An Internet Browser-Based Mapping Application for Improving Mine Safety in Virginia[1]

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Abstract. The Virginia Department of Mines, Minerals, & Energy is developing a comprehensive, spatial database of mining, minerals, and energy in the Southwest Virginia coalfield. A searchable web-based mapping system, based on AutoDesk's MapGuide server, has been established to provide a graphical tool to access georeferenced mine maps and related mine data critical to supporting Virginia's strategy to reduce mine safety risks. The MapGuide application is a relatively low-cost platform that provides the ability to share raster images, ESRI shapefiles, AutoDesk drawing files, connectivity to external database layers, and other complex spatial data sources concurrently and seamlessly. MapGuide also offers users a highly customizable user interface.

Additional Key Words: Web-Based Mapping, GIS, Abandoned Mine Maps

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Introduction

The Department of Mines, Mineral and Energy (DMME) has implemented web-based map viewing applications based on Autodesk MapGuide®. Through these applications, DMME users may view a collage of GIS data from various internal and external sources. This application provides rapid and easy access to massive amounts of data in both raster and vector based data sets. This paper describes the background for this application creation, the tools and infrastructure used, how it was interfaced with other systems, as well as some of the custom functionality added to provided increased utility.

Agency Background

The Department of Mines, Minerals and Energy's mission is "to enhance the development and conservation of energy and mineral resources in a safe and environmentally sound manner in order to support a more productive economy in Virginia." In order for our staff to accomplish this mission, DMME must provide tools to search, review, analyze and understand what active and abandoned mine workings exist in the state of Virginia and how those activities relate to other land uses.

Customers

DMME mine engineers, inspectors, technical specialists, and other staff frequently receive requests for information from engineers, consultants, mining companies, contractors and citizens concerning previous mine history for specific areas either adjacent to existing mine works or areas of new mining. DMME personnel frequently review active mine sites, as well as adjacent mine workings as part of their mine safety regulatory responsibility. DMME provides technical assistance, inspections and reviews in order to assist mine operators and owners in maintaining safe operations for its workers. Citizens contact DMME directly for issues and complaints related to subsidence, water loss, or other surface and underground mining-related problems.

Problem Statement

DMME staff and other mine operators and engineers require a method for searching and displaying large volumes of scanned mine maps for abandoned and active mine workings. Virginia has a large number of abandoned overlapping mine works with large inventory of associated mine maps (18,000+ and growing).

Solution

DMME's Digital Mapping Work Group selected Autodesk's MapGuide to provide web-based access to DMME GIS data. Web-based mapping was seen as a good option for providing a single and comprehensive tool for accessing DMME's various and complex GIS data through a single seamless user interface. One of the first data sets to be developed for MapGuide use was the DMME Abandoned Mine Map Inventory data. This data set is currently under development by DMME with the assistance of a Federal

Mine Safety and Health Administration (MSHA) grant. DMME considered ESRI's IMS® web solution a viable alternative, but MapGuide was selected due to its lower cost of acquisition. Due to the number of maps, scans, and data sources, server-based delivery offered a number of benefits over traditional full blown desktop GIS applications such as ESRI's ArcView®, ArcGIS®, and AutoCAD MAP®. Client tools are more expensive per user when compared to MapGuide® as well as requiring significant specialized individual training. MapGuide® is much easier to use and operate for the novice GIS user as most DMME inspectors have operation backgrounds from their respective industries rather than formal GIS training; few, if any, have advanced technical expertise in GIS applications. Desktop Client GIS client applications also require much faster network bandwidths to use large remote GIS data sets. The faster bandwidth requirement is critical to DMME staff since its users are located in six remote locations and frequently work from offsite locations. In addition, desktop-based GIS client software is more difficult to customize to DMME's requirements. The database interfacing and web connectivity of thick client software is limited when compared to web-based GIS tools. It is also much easier to deploy software and functionality upgrades via a web-based user interface.

Technology

In order to provide a user interface to access data developed in the DMME Abandoned Mine Map Inventory Project, a method for providing access to the scans and data developed under this project was immediately necessary. MapGuide was considered the best choice because DMME was using the software in work group settings and the upgrade cost was relatively inexpensive (~$2500). This affordability made it very attractive due to the low financial risk. MapGuide provides a web-based user interface for accessing data from a variety of data sources. These sources include Raster Image files (TIFF, JPEG, etc.), ESRI shapefiles, Autodesk drawing and SDF files, SQL and Oracle databases, Access databases, including other data sources via Microsoft® ODBC connectivity.

MapGuide was initially configured to provide DMME staff with access to map scans, mine polygons, and other related spatial data sets. The DMME Division of Mineral Resources has created Autodesk SDF (Spatial Data File) files that contain polygons for all underground coal mines depicted on mine maps georeferenced in the Mine Map Inventory Project. DMME has also created tools to interface the scanned mine map images with the mine outline polygons. This provides end users with the ability to display both the mine outline and the associated georeferenced maps (Fig. 1). Maps which have not been georeferenced but are associated with the mine polygon are available via HTTP based file downloads through the SDF polygon mine map report (Fig. 2).

