DRAFT -- To be published in DMT'08 Proceedings
(see http://ngmdb.usgs.gov/Info/dmt/)

Kentucky Field Data Entry Tools Developed in ArcIMS

By Gerald A. Weisenfluh and Douglas C. Curl

Kentucky Geological Survey
228 Mining and Mineral Resources Bldg.
University of Kentucky
Lexington, KY 40506-0107
Telephone: (859) 257-5500
Fax: (859) 257-1147
email: {jerryw, doug}@uky.edu

INTRODUCTION

Between 1996 and 2006, under the National Cooperative Geologic Mapping Program's STATEMAP program, the Kentucky Geological Survey's (KGS) digital mapping program compiled 707 geologic quadrangle maps into a seamless spatial database of geologic information for the state. These maps, originally published between 1960 and 1978, focus primarily on the bedrock geology of Kentucky—Paleozoic and Mesozoic sedimentary rocks. Delineation of unconsolidated deposits was only done in a generalized manner. These geologic data now support an Internet-based map service (Weisenfluh and others, 2005) that allows users to create customized geologic maps with overlays of a variety of related geoscience data maintained in KGS databases. Geologic map unit descriptions from the collars of the maps were also digitized into a database and can be accessed from the map and other searchable Web pages.

Once the digital compilation was complete, KGS shifted its STATEMAP effort to mapping the unconsolidated deposits of the state to support a variety of research activities related to land use and natural hazards mitigation. One of the products of this new mapping will be an additional geologic layer to overlie the bedrock geologic units. Two separate database needs have arisen as a result of this new activity. First, field geologists need to review existing well databases prior to mapping, in order to assess depth to bedrock and unconsolidated lithology recorded for those sites. This can be an extremely time-consuming activity given the large numbers of water, oil, gas, geotechnical, and coal exploration holes drilled in Kentucky. Second, as geologists collect new field data during mapping, it has become desirable to catalog that information in institutional databases to facilitate map preparation and to preserve data for future workers. This paper describes two Web-based ArcIMS programs developed to address these geospatial database problems.

HARVESTING WELL DATABASES TO SUPPORT SURFICIAL MAPPING

The challenge of utilizing well information from a variety of sources in order to assess unconsolidated materials arises from differing qualities of data and differing formats for recording it. Data quality is affected by accuracy of the recorded location and elevation, method of drilling, and the experience and care of the personnel recording the information. In general, the quality of lithology descriptions is better for geotechnical and water wells than for coal drill holes or oil and gas wells. The latter industries are not overly concerned with the composition of the surficial material, but merely need to case through it to prevent open-hole caving. However, there is also variability among wells of a given type that is dependent on the operator or their purpose. There are also differences in how KGS has digitized the records from each type of well.

For water wells and coal exploration holes, subsurface data have been entered into tabular databases for efficient retrieval. Oil and gas drillers' logs are scanned into an electronic image format, and most geotechnical hole information is only found on illustrations of project reports in PDF documents.

Application Requirements

Because the data review prior to geologic mapping involves a qualitative assessment of parts of existing documents containing well data, it was deemed necessary to preserve the results of the review in a new database. New tables were created to store information specific to depth to bedrock measures and lithologic character of the unconsolidated material. Individual geologists typically review data beyond the limits of the quadrangle being mapped; therefore, a way of denoting whether a specific well has already been interpreted was needed to eliminate duplication of effort when adjoining quadrangles are mapped. The application needed to be able to display the various formats of data under review and to extract parts of the legacy data into the new tables to eliminate redundant data entry. Finally, the site locations had to be viewed on a topographic map base so that elevation data in the database could be reconciled with topography.

Application Design

The data harvesting tool was designed as a customized ArcIMS Internet map service. The program uses the ESRI ActiveX connector to facilitate customized controls and database connectivity using Active Server Pages scripting (ASP) with Javascript and DHTML. The ArcIMS choice was primarily driven by the need to dynamically display site locations from a tabular database on a map, and because of previous experience with the same development environment. Both the source and destination database tables are located in the KGS enterprise SQLServer database. The map service was intended only for internal staff use, and therefore is protected by user login functionality. However, because it is a Web-based application, it can be accessed from any computer that can connect to the Internet, so that staff could use the application while in the field.

