Developing a Web Site to Provide Geologic Data and Map Products for Allen County, Indiana

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INTRODUCTION

For more than a century, Indiana geologists have published their analyses and interpretations of geologic data in the form of static, printed maps. Such maps are useful, providing concise interpretations and fine cartographic detail in a compact, portable format. Recently, however, with the new technologies of digital maps and the Internet, geologists are able to present more information in the form of dynamic, versatile Web-based products to a variety of users, from those in government and industry to the general public. The Indiana Geological Survey (IGS) is currently using technologies such as Environmental Systems Research Institute Internet Map Server (ArcIMS©) and Spatial Data Engine (ArcSDE©), and Adobe® ColdFusion® to create a Web-based geologic data and map site for Allen County, Indiana, *http://igs.indiana.edu/AllenCoIndiana*.

Figure 1. Allen County is located in northeastern Indiana. Fort Wayne, the county seat, is the second-largest city in the state.

Allen County, located in northeastern Indiana (Figure 1), has an estimated 2005 population of 344,006 (U.S. Census Bureau, 2007), which includes the population of Indiana's second largest city, Fort Wayne. Interstates 69 and 469 are the dominant transportation corridors and connect the county to the rest of Indiana, as well as to Michigan. The high population density and major transportation corridors in the county make it a priority area for the IGS's mapping and outreach programs. The Allen County Web site will disseminate both interpreted maps and primary geologic information for a region whose societal and economic needs exert increasing pressure on natural resources.

INTERPRETED GEOLOGY AND PRIMARY DATA

The Allen County Web site provides written discussions, maps, images, and databases of geologic information and includes an Internet Map Server (IMS) (Figure 2). The IMS site provides a front-end to the IGS enterprise geodatabase, which contains information used simultaneously for research and general viewing. The ArcSDE geodatabase allows for the efficient creation, management, and distribution of data and maps.

Within the Allen county Web site, the IMS includes regional base map layers such as digital elevation model (DEM) terrain and high-resolution aerial photos from Indiana's 2005 Orthophotography Project. Landsat satellite imagery from the U.S. Geological Survey is also included. Additionally, the site provides interpreted maps from the IGS including surficial geology, drift thickness, bedrock topography, bedrock geology, and water-table elevation (from