Figure 1. Scanned mine maps overlaying mine extent polygons

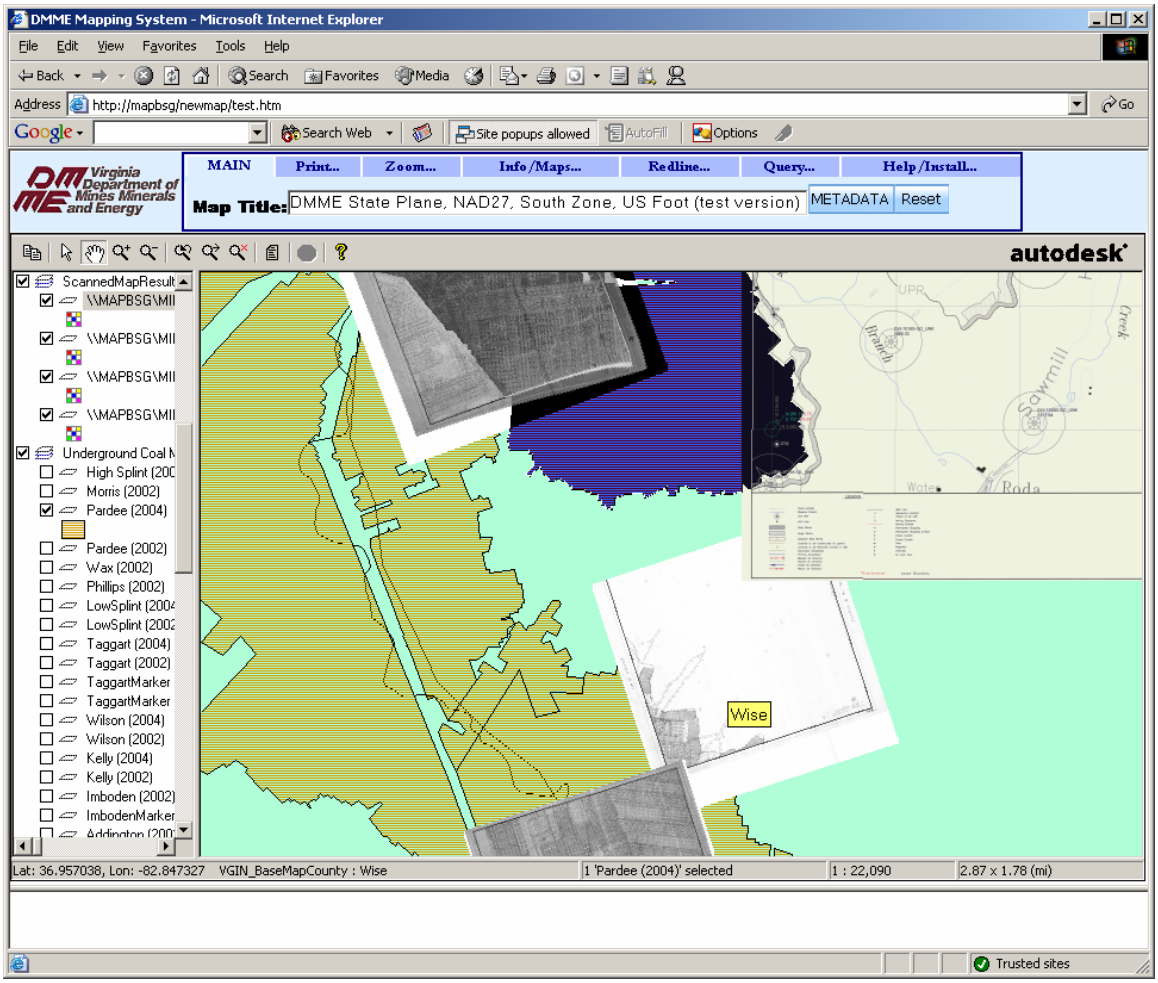
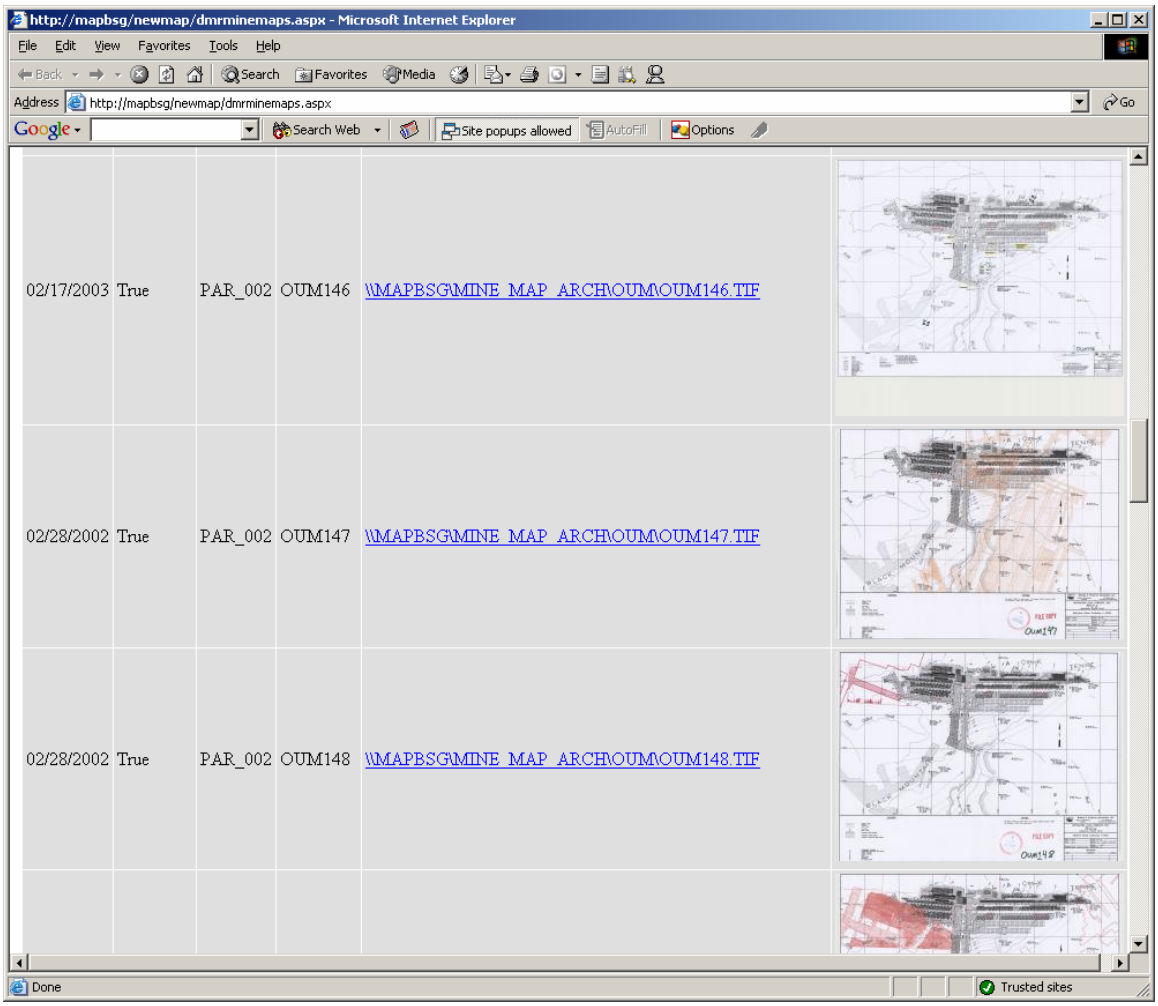