Geologists preferred to review one well type at a time, because of the different methods of processing each kind. The application contains a control to specify the quadrangle of interest and the well type for properly initializing the program. The application form (Figure 1) has four fixed windows. The upper left corner contains the map view that shows the locations of all existing wells of each type, along with a number of controls for managing the view extent and scale. The upper right window contains the controls to log in and specify area and well type of interest (not visible on Figure 1) and a list of wells of the specified type with controls to zoom to a site and to display and edit information for each well. The icons in the two leftmost columns indicate whether the record has already been reviewed. If data have previously been extracted for a well, the "show" and "del" buttons appear in the second column. When the "no data" message appears in the first column, it indicates that the record has been reviewed but contained no useful information for this purpose. Those records that only show the "view/edit" button have never been reviewed. The lower left window is used to display information about the selected well. This window usually contains tabular listings of well characteristics but may also contain images of documents, such as casing reports, drillers' logs, and geophysical logs. The lower right window is the data entry form (blank in Figure 1—see Figure 3 for an example) where harvested data are sent, and along with user additions are submitted to the new database. The interaction between the data display form and the data entry form depend on the well type and its associated data.

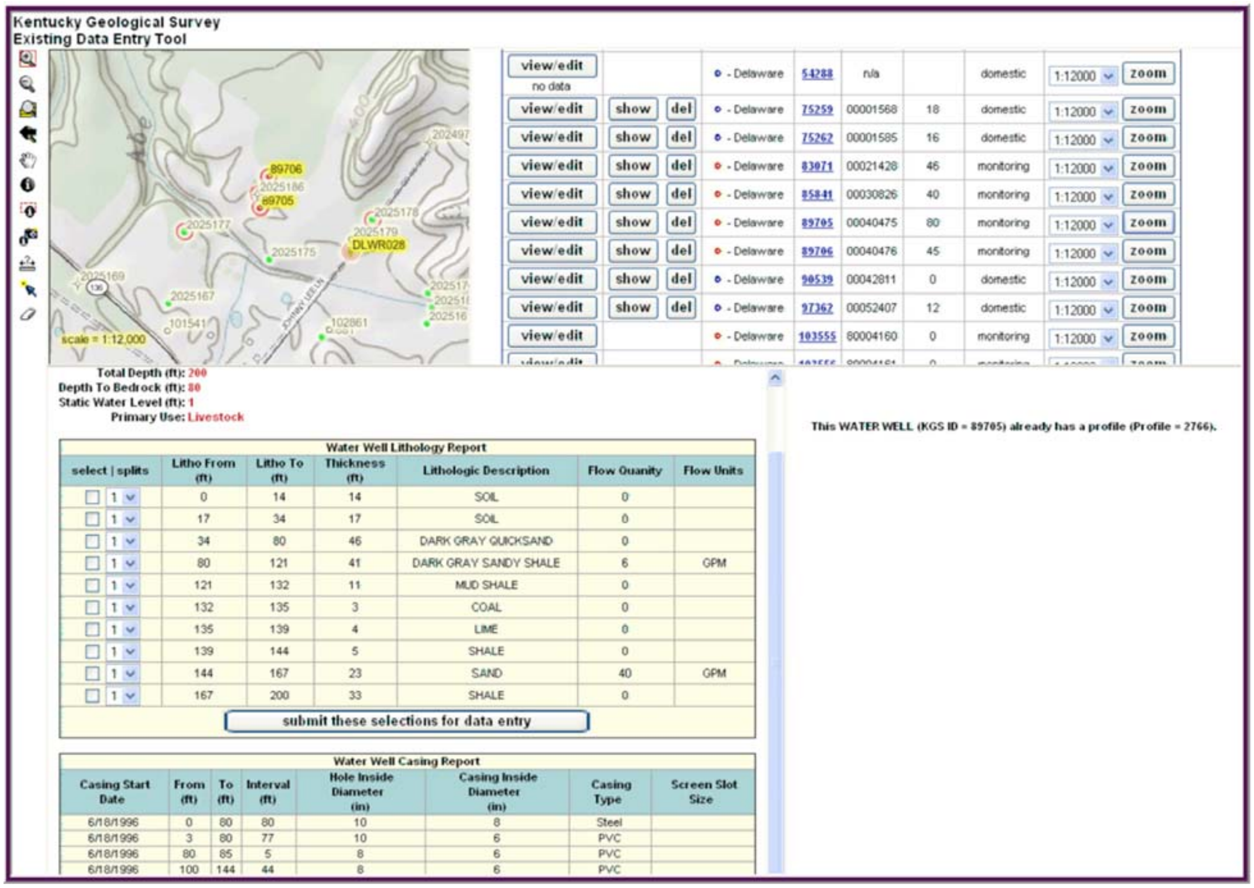

Figure 1. The main page of the KGS well data harvesting tool, showing an example display for water wells.