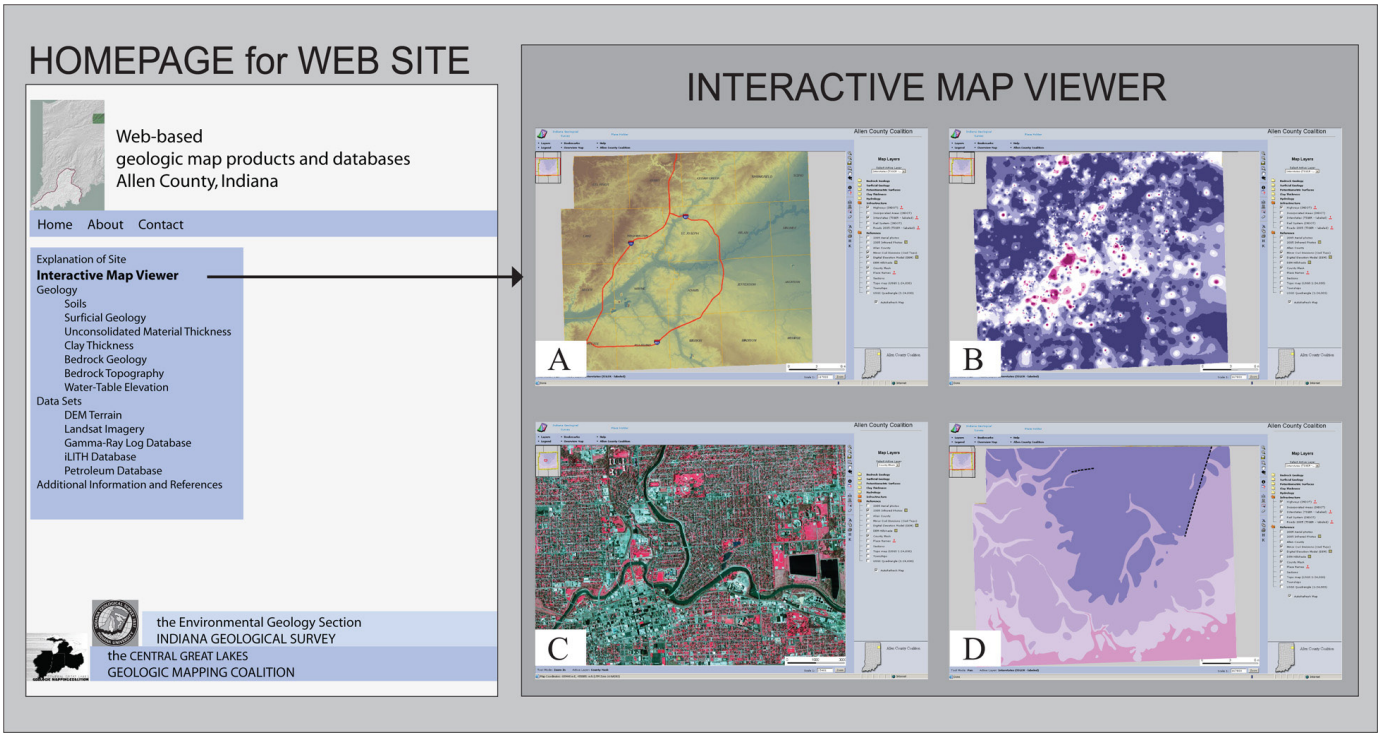

Figure 2. The Allen County Web site (to left) and some images from the Interactive Web Viewer. A. Digital elevation model of the land surface of Allen County. B. Clay thickness of the upper 50 feet of unconsolidated sediments throughout the county. C. Landsat 7 imagery of the Fort Wayne area. D. Map of the bedrock within Allen County, which is buried beneath varying thicknesses of unconsolidated sediments.

Fleming, 1994), and a clay thickness (0 to 50 ft) map generated from the IGS-standardized lithologic water-well data. Primary data provided at this site consists of: (1) the natural gamma-ray geophysical log data collected by the IGS; (2) the iLITH database (Brown and others, 2000), which contains IGS-standardized lithologic information from water-well records of the Indiana Department of Natural Resources, Division of Water; and (3) the stratigraphic test hole and petroleum-well records from the IGS Petroleum Database Management System (PDMS) (Indiana Geological Survey, 2007a) (Figure 3).

DATABASE INTEGRATION

The Allen County Internet Map Server is a GIS data portal that gives the user the capability to visually inspect and analyze the spatial data associated with the available geologic data sets. It also provides access to the attribute data. However, many types of information, such as well production histories or gamma-ray log data, cannot be stored efficiently in an attribute table associated with spatial features. A large amount of information can be associated with a single record and often this data can be more efficiently stored in a relational database containing multiple tables. Primary information can be attached as attributes of the record in the spatial data set, and additional information can be provided to users through links to an external relational database.

ColdFusion

ColdFusion® is a software package that can be used to query data from relational databases and display this information to the user via a Web browser (Figure 4). In this way, ColdFusion is similar to the ArcIMS© technology that is used to query and display spatial data. In the case of the Allen County Web site, ColdFusion is used to query the iLITH database, which contains the standardized water-well information. While the water well GIS data set contains the spatial location data, a Microsoft® Access® database contains more detailed information about the well location and other useful information, including lithology. The ArcIMS viewer displays the primary geographic data from the GIS data set by simply identifying a well, while ColdFusion uses a unique common identifier (well number) to query the Access database to retrieve all the information about that particular well and display it in a report format. This allows the user to access and display all the available information, whether it is contained in the spatial data set or an external database.

