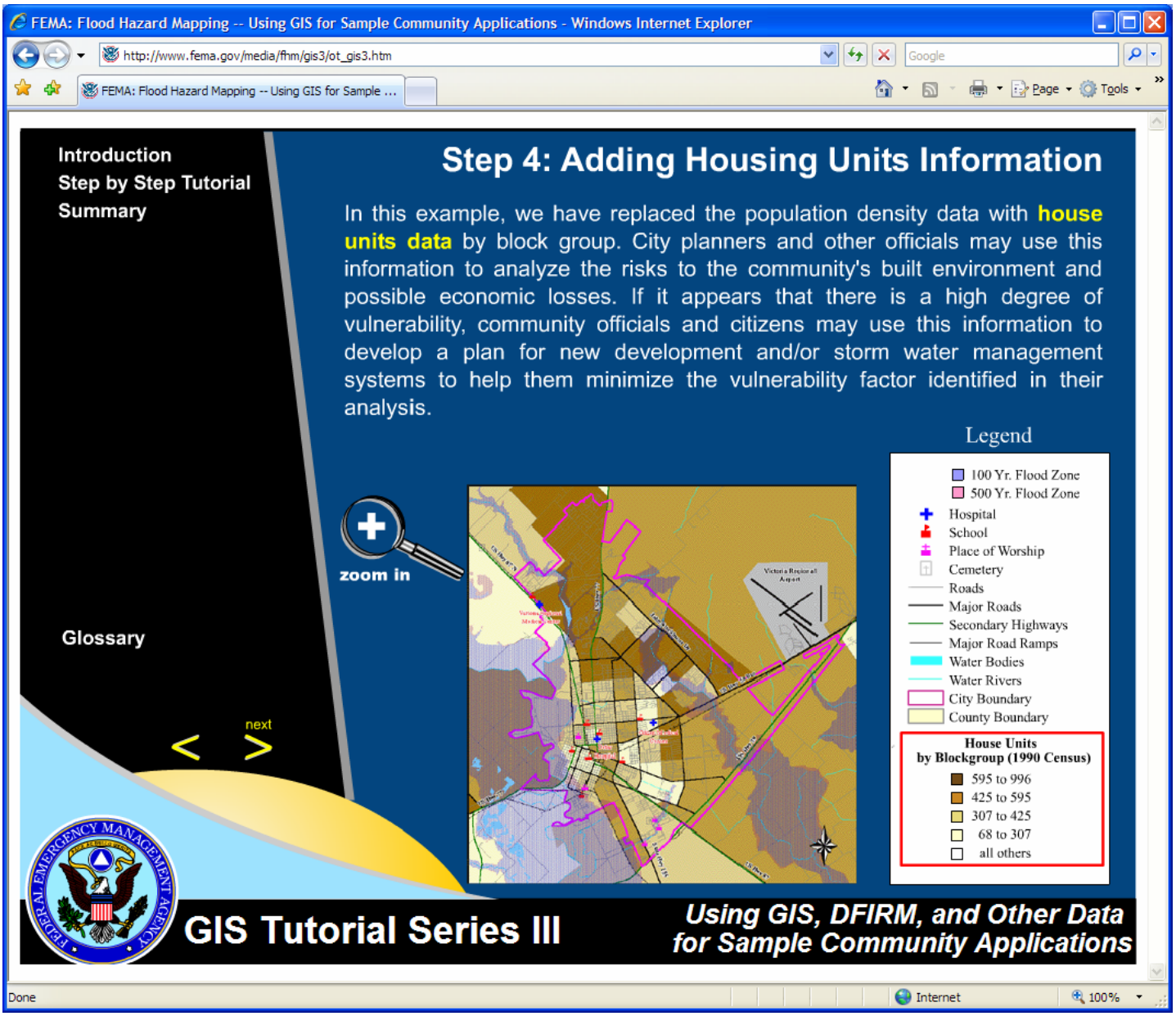
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Step 4: Adding Housing Units Information
In this example, we have replaced the population density data with house units data by block group. City planners and other officials may use this information to analyze the risks to the community's built environment and possible economic losses. If it appears that there is a high degree of vulnerability, community officials and citizens may use this information to develop a plan for new development and/or storm water management systems to help them minimize the vulnerability factor identified in their analysis.
zoom in
Legend
100 Yr. Flood Zone
500 Yr. Flood Zone
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
House Units
by Blockgroup (1990 Census)
595 to 996
425 to 595
307 to 425
68 to 307
all others
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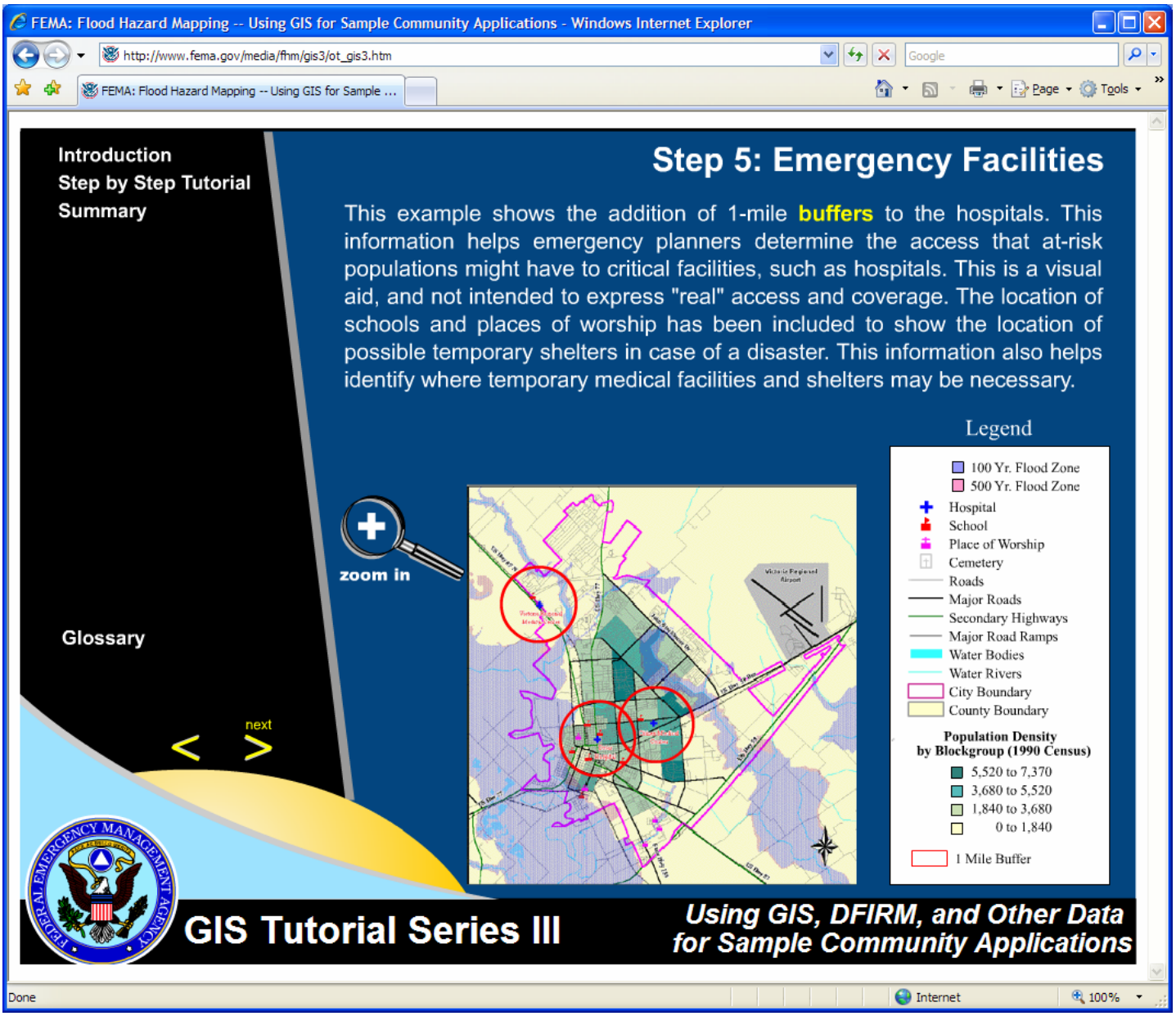
for Sample Community Applications
Done
Internet
100%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Step 5: Emergency Facilities