Processing Oil and Gas Wells

The KGS oil and gas database is structured so that information describing the well is stored in tabular form, but the details of subsurface intervals typically are not. Those data can be found in various documents that are submitted after well completion; these have been scanned and compiled into online image files. The only relevant information that can be directly harvested from the tabular database is the surface elevation—all other information must be manually entered after reviewing the available documents. Once the view/edit button is selected for a particular well, its documents are displayed in the lower left window. The geologist reviews both the driller's log (Figure 2) and the casing report to make a determination of depth to bedrock and the thickness and composition of one or more intervals of unconsolidated material. The number of lithologic intervals is then specified at the top of the right panel of Figure 2, which then builds a data entry form with the corresponding number of records (Figure 3) in the same window. The lithology type, description, and interval footages are manually entered into the form, and any comments relevant to the entry are added before the data are committed to the Quaternary database.

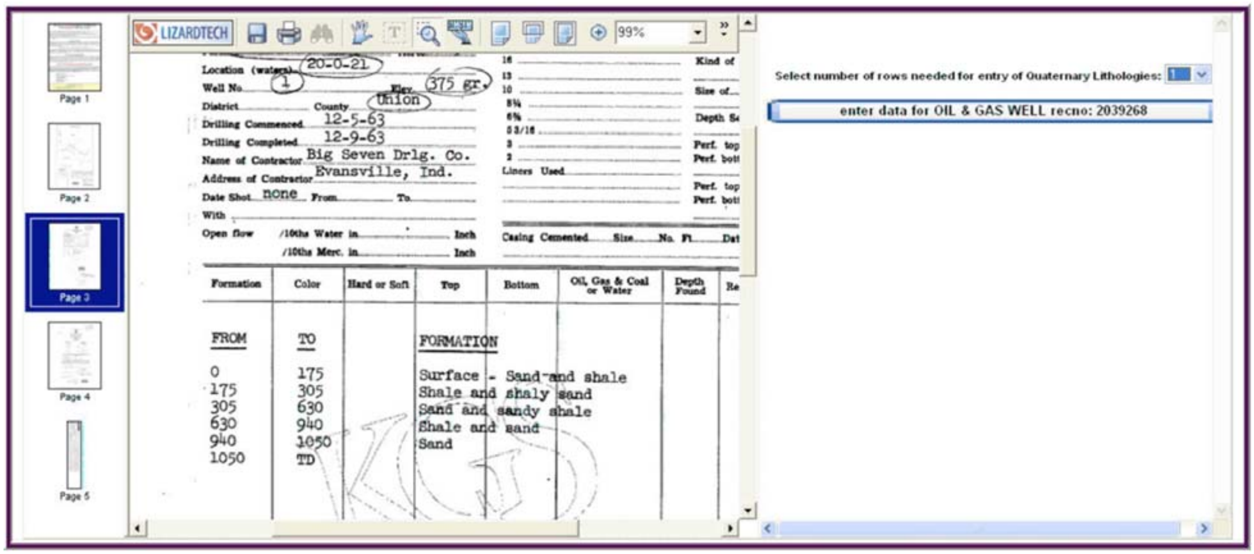

Figure 2. Lower half of application screen showing image of an oil and gas driller's log in display window (left) and control to initiate the correct number of interval entries (right).