The PDMS provides a second example of using ColdFusion to link to an external relational database. The PDMS is an IGS Web application designed to distribute

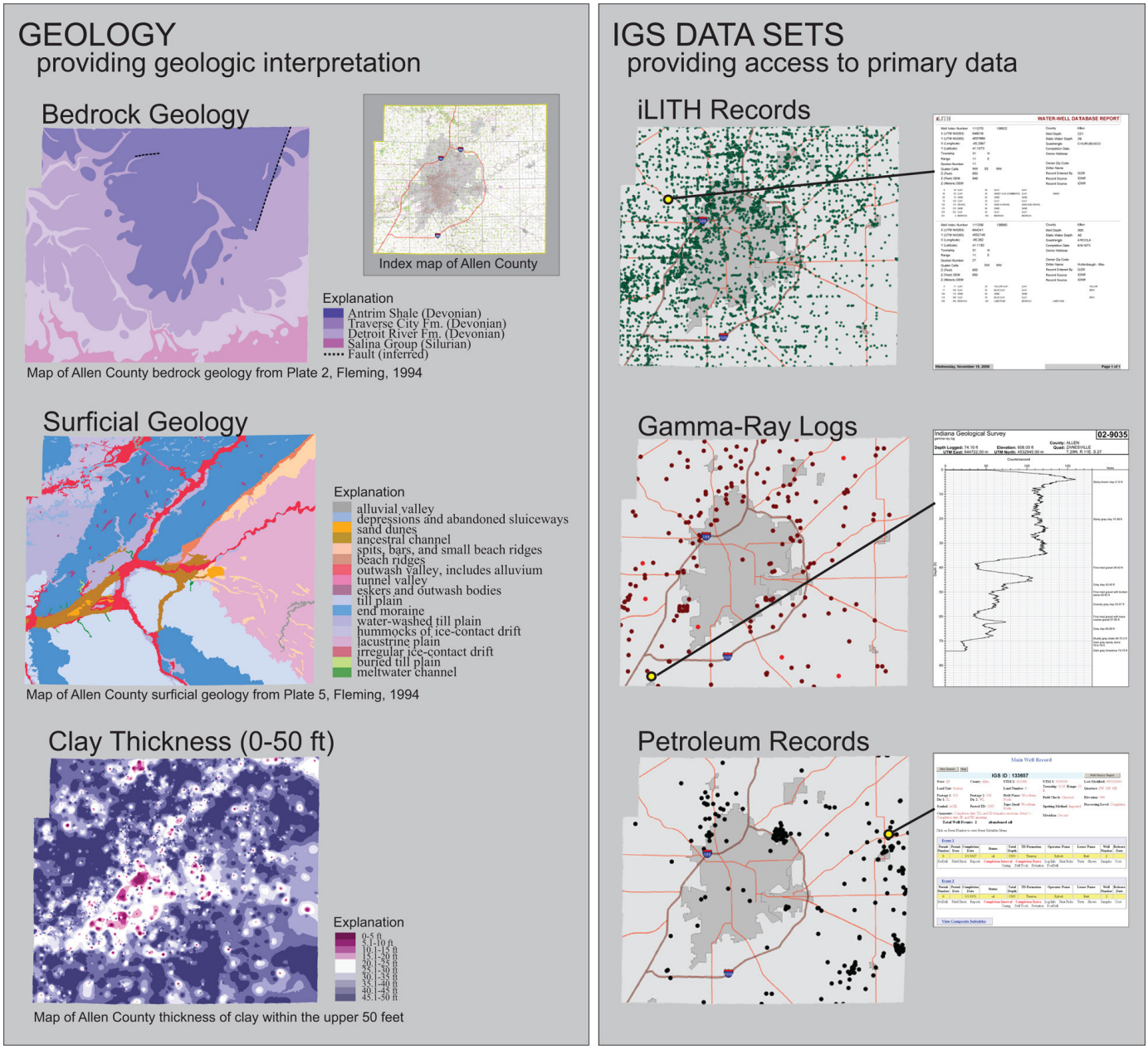

Figure 3. The Interactive Web Viewer provides geologic maps of the Allen County area as well as links to the gamma-ray log, water-well, and petroleum data used to make these maps. The combination of primary data and interpreted maps allows users to make their own interpretations.

petroleum-related information. The PDMS database contains extensive information on more than 70,000 petroleum-related wells drilled in Indiana and several adjacent states. The Allen County IMS site uses a ColdFusion link from the petroleum well layer to connect directly to the existing PDMS database and display detailed records for more than 200 oil and gas wells in the county.