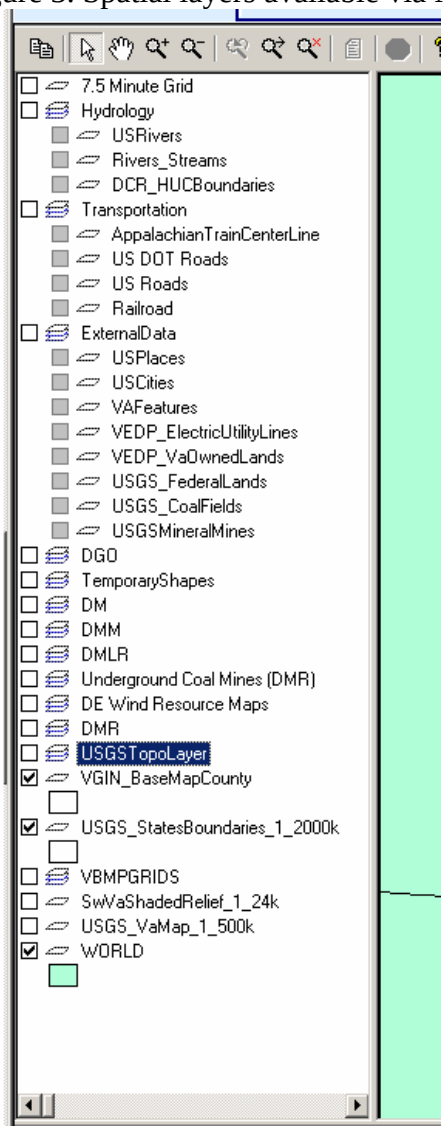
Figure 2. Mine map report with thumbnails of map images, date, index number, and map number.



Additional related spatial layers have been established to provide DMME staff with related data such as:

1. hydrology, geology, and roads;
2. abandoned mined land areas;
3. USGS quad grids;
4. mine portals and active surface mine permits;
5. gas and oil wells, railroads, gas pipelines;
6. Virginia USGS GNIS geologic features;
7. USGS Digital Elevation Model based raster shaded relief map;
8. USGS topographic maps in AutoCAD drawing file format; and
9. high quality raster Orthophoto basemaps produced by Virginia Geographic Information Network (VGIN) (Fig. 3).

Figure 3. Spatial layers available via MapGuide server to DMME staff



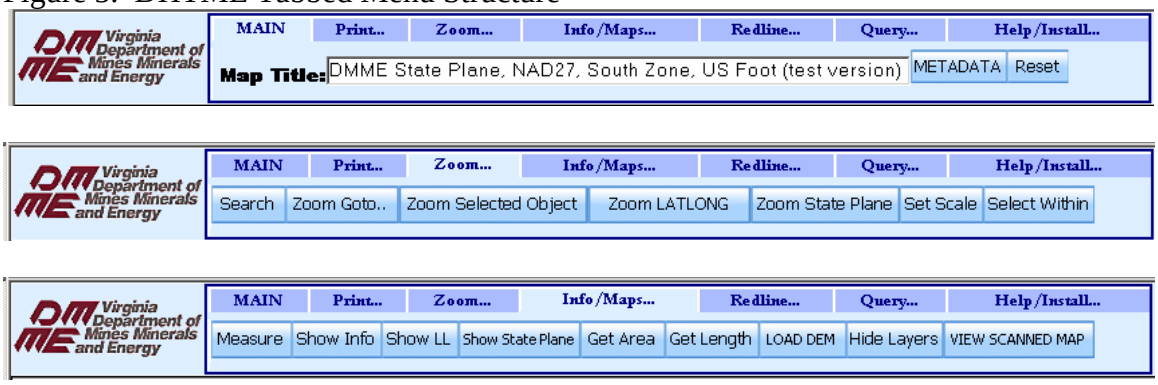
Utilities

The MapGuide ActiveX control provides basic operations via its toolbar (Fig. 4). These functions were extended using the MapGuide API (Application Programming Interface). DMME has also developed several other enhancements and utilities to the MapGuide environment in order to provide necessary functionality. Samples of these functionality upgrades have been included to provide some additional background on the capabilities and limitations of the MapGuide application platform.