This example shows the addition of 1-mile buffers to the hospitals. This information helps emergency planners determine the access that at-risk populations might have to critical facilities, such as hospitals. This is a visual aid, and not intended to express "real" access and coverage. The location of schools and places of worship has been included to show the location of possible temporary shelters in case of a disaster. This information also helps identify where temporary medical facilities and shelters may be necessary.
zoom in
Legend
100 Yr. Flood Zone
500 Yr. Flood Zone
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
Population Density
by Blockgroup (1990 Census)
5,520 to 7,370
3,680 to 5,520
1,840 to 3,680
0 to 1,840
1 Mile Buffer
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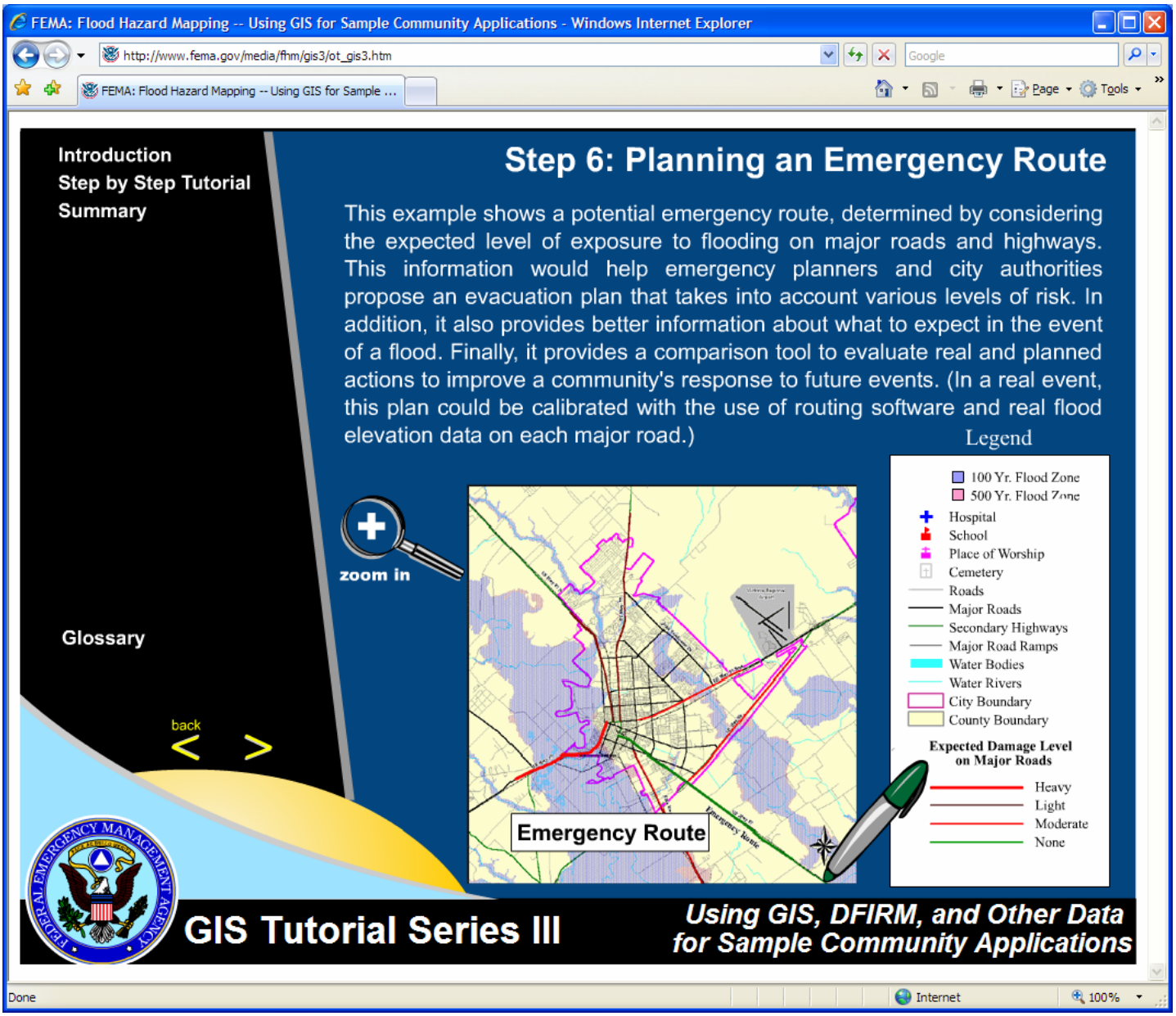
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Step 6: Planning an Emergency Route
This example shows a potential emergency route, determined by considering the expected level of exposure to flooding on major roads and highways. This information would help emergency planners and city authorities propose an evacuation plan that takes into account various levels of risk. In addition, it also provides better information about what to expect in the event of a flood. Finally, it provides a comparison tool to evaluate real and planned actions to improve a community's response to future events. (In a real event, this plan could be calibrated with the use of routing software and real flood elevation data on each major road.)