GammaPlot

Gamma-ray logs provide users with the primary data from which to make their own geologic interpretations (Bleuer, 2004). The Allen County Web site allows users to view and download more than 200 records of gamma-ray data in Portable Document Format (PDF) and Long ASCII Standard (LAS) format.

The PDF files provide a visual representation of numeric gamma-ray data collected digitally in the field and stored as tab-delimited text files. Gamma-log curves are plotted using an IGS-created program, Gammaplot. The program uses tabbed spreadsheets to graph the numeric data and retrieve header information from the Gamma-Log Database, an internal IGS relational database that stores location and description information. The tabbed spreadsheets are also used to modify

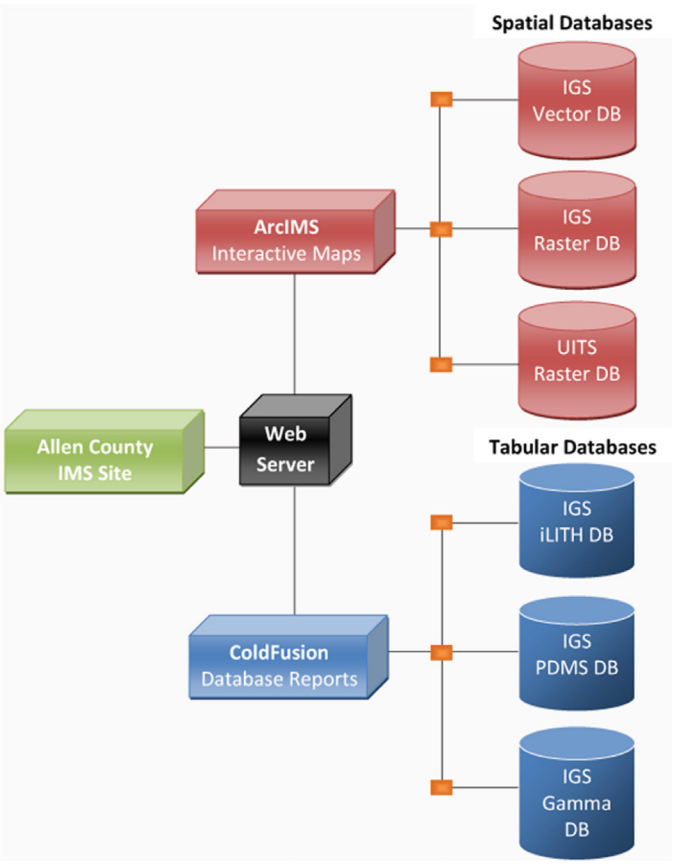

Figure 4. System diagram showing the relationship between spatial and tabular databases that support the Allen County IMS site. ArcIMS provides maps and associated attribute information, while ColdFusion presents tabular reports from related databa

the appearance of the gamma-ray log graph. Once plotted, the gamma-ray logs are printed to a PDF file.

In addition to PDF format, the numeric gamma-ray data can be downloaded as an LAS file, a standard format used primarily in the petroleum industry for plotting geophysical logs, *http://www.cwls.org/docs/LAS20_Standards.txt*. A custom application was developed by IGS staff to extract header information from the Gamma-Log Database, merge it with the numeric data, and convert it to a comma-delimited LAS file.

The PDF and LAS files can be accessed by identifying a gamma-ray log point in the IMS viewer using the information tool. The unique gamma-ray log number appears with the spatial attribute data and provides a link to the downloadable file.

ARCIMS Application

The tabular, nonspatial databases and the digital maps on the Allen County Web site are integrated using a single ArcIMS application (Figure 4). The IMS site accesses a variety of geographic and geologic information stored within the larger IGS enterprise geodatabase. This enterprise geodatabase provides most of the GIS layers for the IGS mapping sites, including A *GIS Atlas for Indiana* (Indiana Geological Survey, 2007b), which serves as a template for the Allen County Web site.

All the capabilities of the *GIS Atlas for Indiana* are retained in the Allen County IMS by simply placing a county mask over the statewide data, thereby displaying only specific information for Allen County. The statewide data is behind the mask, but does not interfere with the efficiency of the site. The link between the Allen County IMS and the larger IGS enterprise geodatabase allows the Allen County site to stay current because any routine updates made to the GIS Atlas site and databases will be immediately available to the Allen County site.

