PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

Archiving and Web Dissemination of Geotechnical Data: Development of a Pilot Geotechnical Virtual Data Center

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PEER Lifelines Project 2L02
Draft Final Report
Consortium of Organizations for Strong-Motion Observation Systems
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ABSTRACT

A pilot distributed system for archiving and web dissemination of geotechnical data collected and stored by various agencies and organization, the COSMOS/PEER LL GVDC, is described in this report. The pilot system design is based on an extensive survey of users and uses of geotechnical data and current practices that principal data providers use for archiving and dissemination of data. The project implementation involved a large number of academic and practicing specialists in the acquisition and use of geotechnical data for both practice and research working together with government agency and private sector geotechnical data archiving and dissemination specialists. Three geotechnical data providers, the California Geological Survey, Caltrans, the U. S. Geological Survey, and the Pacific Gas and Electric Company collaborated with the project and served as resources for their data types and their data archiving and dissemination practices. Three working groups, each responsible for the accomplishment of an independent task but working together in a coordinated project management structure, accomplished the work. Working Group 1 established the basic requirements for system design based on uses of geotechnical data and on data providers' practices for archiving and disseminating data. Working Group 2 developed a geotechnical data dictionary standard for the Pilot GVDC that is extensible to include the range of geotechnical data from many data providers. Working Group 3 performed the code development and integration required to implement the Pilot GVDC architecture. The system design specifically responds to data providers' individual data dissemination polices by allowing multiple data providers to make their data available through a uniform web interface, while each retains possession and control of the data. A user is able to view and download data from multiple organizations in a uniform file format with one-stop at the Pilot GVDC. Review and input from the broad community of geotechnical data users and providers was obtained through a workshop, which included both domestic and international participation. Over the long-term, the objective is to extend the Pilot System and link multiple databases of government agencies, universities and private companies.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

Tremendous amounts of geotechnical exploratory data have been, and continue to be generated for characterization of subsurface conditions and materials for the design and construction of significant buildings, highway bridges, dams, embankments, and other important structures. For example, geotechnical data sets for the Los Angeles region used by the California Geological Survey (CGS) for seismic hazard mapping exceed 12,500 borings. Hundreds of new borings are generated statewide each year by the California Department of Transportation (Caltrans) alone. Other sources of data include a variety of state and federal agencies as well as private consulting firms.

These data sets have remarkable untapped potential for project designers, especially for early site reconnaissance phases of project development. Information from nearby borings can be used to establish general subsurface conditions and to identify problematic strata that could affect the project design. Having quality access to this information can help to tailor a drilling program to assure good coverage of problematic zones or layers. This, in turn, would lead to better subsurface characterization with fewer surprises and reduced drilling costs. Each boring that does not need to be drilled results in a savings on the order of several thousands to tens of thousands of dollars.

Geotechnical research and practice demands efficient organization, archiving and dissemination of data collected by various independent organizations. Access is the primary impediment to realizing the full potential of utilizing the vast resource of existing subsurface data. The major barriers to access are: 1) simple lack of knowledge regarding data availability, 2) differing and incompatible methods, both paper and electronic, for archiving and distributing the data, and 3) institutional barriers that restrict the sharing and dissemination of data. Although only very limited efforts have been made to date to archive data in searchable electronic databases, the economic benefit of having geotechnical data readily accessible to the broad community of users is clearly recognized. This report describes how the critical issues related to archiving and electronic dissemination of geotechnical data were address and accommodated for the development of a Pilot Virtual Geotechnical Data Center (GVDC).

1.1 Project Concept

The work described in this report constitutes Phase II of a COSMOS project (referred to as the COSMOS-PEER LL GVDC project) supported by the Pacific Earthquake Engineering Research Center (PEER) Lifelines Program (LL) for development and implementation of technologies for Archiving and Web Dissemination of Geotechnical Data. Phase I of the project consisted of a workshop held on October 4 and 5, 2001. The objectives of the workshop were to develop consensus recommendations for classifying, archiving, and web dissemination of various types of geotechnical data and to develop a plan of action leading to development of a web-based virtual data center system linked to multiple databases. Discussion papers together with the complete conclusions and recommendations of the workshop are published in the workshop proceeding (Swift, et, al., 2002).

The most important finding of the workshop was that the development of a web-based virtual center for dissemination of geotechnical data from multiple linked databases is primarily a matter of applying existing technologies for digital database structures and Internet communications and data exchange protocols. The remaining principal needs are to define the functional requirements of the center, standardize data formats, establish data indexes, and develop exchange standards. The functional requirements of a virtual data center depend on the types of data users and the range of their uses of the data, which are together called user scenarios. Standardization of data formats is considered to be essential in the long-term. However, translator routines can be developed to access data in varied formats from multiple linked databases and to deliver them to the user in a standard format. An index of each database or collection of data files linked to the virtual center is required to define the data that can be obtained through the virtual center. Finally, a standard data dictionary, which to the extent practicable is common for all databases linked in the system, is required.

A functional geotechnical virtual data center must be able to accommodate the varied data archiving and dissemination policies of participating organizations. For this reason, the virtual data center hub normally will not house data, but it could house metadata (the descriptions of the data) and/or data indexes and translators that allow data to be accessed through the hub from various linked database providers. The concept is that the data sources or providers will also be users, and the general user community will be able to access data from all database providers through the virtual center. In this configuration the virtual center can be expanded to link any number of geotechnical databases.

1.2 Project Design

Participants in the Phase I workshop recommended that a project be undertaken to design a pilot web-based geotechnical data dissemination system, initially linking a few databases. COSMOS lead the development of a research project to implement this recommendation. COSMOS provided the project management of the research, which had substantial direct participation of researchers and geotechnical database specialists from a number of academic, government, and private organizations listed in Appendix E. The University of Southern California (USC), the University of New Hampshire (UNH), and the University of Illinois National Center for Supercomputing Applications (UI NCSA) had major direct participation in the project. In addition, the Petrotechnical Open Standards Consortium (POSC) provided liaison and made significant contributions to the project. Four database providers had important direct participation in the project, the California Department of Transportation (Caltrans), the California Geological Survey (CGS), the U. S. Geological Survey (USGS), and the Pacific Gas and Electric Company (PG&E), and provided data sets for the Pilot GVDC. The PEER Lifelines Program Committee provided oversight for the work. The pilot project included holding a workshop for the purpose of obtaining broad feedback and input form the geotechnical engineering community. The Federal Highway Administration Resource Center and a number of state Transportation Departments provided support for the workshop. While the objective of this project is to develop a pilot virtual database system linking a few geotechnical databases, the ultimate goal is to link public and private geotechnical databases throughout the United States and internationally.

1.3 Project Implementation

The GVDC project is a strong success story joining academic, industry and agency collaboration. Implementation of the project was accomplished in four main technical tasks: 1) definition of geotechnical data user scenarios for a pilot virtual geotechnical data dissemination system, 2) development of a data dictionary standard for the pilot system that is expansible to an anticipated larger dictionary standard that links multiple geotechnical databases, 3) integration of these results into the design of a pilot geotechnical virtual data center system architecture, and 4) planning and implementation of a workshop structured to obtain geotechnical community review and recommendations. Three Working Groups constituted of 5 to 7 experts from government agencies, industry, and academia were organized to accomplish these tasks; each Working Group was assigned a specific task to accomplish. The Work Groups proceeded independently, meeting together at predetermined stages of work completion in project meetings to review and coordinate progress and to identify technical issues requiring resolution. These coordination meetings identified a number of specific software development needs; specialized software developers were engaged to develop the code packages, which were integrated into the system architecture Working Group 3.

1.4 Report Organization

The following sections of this report describe the results of the three main technical tasks. The fourth task, the workshop, is described in a separate workshop proceedings (In preparation). Section 2 describes the results of user scenario task and is supported by results presented in Appendix 1. Section 3 describes data dictionary standard development results and is supported by results presented in Appendix 2. Section 4 describes the GVDC system architecture development and is supported by results presented in Appendix 3. The conclusions and recommendations of the Pilot GVDC workshop held on June 21 – 23, 2004 are presented in Appendix 4.

1.5 References

Swift, J. N., J. C. Stepp, C. J. Roblee, L. L. Turner, C. R. Real, W. U. Savage, 2001. *Proceedings: Invited Workshop on Archiving and Web Dissemination of Geotechnical Data.* COSMOS Publication No. CP-2001/03, COSMOS, Richmond, CA

2 ESTABLISHING BASELINE PRACTICES AND IDENTIFYING USER NEEDS FOR ELECTRONIC ARCHIVING AND WEB DISSEMINATION OF GEOTECHNICAL DATA

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2.1 INTRODUCTION

This section presents the findings and recommendations of the *User Scenario Work Group (USWG)* in identifying a baseline of current practices within the geo-professional community and prioritizing desired functional requirements in the development of a proposed comprehensive geotechnical information management system. This work was

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[1] Caltrans

[2] City of Los Angeles Bureau of Engineering

[3] California Energy Commission

[4] Los Angeles Department of Water and Power

[5] Geovision, Inc.

[6] Pacific Gas & Electric Company

[7] U. S. Geological Survey

[8] University of Southern California

9 California Geological Survey

10 PEER Lifelines Program

11 UC-Santa Barbara

conducted as an initial phase of the larger Pilot GVDC system development to demonstrate the effectiveness of a web based virtual data center for the dissemination of geotechnical data from multiple linked databases of various government and private sector organizations. An online survey was administered over the course of several months, reaching practitioners across the nation. The results from the survey were compiled and examined to provide direction and focus for the other project teams in the development of a user-driven pilot data system.

2.2 BACKGROUND AND APPROACH

The primary task of the USWG was to define and document *user scenarios*. User scenarios are commonly used in the computer sciences in the life cycle development of software. They have been defined as descriptions of how one or more users engage in some meaningful activity with an envisioned system in order to guide the design process (Rosson and Carroll, 1996). In many design applications, the user scenarios are developed early in a project as a way to clarify the problem for which the software is to address. With some analysis, the problem can be formatted into a set of functional system requirements, which, in turn can be transformed into specifications. The specifications are then used to develop and implement the system. This type of approach, referred to as the *cartesian* design method (Ostwald 1996), is widely employed in software development cycles. The *skill-based* method (Ostwald 1996), a more recent generation of design methodology, recognizes that users don't necessarily know precisely what features they want or need in a system beforehand. This approach takes into consideration that users need a model to which they can react and provide feedback to designers. The use of prototyping and mockups are an integral component of this method. A combination of both approaches was used for this project, as the activities of the three work groups proceeded in parallel.

2.3 USER SURVEY

The USWG held its first meeting in June 2002 during the kickoff workshop for the project. Following discussion on strategies of developing user scenarios, the group concurred that an approach utilizing a user survey was likely to provide the best information in the short timeframe of the project. The results of the survey were needed quickly to guide the other work group's efforts in the development of the data dictionaries and web-technologies.

Over the next few months a survey was developed, using input from the group and other practitioners, to gather information on how geo-professionals, both in practice and in research fields, currently generate, store, and disseminate geotechnical information. The two primary goals of the survey were to (1) establish a baseline of current practices, and (2) identify desired functional requirements of a geotechnical information management system. Establishing the baseline entailed gathering information on the who the users and providers of geotechnical data are, the types of geotechnical data being used, the lifecycle of the geotechnical data (i.e. field data collection, analysis, presentation, storage), and the patterns of use. Identifying functional requirements required input and suggestions from potential end users on software user interface, access methods (e.g. internet), data availability, and data formats (e.g. Excel, XML). The collection of this type of information would then be used to identify functional system requirements and develop mock-ups for design iteration.

The survey was structured as a series of multiple choice questions and organized by topical areas of practice. The survey was comprised of a total of 98 questions. The distribution of questions across topical areas are as shown in Table 2-1.

Topic Area	**Number of Questions**
Demographics, area of practice, license, education, and years in profession	6
Baseline practice questions	
• Geotechnical and geological borehole data collection practices	35
• Geotechnical lab test data	7
• In-situ engineering test data	7
• Geophysical test data	8
• Dynamic lab test data	6
• Analysis, presentation, and storage of data	8
Desired functional requirements of a new geotechnical information management system	21
Total	**98**

Table 2-1 – Distribution of Survey Questions

The survey was administered through the internet using a series of interactive web pages containing a combination of check boxes (e.g. radio buttons) for multiple choice questions and text entry fields for written responses as shown in Figure 2-1. The online version of the survey was developed using ASP and Javascript technologies. Survey responses were recorded into a Microsoft Access database, which significantly reduced the time required to compile survey results afterwards. The use of the web-based survey allowed for a more dynamic experience for the respondent while only presenting questions when appropriate. For example, a respondent who did not indicate that they generated or used geophysical data would not have been presented with the series of questions pertaining to that topic. As such, the survey was kept as short as possible.

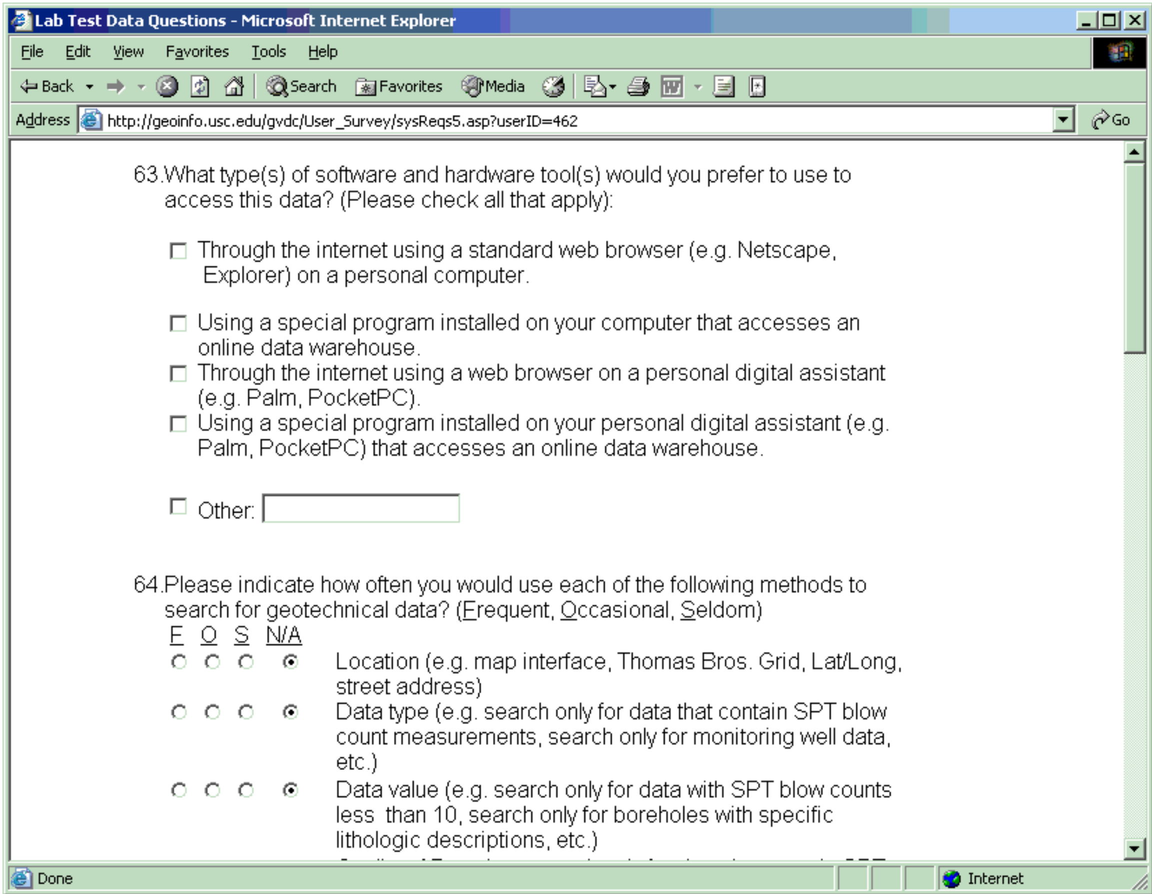

Figure 2-1 – Online survey

The online survey was conducted between July 19, 2002 and February 4, 2003, through the GeoInfo website, a site hosted by one of the project team members at the University of Southern California (http://geoinfo.usc.edu/GVDC/home.htm). During this time period, 217 complete responses were captured through the online website. Over 1000 notices of the survey were sent by email and over 200 were sent by conventional mail to individual professional contacts in industry, government, and academia. These contacts included geotechnical engineers and geologists in every State Department of Transportation, every State Geological Survey, and the FHWA. The survey announcement was also distributed through email lists through the United States Universities Council on Geotechnical Engineering Research (USUCGER), USGEOTECH, and the GeoCouncil. Survey results were compiled, and statistical calculations were performed using the data. Charts showing the responses for each question are presented in the appendix.

2.4 SURVEY RESULTS: ABOUT THE RESPONDENTS

More responses came from California-based practitioners (32%) than any of the other states as shown in Table 2-2. There was strong representation from the practice of geotechnical design (29%), with smaller groups in the practices of engineering geology and regional geology, earthquake engineering, research, and testing services, as shown in Figure 2-2. The surveyed group was comprised mainly of professionals working in government agencies (64%), the consultant sector (24%), and research communities (9%) as shown in Figure 2-3. Due to the large group represented in geotechnical design practice and engineering and regional geology, it was not surprising to find that 57% of the respondents held a Professional Engineering (P.E.) license, and 46% were either a Registered Geologist (R.G.) or a Certified Engineering Geologist (C.E.G.) as shown in Figure 2-4. Of the 11% that indicated "other" when asked about professional licenses, typical responses included: Registered Geophysicist, Professional Geologist (P.G.), Licensed Professional Geologist (L.P.G.), Certified Soil Scientist, and Certified Petroleum Geologist. Advanced graduate degrees were held by 68% of respondents as shown in Figure 2-5. And, most respondents (72%) had been in practice from 2 to 5 years as shown in Figure 2-6.

State	*Count*	*%Total*	*State*	*Count*	*%Total*
AK	2	0.9%	MT	1	0.5%
AL	3	1.4%	NC	4	1.8%
AR	1	0.5%	ND	3	1.4%
AZ	1	0.5%	NE	2	0.9%
CA	70	32.3%	NH	2	0.9%
CO	5	2.3%	NJ	1	0.5%
CT	2	0.9%	NM	1	0.5%
DE	2	0.9%	NV	3	1.4%
FL	3	1.4%	NY	2	0.9%
GA	0	0.0%	OH	3	1.4%
HI	0	0.0%	OK	0	0.0%
IA	1	0.5%	OR	2	0.9%
ID	1	0.5%	PA	3	1.4%
IL	0	0.0%	RI	0	0.0%
IN	3	1.4%	SC	4	1.8%
KS	3	1.4%	SD	1	0.5%
KY	0	0.0%	TN	2	0.9%
LA	0	0.0%	TX	3	1.4%
MA	1	0.5%	UT	1	0.5%
MD	2	0.9%	VA	1	0.5%
ME	0	0.0%	VT	0	0.0%
MI	3	1.4%	WA	4	1.8%
MN	3	1.4%	WI	2	0.9%
MO	2	0.9%	WV	0	0.0%
MS	0	0.0%	WY	2	0.9%

Table 2-2 – Survey Response by State

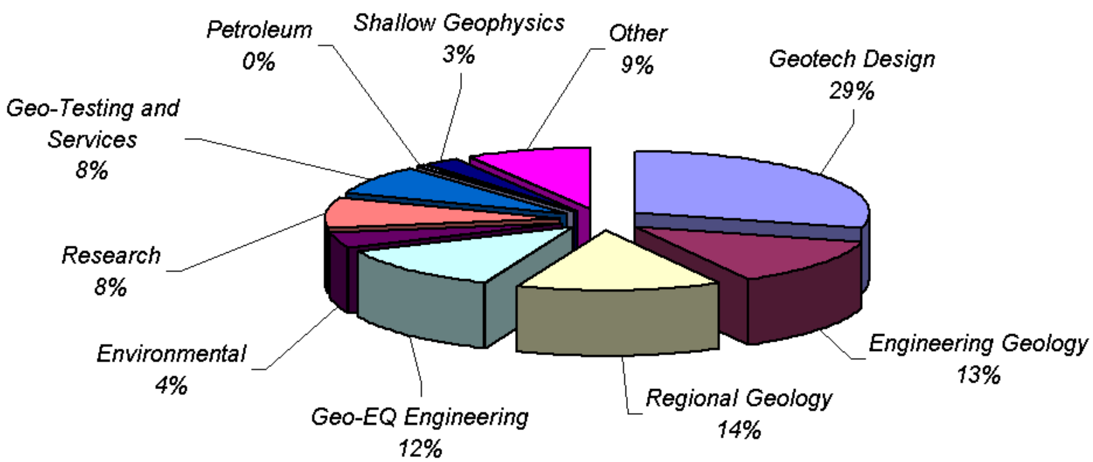

Figure 2-2 – Primary area(s) of practice

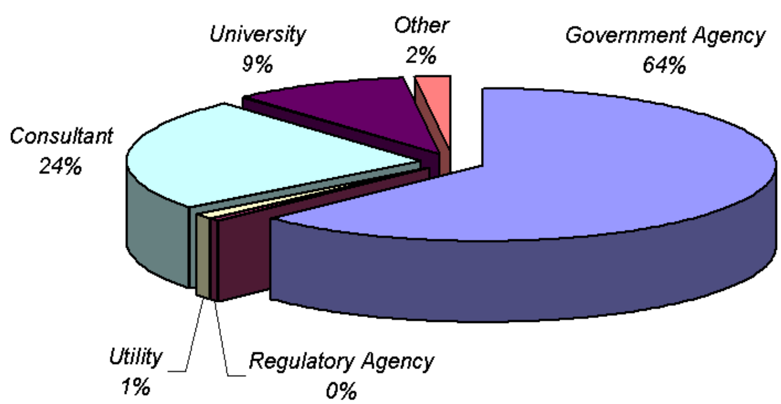

Figure 2-3 – Type of entity of organization

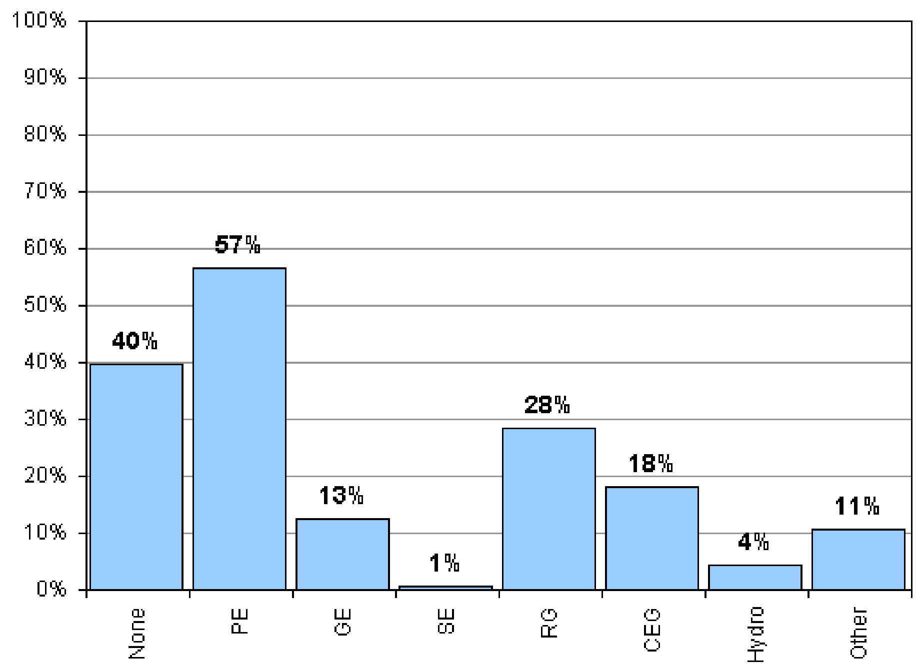

Figure 2-4 – Percent of respondents holding professional licenses

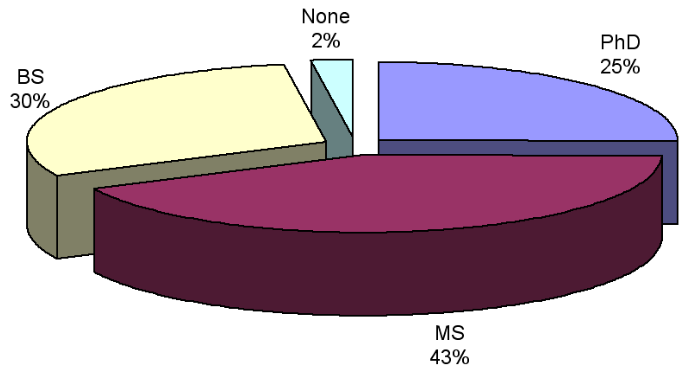

Figure 2-5 – Educational background of survey respondents

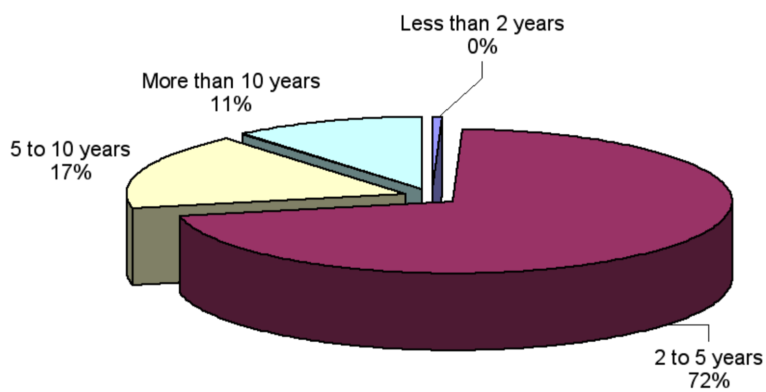

Figure 2-6 – Number of years in practice

2.5 SURVEY RESULTS: BASELINE PRACTICES

Survey results reflect the practices primarily of engineers and geologists, working in government agencies and in the consulting sector, performing geotechnical designs or regional geologic studies. Observations resulting from the survey are listed here.