zoom in
Emergency Route
Legend
100 Yr. Flood Zone
500 Yr. Flood Zone
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
Expected Damage Level on Major Roads
Heavy
Light
Moderate
None
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Internet
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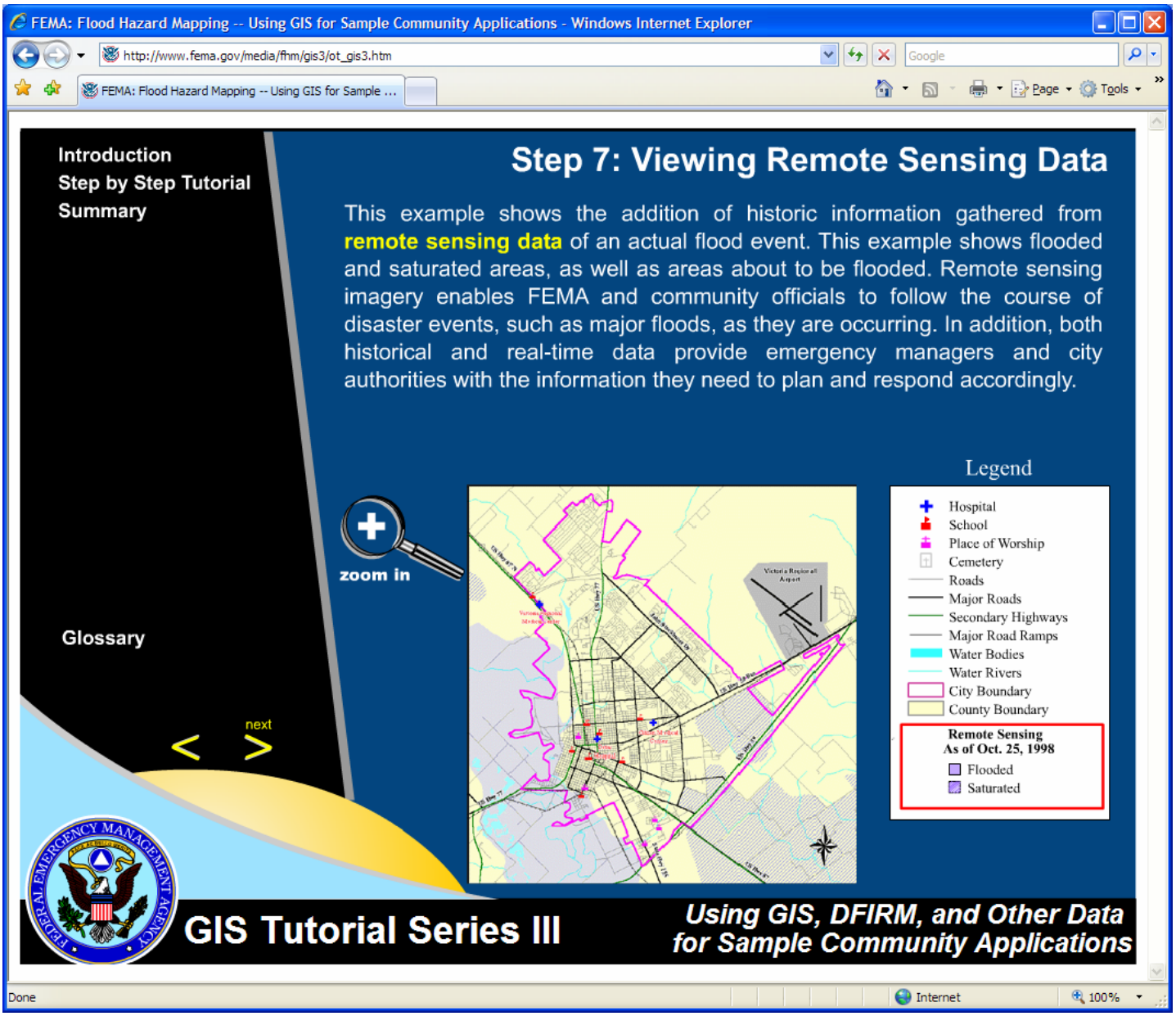
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Step 7: Viewing Remote Sensing Data
This example shows the addition of historic information gathered from remote sensing data of an actual flood event. This example shows flooded and saturated areas, as well as areas about to be flooded. Remote sensing imagery enables FEMA and community officials to follow the course of disaster events, such as major floods, as they are occurring. In addition, both historical and real-time data provide emergency managers and city authorities with the information they need to plan and respond accordingly.
zoom in
Legend
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
Remote Sensing
As of Oct. 25, 1998
Flooded
Saturated
GIS Tutorial Series III