The *GIS Atlas for Indiana* started with an out-of-the-box ArcIMS HTML viewer more than 6 years ago and has since been customized by IGS staff to allow for more versatility. Improvements and additions to the ArcIMS viewer are made regularly in order to maintain a robust, user-friendly site. The customization includes making many of the standard tools and menu items easier to use. Some of the customized features available on the GIS Atlas site and the Allen County IMS site include: draw tools, bookmarks, hyperlinks, custom legends, and map output options.

The draw menu contains tools that enable users to add custom text and geometric shapes to the map view for labeling and analysis of specific cross sections or areas of interest. The text tool adds points to the map and associates text or coordinates with that point (Figure 5). Lines, polygons, and circles can be drawn on-screen with predefined measurements or simply by pointing and clicking on the map (Figure 6). These are graphics that may represent areas or locations of interest on the map.

The legends in the interactive viewer are customized to allow viewing of individual layer symbology in the Table of Contents (TOC) rather than having to toggle between a specific layer and the TOC (Figure 7). The layer symbology is represented by GIF images linked to the associated layer in the TOC. This customization also allows the user to choose the legend elements to be included in the final map layout.

Bookmarks and hyperlinks allow map users to create, save, and restore their own custom maps, as well as share them with colleagues. Bookmarks are saved in a Web browser and stored as cookies on the local computer. Hyperlinks are created in the map view from the Map menu and can be copied and pasted into an e-mail or other document, enabling an efficient transfer of data and ideas. Both links provide a means of "saving" a customized view of maps and data in the IMS. The links allow users to return to a custom view extent, with the predetermined layers turned on for viewing. Unfortunately, bookmarks and hyperlinks will not maintain the user-defined text or shapes shown in Figures 5 and 6. Users can, however, save their custom map, including text and shapes, as a JPG file for use in other applications such as a GIS. Once the image is saved, a dialog box appears with information to create a world file for georeferencing. This world file information can be copied to a TXT file and saved as a JGW file.