2.5.1 General Comments

- Geotechnical borehole data, lab test data, and in-situ engineering test data are the most frequently used data sets in practice. Usage of geologic borehole data and geophysical test data is also significant. Seismic related data is important to many.
- The data is most often used in a geotechnical design process. Less common, but significant, is the use of the data in regional geologic scale studies and hazard mapping.

- Organizations develop and acquire borehole data equally using in-house staff resources, contracted staff, publicly available data generated by others, and combinations of these three methods.
- Map development is common within the practices, primarily utilizing GIS software, or, less common, hand drafting techniques or computer aided design software.
- The most important practice for referencing project locations is using a geodetic system (i.e. latitude and longitude) or coordinate system (e.g. State Plane Northing and Easting), thereby facilitating GIS implementation. However, systems utilizing street addresses are still common.

2.5.2 Borehole Drilling & Sampling Practices

- For borehole drilling operations, the following data are important and recorded for most data sets:
  - ❑ Drill site reference elevations, and the methods used to obtain them (e.g. surveyed by DGPS).
  - ❑ Description of the setting at the location of the borehole (e.g. natural ground, fill, raised casing, etc.).
  - ❑ The source of the data (e.g. organization, name of logger, name of driller, etc.).
  - ❑ Specific information on the drilling equipment (e.g. manufacturer, model, etc.) and drilling tools (e.g. auger type and measurements, drill rod and casing type and measurements, drill bits, sampler types, etc.).
  - ❑ Total borehole depth.
  - ❑ Purpose of the borehole (e.g. geotechnical, environmental, monitoring well, etc.).

  Less common but significant information includes environmental or situational conditions during the drilling operations (e.g. weather, breakdowns, delays, etc.), and drilling rates.
- The USCS Visual-Manual (ASTM D2488) and Lab-Based (ASTM D2487) are the most commonly implemented soil classification methods used in practice. Other observations related to soil description and classification are as follows:
  - ❑ Soil color is commonly recorded.
  - ❑ Age of deposits are almost always determined, using primarily radiocarbon, pediologic, and paleontologic methods.
  - ❑ Information on chemical composition of the deposits or pore fluids is typically not needed.
- Pocket penetrometer testing is used frequently, as is torvane testing, for quick field testing procedures.
- Most users find it important to have soil layer interpretations and comments (e.g. fill, alluvium, colluvium, etc.) recorded and available.

- Final water depths in boreholes are routinely recorded. Half of the time, multiple measurements are taken, including first water encountered, with key parameters such as dates and times of recordings. Although not frequently done, long term water level monitoring is performed in some cases.
- Groundwater modeling is performed in about a third of the practice. MODFLO is the most frequently used analysis tool.

2.5.3 Geotechnical Lab Testing Practice

- Common geotechnical lab testing associated with borehole logging practices includes testing for unit weight, moisture content, maximum/minimum density, relative density, specific gravity, particle size analysis, atterberg limits, consolidation, direct shear strength (friction angle and cohesion), unconfined compressive strength, and triaxial shear strength parameters (friction angle and cohesion). Less common, but still prevalent, are tests for Mohr-Coulomb envelope from triaxial tests, full stress-strain curves from strength tests, R-value/CBR, and cyclic/dynamic properties.
- Geotechnical lab test data is typically acquired by a combination of using in-house resources, contracted resources, publicly available data generated by others, and combinations of these three methods. No single method is used more frequently than the others.
- For lab test data, in addition to the *interpreted data* (e.g. Compression Index, Shear Strength, Unit Weight), most users need ready access to the *primary data* (e.g. calibrated settlement vs. time) readily available, as well as information on the factors and methods used to develop the primary data (e.g. calibration constants, filtering techniques, etc.). About half of the users routinely need access to the *raw data* (e.g. unprocessed transducer voltages), along with transducer calibrations and information regarding lab test equipment (e.g. make, model, type, key dimensions, transducers, etc.), test conditions (e.g. estimated in-situ vertical pressure for a consolidation test), and test specimen (e.g. initial sample thickness for a consolidation test). Definitions of *raw, primary*, and *interpreted* are shown in Table 2-3.

Data Type	**Description**
Raw Data	This data is comprised of the most fundamental measurement from a particular test. This data may be the uncorrected readings from a pressure dial gauge, the raw unfiltered voltages from a strain gauge, a visual reading off of a linear scale, etc.
Primary Data	This data is comprised of measurements that have been converted from raw data and processed to engineering units and corrected for other factors. This data may also have been filtered for electrical noise, zeroed to a baseline, or clipped to remove outliers. An

	example of primary data would be load reported in pounds versus settlement reported in inches.
Interpreted Data	This data typically consists of the result(s) of a particular test. In many cases the interpreted data requires some level of judgment by the person performing the test and generating the result. A first order interpretation could be defining the slope of a line through a scatter of data points. A second order interpretation could be to average a collection of first order interpreted results to come up with an average value representative of a larger group.

Table 2-3 – Definition of Data Types

- Dynamic lab test data is used by approximately a third of the practitioners. Only about one quarter of those using and generating this data are in the research fields.
- The most common dynamic test methods include cyclic simple shear and cyclic triaxial to obtain shear modulus and damping parameters as a function of strain as well as assess liquefaction behavior and cyclic densification and settlement.
- Organizations acquire dynamic lab test data largely through contract testing services and internal testing, and to a lesser extent through the use of existing, publicly available, data generated by others.

2.5.4 Geotechnical In-situ Testing Practice

- By far, the most commonly used geotechnical in-situ test methods are the Standard Penetration Test (SPT) and the Cone Penetration Test (CPT).
- For geotechnical in-situ testing most organizations use a balanced combination of in-house testing services and contracted testing services. Existing, publicly available data is used less often.
- For geotechnical in-situ test data, users want access, in most cases, to the *interpreted data* (e.g. CPT-based soil type, undrained shear strength, pressuremeter modulus, corrected N1-60 SPT blow counts), as well as information on the methods used to make the interpretations (e.g. assumptions of the water level elevation or soil unit weight, etc.). Equally important was ready access to the *primary data* (e.g. CPT tip resistance and sleeve friction, depth, etc.) readily available, as well as information on the factors and methods used to develop the primary data (e.g. calibration constants, filtering techniques, etc.). More than half of the users routinely need access to the *raw data* (e.g. unprocessed voltages from pressure and load transducers for CPT, uncorrected blow counts for SPT), along with transducer calibrations (e.g. calibration for a pore pressure transducer on a CPT cone), information on the in-situ test equipment (e.g. make, model, type, key dimensions, transducers, CPT cone tip size, SPT hammer lifting mechanism, SPT hammer drop weight/length, SPT energy

transfer efficiency, etc.) and field test conditions (e.g. setup, layout, etc.). Definitions of *raw, primary*, and *interpreted* are presented in Table 2-3.

2.5.5 Geophysical Testing Practice

- For geophysical testing, P and S wave velocity measurements are the most commonly employed borehole techniques.
- The most common surface geophysical testing methods are seismic refraction, seismic reflection, and SASW.
- Geophysical test data is typically acquired by an equal combination of in-house resources, contracted resources, and publicly available data generated by others.
- For geophysical test data, users want access, in most cases, to the *interpreted data* e.g. Poisson's Ratio, shear modulus, shear wave velocity, etc.) readily available, as well as information on the methods used to make the interpretations (e.g. wave arrival picks, etc.). Equally important was ready access to the *primary data* (e.g. calibrated and filtered wave traces, etc.), as well as information on the factors and methods used to develop the primary data (e.g. calibration constants, filtering techniques, etc.). Slightly less than half of the users routinely need access to the *raw data* (e.g. unprocessed transducer voltages), along with transducer calibrations, information on the in-situ test equipment (e.g. make, model, type, key dimensions, transducers, etc.) and field test conditions (e.g. setup, layout, etc.). Definitions of *raw, primary*, and *interpreted* are presented in Table 2-3.

2.5.6 Data Storage and Management Practices

- Organizations currently prepare, report, and archive geotechnical in an equal mix of paper and electronic formats.
- The most common format of electronic storage is a spreadsheet file (e.g. Microsoft Excel), followed by image files, database files, and rich text files (e.g. Microsoft Word).
- In preparing geotechnical report products, Microsoft Word and Excel are the most widely used applications. ArcView, Microstation, and AutoCAD are also used frequently.
- Most users find it absolutely necessary, if not important, to store geotechnical data electronically.
- About half of the users consider electronic data collection important to their overall data management process. Most electronic data collection applications involve manual data entry on a computer. However, a significant share of applications involves automated data acquisition using PCs. Only a small percentage uses the smaller PDAs for automated or manual electronic data collection.
- Two out of five organizations currently have a system in place that allows access to that organization's geotechnical data in an electronic format.

2.6 SURVEY RESULTS: END-USER NEEDS

The survey provided a good indication of the types of features and interface necessary for a successful geotechnical data management system. In general, most users thought that it would be absolutely necessary in the future to have geotechnical data stored electronically. Also, there were strong indicators to suggest that in the future users would need to initially collect geotechnical data electronically in both automated and manual fashion, using some type of computing device such as a personal computer (PC) or a personal digital assistant (PDA).

The majority of users were interested in taking advantage of electronic data management systems, both within their respective organizations as well as on a larger multi-organization system. Also, most expressed a willingness to contribute their data to a larger data management system for use by others. As most survey respondents were from governmental agencies, they suggested that the data should be made available freely to anyone, or at least free to the data contributors. Some users felt that a fee-based system would be necessary to cover the expenses in operating such a large and complex system.

Most users concurred that an internet-based system using a standard web browser would provide the best overall user experience. The interface needs to facilitate users in searching for data based upon a number of key parameters, of which *location* and *data type* are the two most important. Search results need to be presented to the user in a variety of formats, including summary tables and short descriptions. Additionally, search results should be easily sorted. The users need a function to preview the data, either as text or in a graphical format, and an efficient method to download the data. Users prefer to receive the data in a format consistent with their practice. Users suggested common spreadsheet, image file, database, and text file formats for downloads.

2.7 USER SCENARIO: MOCK-UP OF THE PILOT GEOTECHNICAL VIRTUAL DATA CENTER (GVDC)

Although the survey results provide information on a wide range of uses of geotechnical and related data, they are probably best used as an indicator of current geotechnical design practice. A user scenario for a geotechnical designer is presented in this paper to show the activities involved in a typical geotechnical design investigation. A mock up of the Virtual Data Center is shown within the context of this user scenario.

In this particular scenario a geotechnical engineer is contracted by a public agency to develop foundation recommendations for a new structure near an existing state highway. A primary task for the engineer is to define the scope of the site investigation required to develop an adequate understanding of the subsurface site conditions and the engineering properties of the soils. The greater the uncertainty or variability at the site, the more drilling that is required in developing the information. Often times others have developed information in the vicinity. Perhaps a utility company had performed an investigation in support of a tower installation. Or, perhaps the State or City had conducted subsurface investigations for roadways, walls, or highway facilities in the area. Other information may have been developed for nearby structures or for environmental purposes. In any case, the difficulty for the engineer lies in identifying the availability of data, accessing the files, and interpreting this past information. In many cases, it's difficult to assess the availability of past investigations. Even when it's apparent that boring logs have been developed by others, accessing the actual document may be a problem. Finally, the boring logs may not contain sufficient detail or meet quality standards required by the end-user. If information is limited in any of these ways, new drilling will be required. However, ready access to even substandard data would serve a reconnaissance purpose and help guide the new drilling program.

The engineer in this scenario gathers the necessary information with the help of the internet. Using a web browser, the user navigates to a Virtual Data Center (VDC), a website maintained by a reputable geo-standards consortium as shown in Figure 2-7. The site links public data repositories of multiple data providers and presents a uniform interface to the end-user. The end-user effectively has access to geotechnical data from a variety of sources, including their own, while maintaining a degree of uniformity in the presentation and format of the data. An online Geographic Information Systems (GIS) interface is used to search for data in a particular area as well as present search results.

The main search page consists of a GIS map interface as well as a few additional search parameters. The client uses familiar map tools (e.g. ZOOM, PAN, turn layers on and off, etc.) to navigate and locate a general area of interest. In the scenario shown in Figure 2-7, the area of interest is California.

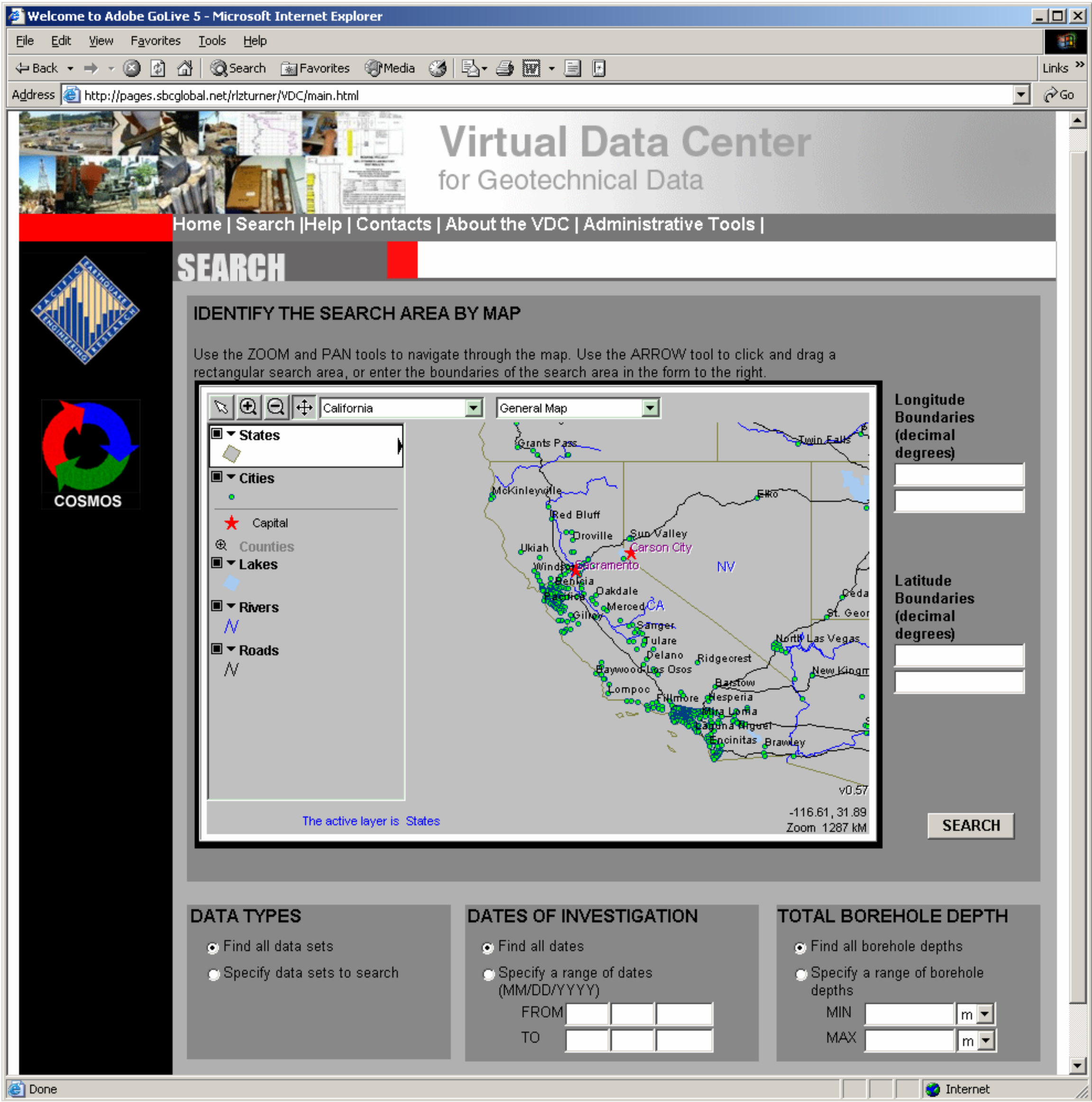

Figure 2-7 – Main page of the Virtual Data Center

The client uses the arrow selection tool to draw a rectangle on the map. The rectangle defines an area in which the user wishes to identify the availability of existing data. In Figure 2-8 the area is shown as a red box. The limits of the area are automatically entered into the boundary fields for longitude and latitude, shown to the right of the map. As an alternate method of defining the search area, the client could enter coordinates directly into the boundary fields.

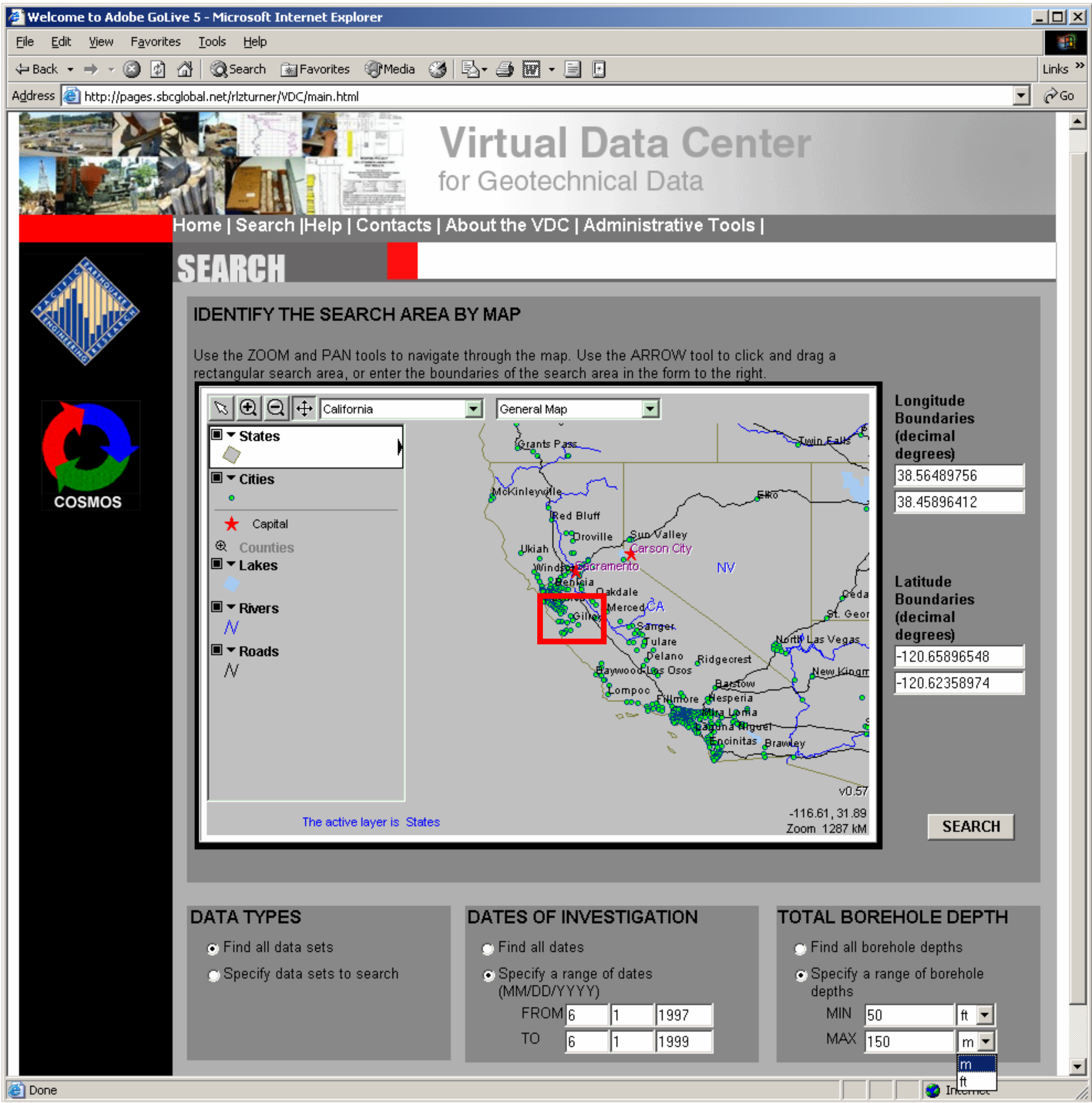

Figure 2-8 – Selecting an area in the map interface

The client can choose to specify a range of dates for which to search using the form at the bottom of the page. Also, the client can choose to specify a range of borehole depths to include in the search. Note that both "feet" and "meters" are available to facilitate metric and English units. The client is given a choice to search for "all data sets" or to "specify data sets to search." If the latter is clicked a small window pops up with additional choices as shown in Figure 2-9. The client is presented with a list of data types. The "+" symbol next to a label indicates that the client would like to include that type of data in the search. The carat symbol, or triangle, next to the label indicates that additional options are available under that particular category.