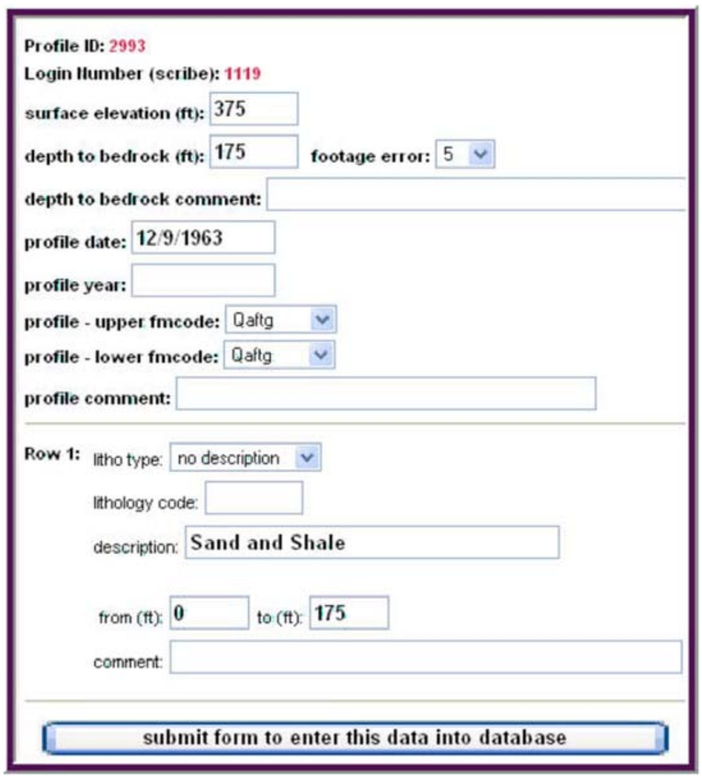

Figure 3. Example data entry form for oil and gas well, found in lower right part of the well data harvesting tool.

Processing Water Wells and Coal Exploration Wells

Unlike the database for oil and gas wells, the KGS water well and coal borehole databases contain tabular records of subsurface sediment and rock lithologies. For these well types, the existing database information is shown in the display window (Figure 4). The user only has to select which entries pertain to unconsolidated materials by checking the appropriate lines. In some cases, a single database entry may describe more than one lithology, and the option is presented to split the interval into two or more lines. Once these selections are submitted, the data entry form is constructed with the correct number of records and each is pre-populated with interval footages and lithology terms. The user only has to set the lithology type (sediment, rock, or artificial material) and enter footages for any split intervals.

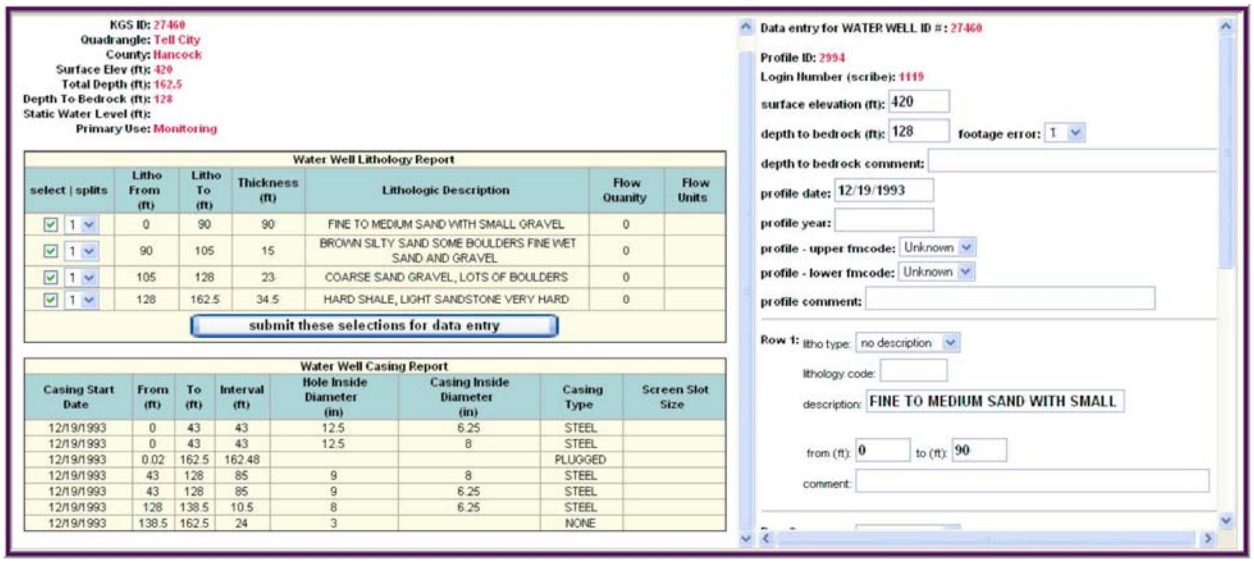

Figure 4. Data display and entry form for water well. Upper part of data entry form has information about the site, and the lower part has successive entry sections for each lithology interval.

Quaternary Database

The output of this program adds information to three database tables. Summary information about the well is first added to a site description table that describes the location and context of geologic observations. Another entry is made to a table where bedrock depth and an assessment of the accuracy of the value are documented. These data are extracted, imported to GIS, and contoured prior to conducting fieldwork. Finally, one or more records of subsurface materials are added to a Quaternary lithology table for assessing the stratigraphy of unconsolidated units in the map area.