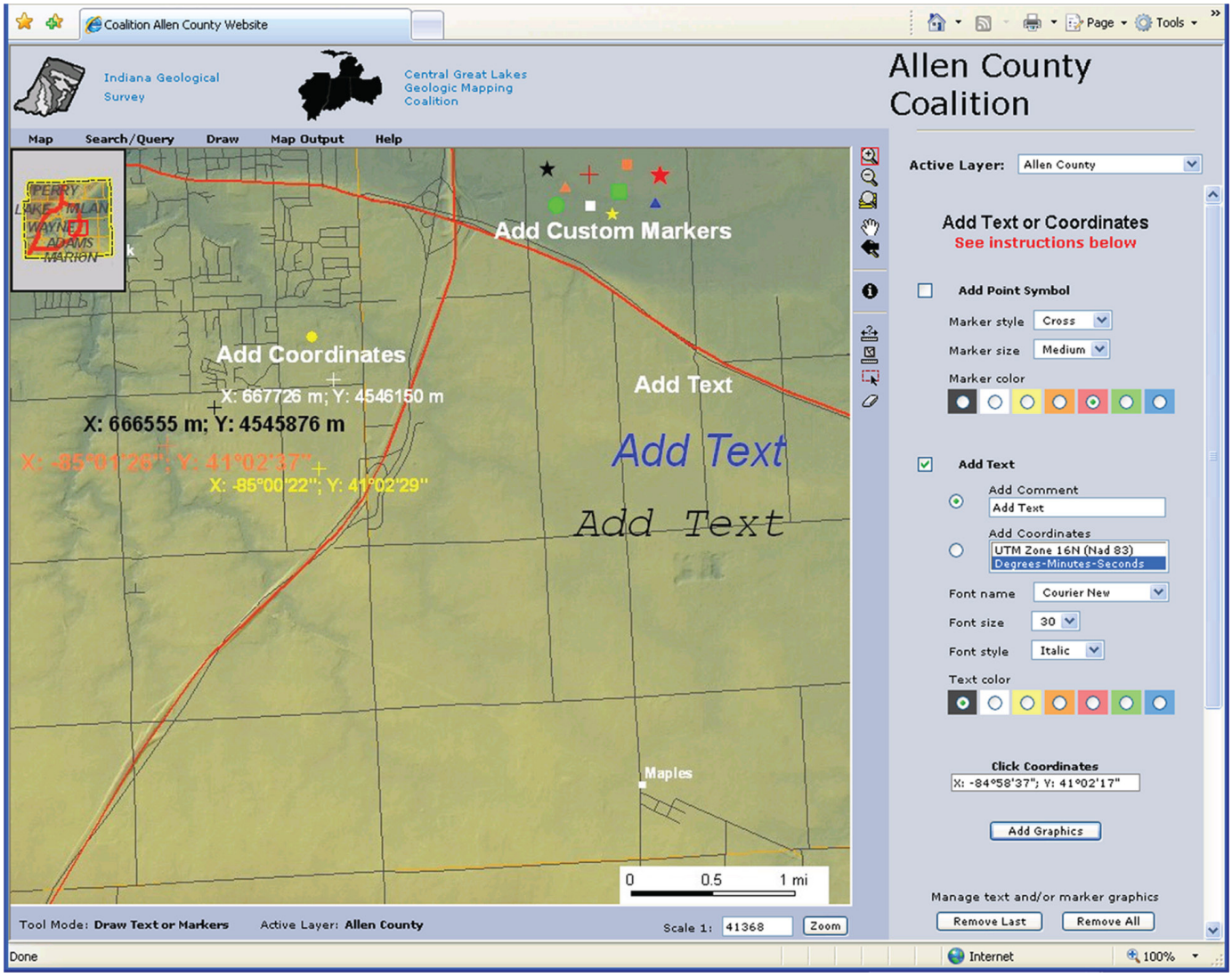

Figure 5. The custom text and marker tool allows users to select from a variety of font styles and scales, as well as points with different shapes, sizes, and colors.

The print dialog gives users additional options for map output. It allows for layouts for standard printers, as well as custom layouts for large-format plotters. Once the print dimensions are defined, the layout is automatically adjusted to fit the page. The print dialog box also gives the option of which map elements to incorporate in the layout, including title and legend elements. This feature provides users with a high degree of flexibility in presenting their data.

SUMMARY

The IGS created this Web site to provide maps, images, and databases of geologic information for Allen County, Indiana. Data included on the site are (1) digital elevation model (DEM) terrain, high-resolution aerial photos, and Landsat imagery, (2) geologic and hydrogeologic maps, and (3) primary data from geophysical log, water-well, and petroleum-well records.

Using enterprise GIS and database technologies- including an Internet Map Server, Microsoft SQL Server, and ColdFusion, the IGS is able to present data in the form of dynamic and versatile interpretive maps along with raw "primary" geologic information to an expanded group of users within Allen County, throughout the state of Indiana, and across the nation. The IMS site provides a front-end to the IGS enterprise geodatabase, which contains information used simultaneously for research and general viewing. The ArcSDE geodatabase allows for the efficient creation, management, and distribution of the data and maps. Through links to ColdFusion, the site also allows direct access to other IGS enterprise database systems containing petroleum well records, gamma-ray logs, and water well information. The combination of these spatial (geodatabase) and traditional database technologies allows users to access more information than ever before. By making