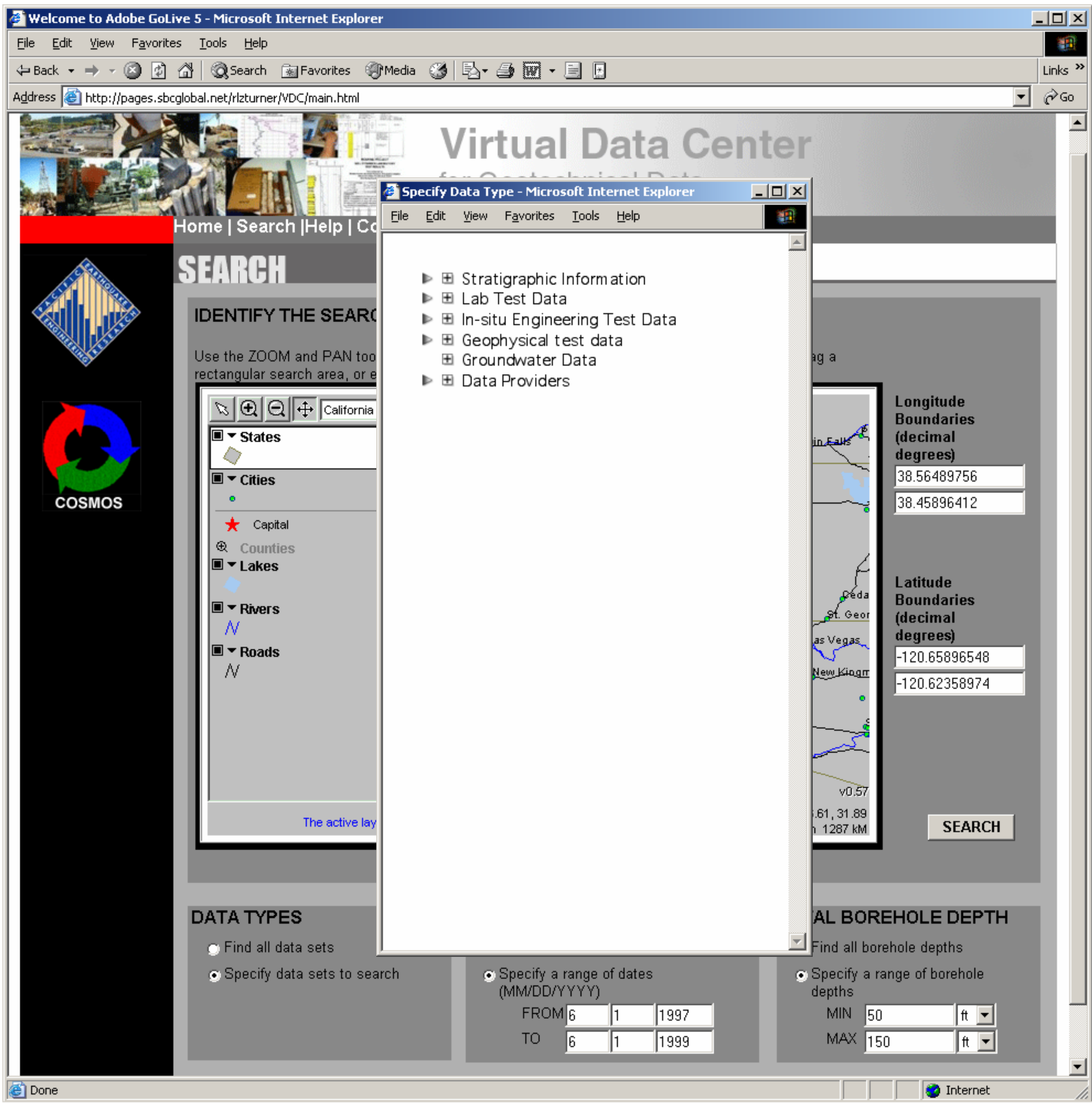

Figure 2-9 – Advanced search features

For example, if the client expands all search options, the list of options appears as shown in Figure 2-10. The client can then select any combination of data type for the search. In this example, the client is searching for all stratigraphic information, and all geophysical information, but only some in-situ and some lab test data. The client is also only interested in data from some of the providers.

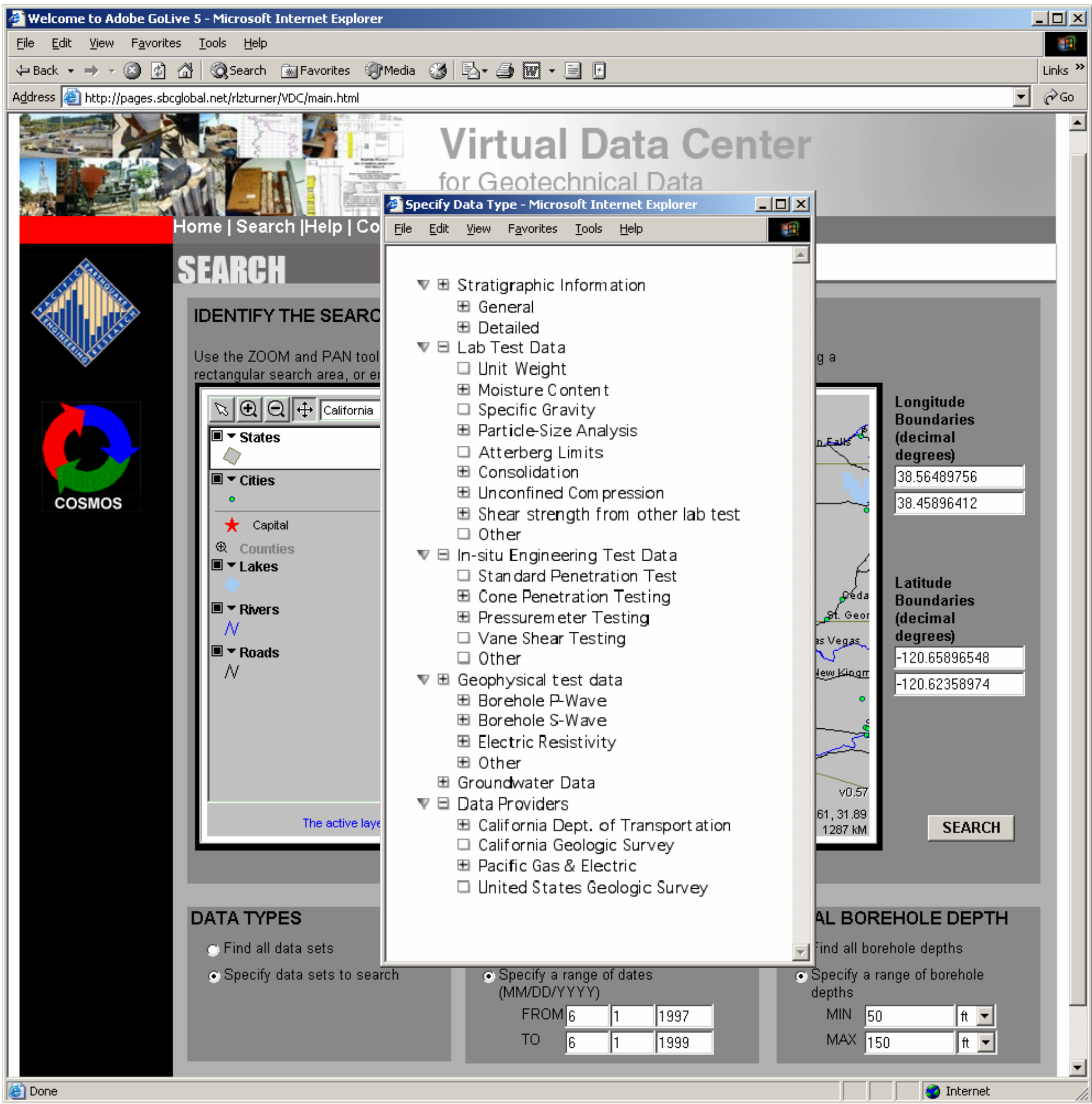

Figure 2-10 – Advanced search features expanded

With the data types specified, the client clicks the "SEARCH" button to begin the search. Search results are presented as shown in Figures 2-11 and 2-12. A short summary is presented at the top with an abbreviated list of search results by category and the number of results within each category. A detailed list of results follows below the summary with additional information on each result, including the project name, the data type, the data source, date, and any available downloads or contact information.

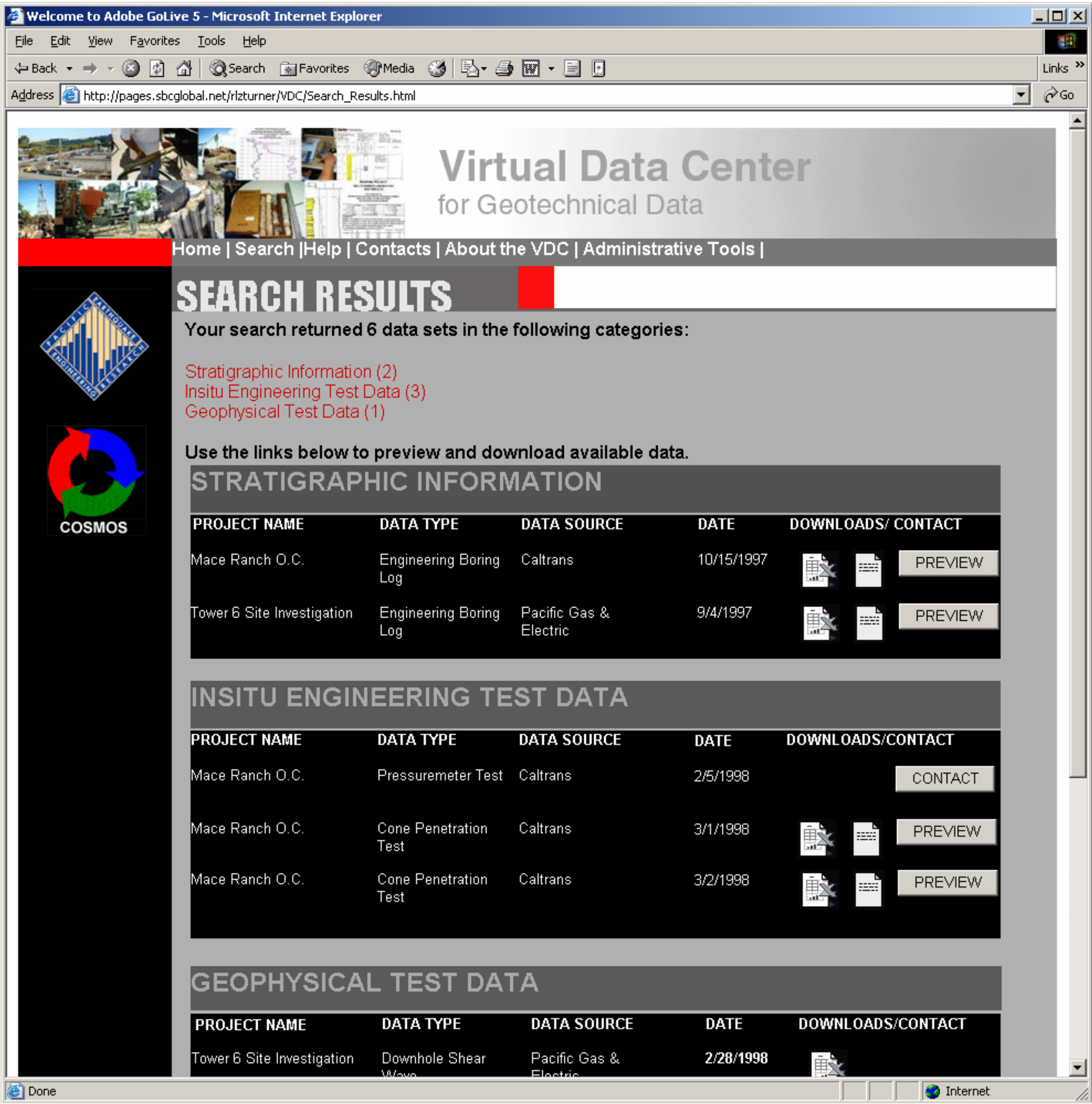

Figure 2-11 – Search results

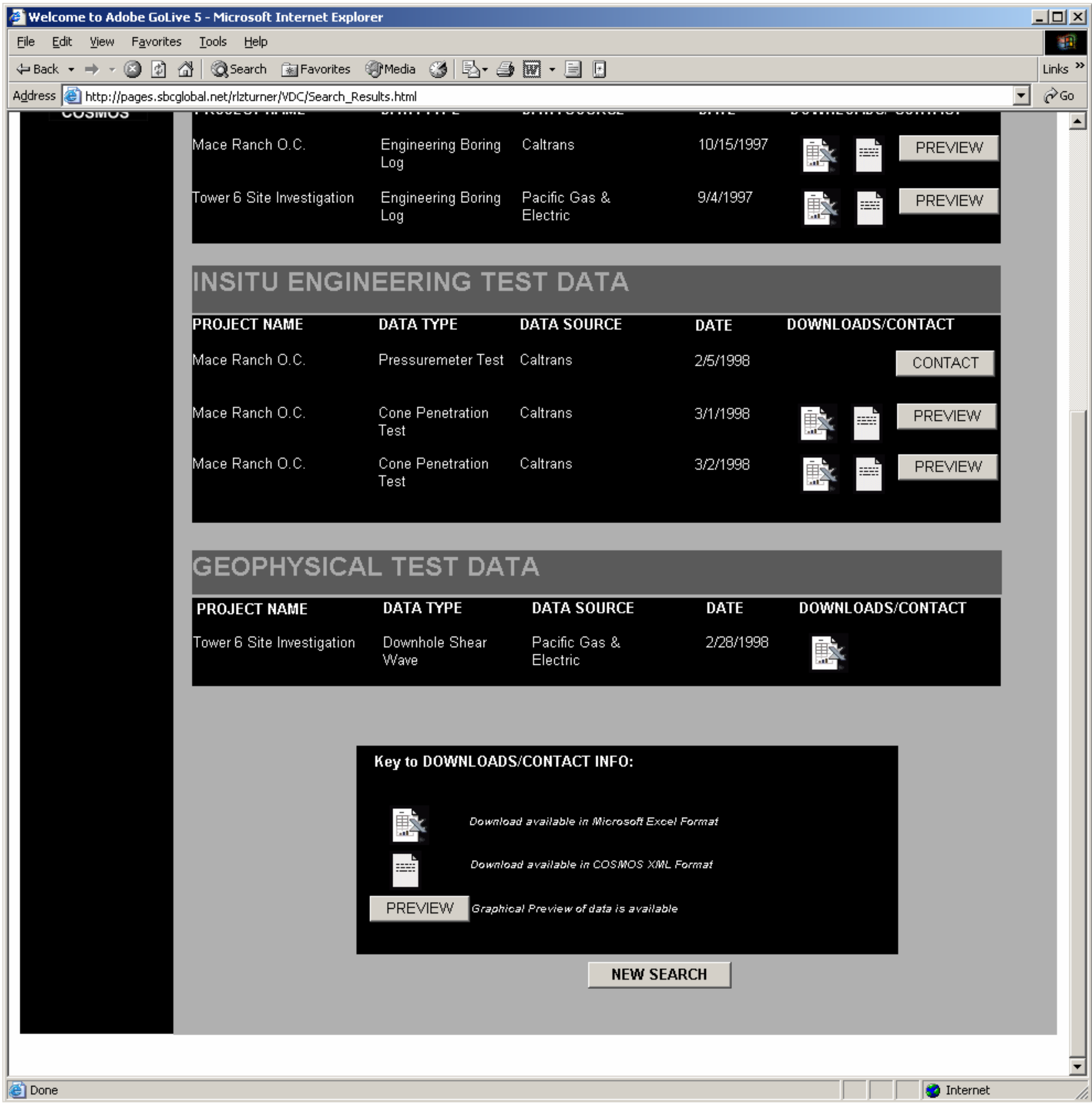

Figure 2-12 – Search results (continued)

File downloads in Microsoft Excel or a new consensus XML format are initiated by clicking on the icons under the "Downloads" column. The "Preview" button is used to give the user a quick visual on the data. For example, if the client previews a CPT file, a plot would be delivered on the web page as shown in Figure 2-13. The client could then go back and download the data if acceptable.

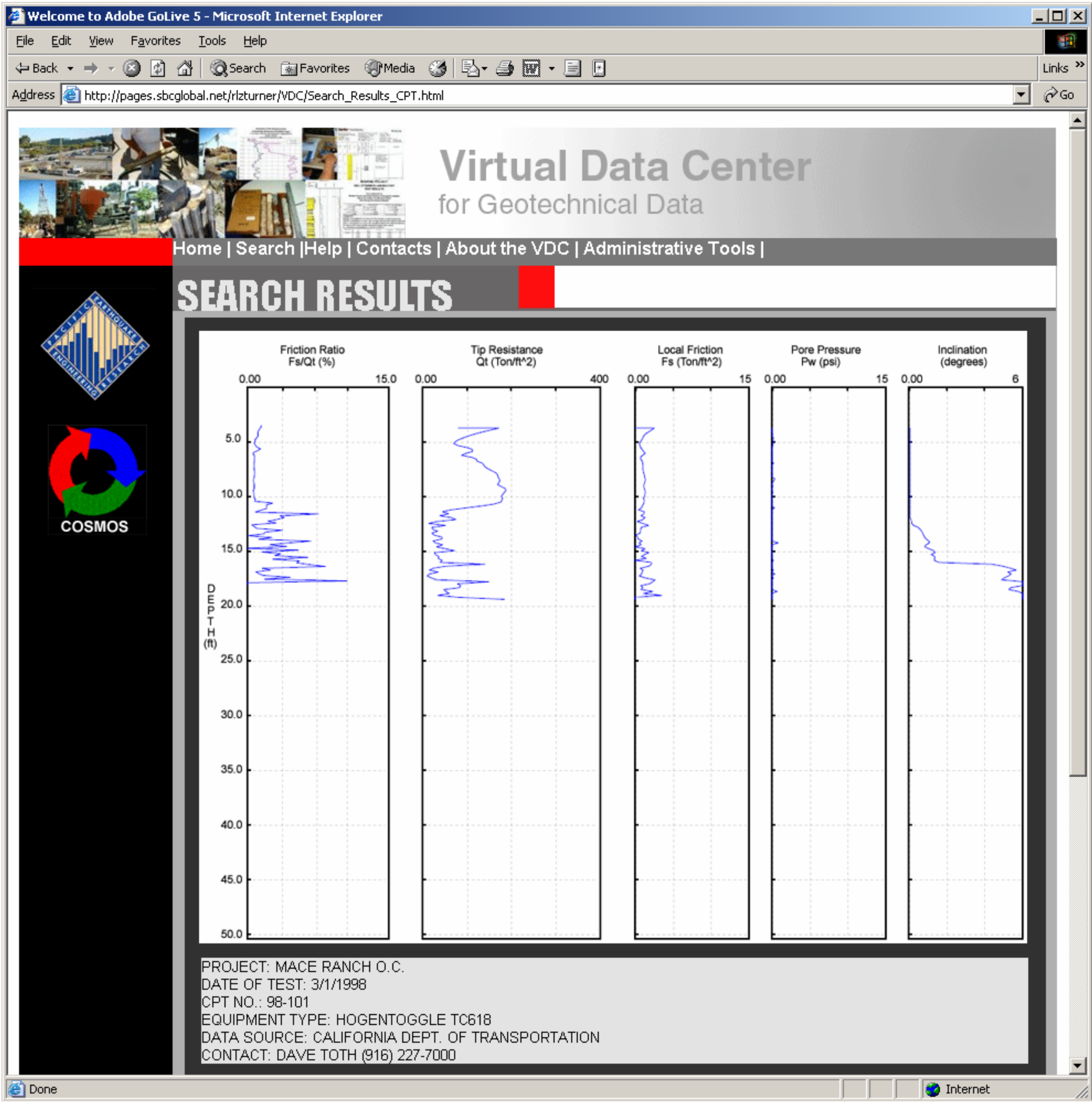

Figure 2-13 – Preview of CPT data prior to downloading

For data where no direct download exists, the client can click the "CONTACT" button to view contact information for that particular data set. This feature is shown in Figure 2-14.

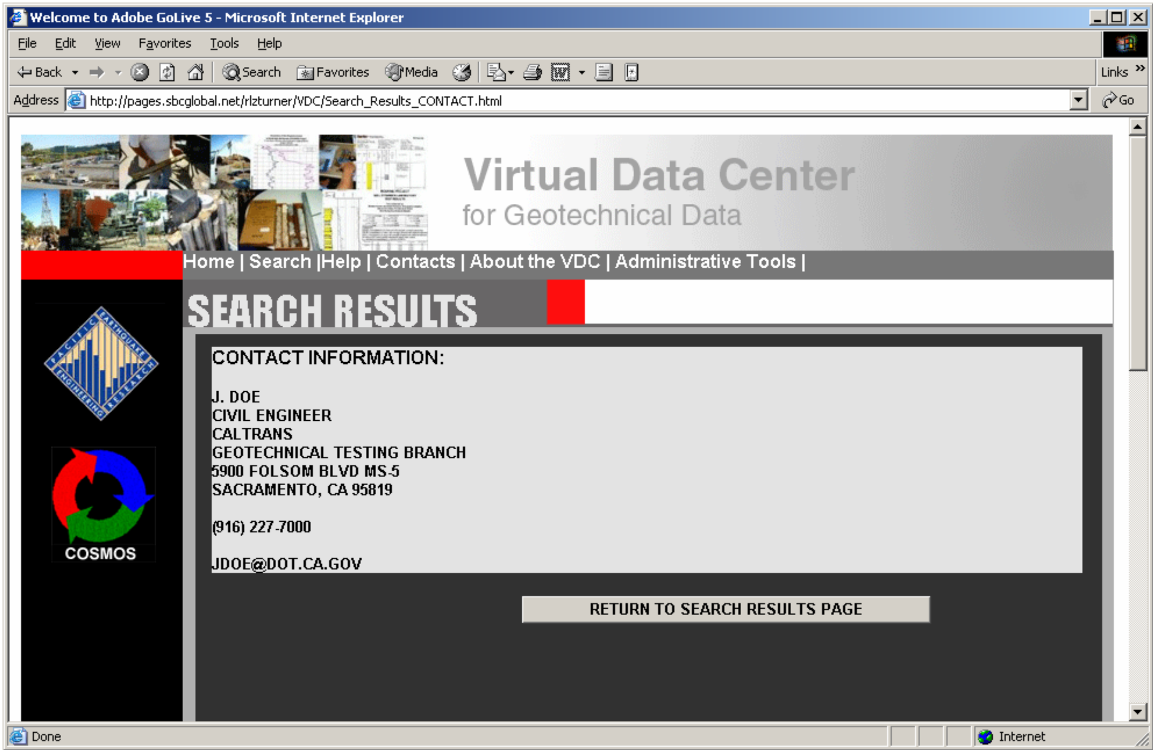

Figure 2-14 – Display of contact information

2.8 CONCLUSIONS

Using the results from a recently administered online survey of geo-professionals nationwide, the User Scenario Work Group has established a baseline of current practices and has identified functional requirements for a pilot geotechnical information management system. A user scenario is presented for one of the more common practices, developing geotechnical design recommendations for the construction of a structure. Within the context of that particular scenario, a mock up is presented with proposed features and an interface intended to meet the needs voiced by the respondents of the survey. Recognizing that the design of the system is an iterative process, the user scenario and mock-up represent only and initial recommendation for the user experience. Continued feedback from end-users and revision are necessary to develop a successful system.