FIELD DATA ENTRY APPLICATION

Once fieldwork had commenced, geologists needed a mechanism of cataloging site descriptions, field observations, samples, measurements, and photographs. The KGS database has the capability of treating many of these elements individually, but there was not a single computer application that streamlined the process of data entry—a long-term impediment to institutionalizing valuable information. There also was a need to associate the various kinds of information, stored in separate database structures, according to the site of collection and the author. This issue is easy to address at the database level, but difficult to implement when using separate data entry applications for each kind of information. A tool for entering field data was developed to accommodate these needs.

Like the data harvesting tool, the field data tool is an ArcIMS application with similar layout (Figure 5). It has a map frame to view the locations of both harvested wells and other kinds of field sites. A list of sites shown on the map frame (lower right corner of Figure 5) is created dynamically as the user pans the map. This list shows the type of site (e.g., outcrop, landform, water well), indicates by yellow highlighting whether the current user created the site in the system, shows icons to indicate the kinds and numbers of data that have been cataloged for the site, and provides controls for zooming to a site and adding more information to the catalog. The lower left corner of the application frame contains a number of functions for adding different kinds of field data to the system for the selected site. The upper right hand corner has a function to upload a GPS waypoint file to simplify the process of establishing sites.

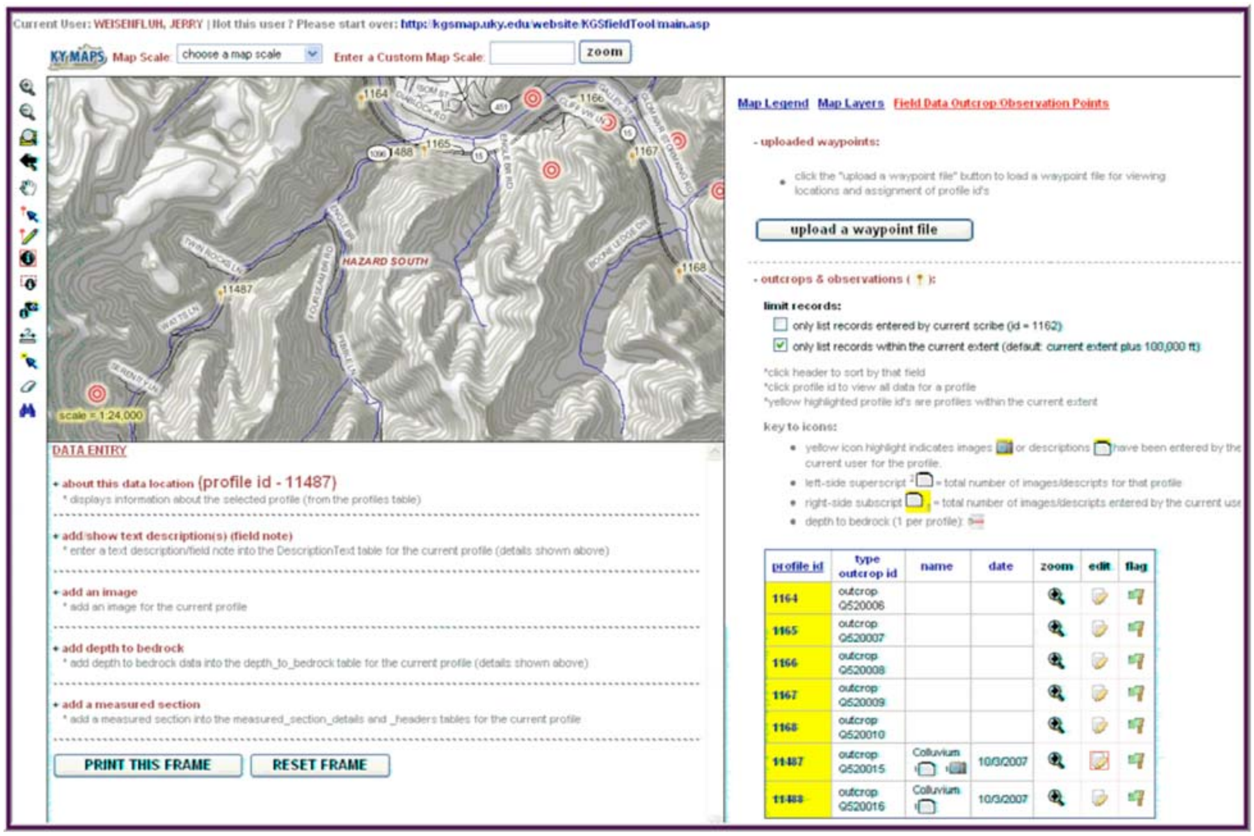

Figure 5. The main page of the KGS tool for entering field data.