Figure 4. MapGuide ActiveX Control Toolbar

A DHTML (Dynamic Hypertext Markup Language) menu system was developed to provide end users with a clear and easy-to-use interface to the custom MapGuide API functionality. This menu system is based on a tab structure with image-based buttons (Fig. 5).

Figure 5. DHTML Tabbed Menu Structure



XML Metadata Integration

DMME has created an XML Metadata repository to provide end users with direct access to DMME's metadata. This catalog has been combined with the MapGuide user interface menu to provide direct access from MapGuide spatial layers to the associated XML catalog record (Fig. 6). In order to display the associated XML catalog entries, an FGDC (Federal Geographic Data Committee) XSLT (Extensible Stylesheet Language Transformations) stylesheet is used to present the XML catalog file to the end user (Fig. 7).

Figure 6. Metadata Search Tool

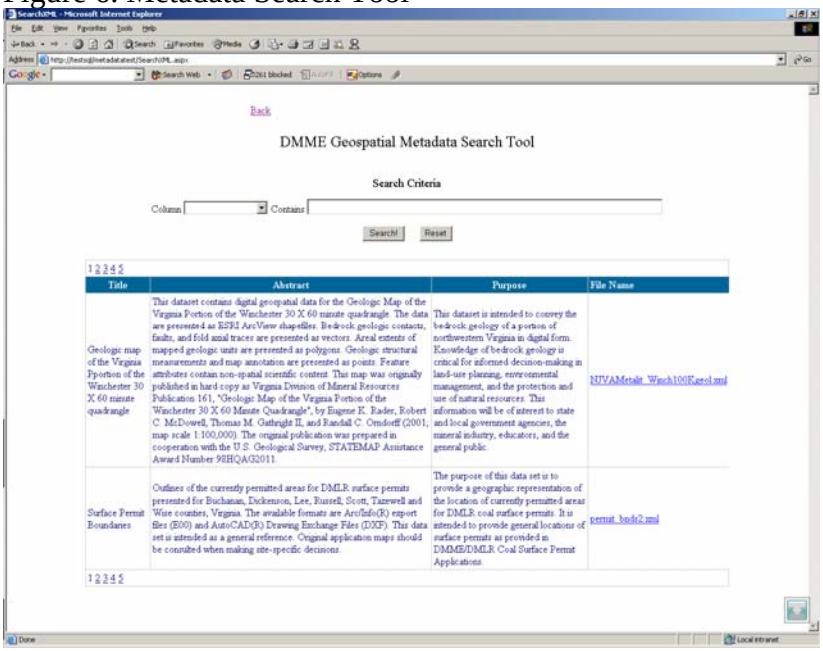
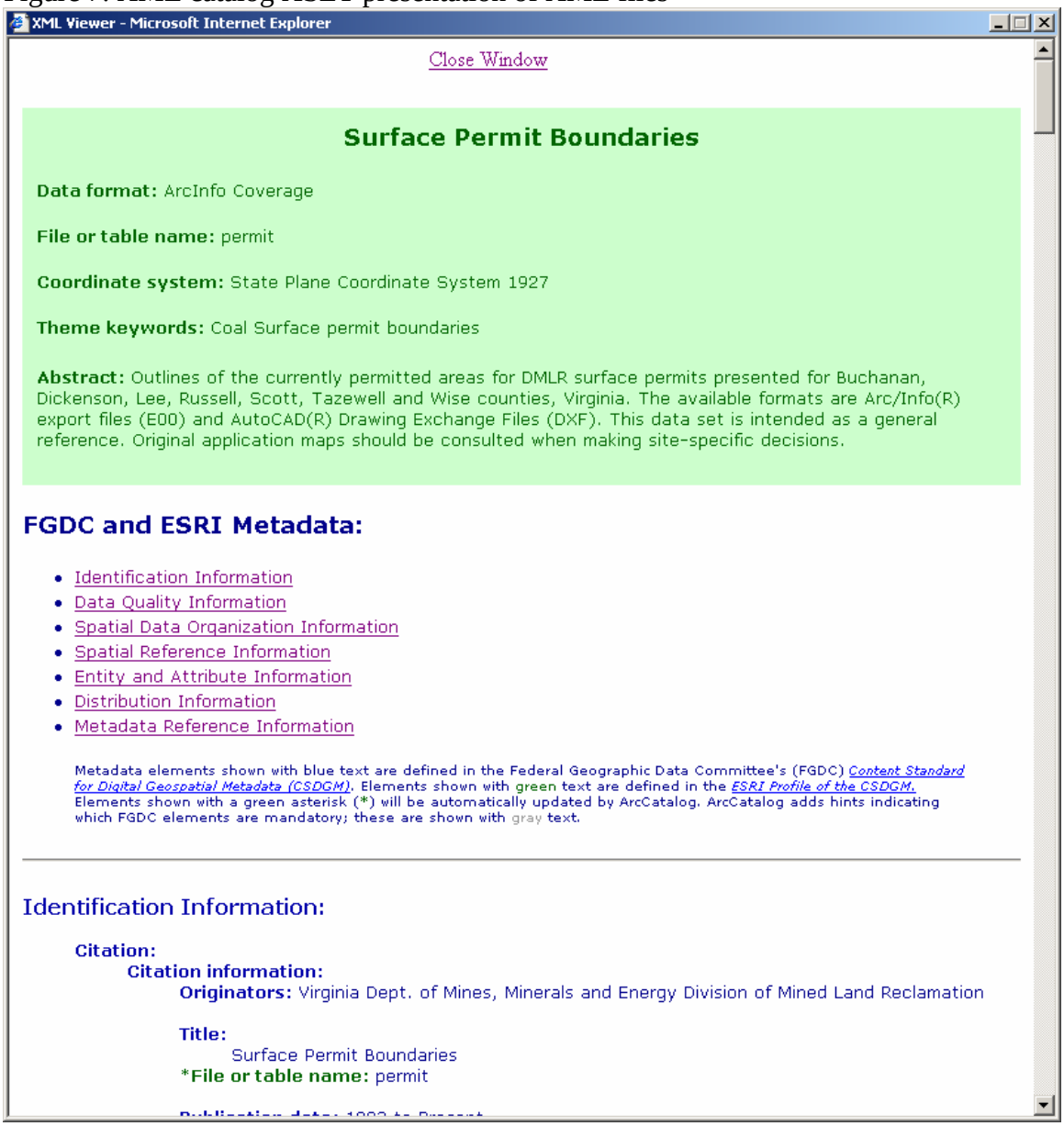
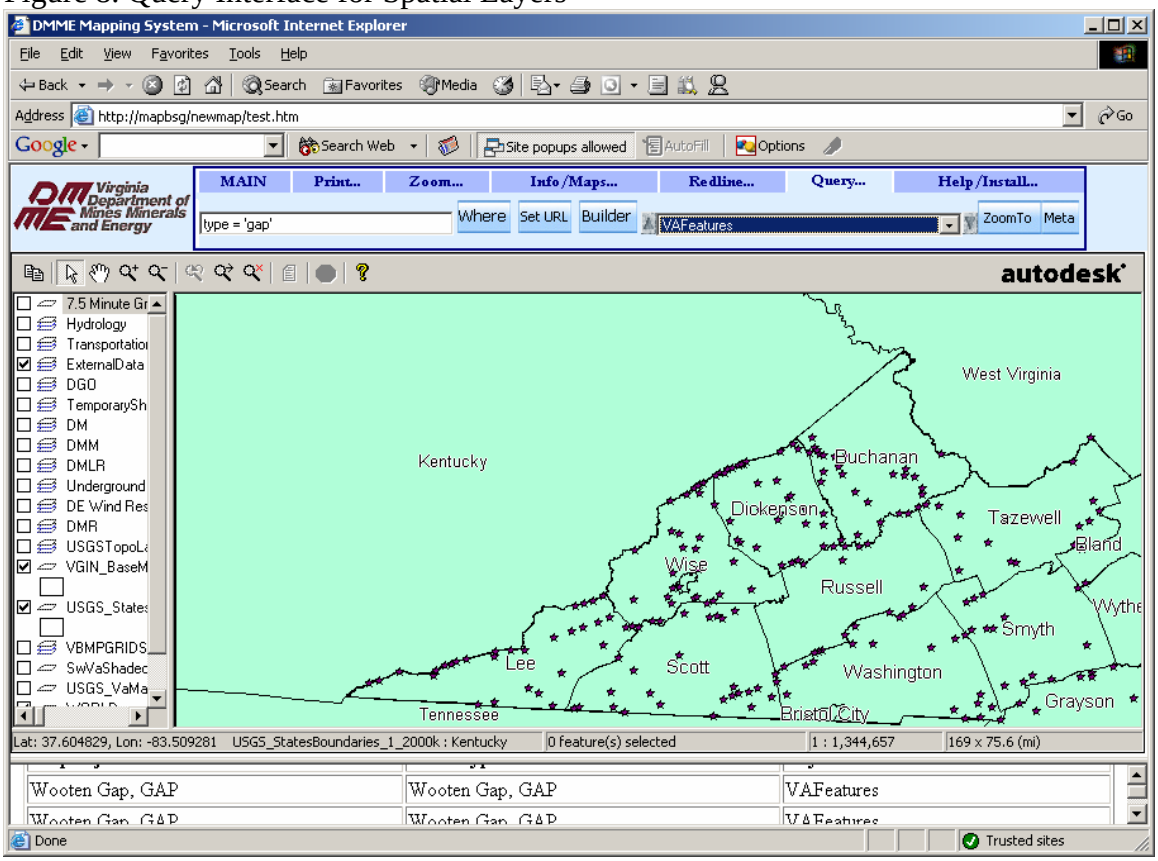


Figure 7. XML catalog XSLT presentation of XML files



Customer Layer Query functionality was developed to provide end users with the ability to limit the display of spatial data based on “where” clauses. A query builder interface was provided to assist users with syntactic construction of SQL (Structured Query Language) based “where” clauses. This allows users to perform simple filters on data such as type = ‘gap’ or type = ‘cemetery’ (Fig. 8).