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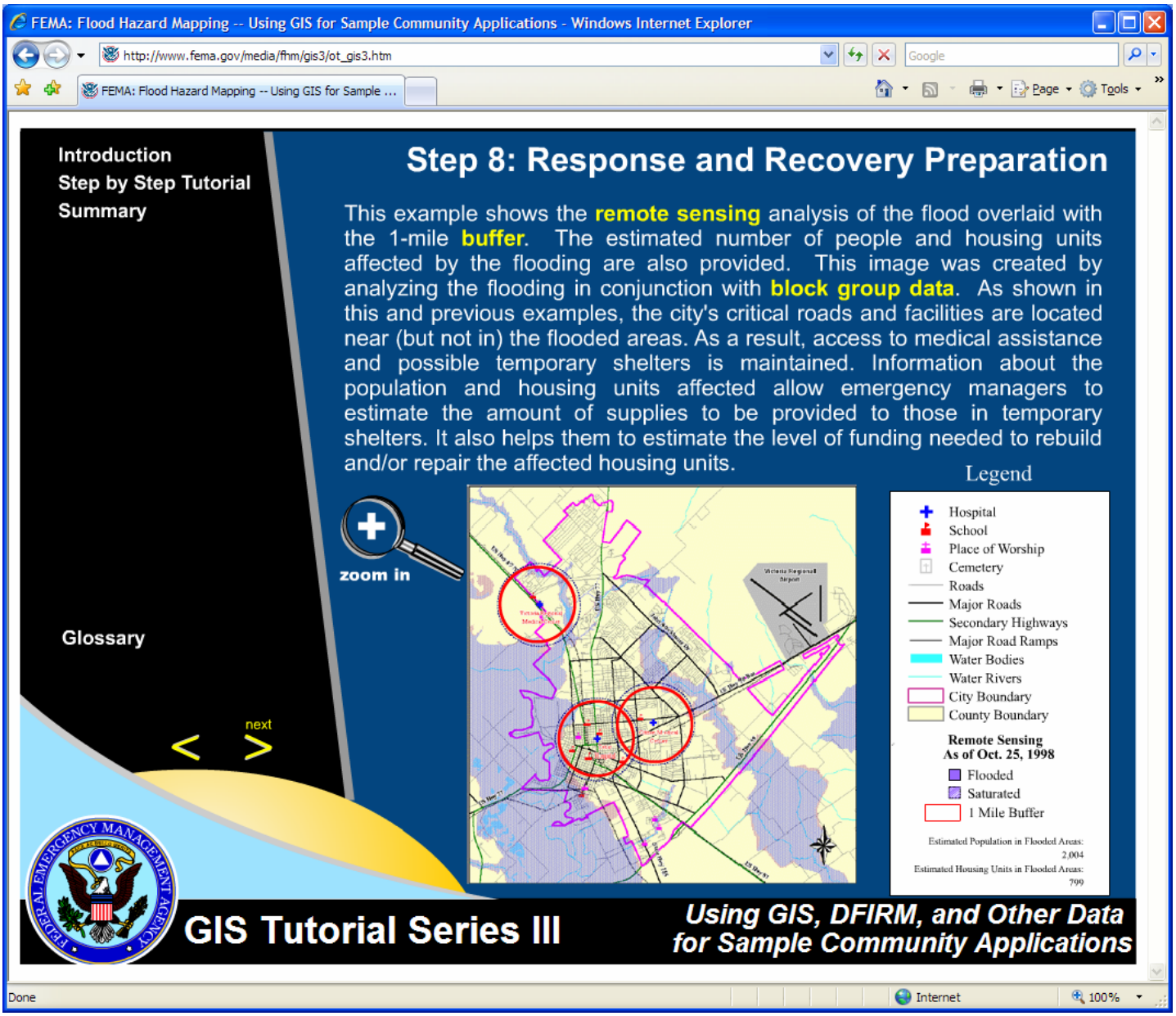
Done
Internet
100%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Step 8: Response and Recovery Preparation
This example shows the remote sensing analysis of the flood overlaid with the 1-mile buffer. The estimated number of people and housing units affected by the flooding are also provided. This image was created by analyzing the flooding in conjunction with block group data. As shown in this and previous examples, the city's critical roads and facilities are located near (but not in) the flooded areas. As a result, access to medical assistance and possible temporary shelters is maintained. Information about the population and housing units affected allow emergency managers to estimate the amount of supplies to be provided to those in temporary shelters. It also helps them to estimate the level of funding needed to rebuild and/or repair the affected housing units.
zoom in
Legend
Hospital
School
Place of Worship
Cemetery
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
Remote Sensing
As of Oct. 25, 1998
Flooded
Saturated
1 Mile Buffer
Estimated Population in Flooded Areas: 2,004
Estimated Housing Units in Flooded Areas: 799
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100%