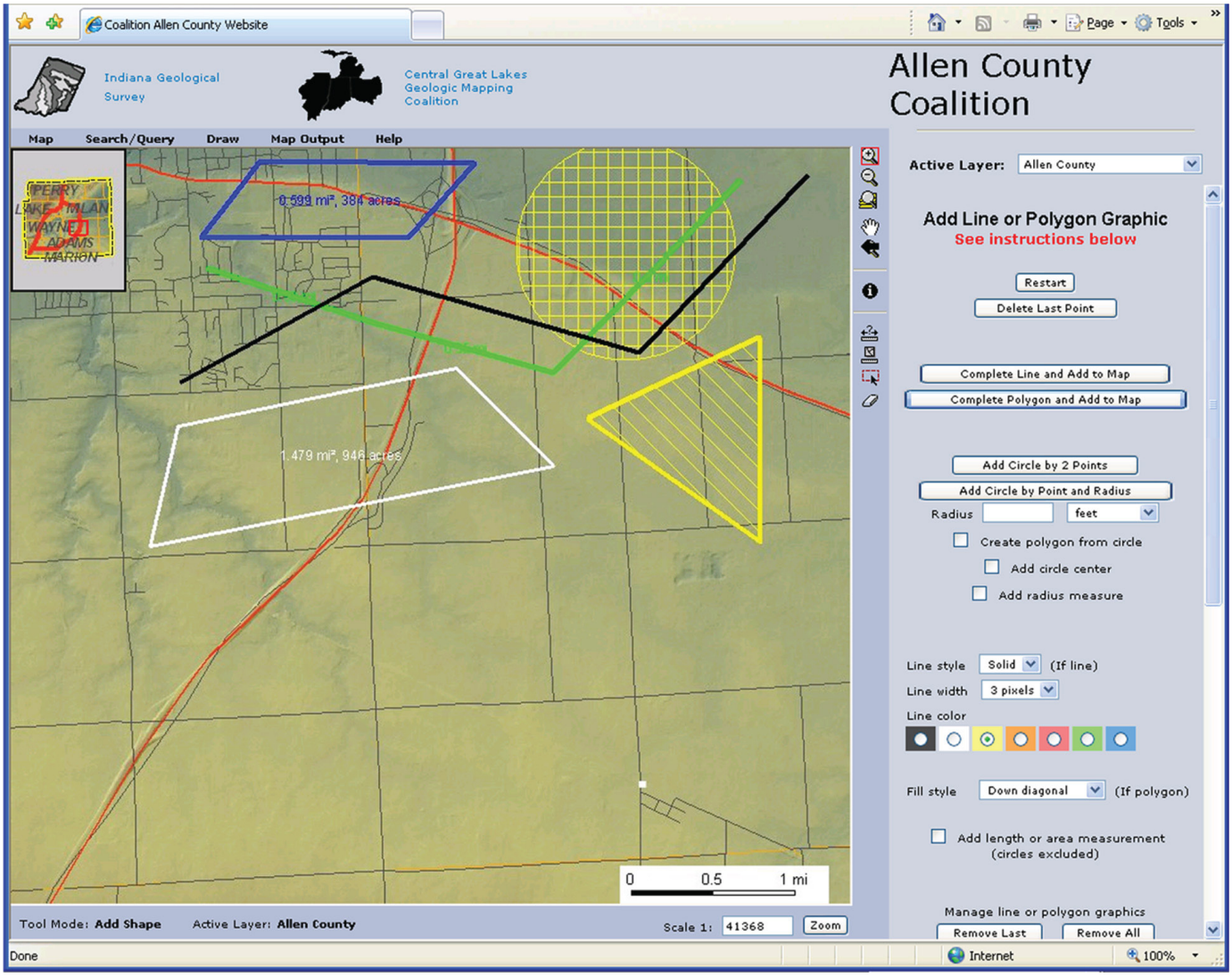

Figure 6. A variety of geometric shapes (i.e., lines and polygons) can be added to the map to define a cross

primary geologic data such as well records and gamma-ray logs widely available on the Internet, the IGS is changing its paradigm for how we distribute geologic information to the public.

The IGS was able to use an existing ArcIMS template, the *GIS Atlas for Indiana* IMS site, and adapt it to create the Allen County site. All the capabilities of the GIS Atlas site are retained in the Allen County IMS by placing a county mask over the statewide data, thus displaying only specific information for Allen County. The link between the Allen County IMS and the larger IGS enterprise geodatabase allows the Allen County site to always be current because updates made to the GIS Atlas site are immediately available to the county site.

The ArcIMS HTML viewer used for the GIS Atlas and Allen County IMS sites has been customized by IGS staff to make many of the standard tools and menu items more user-friendly and versatile. Some of the customized features available on IMS sites include: draw tools, bookmarks, hyperlinks, custom legends, and map output options.