2.9 REFERENCES

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Ostwald, J. (1996). *Knowledge Construction in Software Development: The Evolving Artifact Approach*, A thesis submitted to the Faculty of the Graduate School of the University of Colorado in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Department of Computer Science. http://www.cs.colorado.edu/~ostwald/thesis/section3-4.html

3 Data Dictionary and Formatting Standard for Dissemination of Geotechnical Data

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3.1 INTRODUCTION

Following the invited workshop on Archiving and Web Dissemination of Geotechnical Data (COSMOS PEER, 2001), discussions of available geotechnical databases provided a framework for developing a pilot project for archiving and web dissemination of geotechnical data. The main purpose of the project is to allow geotechnical information offered by various agencies or companies to be discovered and accessed through a single virtual data center interface. The project, sponsored by the Consortium of Organizations for Strong-Motion Observation Systems (COSMOS) and by the Pacific Earthquake Engineering Research Center Lifelines Program (PEER) is to link databases from various agencies such as the California Department of Transportation (Caltrans), the California Geological Survey (CGS), the U.S. Geological Survey (USGS) and Pacific Gas and Electric (PG&E). The scope of this virtual data center project consists of three main tasks: 1) define appropriate geotechnical data user scenarios, 2) develop a data model and data dictionary and, 3) develop and implement the pilot system architecture based on user needs. In Task 1, the user scenarios survey of various agencies, practitioners and researchers provided the necessary guidance to develop a system that would satisfy most users and participating agencies.

3.2 DATA DICTIONARY

Information to be shared among different systems has to be standardized using a common data model with an associated data dictionary. The data model defines the information content, structure, and relationships of the data, and the data dictionary specifies the meaning of the various attributes. Several data dictionaries have been developed for geotechnical databases with different contents and structures to suit the needs of the users of those databases. For the development of the data dictionary for the pilot virtual data center, a review of some of the existing data dictionaries provided the framework for the current design. It was decided to use the data dictionary developed for the National Geotechnical Experimentation Sites (NGES) program (Benoît et al. 1994) as a starting point. The NGES

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[2] GEOCOMP Corporation
[3] Petrotechnical Open Standards Consortium
[4] California Geological Survey
[5] U. S. Geological Survey
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[7] University of Washington
[8] UC-Santa Barbara
[9] Caltrans

data dictionary was modeled after existing standards and databases such as those drawn by the Association of Geotechnical Specialists (AGS, 1992) in the United Kingdom for the electronic transfer of geotechnical data in ground investigations. The content of the NGES data dictionary was based on actual test results, available ASTM standards, and input from various experts in laboratory and in situ testing. Unlike other systems such as the AGS, which was initially designed for use by consultants and contractors to develop proposals and bids, the design of the NGES data dictionary aimed at providing research quality information with a high level of detail to users of the experimental test sites and test results.

Although current development is for a pilot system, the data dictionary for this project is designed to be expandable to allow the virtual data center to link to multiple databases with diverse structures. After the review of the NGES and other data dictionaries, it was concluded that a new approach had to be undertaken to ensure the requirement for flexibility and expandability to satisfy the needs of the geotechnical profession based on results from the user scenarios survey. Such a system would allow for archiving, exchange and sharing of reliable and complete geotechnical information with maximum compatibility. It would also have the capability to provide users with data in tabular, graphical and/or image form.

The data model used for this pilot system is shown in Figure 3-1 as an entity-relationship diagram. A series of entities was developed for the pilot system data dictionary. Those include information about the site, the boreholes, and the testing associated with the boreholes or soundings and/or the samples recovered from the boreholes. The entities can be thought of as tables within a relational database system (RDBMS), but no such RDBMS needs to exist in actuality. The relational database at the geotechnical virtual data center repository (GVDC), in fact only stores a subset of attributes from a few of the entities in the data model.

The GVDC does not contain the data itself, but only stores sufficient metadata for identification and querying purposes, along with the appropriate URL that points to the actual data, which resides in XML files generated by the data providers. The following 20 entities are part of the current pilot system.

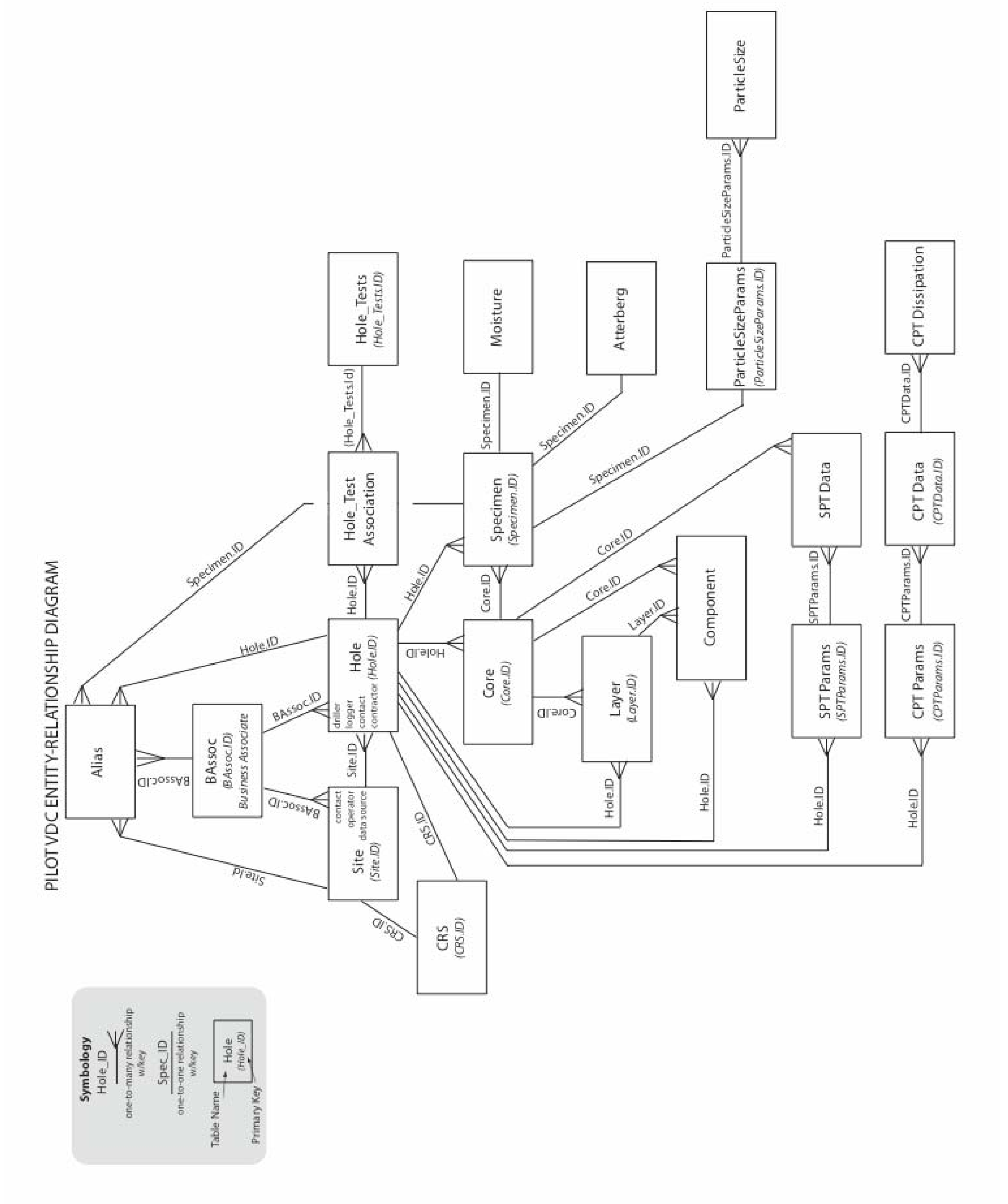

Figure 3-1. Entity-Relationship Diagram for Pilot Virtual Data Center

Entities with a subset of attributes stored in the GVDC RDBMS	Entities with attributes given in XML to the end user by the data provider
Business Associate	Alias
Site	Core
Coordinate Reference System	Layer
Hole	Component
Hole Test Association	Specimen
Hole Tests	Moisture
	Atterberg
	Particle Size Parameters
	Particle Size
	Standard Penetration Test Parameters
	Standard Penetration Test Data
	Cone Penetration Test Parameters
	Cone Penetration Test Data
	Cone Penetration Dissipation Test

The data model itself is implemented in XML, which is provided to the end user by the data provider. Within the XML file, relationships among the entities shown in Figure 3-1 are defined via keys and/or the XML structure itself. The entity that sits at the top level of the context hierarchy is the Site, which is defined as a collection of holes and samples obtained at a common place. To fully describe the sampling stations and stratigraphy at a given Site, the Hole, Core, Layer, Component and Specimen entities were defined to allow completeness and flexibility. Figure 3-2 shows those relationships along with definitions for each of those entities. At each site can be a collection of holes from which layers and components are defined and where cores are obtained for laboratory testing. Cores may be sub-sampled into specimens (and specimens further sub-sampled) for specific tests. A Hole is broadly defined as a single sampling station or profile, from which earth materials are collected or described, or earth material properties are measured. Furthermore, this term is used to represent the sample collecting activity as well as the sampling station. Therefore, in addition to a conventional borehole, a Hole could represent sampling or measurements from an outcrop or surface excavation, a cone penetration test (CPT) sounding, or a geophysical profile. The relationships among the entities clearly provide the data suppliers and the users with the necessary information to track the results from the initial site investigation to the final results.

Only a limited number of entities for laboratory and in situ tests were generated for this pilot project. For some of these tests, the metadata that provides descriptive, non-quantifiable contextual information about the tests are included in a separate entity from the entities that contain the test results. Table 3-1 gives an example of the attributes defined for the Cone Penetration Test. Three entities are defined: 1) Cone Penetration Test Parameters, 2) Cone Penetration Test Data, and 3) Cone Penetration Test Dissipation Data. The first entity contains the metadata for the CPT test, whereas the second entity provides the actual data obtained from a CPT sounding (e.g. tip resistance and sleeve friction for each depth interval). The third entity provides for pore pressure measurements at different time intervals at a specific testing depth. In future expansions of the data model, additional entities can be defined to accommodate other types of data collected during a CPT test (e.g. wave form data from a seismic cone).

Dictionary tables like those in Table 3-1 were constructed for each of the entities in the data model and form the basis for the development of the XML schema. These tables and those for the remaining entities are given in Appendix A. These tables are solely informative while the schema is the normative document. The tables only list part of the information for each entity. The schema provides all necessary details including key fields, data types, units of measure, ranges of acceptable values, enumerated lists, and whether certain attributes are required or not. The mandatory attributes provide the necessary level of completeness of the data for conventional geotechnical practice. Optional attributes increase the completeness of the data and provide additional information for more in-depth analysis of the results.

Figure 3-3 shows an example of the schema for the Site entity, derived from the online documentation, including both the XML instance representation as well as the schema component representation. The complete schema developed from this pilot dictionary is an extensive interactive online document with multiple links and pop-up windows providing definitions of the various attributes. A link to the complete geotechnical schema is available at the following web address:

http://www.cosmos-eq.org

As an example, Appendix 2 shows how the Site data dictionary table is translated into the XML schema.

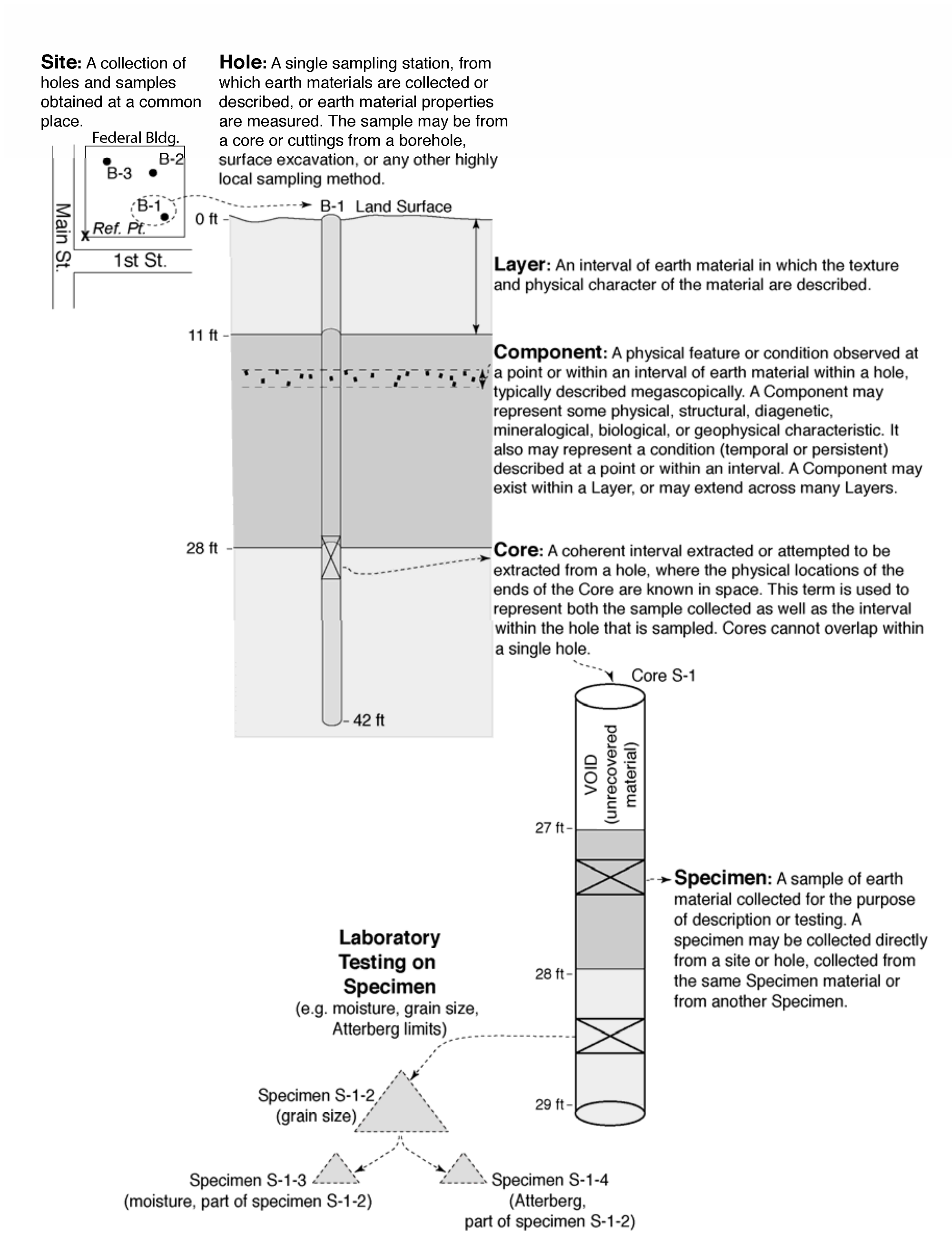

Figure 3-2. Relationships Among Site, Hole, Core, Layer, Component and Specimen Object

Table 3-1 Data Dictionary Tables for Cone Penetration Test

Cone Penetration Test Parameters	The cone penetration test (CPT) consists in determining the resistance to penetration of a conical pointed penetrometer into subsurface soils. Standard testing procedures are described in ASTM D 5778. Relevant testing parameters are described in this table.

Name	**Definition**
Hole	The hole, of which these CPT parameters are a part. The CPT parameters must be related to a hole. This value is a foreign key that should select an instance of Hole based on the Id value of the Hole.
Cone Type	The type of cone penetrometer used for testing. The following provides a list of available cone penetrometers: a) mechanical cone, b) electric cone, c) piezocone, d) seismic piezocone, e) lateral stress cone, f) dynamic cone, g) acoustic cone, h) resistivity cone, i) vibratory cone, j) miniature cone, or k) other.
Cone Manufacturer	The business name of the company manucturing the cone penetrometer. For example, Fugro, Hogentogler, Delft, etc.
Tip Area	The conical base area of the penetrometer tip. Typical values are 10 cm2 and 15 cm 2
Tip Apex Angle	The apex angle of the conical point of the penetrometer tip. The standard value is 60 degrees.
Friction Sleeve Area	The surface area of the friction sleeve located immediately behind the penetrometer tip. Typical values are 150 cm2 for the 10 cm2 and 200 cm2 for the 15 cm2.
Distance Tip to Sleeve	The distance between the tip and the center of the friction sleeve.
Piezocone Type	The type of Piezocone is defined in part by the position of the filter element. The types in use are the following: a) Type 1 (on the tip apex or at the midface on the tip), b) Type 2 (at the shoulder or behind the tip), c) Type 3 (above the friction sleeve), or d) other.
Porous Element Type	The type of material used as porous filter element. The following materials are typically used: a) plastic, b) sintered bronze, c) sintered steel, d) ceramic, or e) other.
Saturation Fluid	The fluid used to saturate the porous filter element. The following deaired fluids are typically used: a) water, b) glycerin, c) silicon oil, or d) other.
Saturation Method	A description of the procedure used to saturate the porous filter element.

Net Area Ratio Correction	The correction necessary to adjust the penetration cone resistance due to penetration water pressures acting behind the cone tip. The net area ratio correction, a, is applied to the cone resistance qc which becomes the corrected total cone resistance qt. The value a is dimensionless.
Push Rod Type	The type of pushing rods used for CPT penetration. Standard nomenclature can be used such as A-rod or N-rod.
Friction Reducer	A description of the type, size and location of the friction reducer behind the base of the cone should be reported if used.
Penetration Rate	The rate of advance of the penetrometer. Rate should be between 20 +/- 5 mm/second.
Tip Load Cell Capacity	The capacity of the tip load cell.

Sleeve Load Cell Capacity	The capacity of the sleeve load cell.
Surface Load Cell Capacity	The capacity of the surface load cell.
Pore Pressure Load Cell Capacity	The capacity of the pore pressure load cell.
Last Calibration Date	The date of the last calibration of the penetrometer. Specify which components were calibrated.
Remarks	A text descriptor providing additional information relevant to the CPT parameters and equipment especially if those differ from standard requirements.
Date Last Updated	The date of the last update to the data in this table

Cone Penetration Test Data	The cone penetration test (CPT) consists in determining the resistance to penetration of a conical pointed penetrometer into subsurface soils. Standard testing procedures are described in ASTM D 5778. Cone Penetration data are presented in this table.

Name	**Definition**
Cone Penetration Test Parameters	The Cone Penetration Test Parameters, of which these CPT data are a part. The CPT data must be related to a Cone Penetration Test Parameters. This value is a foreign key that should select an instance of Cone Penetration Test Parameters based on the Id value of the Cone Penetration Test Parameters.
Tip Depth	The depth of measurement at the penetrometer tip.
Tip Resistance	The end-bearing component of penetration resistance in units of stress referred to as qc (uncorrected for net area ratio).
Friction Sleeve Resistance	The friction component of penetration resistance in units of stress developed on a friction sleeve refereed to as fs.
Penetration Pore Pressure	Fluid pressure measured using the piezocone penetration test.
Inclination	Inclination of the penetrometer during advance in degrees.
Remarks	A text descriptor providing additional information relevant to the CPT data and results.
Date Last Updated	The date of the last update to the data in this table

Cone Penetration Test Dissipation Data	During cone penetration testing it is possible to conduct dissipation tests to evaluate the hydraulic conductivity of soils. The process consists in stopping the penetrometer advance at the depth of interest and observing the pore pressure decay with time. Standard testing procedures are described in ASTM D 5778. Cone Penetration dissipation data are presented in this table.

Name	**Definition**
Cone Penetration Test Data	The Cone Penetration Test Data, of which these CPT dissipation data are a part. The CPT dissipation data must be related to a Cone Penetration Test Data. This value is a

	foreign key that should select an instance of Cone Penetration Test Data based on the Id value of the Cone Penetration Test Data.
Tip Depth	The depth of dissipation measurement at the penetrometer tip.
Penetration Pore Pressure	Fluid pressure measured using the piezocone during the dissipation test.
Elapsed Time	Elapsed time of reading for dissipation measurement.
Remarks	A text descriptor providing additional information relevant to the CPT dissipation data, results and procedures.
Date Last Updated	The date of the last update to the data in this table

3.3 CONCLUSIONS

A data dictionary was devised for use with a pilot system for archiving and web dissemination of geotechnical data. The tables for the pilot system are easily expandable and designed to encourage data providers to contribute new as well as legacy data to the geotechnical virtual data center. This pilot system will be reviewed to obtain input and consensus of the geotechnical community.

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Swift, J. N., et al., 2001. “Proceedings: Invited Workshop on Archiving and Web Dissemination of Geotechnical Data”, October 4-5, Richmond, CA, COSMOS Publication CP-2001/03.