Figure 8. Query Interface for Spatial Layers

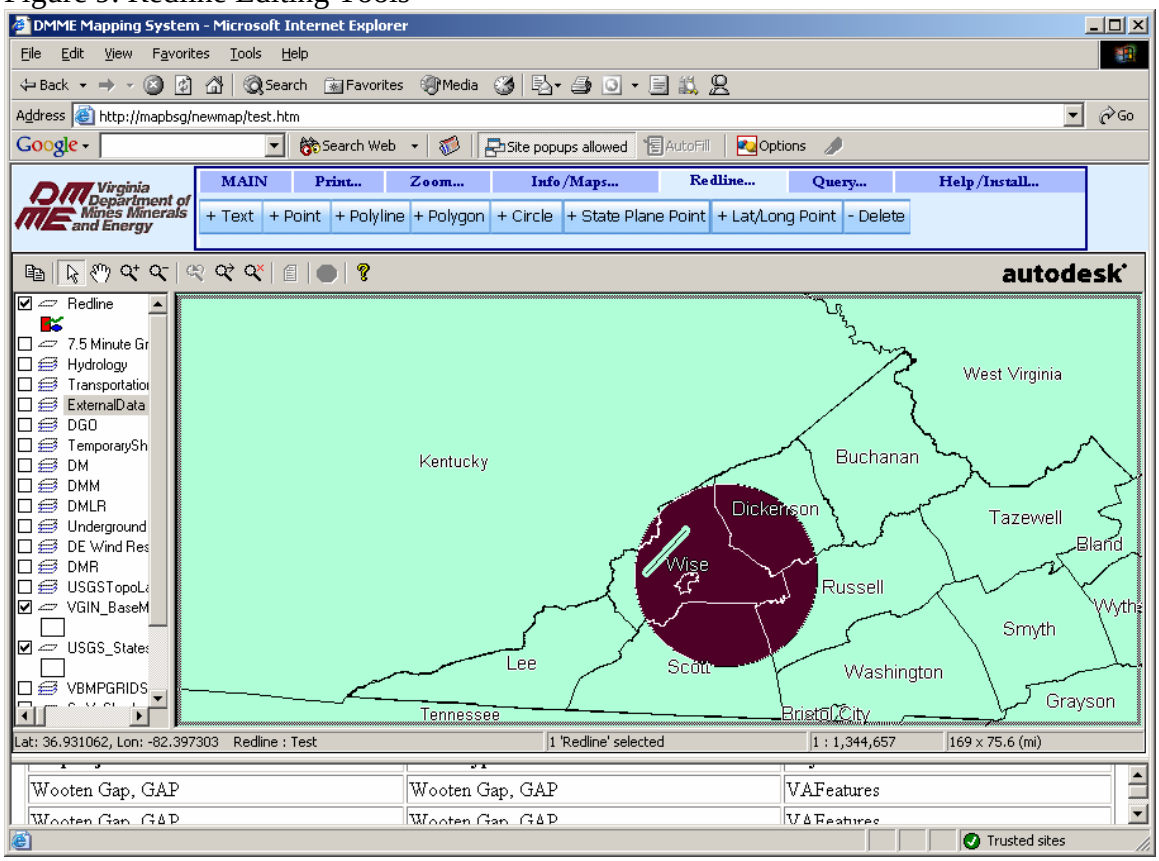


End users frequently have a need to hide overlapping layers in order to see data from lower spatial layers. In order to assist with this a “Hide Layers” button was added which permits the user to select any map object or objects and click “Hide Layers”. All features associated with the spatial layer are then hidden, thereby removing the obscuring layers from view.

By default, all expanded MapGuide layers and groups provide a very long list that extends past the viewer legend area. The MapGuide HTML page automatically collapses all layers and groups at start in order to simplify the view.

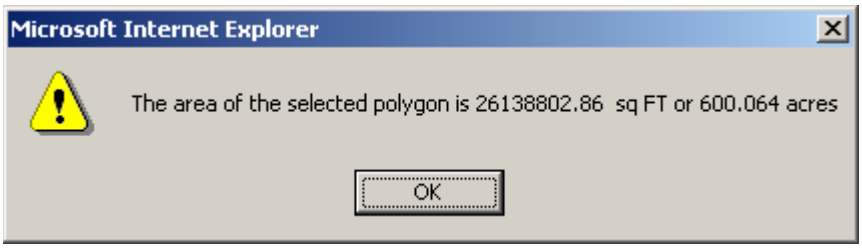
Simple primitive editing functions have been added to provide a rudimentary redline editing function. These include point, circle, polygon, polyline, add state plane point, and add latitude and longitude point to map (Fig. 9).