Creating Field Site Entries

When a user logs into the application and zooms to an area of interest, the map shows any existing sites that have been previously created, by any registered user, which may or may not have associated field data. The sites are generic; that is, they are not associated with a particular staff member, and so if the geologist has visited one of these existing localities, they can add their information to it. Otherwise, a new site must be created. There are several means of adding new sites. The first is to manually enter a coordinate value for the location. This tool (pencil icon on left side of map) permits the coordinate to be entered in any valid projection and datum. The second method is to use a map tool (blue arrow on left side of map) to digitize a point on the map so that the system can calculate the coordinates. The final, and most efficient method is to upload a waypoint coordinate file obtained from a GPS device. When this method is used, a list of waypoints is constructed, and displayed immediately below the waypoint upload button. The user can sequentially focus the map on each waypoint, validate its location, and add it to the lower site list so that field data can be entered. When a new site is added, an entry form is provided to describe the type of locality, its geologic context, and other locale information such as a roadway milepoint designation for an outcrop.

Adding Data To Field Sites

Individual tools are provided for adding each specific kind of field data to a site; these tools are available on the left side of the field data-entry tool (Figure 5). At the present time, users can add text descriptions (field notes), depth to bedrock measurements, and photographs. To enter a field note (Figure 6), a description category must be selected from a pull-down menu (e.g., lithology, landform, geotechnical) and one or more geologic unit names ("fmcode") can be assigned, if applicable. KGS uses AAPG-style codes for stratigraphic units and these standard codes can be looked up using the "Display Fmcode Finder" link. The note is entered as free text in the description text box. Field notes inherit the location of the site by default. However, if several observations from a single site are made, each can be assigned its own coordinate location because sites may be large enough to encompass several point location observations. The user can choose to keep a note private (i.e., not accessible to the general public) while the project is under way, or in cases where the context of the information would not be useful to other parties. Entering depth to bedrock information is equally simple (Figure 7). Users enter the surface elevation of the site, the depth to bedrock in feet, a code qualifying the accuracy of the measurement, and any comments. This function would be used to document observations of bedrock exposure and shallow bedrock depths obtained by rod or auger soundings. Photos or other images, such as drawings, cross sections, or diagrams, can be added using a preexisting data entry application (Weisenfluh and Curl, 2007). Image files are uploaded to a Web server, can be overprinted with credit text, and fully attributed with captions and keywords. This field data application links to the photo application and passes the user's authentication and site identifier to that program to maintain these key relationships.

Other data entry applications are under development for adding documents (data files or reports), measured sections, and sample descriptions of rock, liquid, or gas to a site.

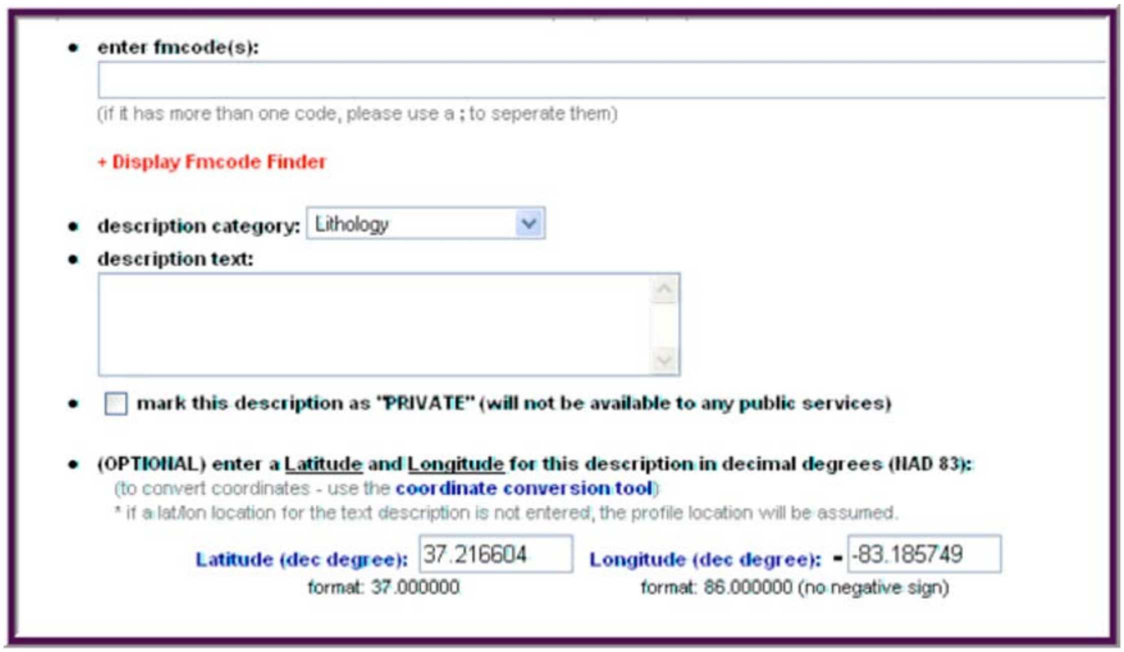

Figure 6. Data entry form for field note or other text description.