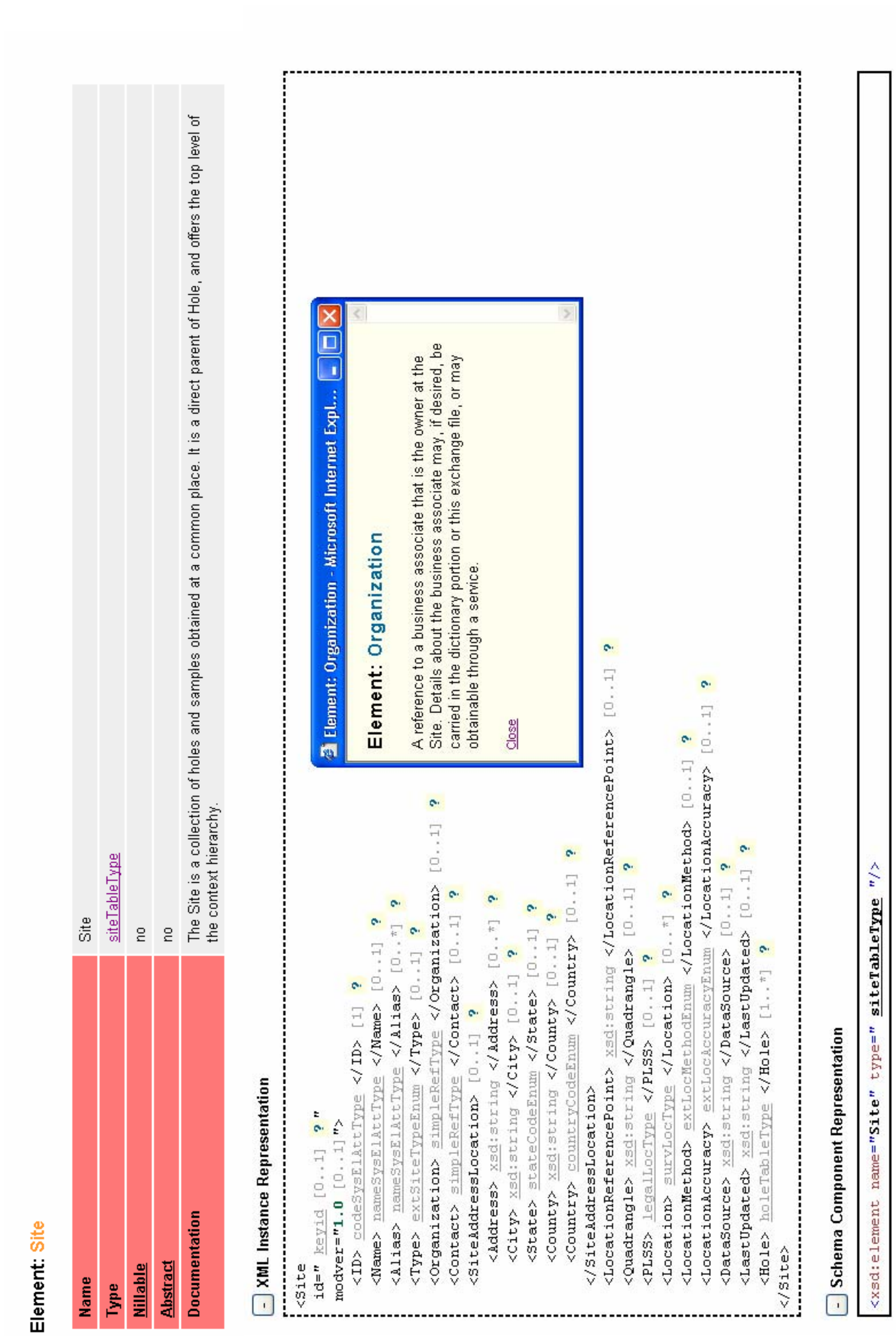

Figure 3-3. Schema Example for Site

Complex Type: siteTableType

Parent type:	None
Direct sub-types:	None

Name	siteTableType
Abstract	no
Documentation	The Site is a collection of holes and samples obtained at a common place. It is a direct parent of Hole, and offers the top level of the context hierarchy.

XML Instance Representation

```
<...
 id=" keyid [0..1] ? "
 modver="1.0 [0..1]">
  <ID> codeSysElAttType </ID> [1] ?
  <Name> nameSysElAttType </Name> [0..1] ?
  <Alias> nameSysElAttType </Alias> [0..*] ?
  <Type> extSiteTypeEnum </Type> [0..1] ?
  <Organization> simpleRefType </Organization> [0..1] ?
  <Contact> simpleRefType </Contact> [0..1] ?
  <SiteAddressLocation> [0..1] ?
    <Address> xsd:string </Address> [0..*] ?
    <City> xsd:string </City> [0..1] ?
    <State> stateCodeEnum </State> [0..1] ?
    <County> xsd:string </County> [0..1] ?
    <Country> countryCodeEnum </Country> [0..1] ?
  </SiteAddressLocation>
  <LocationReferencePoint> xsd:string </LocationReferencePoint> [0..1] ?
  <Quadrangle> xsd:string </Quadrangle> [0..1] ?
  <PLSS> legalLocType </PLSS> [0..1] ?
  <Location> survLocType </Location> [0..*] ?
  <LocationMethod> extLocMethodEnum </LocationMethod> [0..1] ?
  <LocationAccuracy> extLocAccuracyEnum </LocationAccuracy> [0..1] ?
  <DataSource> xsd:string </DataSource> [0..1] ?
  <LastUpdated> xsd:string </LastUpdated> [0..1] ?
  <Hole> holeTableType </Hole> [1..*] ?
</...>
```

Figure 3-4. Schema Example for Site (continued)

Schema Component Representation

```
<xsd:complexType name="siteTableType">
  <xsd:sequence>
    <xsd:element name="ID" type=" codeSysElAttType "/>
    <xsd:element name="Name" type=" nameSysElAttType " minOccurs="0"/>
    <xsd:element name="Alias" type=" nameSysElAttType " minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="Type" type=" extSiteTypeEnum " minOccurs="0"/>
    <xsd:element name="Organization" type=" simpleRefType " minOccurs="0"/>
    <xsd:element name="Contact" type=" simpleRefType " minOccurs="0"/>
    <xsd:element name="SiteAddressLocation" minOccurs="0">
      <xsd:complexType>
        <xsd:sequence>
          <xsd:element name="Address" type=" xsd:string " minOccurs="0" maxOccurs="unbounded"/>
          <xsd:element name="City" type=" xsd:string " minOccurs="0"/>
          <xsd:element name="State" type=" stateCodeEnum " minOccurs="0"/>
          <xsd:element name="County" type=" xsd:string " minOccurs="0"/>
          <xsd:element name="Country" type=" countryCodeEnum " minOccurs="0"/>
        </xsd:sequence>
      </xsd:complexType>
    </xsd:element>
    <xsd:element name="LocationReferencePoint" type=" xsd:string " minOccurs="0"/>
    <xsd:element name="Quadrangle" type=" xsd:string " minOccurs="0"/>
    <xsd:element name="PLSS" type=" legalLocType " minOccurs="0"/>
    <xsd:element name="Location" type=" survLocType " minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="LocationMethod" type=" extLocMethodEnum " minOccurs="0"/>
    <xsd:element name="LocationAccuracy" type=" extLocAccuracyEnum " minOccurs="0"/>
    <xsd:element name="DataSource" type=" xsd:string " minOccurs="0"/>
    <xsd:element name="LastUpdated" type=" xsd:string " minOccurs="0"/>
    <xsd:element name="Hole" type=" holeTableType " maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="id" type=" keyid " use="optional"/>
  <xsd:attribute name="modver" type=" xsd:string " fixed="1.0"/>
</xsd:complexType>
```

Figure 3-5. Schema Example for Site (continued)

4 PILOT GEOTECHNICAL VIRTUAL DATA CENTER SYSTEM ARCHITECTURE AND DATABASES

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4.1 GVDC PILOT SYSTEM ARCHITECTURE

The Pilot COSMOS/PEER-LL GVDC (Geotechnical Virtual Data Center) Project supported by the PEER-Lifelines (LL) Program (Pacific Earthquake Engineering Research Institute) has finalized the system architecture supporting web-based interfaces providing access to participating publicly available geotechnical data sets. Over the long-term, the main objective is to extend this pilot system and link multiple data sets of other government agencies, universities and private companies. The GVDC is capable of serving the broad needs of practicing geotechnical engineering and earthquake hazards professionals as a central repository of searchable metadata on publicly available geotechnical data sets uploaded from data providers.

The project's Virtual Data Center Work Group (VDCWG) consists of seventeen participants from government agencies, industry and academia. The VDCWG has designed and implemented a pilot Geotechnical Virtual Data Center (GVDC) that allows users to download geotechnical borehole data from four data providers including California Geological Survey (CGS), California Department of Transportation (Caltrans), the United States Geological Survey (USGS; Ponti, 2004) and the Pacific Gas and Electric Company (PG&E) (Figures 4-1 and 4-2). The GVDC consists of both a GIS-enabled end-user web interface (Figure 4-3), and an administrative web interface (Figure 4-4). The system architecture design is based on the results of the geotechnical user scenario survey and on the data dictionary developed by the project's User Scenario

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[8] Internovations, Inc.

[9] Savage Software, Inc.

[10] Geotechnology Consortium of Strong Motion Observation Systems (COSMOS)

(USWG) and Data Dictionary (DDWG) Work Groups (see Chapter 2, Turner et al., and Chapter 3, Benoit et al., this report, respectively; Bobbitt et al., 2004). GVDC website security has been significantly enhanced with SSL (Secure Socket Layer), meaning all transactions are now confidential and are secured with SSL encryption, and end user and data provider information (registration, MySQL metadata, and other website information) are protected.

The following software applications were developed by the VDCWG to support the pilot implementation of the GVDC: 1) a user friendly GIS (ArcIMS) front end designed by the USWG (Chapter 2, Turner et al., this report; Turner et al., 2004), including on-the-fly downloading of geotechnical data in Extensible Markup Language (XML; W3C, 2004a) and Excel file formats, 2) Open Archives in a Box (OAIB) Java applications (NCSA, 2004; OAI, 2004) customized and installed on the data providers' servers to allow search parameter data to be harvested from the data providers' data sets, 3) back end GVDC Java applications interacting with the OAIB installations, supporting a combination

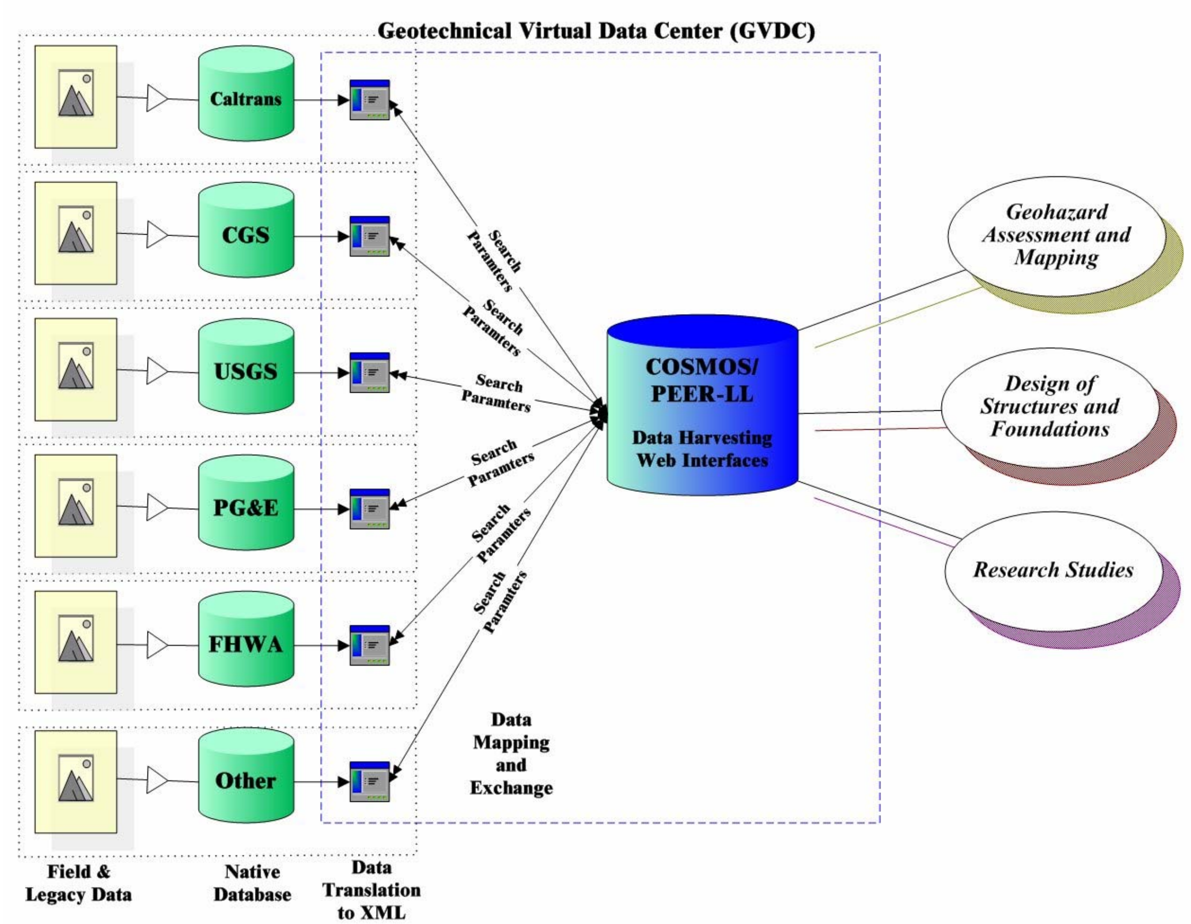

Figure 4-1. General overview of GVDC system architecture.

harvesting/federation system architecture, and 4) XML translators for producing downloadable XML files from the various data provider's databases mapped to the geotechnical data dictionary developed by the DDWG (Chapter 3, Benoit et al., this report). A detailed discussion on all of these applications can be found in Appendix 3 of this report. A data storage strategy to permanently archive geotechnical data generated through PEER Lifelines funding or by others is currently being designed and will be implemented in the next phase of this project (COSMOS/PEER-LL 2L03).

4.2 FRONT END SYSTEM ARCHITECTURE

Technologically, the GVDC is essentially a GIS-based end user search interface coupled with a back end database and harvester, and data translators (Figure 4-1). The GVDC does not contain the actual boring logs, but rather maintains an index or metadata catalog to available data from participating data providers in a MySQL database (MySQL, 2004), consiting of descriptive information about the boreholes (e.g. date drilled, total depth, types of test information available, etc.). The structure of the MySQL database conforms precisely to the COSMOS/PEER-LL Geotechnical data dictionary and XML Schema format (Chapter 3, Benoit et. al., and Appendices 2 and 3, this report). The GIS end user interface was written in Microsoft Active Server Pages (ASP; W3C, 2004b) and utilizes ESRI ArcIMS software for the map rendering service (Farallon, 2004). The GIS interface is customized primarily in VBScript (W3C, 2004c) embedded in ASP web pages, while the administrative (back end) Java Harvester fucntions are coded in Java Server Pages (JSP; Sun, 2004) embedded in the overall ASP website design.

All end users connect to the GVDC system through browsers (Figure 4-2). The end user is required to register and provide a user name and password (Figures 4-5). Once a user has successfully logged into the website, the GIS map interface allows effective search of the GVDC database by location or a specified region of interest (Figure 4-3). The user may use the map tools (e.g. buttons for ZOOM, PAN, turn layers on and off) to navigate and locate a general area of interest. The user may use the arrow selection tool to define an area of interest on the map. Figure 4-6 shows an example area of interest delimited by a box encompassing many boreholes in the Los Angeles area. The limits of the area are automatically entered into the longitude and latitude boundaries form to the right of the map. As an alternate method of defining a search area, the end user may enter coordinates directly into the longitude and latitude boundaries form rather than drawing a box on the map. Additional search criteria, including data types, dates of investigation, and total borehole depth may be used to narrow the data selection (e.g. Figure 4-7: only boreholes with SPT data that are between 1 and 10-m deep). Once the desired data are identified and the user submits a search, a detailed list of borehole records follows with additional information on each result, including the project name, the data type, the data source, date, and any available downloads or contact information (Figure 4-8). The available data are grouped in sets on the search results page, according to data provider. Check boxes are provided to the right of each record on a search results page to allow the end user to download geotechnical data in XML (ASCII) and/or Microsoft Excel formats. A VBscript translator converts COSMOS/PEER-LL geotechnical XML schema-compliant data on-the-fly into Excel (Softartisans, 2004). Each record represents a COSMOS/PEER-LL geotechnical XML schema-compliant XML file, containing data on a single type of test data from one borehole. Data exchange using the standardaized XML

Figure 4-2. GVDC user entry web page, https://geodata-cosmos-data.org.

files means that all data are downloadable in Excel and XML, irrespective of data source. There may be many records in the list for each borehole, each containing a different type of test data. Multiple files in one or both formats can be zipped simultaneousy on-the-fly (ZBit, 2004). After a user has selected the desired records, the request is submitted by clicking on the "Download Data From this Provider" button at the base of each set of search results. The user must agree to the data usage policy, privacy policy and any

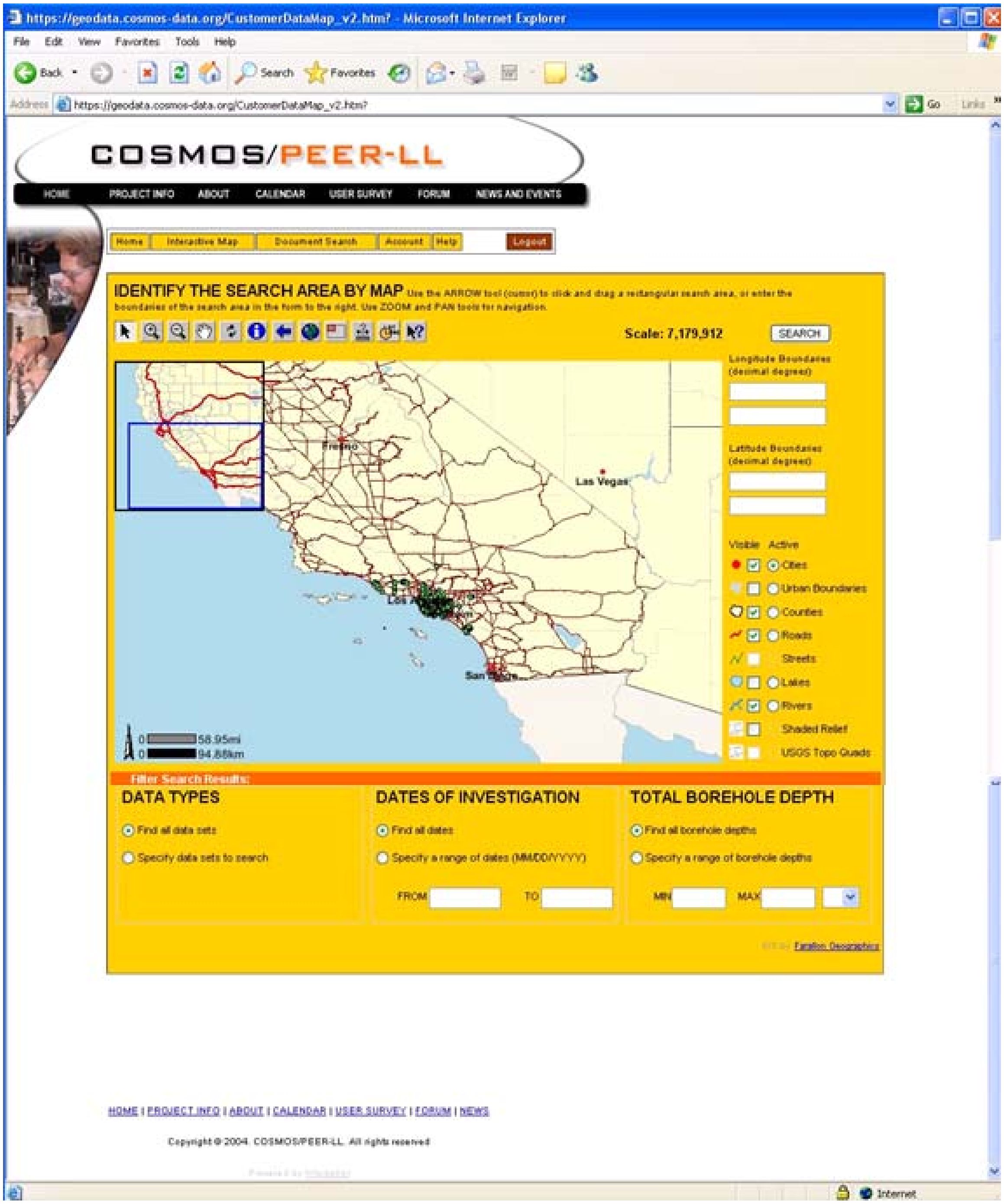

Figure 4-3. GVDC front end user GIS map interface.

disclaimer specified by the data provider, prior to downloading the data (Figure 4-9). If the user agrees, the zip file containing the user's selections is then streamed to the user through a typical windows download dialog. The data zip file can then be can be saved to a permanent media as desired by the end user.

Two data previewers are currently available that allow on-the-fly visualization of geotechnical data through a GVDC search results page. A user can preview Cone

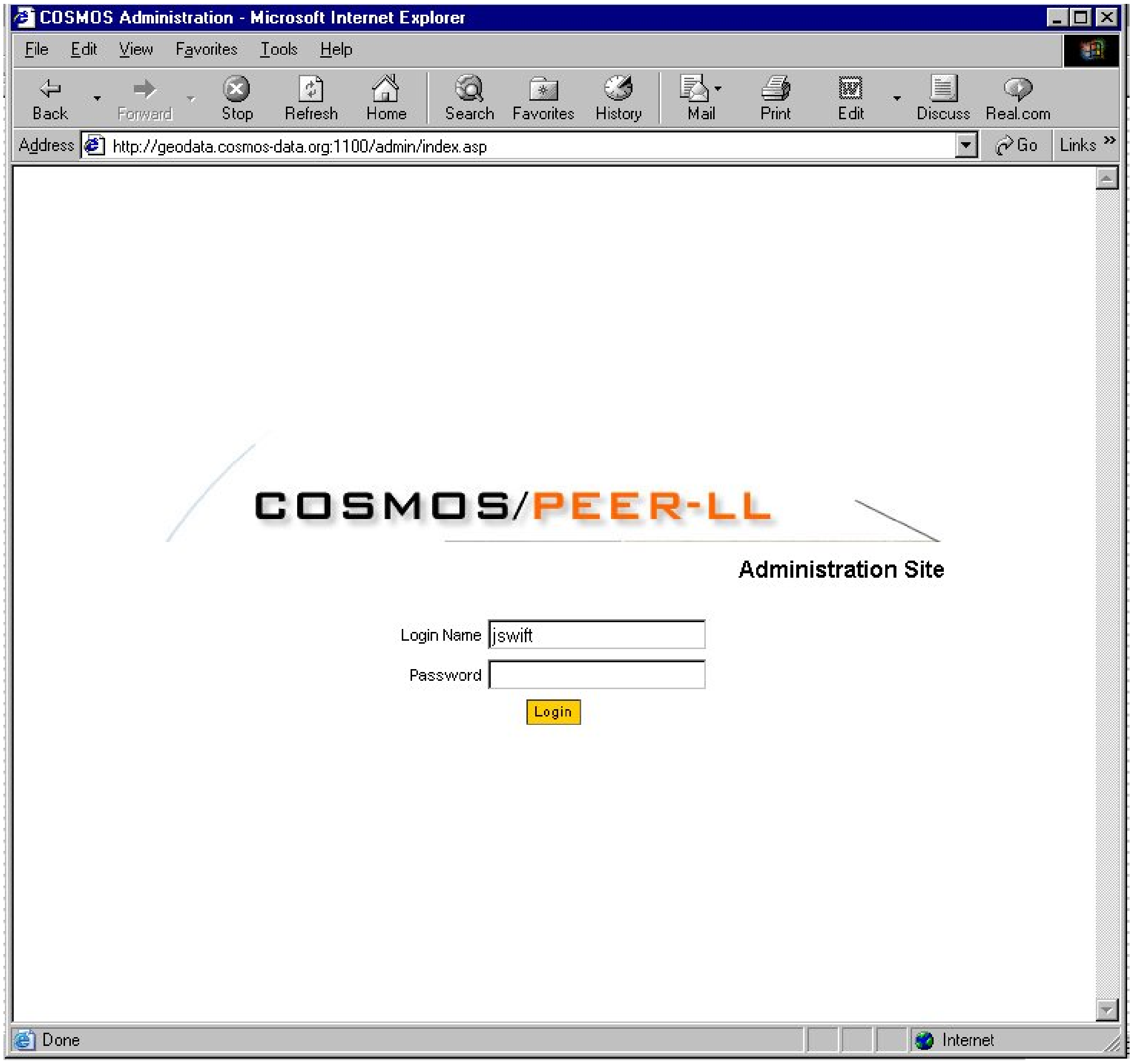

Figure 4-4. GVDC administrative web interface.