Figure 9. Redline Editing Tools



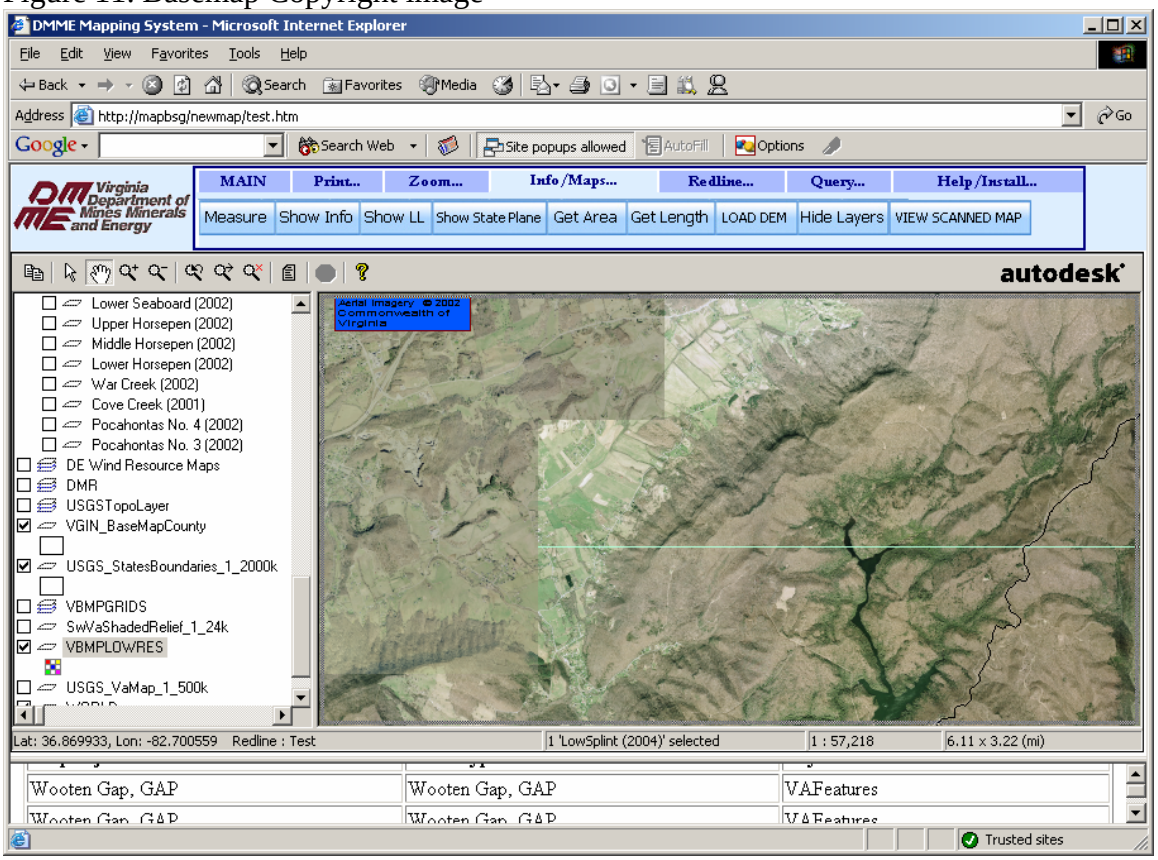
A basic measure tool is provided in the MapGuide client functionality. This tool allows distance to be measured from one digitized point to another. DMME has added additional functions to the application via the MapGuide API to provide polyline length and polygon area calculation (Fig. 10).

Figure 10. Get Area function



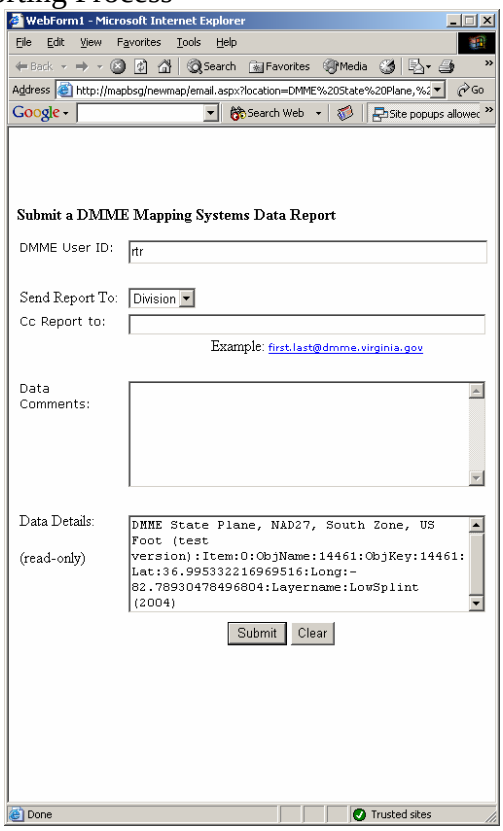
The VGIN orthophoto images provide DMME with very detailed basemap imagery. This imagery data is copyrighted by the Commonwealth of Virginia and DMME staff must include a VGIN copyright statement whenever these data are printed. In order to assure compliance, a copyright watermark has been configured through JavaScript to display automatically when imagery from the basemap is shown (Fig. 11).

Figure 11. Basemap Copyright image



In order to assist DMME staff with correcting data errors identified by end users, a Map Data Error Reporting function was developed to provide feedback concerning MapGuide spatial data/features. End users may select any object or group of objects and click the “Report Error” button. This will then provide an automated message with all necessary details of the selected MapGuide object and the currently active spatial layers to that division’s data custodian. End users need not know the specifics of the data layer to report errors (Fig. 12).