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Step 9: Planning Alternate Routes
A previous example in the tutorial shows an emergency route planned according to expected levels of damage on major roads. This example shows that flooding did affect some of the major roads, as expected (U.S. Highway 77). This example also shows that the road suggested by our initial analysis as the best emergency route, U.S. Highway 87 South, became saturated. Other highways in the area, U.S. Highway 87 North, U.S. Highway 77 North, and State Highway 185 South were not flooded. If necessary, these (major roads) could be used as alternate emergency routes.
zoom in
Alternate Route
Legend
Roads
Major Roads
Secondary Highways
Major Road Ramps
Water Bodies
Water Rivers
City Boundary
County Boundary
Remote Sensing As of Oct. 25, 1998
Flooded
Saturated
Expected Damage Level on Major Roads
Heavy
Light
Moderate
None
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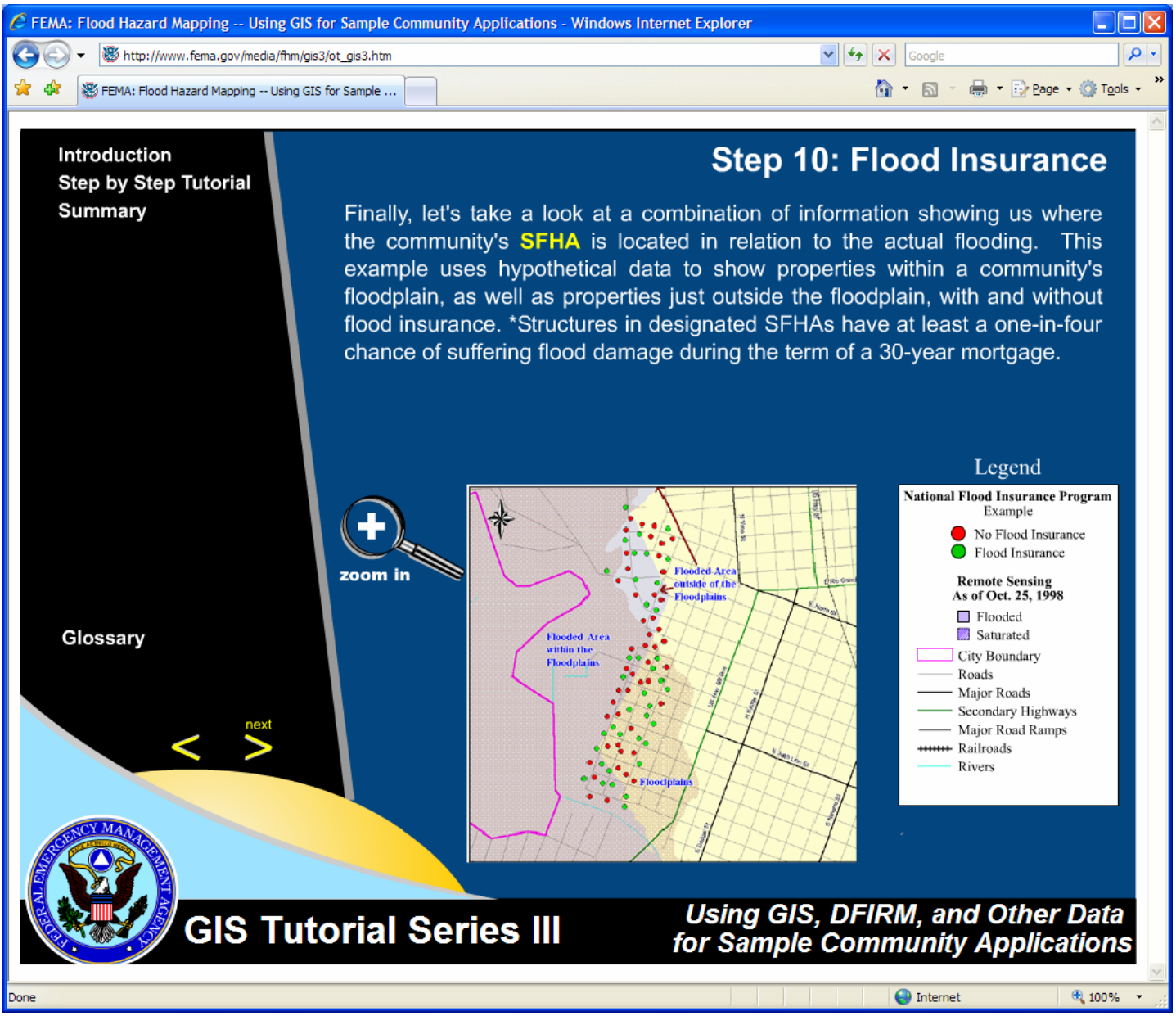
Internet
100%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Step 10: Flood Insurance
Finally, let's take a look at a combination of information showing us where the community's SFHA is located in relation to the actual flooding. This example uses hypothetical data to show properties within a community's floodplain, as well as properties just outside the floodplain, with and without flood insurance. *Structures in designated SFHAs have at least a one-in-four chance of suffering flood damage during the term of a 30-year mortgage.
zoom in
Flooded Area outside of the Floodplains
Flooded Area within the Floodplains
Floodplains
Legend
National Flood Insurance Program
Example
No Flood Insurance
Flood Insurance
Remote Sensing
As of Oct. 25, 1998
Flooded
Saturated
City Boundary
Roads
Major Roads
Secondary Highways
Major Road Ramps
Railroads
Rivers
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This tutorial also offers a Certificate of Completion.