Penetration Tests (CPT) logs and borelogs dynamically. The previewers are activated by clicking on "CPT" and "BLG" (Basic Lithology) under heading "Data Types" on a search results page, respectively (i.e. Figure 4-10). The CPT previewer was created in .NET by Caltrans, and displays CPT XML files on-the-fly using SVG (Scalable Vector Graphics) (SVG; W3C, 2004; Grimes, 2004b). The borehole previewer was coded in VB.NET and C/C++ by Savage Software (Savage, 2004). Borehole previews display geologic and geotechnical information in a typical boring log format, for borehole records containing sufficient detailed lithologic information (ROSRINE, 2001). Behind the scenes (the back end), the data are retrieved using hyperlinks (URL's) from the host machine of the applicable agency.

If a borehole is shown on the map but the corresponding data is not yet available in the COSMOS/PEER-LL standard format, contact information also stored in the GVDC MySQL database is provided in the search results page.

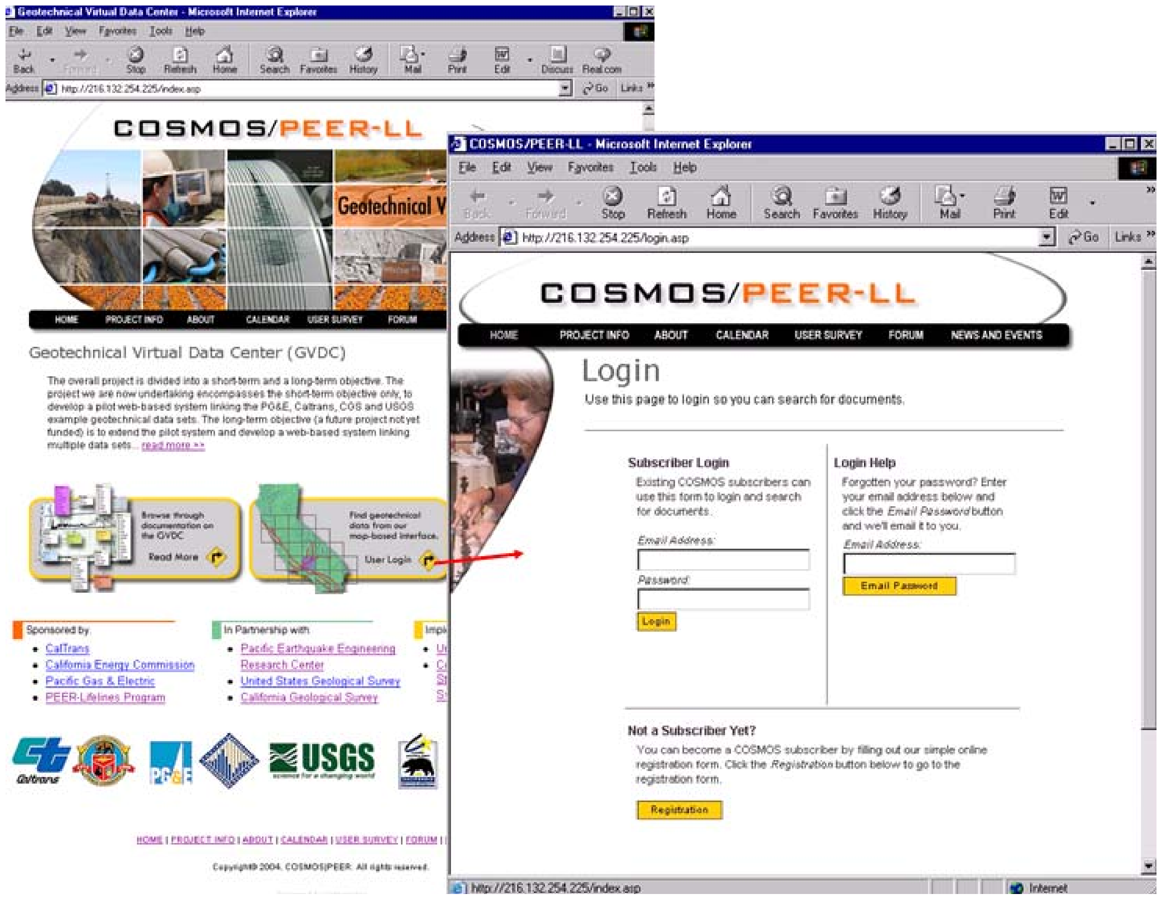

Figure 4-5. Secure (SSL) GVDC system login page. This link takes the user to the map interface and text-based documents search.

4.3 BACK END SYSTEM ARCHITECTURE

A comprehensive overview of the pilot project system architecture is provided in Figure 4-11. The details for the pilot project data providers' (Caltrans, CGS, USGS and PG&E) systems are illustrated on the right, and are discussed in detail in Appendix 3. Each data provider maintains: 1) a native geotechnical data set or database including the searchable parameters for the GVDC front end; 2) an OAIB installation which allows the GVDC to harvest the search parameter data from the native database or data set; and 3) a data translator for exporting data from it's respective native format (such as Microsoft Access, MySQL or PostgreSQL databases) into the standardized COSMOS/PEER-LL geotechnical data XML format (Benoit et al., 2004).

Caltrans, CGS and PG&E maintain their searchable geotechnical parameters in Microsoft Access databases, while the USGS utilizes PostgreSQL. Caltrans and USGS developed new geotechnical databases based on the COSMOS/PEER-LL XML data format as part of this project, while existing CGS and PG&E database structures were customized to interact with the GVDC harvester. CGS is also currently implementing other custom borehole download features through the CGS Seismic Hazards Mapping Program website, a separate effort from this project (CGS, 2004). The GVDC CGS harvesting and

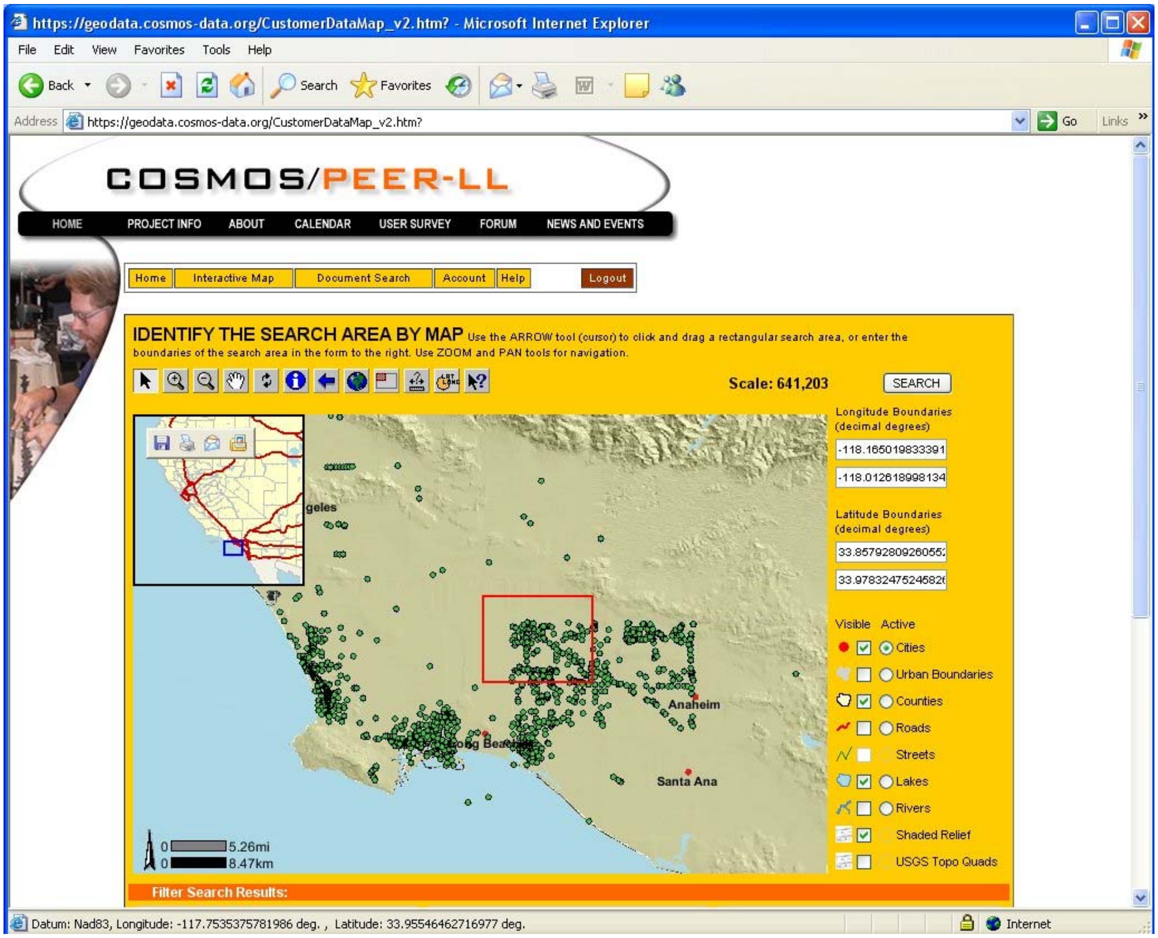

Figure 4-6. GVDC front end user GIS map interface, showing are selected using arrow tool (upper left). A search of the GVDC MySQL database for the boreholes within the search box will be invoked when the user clicks on the "Search" button (upper right).

data translation features were implemented using the same geotechnical database structure currently integrated with the SHMP mapping website (CGS, 2004). Custom Microsoft Visual Basic applications were written for the CGS and PG&E Access databases, which directly translate the geotechnical data tables into XML files which are automatically saved to the data providers' servers. These XML translators also automatically generate and store the URL's to the XML files within these Access databases. The URL's are harvested concurrently with the other search parameters, whenever the GVDC interacts with the OAIB installations. Caltrans wrote a .NET translator that converts native CPT data files into COSMOS/PEER_LL geotechnical data XML files (Grimes, 2004a). The USGS created a Java translator that dynamically generates USGS XML files as XML, or initiates the GVDC Excel translator and generates Excel spreadsheets containing the borehole record (Devlin, 2004). This information is passed seamlessly as selected records are streamed to the user in a data zip file. Thus the USGS data provider does not need to create and store XML files on their server. The USGS Java translator is installed on the GVDC server.

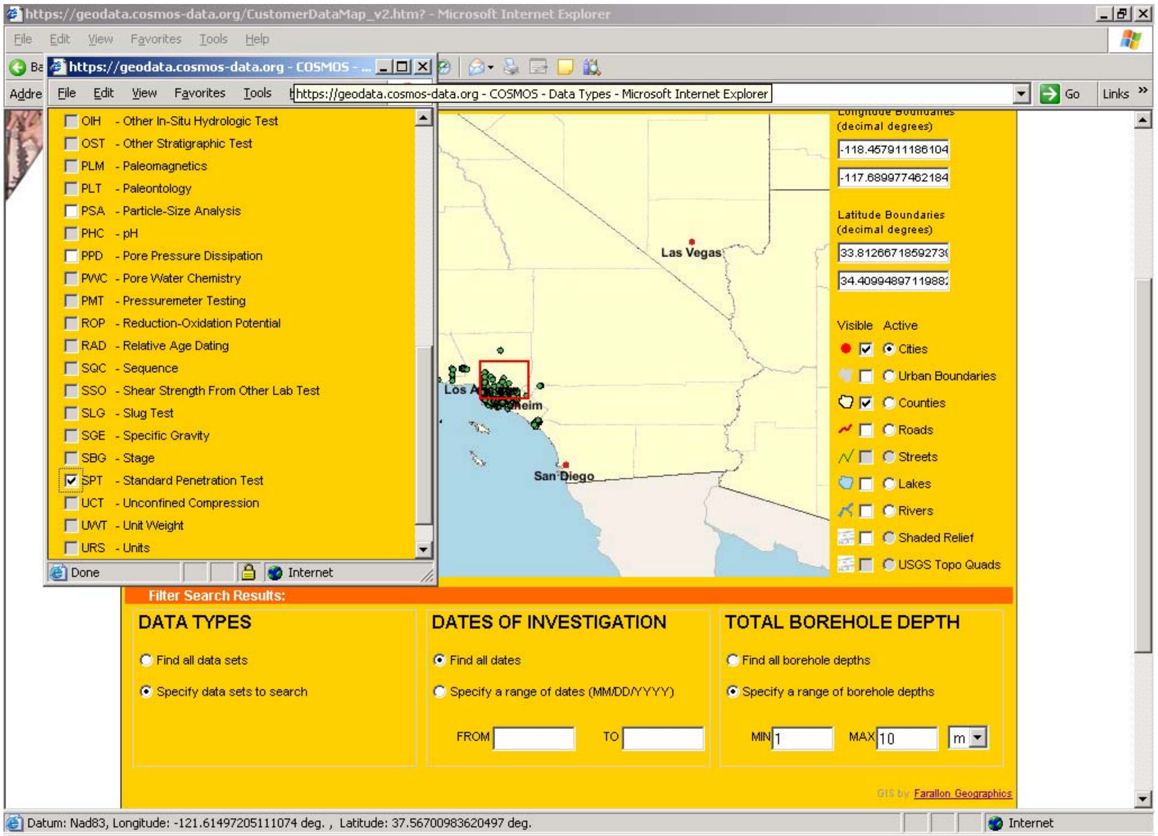

Figure 4-7. GVDC front end user GIS map interface, showing use of Data Types Filter (popup check boxes) and Total Borehole Depth Filter (lower right).

The Open Archives Initiative Protocol for Metadata Harvesting (OAI) was selected by the project participants as an appropriate digital library protocol to implement the GVDC harvester system (OAI, 2004). OAIB (NCSA, 2004a) was used to provide a set of OAI - compliant data services backed by the providers' databases, and a harvesting service used by the GVDC to acquire data from those services. The OAIB installations on the data providers' servers include the following components: 1) Java Development Kit (JDK), 2) Java, 3) Apache's Jakarta Tomcat, 4) the OAIB Java files (NCSA, 2004), and 5) configuration files mapping native data set attributes to their corresponding data names in the MySQL database. The data provider's servers and GVDC harvester components are configured to allow access only to the GVDC server, and only to specific databases and XML file directories. All four data providers will utilize firewalls to protect their OAIB servers.

The system administrators include the GVDC developers and the data providers' database administrators. The administrators are the super-users of the system. The GVDC developer maintains the front end and back end web interfaces as well as an index of available geotechnical borehole data from participating data providers in a MySQL database. Administrators can activate the harvester and update the central database whenever required (e.g. Figure 4-4). Whenever the update button is clicked, the GVDC harvester interacts with the OAIB installations on the data providers' servers. This interaction takes the form of an update, which is either, and addition, update, or deletion

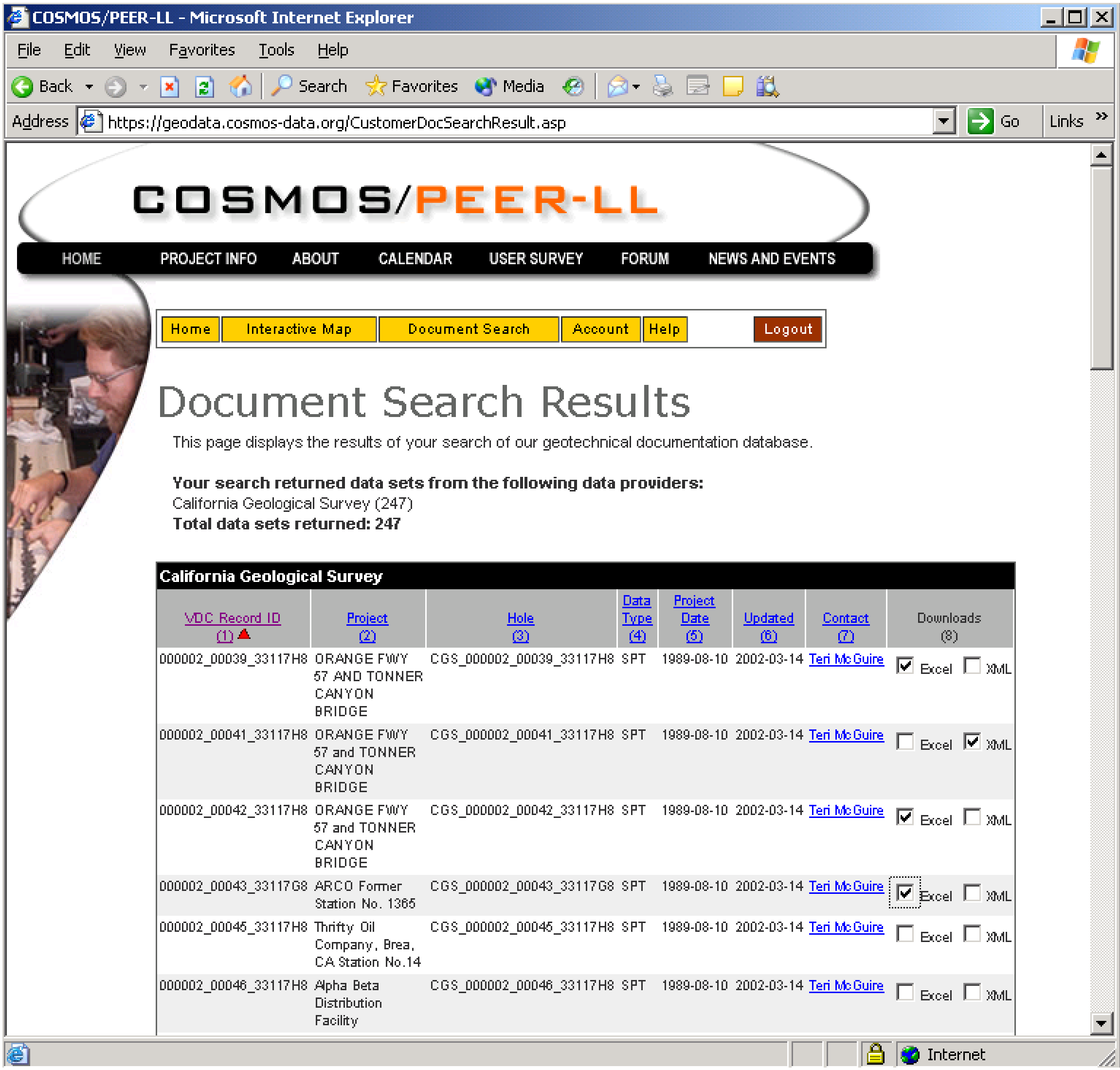

Figure 4-8. Search results page, listing records from the GVDC MySQL database corresponding to the boreholes containing only SPT data, selected using the map interface and arrow tool (Figure 4-7).

of data from the GVDC MySQL database. A confirmation is provided indicating either success or failure for each update. If deleting records from the MySQL database, the administrator must then click on the Delete option in order to delete records from the GVDC that were earlier marked for deletion in the data providers' database and uploaded as such into the MySQL database. Thus each time an end user visits the GIS map interface, the map is dynamically updated to display only the boeholes contained with the GVDC MySQL database at that point in time.

The operation and maintenance costs for the GVDC system are minimal. The system uses freeware and one yearly license for ESRI ArcIMS, and a one-time license for Softartisan ExcelWriter. Upon completion, the labor cost for operation and maintenance of the

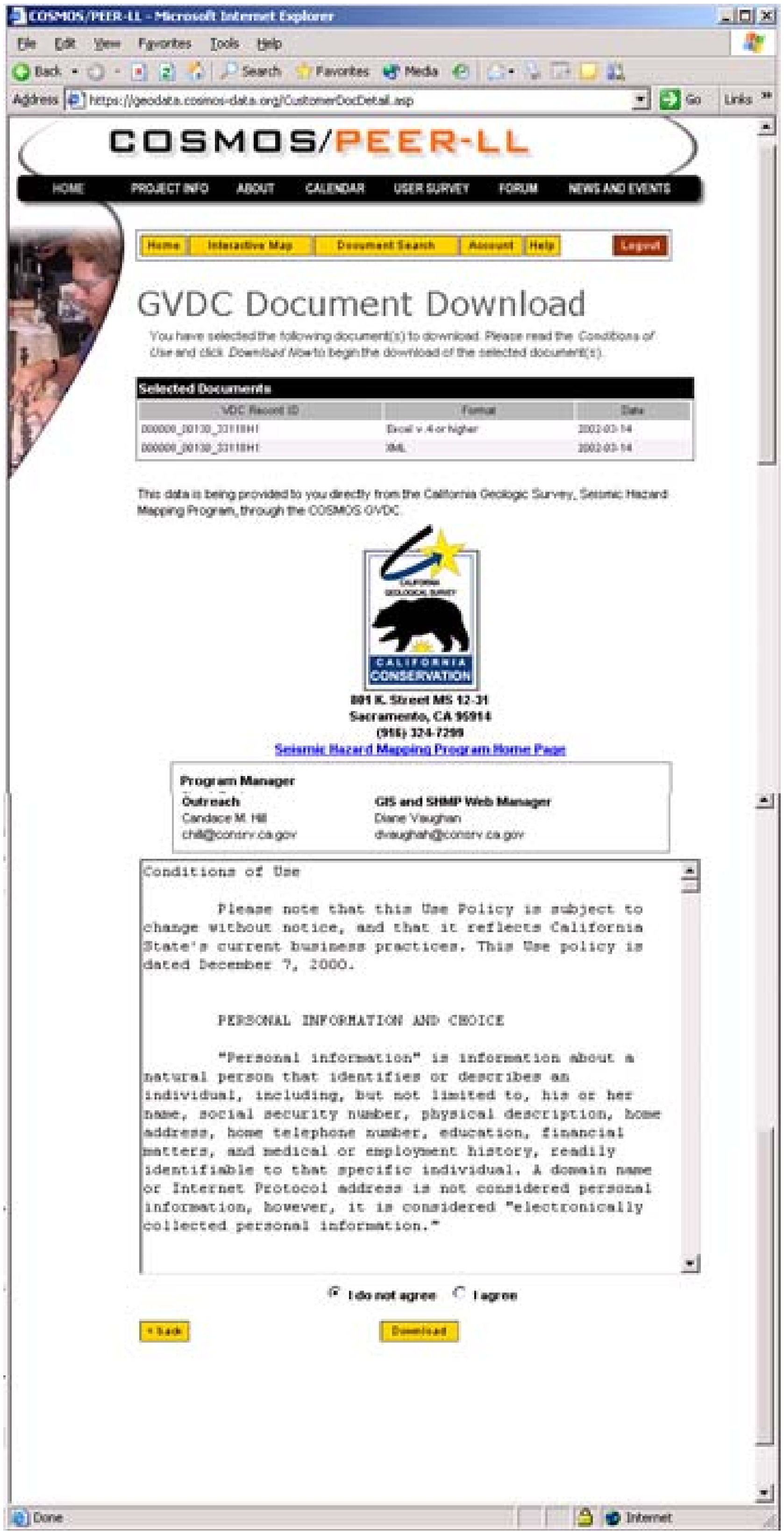

Figure 4-9. The CGS Data Usage and Privacy Policies. A user must agree to the data provider's data usage and privacy policies in order to download data.