ACKNOWLEDGMENTS

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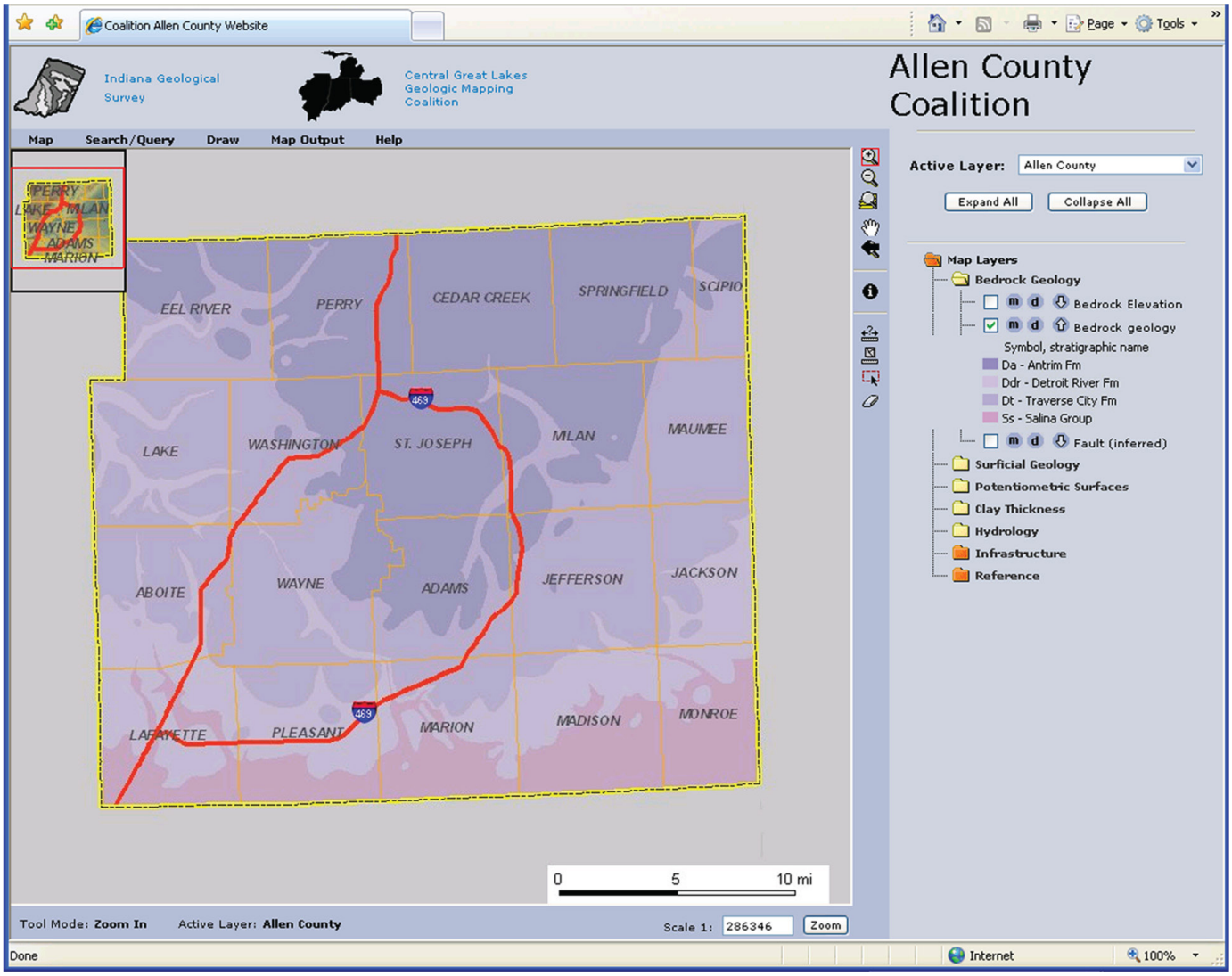

Figure 7. The custom legend in the interactive viewer allows the user to simplify viewing by activating layers from within the TOC.

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ColdFusion—Adobe Systems Incorporated, *http://www.adobe.com/*.

Microsoft Access, SQL Server—Microsoft Corporation, *http://www.microsoft.com/*.