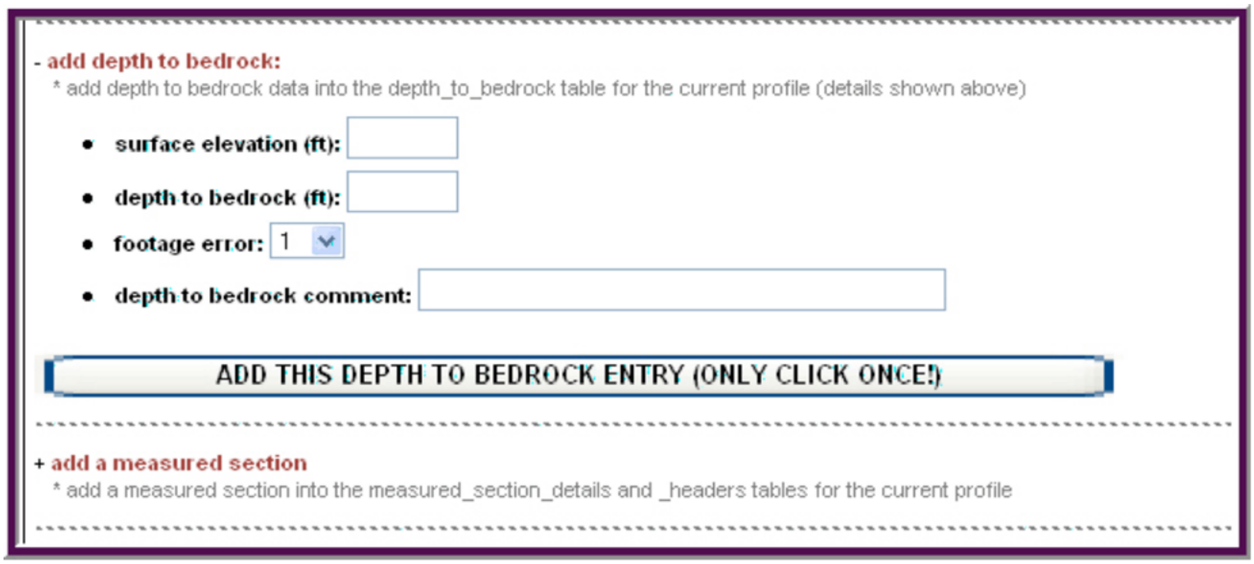

Figure 7. Data entry form for depth to bedrock measurement.

ACCESSING FIELD DATA

One of the main advantages of entering field data into an enterprise database is the increased accessibility of the information to the researcher, but also to others who would benefit from it. The last 1:24,000-scale bedrock geologic map for Kentucky was published in 1978, and KGS still regularly receives requests for station maps and field notebooks. Unfortunately, most of the latter remained in the possession of the authors. Unless current mappers elect to mark field notes as "private," the information is available on the KGS Web site as soon as it is submitted. The decision to release data is made by the geologist and is guided by the question of whether the information is generally useful to other practitioners. There are two ways that the data can be discovered by the public. The first is Web-based search forms specific to each kind of data (http://kgsweb.uky.edu/main.asp). One service is used to find photographs and other images by geographic and keyword criteria. The other service is a geologic description search page that returns published descriptions from geologic maps as well as field notes or other unpublished text descriptions. The results of these queries are sorted by source and map scale for published materials and by author for unpublished data. The search results also show a statewide geologic map with quadrangles highlighted where the search term was found. The user can identify these quadrangles and link to a detailed geologic map with the specific geologic units highlighted.

The second method of finding field data is to view the KGS geologic map service (http://kgsmap.uky.edu/website/KGSGeology/viewer.asp) for an area of interest. The map (Figure 8) can be formatted by the user to display field sites, photograph locations, and wells of any type, and the associated information for these localities can be accessed using tools provided on the map.