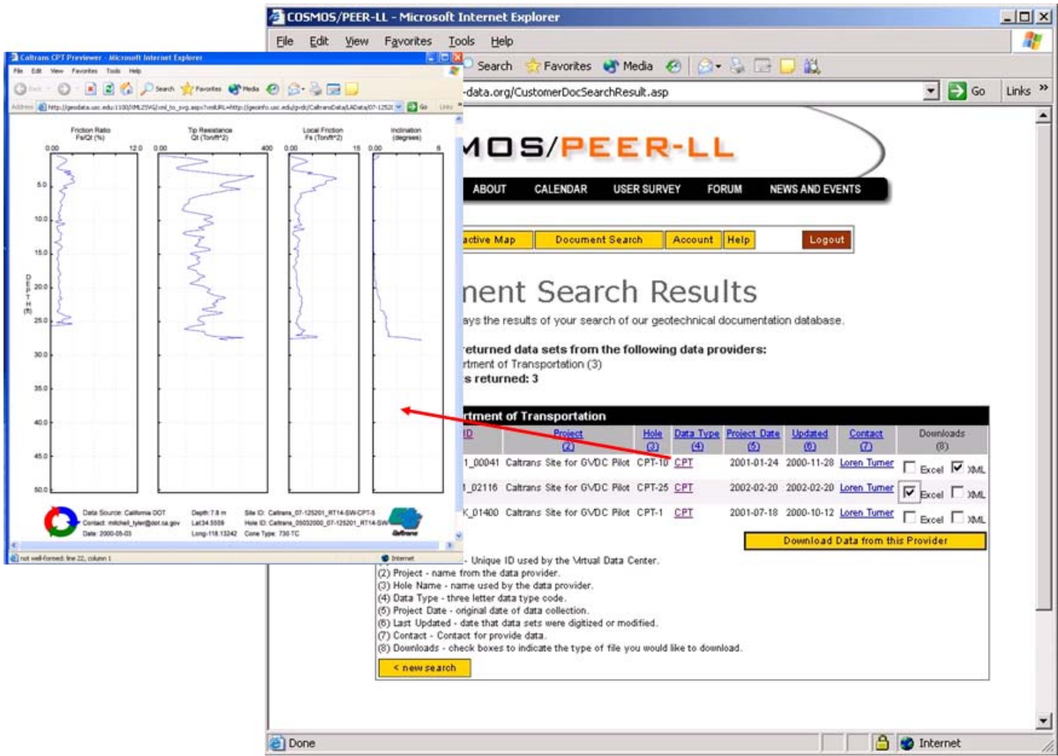

Figure 4-10. A CPT Log is dynamically displayed in a new browser window by clicking on the “CPT” link beneath “Data Types”.

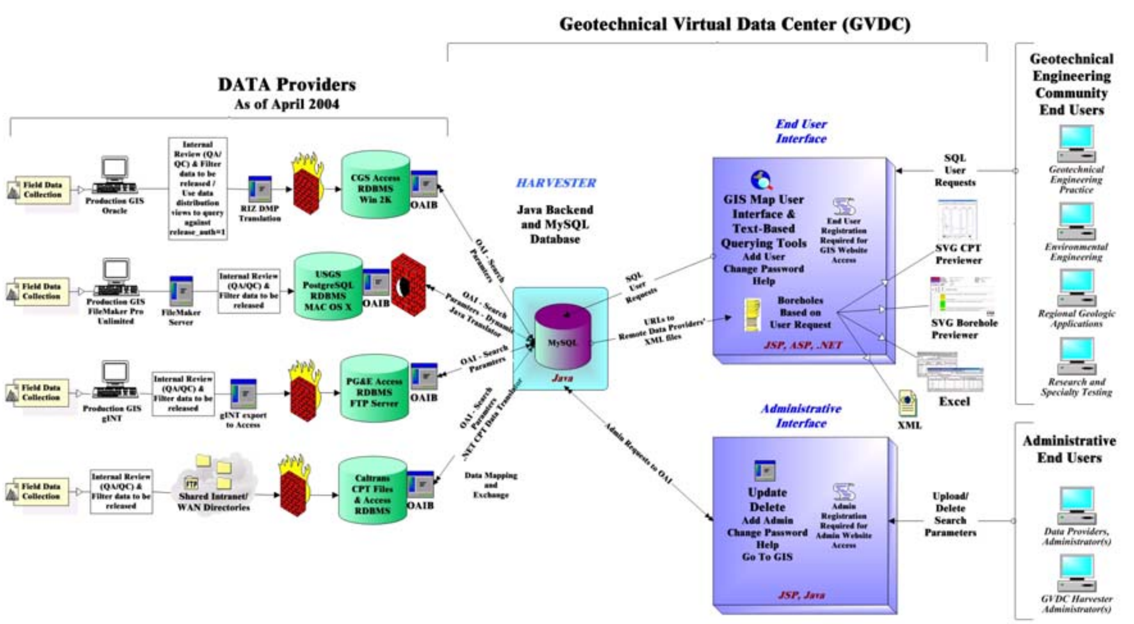

Figure 4-11. Detailed overview of current GVDC system architecture.

existing system (four data providers) is estimated to be approximately 5 hours and 1 hour per week, respectively. The time required to integrate new data providers to the GVDC system, however, would require a full-time system developer.

4.4 SUMMARY OF GVDC SYSTEM

The development of the GVDC system is outlined the following steps:

- Basic administrative web interfaces were created using JSP forms.
- A GVDC MySQL database was created based on the COSMOS/PEER-LL geotechnical data XML format, and connectivity from server-side scripts was established.
- The data provider's native geotechnical data sets were mapped to the COSMOS/PEER-LL geotechnical data XML format, including complete borehole test data attributes (Chapter 3, Benoit et al., this report).
- The OAIB components were installed on the data providers' servers, and configuration files were written to map the native data sets' search parameters to the COSMOS/PEER-LL geotechnical data XML format.
- The GVDC harvester code was written and implemented in Java. GVDC administrators may add, update or delete beorhole recors through the GVDC administrative website.
- The harvester code was connected to the OAIB services maintained on the data providers' servers.
- Tables for end user and administrator registration were created in the MySQL database.
- The ability to change user login information is also provided; both end users and administrators have the ability to save and change his/her profile. Administrators also have an interface withint the administrator website for maintaining users (subscribers) accounts.
- Data providers' privacy policies were provided for the GVDC. These policies are displayed on the end user data download pages, and are editable from within the administrative user interface. A user must agree to these policies in order to download data.
- Administrators may obtain resports on data download statistics through the GVDC administrator website.
- The GIS end user interface was created in ASP (Farallon, 2004) using ESRI ArcIMS and integrated into the existing overall website design, also written in ASP.
- The ability to download data in Microsoft Excel was implemented using ASP and Softartisan ExcelWriter.
- CPT and borelog previewers were written in VB.NET and and C/C++ and integrated into the ASP search results web page.

The main advantages of the GVDC are as follows: 1) there is a central repository for geotechnical search parameters from an unlimited number of data providers; 2) the GVDC allows fast and efficient searching for borehole data; 3) the front end and back end will both work even if one of the data providers is down; and 4) data providers' data sets may be updated as often as an administrator requires;) sufficient accreditation and individual privacy and use policies for each data provider have been integrated into the front end interface; and 5) website security has been significantly enhanced. The principal limitations of the GVDC include the following: 1) the GVDC has no way of ensuring data consistency or quality; 2) data versioning and replication is dealt with solely by the data provider, dependent on the date each record (borehole) was last updated; 3) the end user has no way of knowing if data previously downloaded has been updated; and 4) a tremendous amount of time and effort must be expended in order to accurately map any one data provider's data to the COSMOS/PEER-LL geotechnical data XML format. Plans are currently being implemented to upgrade the front end web interface to address limitations 4) within the next year.

4.5 2004 WORKSHOP

A workshop was held on June 21-23, 2004, to review the results of the project and receive input from the geotechnical engineering community. The workshop included presentations and discussions on the COSMOS-PEER Pilot System for Web Dissemination of Geotechnical Data (this project) from a user as well as an administrative perspective, and presentations, discussions and recommendations regarding an Federal Highway Administration (FHWA) survey and assessment of requirements for a web accessible distributed geotechnical data system for use by FHWA and state DOTs. The workshop also included summary presentations of web enabled geotechnical and environmental data dissemination systems currently deployed by the U. S. Army Corp of Engineers and the British Geological Survey, and the plan for archiving and web dissemination of geotechnical Instrumentation site data by the NEES Consortium. Focused discussions identified issues related to implementation of a web-enabled system for dissemination of distributed geotechnical data for general use.The knowledge gained from this workshop will be applied in future upgrades of the GVDC system architecture and databases. Proceedings of the workshop may be obtained by contacting COSMOS, http://www.cosmos-eq.org, or PEER, http://www.peer.berkeley.edu.

4.6 CONCLUSIONS

To make the Pilot GVDC a reality, institutional and technical hurdles were overcome. On the institutional side, the participating organizations had a common interest in sharing data and agreed on a framework for coordination (Swift et al., 2004). This included finding acceptable mechanisms to assure data provider's adequate control over their data and a mechanism to provide appropriate attribution to the source of the data served by the GVDC. On the technical side, the system architecture is now in place, an extensible "standard" data dictionary and schema have been defined, standard file formats and protocols have been utilized and further developed, CPT and borelog previewers have been coded and implemented, database-to-XML and XML-to-Excel spreadsheet translators have been written and implemented, and the websites are secured by SSL encryption.

The GVDC front end website provides searching capabilities based on standard and well-defined geotechnical attributes. This caters to the current need of researchers and engineers for an accessible, centralized geotechnical data source, and provides a framework for additional organizations to become data providers and share their data online. Being a collaborative project of various organizations, this creates a platform for future joint research, and reduces the need for repeated drilling and thus significantly reduces costs for the organizations involved.

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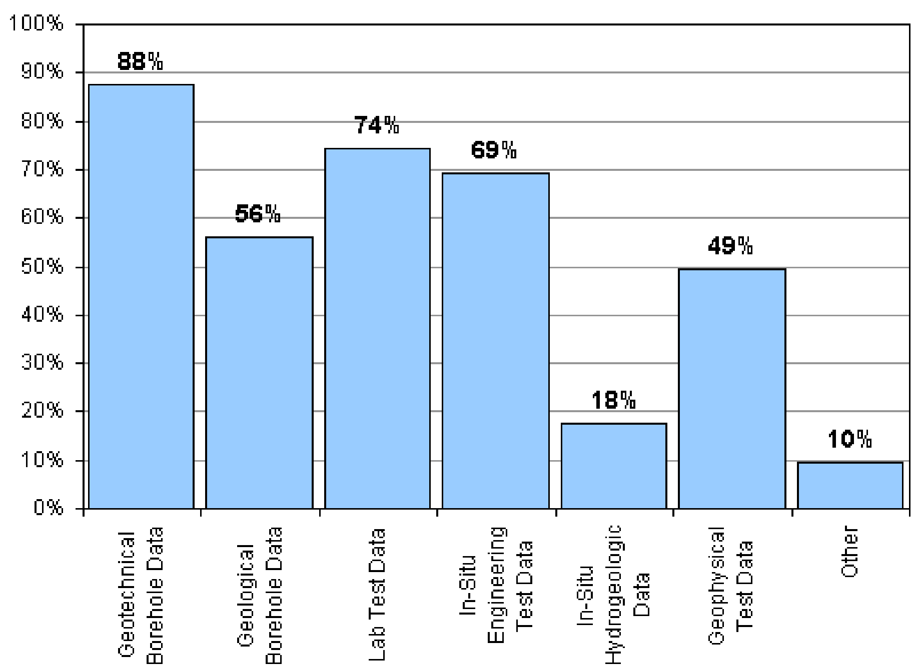
APPENDIX 1

USER SURVEY RESULTS

Responses to the remaining survey questions are summarized in the following pages. In general, bar charts and pie charts show the percentage of the total number of respondents that indicated that particular response. Sub-categories of questions (indicated by XX.X.X numbering notation) were presented to respondents only if they answered "Yes", "Absolutely Necessary", or "Necessary" to the primary question. Percentages shown in the charts reflect the responses only from those to which the questions were presented.

(16) What types of geotechnical and related data do you routinely use in your work? (Please check all that apply):

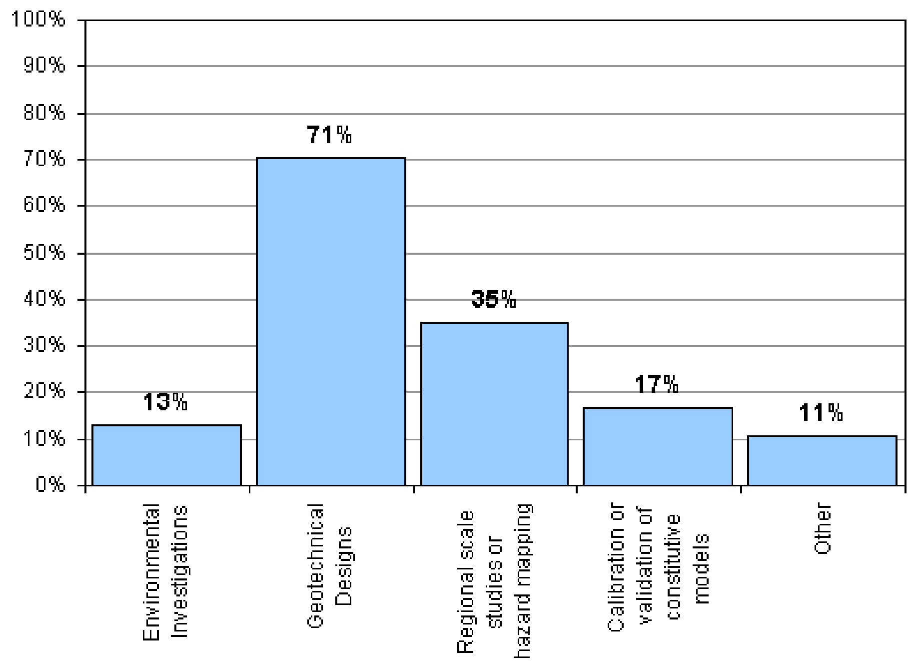
- ❑ Geotechnical borehole data (soil classification, visual description, groundwater level, etc.)
- ❑ Geological borehole data (dating, bedding orientation, etc.)
- ❑ Lab test data (e.g. consolidation, gradation, strength, etc.)
- ❑ In-situ engineering test data (SPT, CPT, vane shear, pressure meter, etc.)
- ❑ In-situ hydrogeologic test data (e.g. pumping tests, dye tests, fluid penetration, etc.)
- ❑ Geophysical test data (e.g. shear wave velocity, etc.)
- ❑ Other



The above chart shows the percentage of all of the respondents that checked the particular response. Those that indicated "other" had responses including: position, location, survey, vibration surveys (particle velocity and frequency), secondary data sources, geotechnical reports, remote sensing data, paleontology, lithologic outcrop data, earthquake catalogues, geologic maps, geochemical sample information, foundation testing data, surface water and weather climate data, faults, DEMS, earthquake epicenters, seismological, and paleomagneto data.

(17) For what general purpose(s) do you use geotechnical data? (Please check all that apply):

- ❑ Environmental investigations
- ❑ Site investigations to develop design recommendations and/or perform geotechnical designs
- ❑ Regional scale studies or hazard mapping
- ❑ Calibration or validation of constitutive or predictive models
- ❑ Other



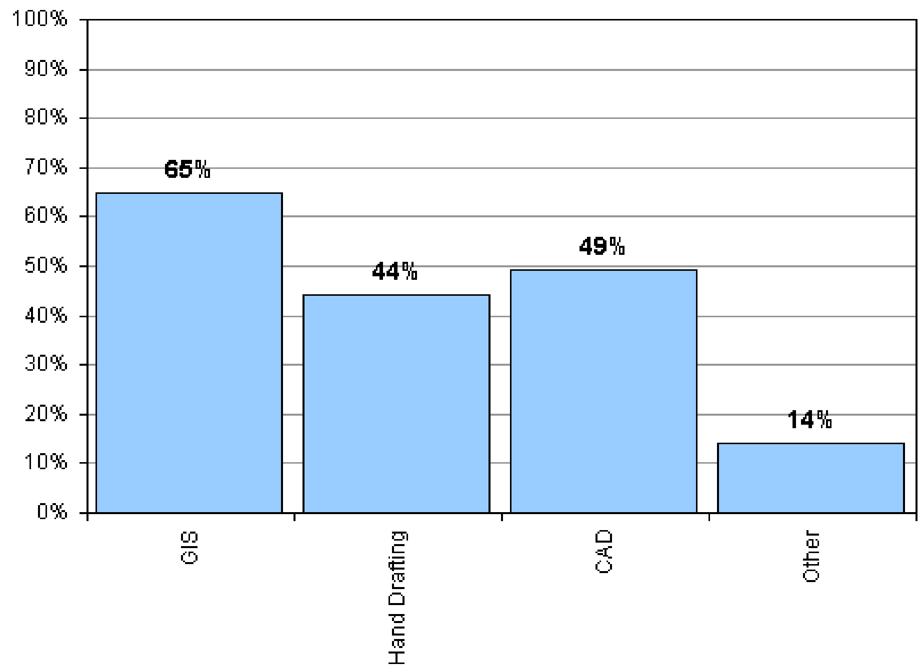
The above chart shows the percentage of all of the respondents that checked the particular response. Those that indicated "other" had responses including: research studies, database development, risk evaluations, fossil identification, geologic mapping, lithostratigraphy, aquifer characterization, construction quality assurance, education, failure analysis, and forensic studies of failures.

(18) Do you develop maps or map related products?

- Yes (63%)
- No (37%)

(18.1) What kind(s) of techniques or software do you use for map making?

- GIS
- Hand drafting
- CAD
- Other



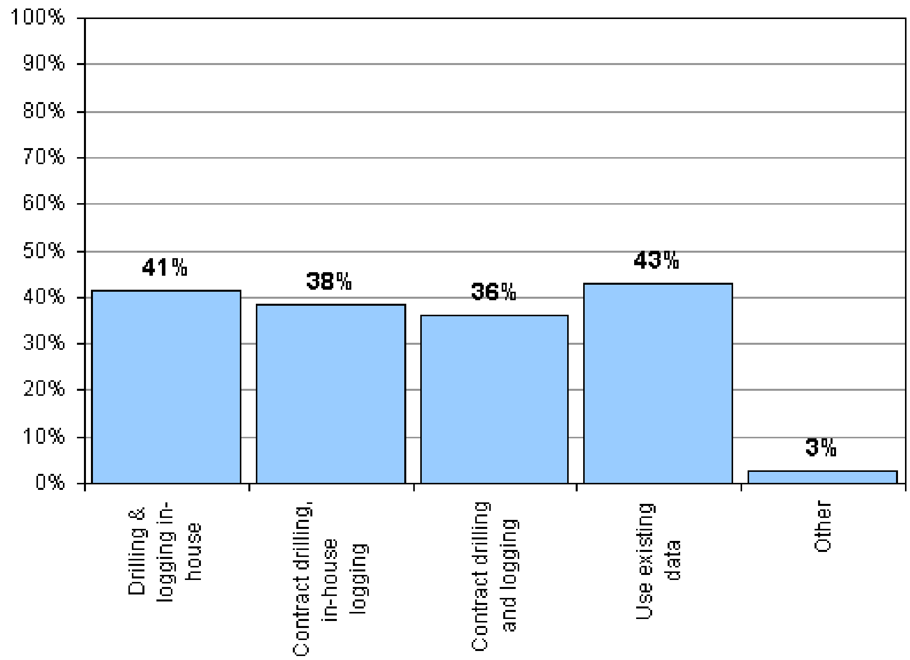
The above chart shows the percentage of all of the respondents that responded "Yes" to the previous question. Those that indicated "other" had responses including: GMT, Freehand, Illustrator, Canvas, contouring routines, and gINT.

(18.2) Does your method of map making require geographic coordinates for borehole locations?

- Yes (82%)
- No (18%)

(19) How does your organization typically acquire borehole data? (Please check all that apply):

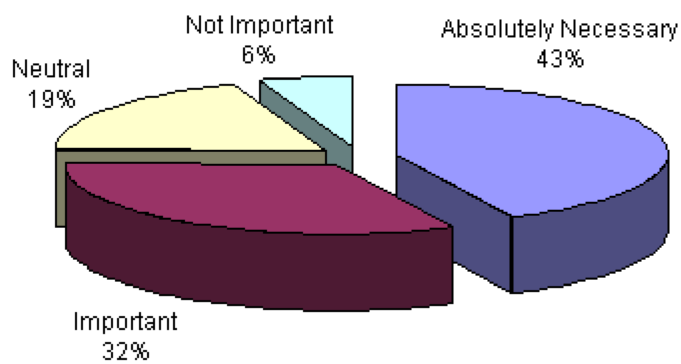
- ❑ Conduct field drilling and logging operations with in-house staff
- ❑ Contract to others for field drilling operations, but use in-house staff for logging
- ❑ Contract to others for field drilling and logging operations
- ❑ Use existing, publicly available, data generated by others
- ❑ Other



The above chart shows the percentage of all of the respondents that checked the particular response. Those that indicated "other" had responses including: private data sets, proprietary data sets, and consultant files.