Figure 12. Error Reporting Process

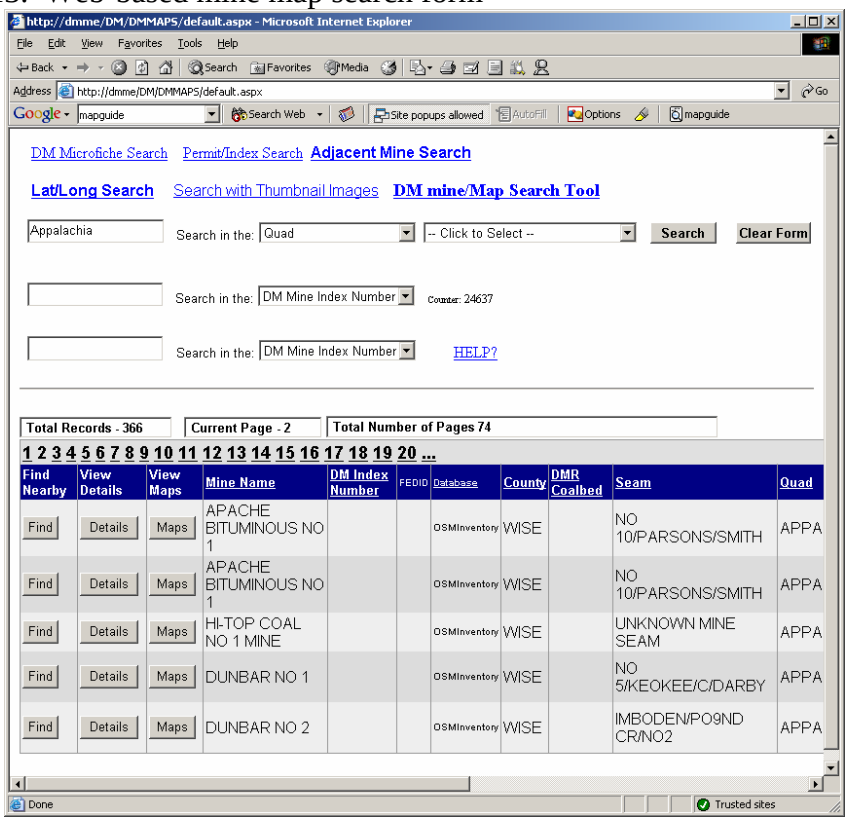


MapGuide provides a useful “Zoomgoto” functionality that allows users to zoom directly to a map feature based on an index or key. To improve this functionality, DMME has developed a search (visible layers function) that extends this zoom function to allow any and all layers to be searched simultaneously for a feature key/name.

Other functionality enhancements developed include an interface to a USGS Digital Elevation Model viewer on a USGS quad sheet basis, layer sorting, zoom to selected layer extents, printing customizations, show latitude and longitude for points, show state plane coordinates for points, display information on selected object, choose the data table column returned, and several other smaller functions.

In order to assist DMME staff with locating mine maps that have not been georeferenced, a text web form has been established to provide a search engine for DMME’s existing mine map inventory data. The application is ASP.NET-based and was developed by DMME Information Systems staff. This application has had 28,000+ hits since its introduction to the agency a little over 24 months ago. This tool allows employees to search by many different fields, such as index number, mine name, county, coal seam, and location description using keyword and dropdown lists. End users may display or download the mine maps from the interface for viewing and printing (Fig. 13).

Figure 13. Web-based mine map search form



Staffing

DMME has developed the DMME web-based mapping system utilizing an agency internal workgroup. The DMME Digital Mapping Work Group is made up of engineers, geologists, and information technology staff members. This system has been setup over a three-month period with members working on an ad hoc basis to establish system requirements. Software development has been performed by the agency's Office of Management Information Systems.

Software

The implementation of a DMME web-based map viewer is made up of several software products. Autodesk MapGuide Server 6.3® provides data layers and data connection services for spatial layers. Autodesk MapGuide Author 6.3® provides a mechanism for spatial data authors to publish layer data via .mwf (Map Window Files). Map Window files associate data layers with data served from the MapGuide server platform. This tool also provides symbology and layer customization functionality for published spatial data files. Microsoft Frontpage 2003® is used to develop the .htm files that are used to provide end users with enhanced API functionality, as well as the basic MapGuide user interface and the MapGuide® ActiveX control.

In order to run reports and to provide interfaces to other DMME applications, the Microsoft ASP.NET Framework 1.1® has been installed on the MapGuide server. The

server operating system used for the MapGuide application server and Web services is the Microsoft Windows 2000 Advanced Server®. Microsoft Internet Information Server version 5.0® was used to host the HTML and .mwf files on the MapGuide application server. Microsoft Web Matrix 0.6® (beta) was used to create some of the rudimentary reports and applications used to interface with MapGuide. Visual Studio.Net 2003 was also used to develop ASP.NET applications for end users. DMME's browser of choice is Microsoft Internet Explorer 6.1®. It should be noted that MapGuide® offers a thin raster-based HTML client via MapGuide LiteView, a JAVA-based MapGuide control, a Netscape® Navigator control, and an ActiveX client control. The ActiveX control provides the most end user functionality. HTML and JavaScript were used to create the MapGuide® application pages. Microsoft® ASP.NET and VB.NET were used to create applications and interfaces from MapGuide® to other applications.

Benefits

Although DMME's implementation of MapGuide® is still relatively new, the usefulness of this application is apparent to DMME members staff almost immediately. The MapGuide application platform has allowed DMME to rapidly and inexpensively develop a useful tool for visualizing data from numerous data sources in a cohesive and seamless manner. The MapGuide server provides direct access to nearly 6TB (Terabytes) of digital information via an easy-to-use web interface. End users accessing MapGuide from remote sites can view extremely large raster image files, as well as accessing large AutoCAD drawing files, Microsoft SQL Server® based data layers, Microsoft Access® JET database (.mdb) based layers, and many other layers. The biggest limitation of MapGuide® is it can only display raster images based on one coordinate (e.g., NAD27) system per .mwf file (Map Window File). Additionally, end users do not need to know how the data were produced, how it was published, or how to combine data from other diverse data sets, or how to maintain the configure and update of the layers themselves.

MapGuide® has enabled DMME users to rapidly search and identify relevant map features, identify nearby risks, potential hazards, as well as relevant regulatory spatial data and existing scanned raster map resources.

Conclusion

The DMME web-based mapping effort has provided DMME staff members with a GIS data visualization and analysis tool that is easy-to-use and relatively low cost. The MapGuide based applications have been relatively simple to customize due to the MapGuide® API and its ease of development utilizing HTML and JavaScript. DMME continues to develop new functionality based on the MapGuide interface. These new functions include web-based reporting of non-GIS data sets using queries from the MapGuide spatial data sets, such as reports on water monitoring data from Hydrologic Unit Code (HUC) boundaries. DMME's web-based mapping system has been well worth the time and effort needed to establish it.