GLOSSARY

(Terms found in FEMA's three GIS tutorials)

100-Year Flood

The flood having a 1-percent chance of being equaled or exceeded in any given year, also known as the base flood. The 1-percent annual chance flood, which is the standard used by most Federal and state agencies, is used by the National Flood Insurance Program (NFIP) as the standard for floodplain management and to determine the need for flood insurance. A structure located within a flood hazard area shown on an NFIP map has a 26 percent chance of suffering flood damage during the term of a 30-year mortgage.

1-percent annual chance floodplain

This is the boundary of the flood that has a 1-percent chance of being equaled or exceeded in any given year. Also known as, "the 100-year floodplain."

500-Year Floodplain

This is the boundary of the flood that has a 0.2-percent chance of being equaled or exceeded in any given year. Officially termed "the 0.2-percent annual chance floodplain."

Accuracy

This term refers to the conformance to a reasonable standard. The statistical meaning of accuracy is the degree with which an estimated mean differs from the true mean.

Different projects require different levels of data accuracy than others. The National Standard for Spatial Data Accuracy (NSSDA) has implemented a well-defined statistical and testing methodology for the positional accuracy of maps and geospatial data derived from sources such as aerial photographs, satellite imagery, or maps. Accuracy specifications for data collection during a FEMA Flood Insurance Study are outlined in several FEMA-authored guidance documents.

Area Data

A fundamental unit of geographic information; it is a measure of a particular extent of the earth’s surface.

Automated Floodplain Mapping

The use of digital elevation models (DEMs) or digital terrain models with digital water surface elevation data in the GIS environment to define the limits of the floodplain.