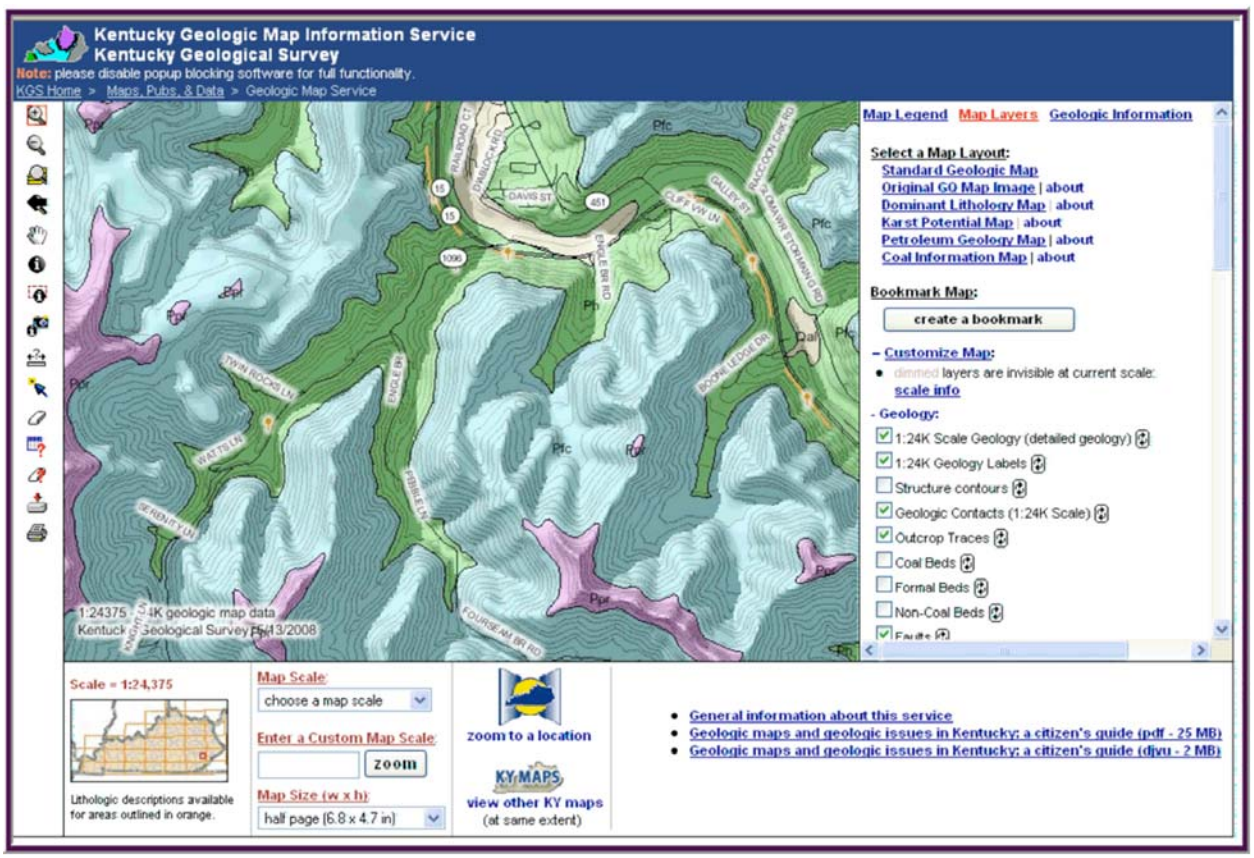

Figure 8. Example KGS geologic map service showing field sites as push pins.

REFERENCES

Weisenfluh, G.A., and Curl, D.C., 2007, Unpublished geologic evidence and other databases of the Kentucky Digital Mapping Program, *in* Soller, D.R., ed., Digital Mapping Techniques '06 – Workshop Proceedings: U.S. Geological Survey Open-File Report 2007-1285, p. 101-106, http://pubs.usgs.gov/of/2007/1285/pdf/Weisenfluh.pdf. (See also http://ngmdb.usgs.gov/Info/dmt/docs/weisenfluh06.ppt for presentation, and http://kgsweb.uky.edu/geology/image_search.asp for Internet service.)

Weisenfluh, G.A., Curl, D.C., and Crawford, M.M., 2005, The Kentucky Geological Survey's online geologic map and information system, *in* Soller, D.R., ed., Digital Mapping Techniques '05 – Workshop Proceedings: U.S. Geological Survey Open-File Report 2005-1428, p. 5-10, http://pubs.usgs.gov/of/2005/1428/weisenfluh/index.html. (Internet service available at http://kgsmap.uky.edu/website/KGSGeology/viewer.asp.)