Base Flood

The flood having a 1-percent chance of being equaled or exceeded in any given year, also known as the 100-year flood. The base flood, which is the standard used by most Federal and state agencies, is used by the National Flood Insurance Program (NFIP) as the standard for floodplain management and to determine the need for flood insurance. A structure located within a special flood hazard area on a NFIP map has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage.

Block Group (data)

A geographical area bounded on all sides by visible or nonvisible features shown on Census maps. A block group is the third smallest geographic entity for which the Census Bureau collects and tabulates decennial Census information.

Buffers

A zone of a specified distance around spatial features. Both constant- and variable-width buffers can be generated for a set of spatial features based on each feature's attribute values. The resulting buffer zones form polygons-areas that are either inside or outside the specified buffer distance from each feature. Buffers are useful for proximity analysis (e.g., find all stream segments within 300 feet of a proposed logging area).

Coordinate System

A reference system used to measure horizontal and vertical distances on a planimetric map. A coordinate system is usually defined by a map projection, a spheroid of reference, a datum, one or more standard parallels, a central meridian, and possible shifts in the x- and y-directions to locate x,y positions of point, line, and area features. In some software packages, it is used to refer to a system with units and characteristics defined by a map projection. A common coordinate system is used to spatially register geographic data for the same area.

Data Sets

A collection of related records.

Datum

A fixed starting point of a scale.

Density (Population Density Data)

The number of inhabitants per unit ia a geographic region.

Digital Flood Insurance Rate Map (DFIRM)

A FIRM is a map produced by FEMA that shows flood hazard information and is used to rate flood insurance. A DFIRM is a FIRM that was produced suing digital technology.

As part of FEMA's Map Modernization Objectives, a new Digital Flood Insurance Rate Map (DFIRM) product is being developed. The new DFIRM product will include a spatial database with options that can be invoked depending on the available data. The DFIRM spatial database will include certain standard features and meet minimum mapping requirements. Additional enhancements will be included depending on community needs, available data, and funding. A review of needs and available data will lead to recommendations concerning which options to exercise.

Digitizing

The process of converting map data from their original visual form (i.e., a paper map) to a digital format that can be handled by a computer.

Discrete (cells)

Self-contained, distinct units.

Flood (also Flooding)

A general and temporary condition of partial or complete inundation of normally dry land areas. For flood insurance claim purposes, two or more structures must be inundated before flood damage will be covered.

Flood Hazard Data

Information about a community's flooding hazards used to prepare Flood Insurance Rate Maps and Flood Insurance Study reports. It may include information such as statistical analyses of records of river-flow, storm tides, and rainfall; information obtained through consultation with the community; floodplain topographic surveys; and hydrologic and hydraulic analyses.

Flood Insurance Rate Map (FIRM)

A map on which the 100-year (1% annual chance) and the 500-year (0.2% annual chance) floodplains, Base Flood Elevations, and risk premium zones (and floodway information on Map Initiatives FIRMs) are delineated to enable insurance agents to issue an accurate flood insurance policies to homeowners in communities participating in the National Flood Insurance Program.

Floodplain or Flood-Prone Area

Any land area susceptible to inundation by water from any source.

Floodplain Management

The operation of the program of corrective and preventive measures for mitigating flood damage, including, but not limited to, emergency preparedness plans, flood-control works, and floodplain management regulations.

Floodway

Channel of the stream plus any adjacent floodplain areas that must be kept free of encroachment so that a 100-year flood discharge can be conveyed without increasing the elevation of the 100-year flood by more than a specified amount (1 foot in most states).

Geocoding

Assigning locational coordinates, such as longitude/latitude, to map features (i.e., assigning a point location on the earth for a mailing address.

Georeference

To establish the relationship between page coordinates on a planar map and known real-world coordinates.

GIS (Geographic Information System)

A Geographic Information System (GIS) is a computer-based system to capture, store, retrieve, manipulate, analyze and display spatial information and its associated attributes. It combines spatial and tabular information to produce maps and to perform spatial analyses.

GPS

The Global Positioning System (GPS) is a satellite-based radio navigation system developed and operated by the U.S. Department of Defense (DOD). It allows land, sea, and airborne users to determine their three-dimensional position, velocity and time precisely and accurately, 24 hours a day, in all weather, anywhere in the world. Each GPS satellite transmits an accurate position and time signal. GPS receivers collect signals from satellites and display the user's position, velocity, and time is needed for their marine, terrestrial, or aeronautical applications.

HAZUZ

PC-based GIS software used to implement a standardized, nationally applicable earthquake loss estimation method. The HAZUZ software is being expanded to perform similar loss evaluations for wind (hurricanes, thunderstorms, tornadoes, extra tropical cyclones and hail) and flood (riverine and coastal) hazards. HAZUZ Development Is Being Funded by FEMA through a Cooperative Agreement with the National Institute of Building Sciences.

Housing Unit (Data)

A house, an apartment or other group of rooms, or a single room, is regarded as a housing unit when it is occupied or intended for occupancy as separate living quarters; that is, when the occupants do not live and eat with any other persons in the structure and there is direct access from the outside or through a common hall.

IFSAR

InterFerometric Synthetic Aperture Radar. It uses airborne or space-born radar antennae to obtain highly accurate terrain data over a larger geographical areas.

LIDAR

Light Detection And Ranging. Airborne laser system that combines a pulsing laser with a positioning system consisting of a Global Positioning System (GPS) receiver and an Inertial Measuring Unit (IMU) to measure the elevation of ground points on the earth's surface.

Labeling

The process of attaching identification codes to map features (i.e., attaching city names to city point locations.

Layer

A layer is a logical separation of mapped information according to theme. Many Geographic Information Systems and CAD/CAM systems allow the user to choose and work on a single layer or any combination of layers at a time.

Line Data

One of the basic geographical primitives. It is defined by at least two pairs of XY coordinates.

National Flood Insurance Program (NFIP)

Federal insurance program under which flood-prone areas are identified and flood insurance is made available to residents of participating communities that agree to adopt and enforce floodplain management ordinances to reduce future flood damage.

Point Data

A position, place or locality.

Polygon

A multi-sited figure representing an area on a map; a geographic primitive.

Projection

A mathematical model the transforms the locations of features on the Earth's surface to locations on a two-dimensional surface. Because the Earth is three-dimensional, some methods must be used to depict a map in two dimensions. Some projections preserve shape; others preserve accuracy of area, distance, or direction. See also coordinates or coordinate system.

Map projections project the earth's surface onto a flat plane. However, any such representation distorts some parameter of the earth's surface be it distance, area, shape, or direction.

Q3 Data

A digital representation of certain features of FEMA's Flood Insurance Rate Map (FIRM) product, intended for use with desktop mapping and GIS technology. Because of the scale of the digital Q3 Flood Data, it cannot be used to determine absolute delineations of flood risk boundaries.

Raster

A regular grid of cells covering an area.

Raster Spatial Data

A discrete set of uniform cells are coded to represent spatial information.

Remote Sensing

Acquiring information about an object without contacting it physically. Methods include aerial photography, radar, and satellite imaging. For example, when responding to a disaster, FEMA's Mapping and Analysis Center (MAC) may receive remote sensing data that indicates areas affected by the disaster, as derived from various imagery products. Typical examples include flooded, saturated and/or damaged areas.

Special Flood Hazard Area (SFHA)

Area inundated by the base (1-percent annual chance) flood, identified on the Flood Insurance Rate Map as Zones A, AE, AH, AO, AR, V, VE, or A99.

Saturated

Soaked with moisture.

Spatial Data (or Spacial Information)

Includes the geographic information of boundaries that make up a map; also known as georeferenced data.

Tabular Data (or Tabular Information)

Data organized in a table format.

Thematic Map

A map showing information about a particular topic, often statistical in nature (i.e., population per state).

Vector

The representation of spatial data by points, lines and polygons.

Below are Zones found on Flood Insurance Rate Maps (FIRMs):

Zone A

The flood insurance rate zone that corresponds to the 100-your floodplains that is determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no Base Flood Elevations or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone A99

The flood insurance rate zone that corresponds to areas of the 100-year floodplains that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No Base Flood Elevations or depths are shown within the zone. Mandatory flood insurance purchase requirements apply.

Zone AE

[Note: In the tutorial, the following definition for Zone AE is accessed through clicking a link titled, "Zone AE and A1-A30.]

The flood insurance rate zone that corresponds to the 100-year floodplains that is determined in the Flood Insurance Study by detailed methods. In most instances, Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone AH

The flood insurance rate zone that corresponds to the areas of the 100-year shallow flooding with a constant water-surface elevation (usually areas of ponding) where average depths are between 1 and 3 feet. The Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zone AO

The flood insurance rate zone that corresponds to the area of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. The depth should be averaged along the cross-section and then along the direction of flow to determine the extent of the zone. Average flood depths derived from the detailed hydraulic analyses are shown within this zone. In addition, alluvial fan flood hazards are shown as Zone AO on the Flood Insurance Rate Map. Mandatory flood insurance purchase requirements apply.

Zone AR

The flood insurance rate zone that results from the decertification of a previously accepted flood protection system that is being restored to provide protection from the 100-year or greater flood event.

Zone D

Designation on National Flood Insurance Program maps used for areas where there are possible, but undetermined, flood hazards. In areas designated as Zone D, no analysis of flood hazards has been conducted. Mandatory flood insurance purchase requirements do not apply, but coverage is available. The flood insurance rates for properties in Zone D are commensurate with the uncertainty of the flood risk.

Zone V

The flood insurance rates zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no Base Flood Elevations are shown within this zone. Mandatory flood insurance purchase requirements apply.

Zone VE

The flood insurance rates zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone. Mandatory flood insurance purchase requirements apply.

Zones B, C and X

The flood insurance rates zone that corresponds to areas outside the 100-year floodplains, areas of 100-year sheet flow flooding where average depths are less than 1 foot, areas of 100-years stream flooding where the contributing drainage area is less than 1 square mile, or areas protected from the 100-year flood by levees. No Based Flood Elevations or depths are shown within this zone.