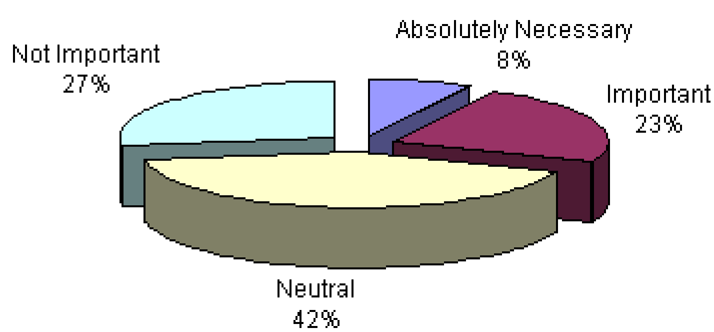
(20) How important is it in your current work to have the project location expressed in a geodetic system (latitude and longitude) or a coordinate system (State Plane Northing and Easting) with appropriate datum and projection reference information?

- Absolutely necessary
- Important
- Neutral
- Not important



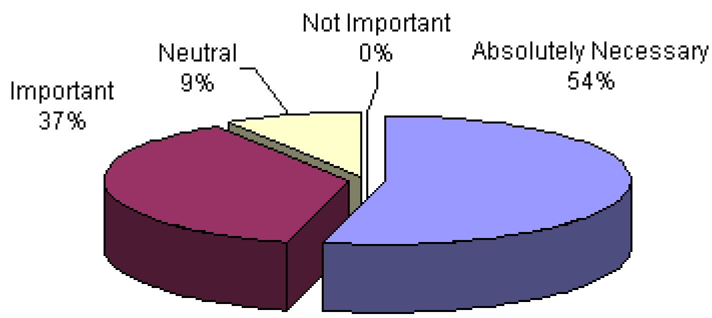
(21) How important is it in your work to have the project location expressed as a street address?

- Absolutely necessary
- Important
- Neutral
- Not important



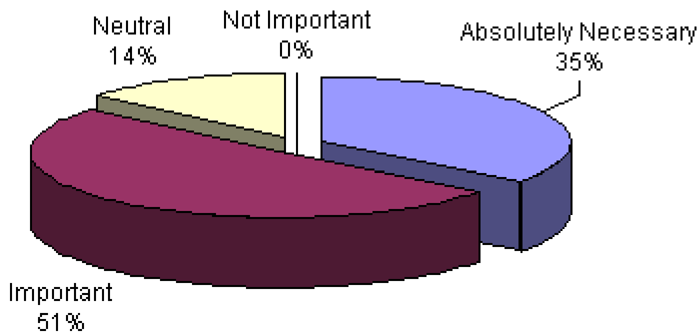
(22) How important is it in your work to have information on the reference elevation of the drill site?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



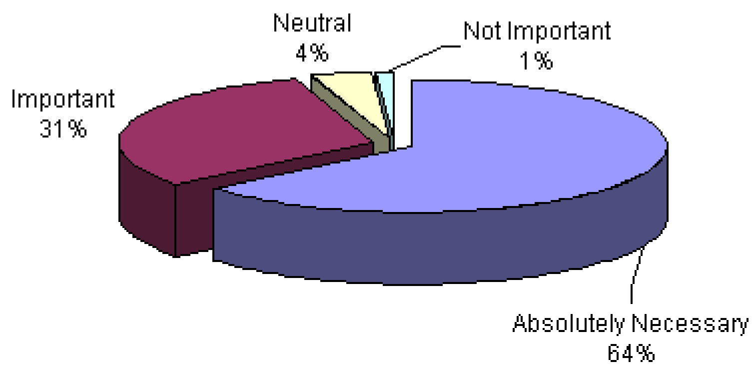
(22.1) How important is it in your work to have information on how the reference elevation was obtained? (e.g. estimated from topo map, surveyed by DGPS, etc.):

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



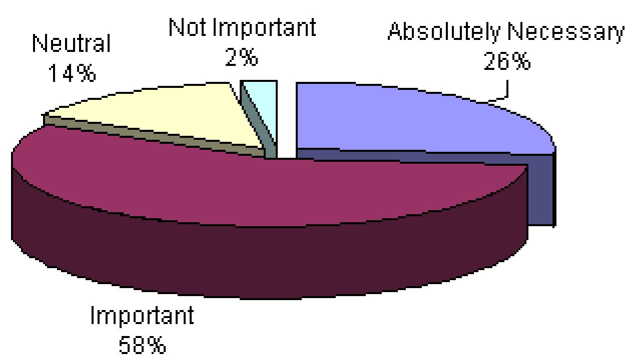
(23) How important is it in your work to have information on the total depth of the borehole?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



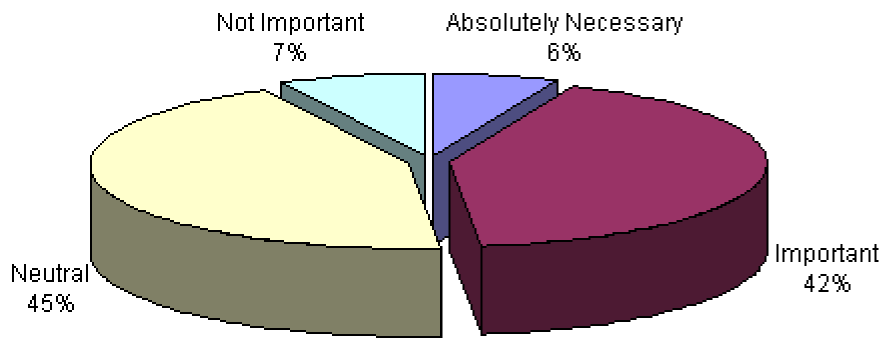
(24) How important is it in your work to have information on the purpose of the borehole (e.g. geotechnical, environmental, monitoring well, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



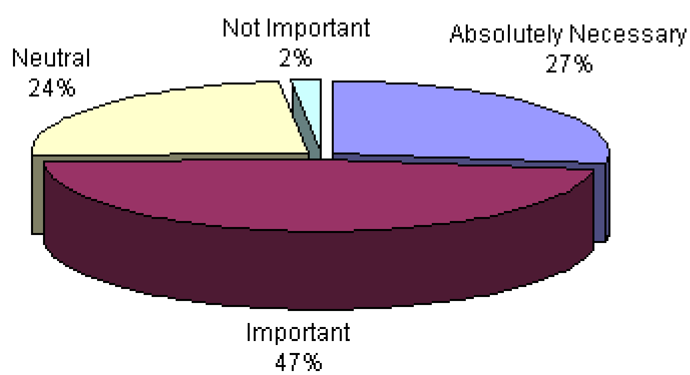
(25) How important is it in your work to have information on environmental or situational conditions during the drilling operations (e.g. weather, temperature, breakdowns, delays, etc.):

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



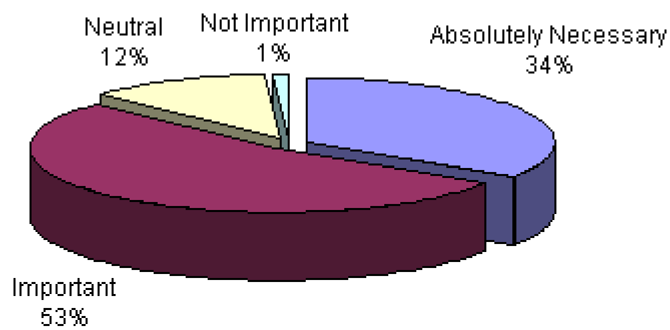
(26) How important is it in your work to have a description of the setting at the location of the borehole (e.g. natural ground, fill, raised casing, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



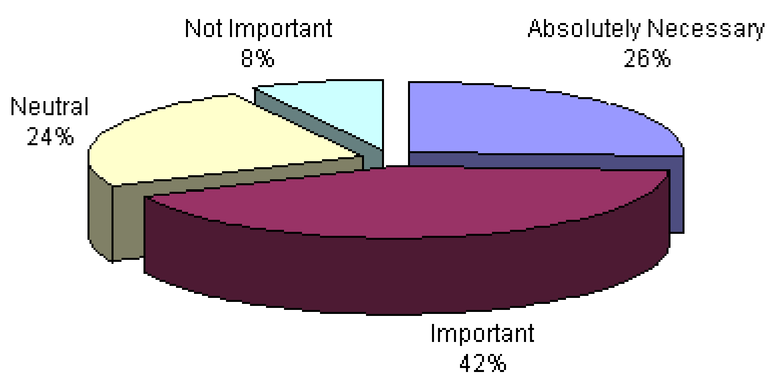
(27) How important is it in your work to have specific information about the source of the data (e.g. organization, name of logger, name of driller, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



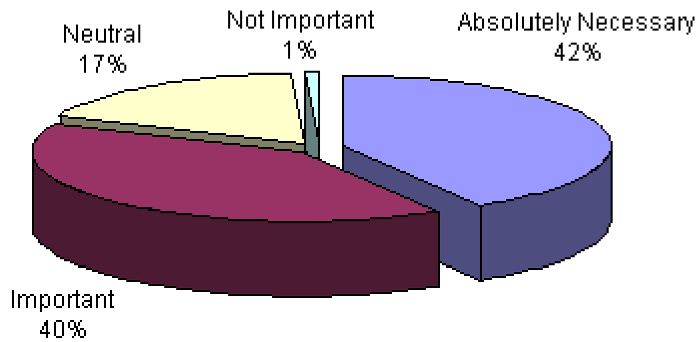
(28) How important is it in your work to have specific information on the drilling equipment used to generate the borehole (e.g. manufacturer, model, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



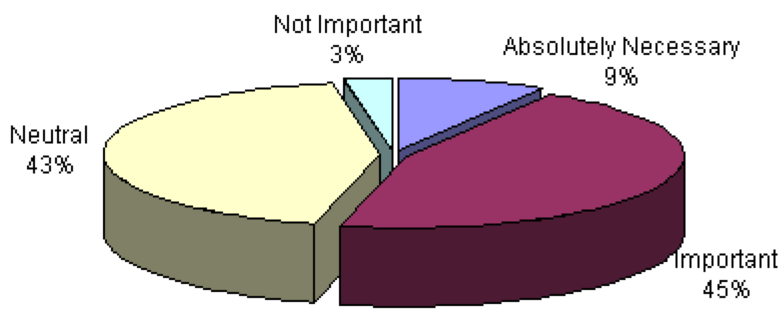
(29) How important is it in your work to have specific information on the drilling tools (e.g. auger type and measurements, drill rod and casing type and measurements, drill bits and sampler types, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



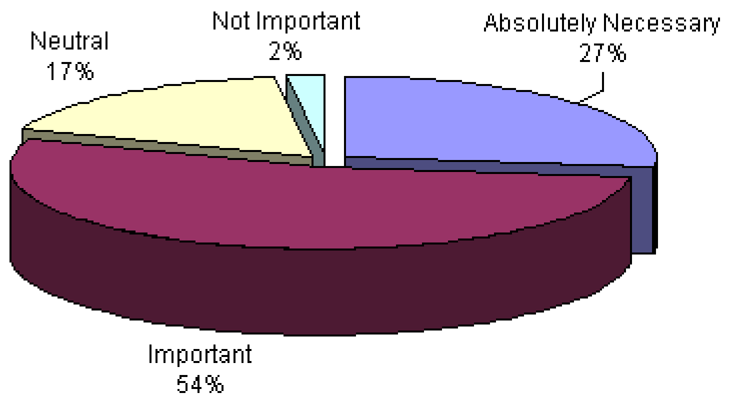
(30) How important is it in your work to have information as to drilling rate?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



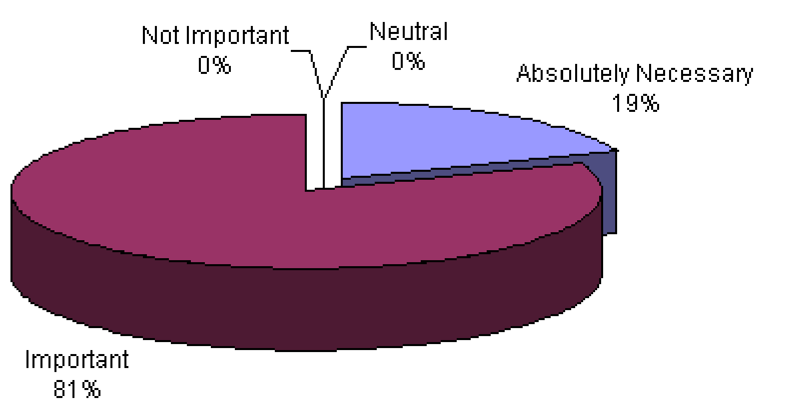
(31) How important is it in your work to have information on soil color?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



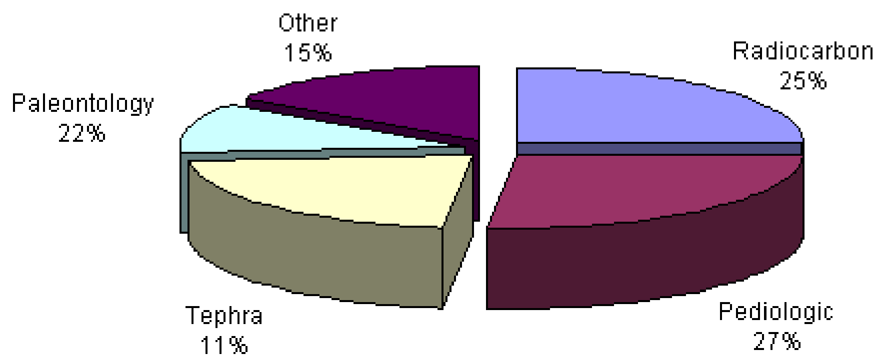
(32) How important is it in your work to have information on the age of the deposits being drilled?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



(32.1) What methods do you employ, or data do you use, to determine the age of the deposits?

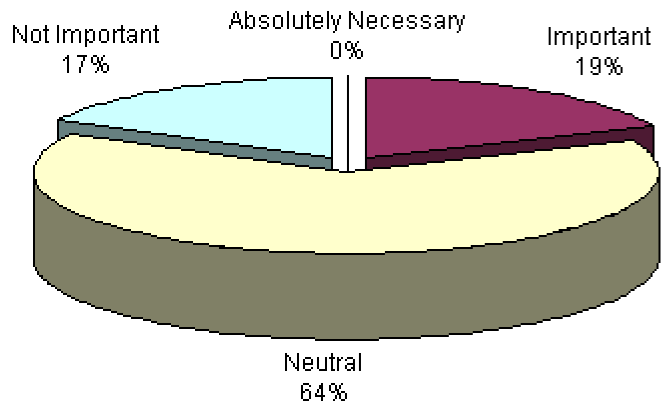
- Radiocarbon or other absolute age samples
- Pediologic profile descriptions
- Paleontology information or faunal lists
- Tephra correlations
- Other



The above chart shows the distribution of methods or data used to determine age of deposits. Those that indicated "other" had responses including: OSI, TL, paleomag, lithologic correlation, stratigraphy, sample descriptions, historic data, reference geologic maps, USGS, visual, relative lucustrine relations, published reports, field relationships, prior regional geologic mapping, and soil description and correlation across boreholes.

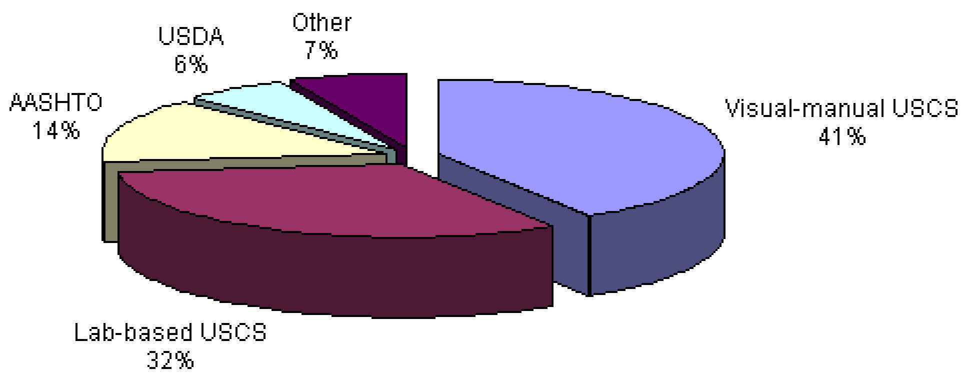
(33) How important is it in your work to have information on the chemical composition of the deposits or the pore fluids being drilled?

- Absolutely necessary
- Important
- Neutral
- Not important


Not Important
17%
Absolutely Necessary
0%
Important
19%
Neutral
64%

(34) What standard does your organization use to classify soils:

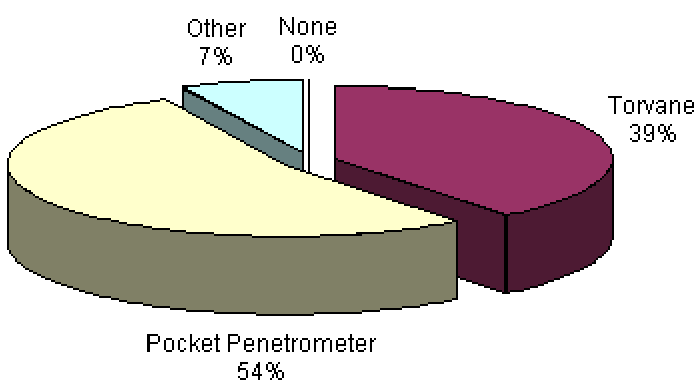
- Visual-manual based USCS or extensions such as ASTM D2488
- Lab-based USCS or extensions such as ASTM D2487
- AASHTO
- USDA Textural Chart
- Other



The above chart shows the distribution of standards used to classify soils. Those that indicated "other" had responses including: modified AASHTO, Burmeister, BS5930, and specific versions of USCS modified for DOT use.

(35) What types of field strength index test data do you utilize (not including in-situ testing)?

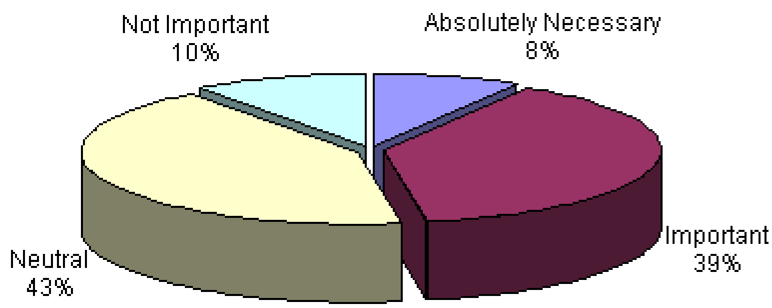
- None
- Torvane
- Pocket Penetrometer
- Other



The above chart shows the distribution of types of strength index tests used in the field. Those that indicated "other" had responses including: point load, unconfined compressive with spring loading, vane shear, finger, thumb, and screwdriver.

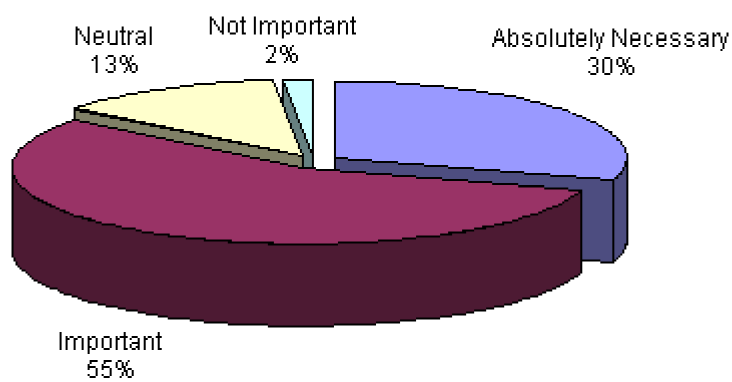
(35.1) How important to your work is it to have information on the make/model of the particular test instrument and any key dimensions or tests parameters?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



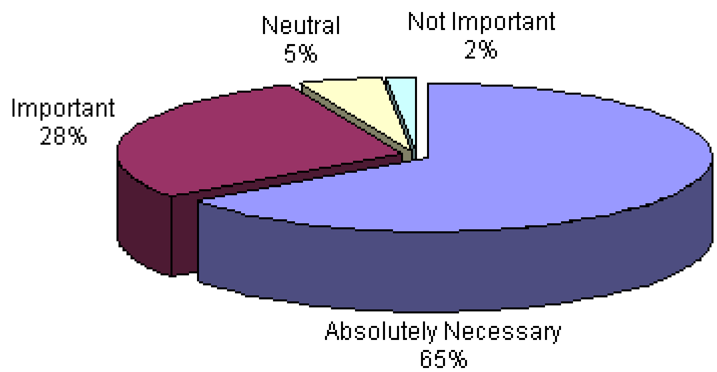
(36) How important is it in your work to have interpretations and comments (other than lithologic descriptions) on a particular soil layer (e.g. fill, alluvium, colluvium, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



(37) How important is it in your work to have the information on the depth of water in a borehole?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important

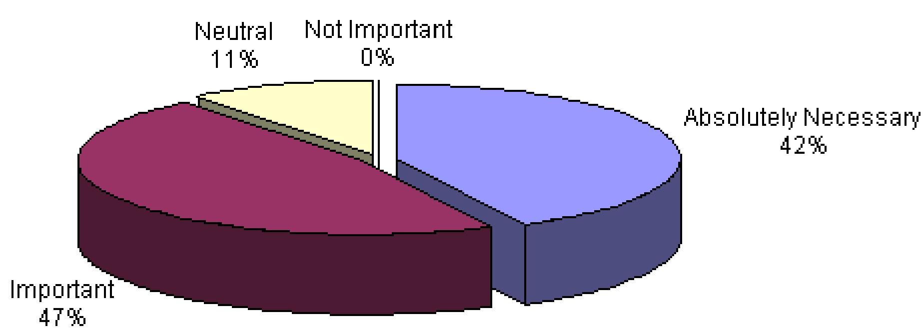


(37.1) Do you require information on depth to water at various times in a boring in addition to the final recorded water level?

- ❑ Yes (52%)
- ❑ No (48%)

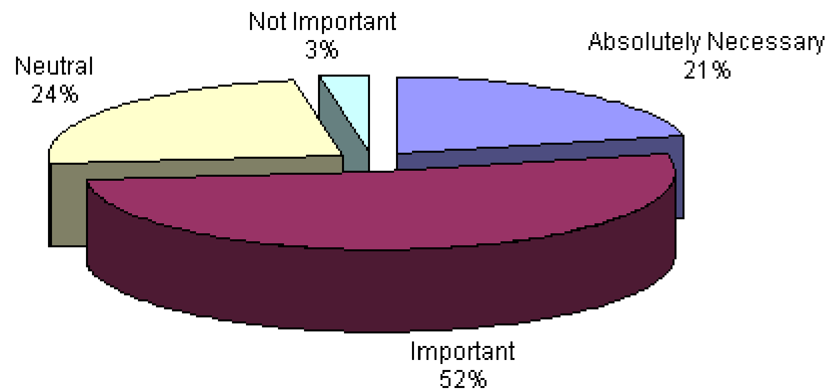
(37.1.1) How important is it in your work to have information on the depth of first water encountered in a borehole?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



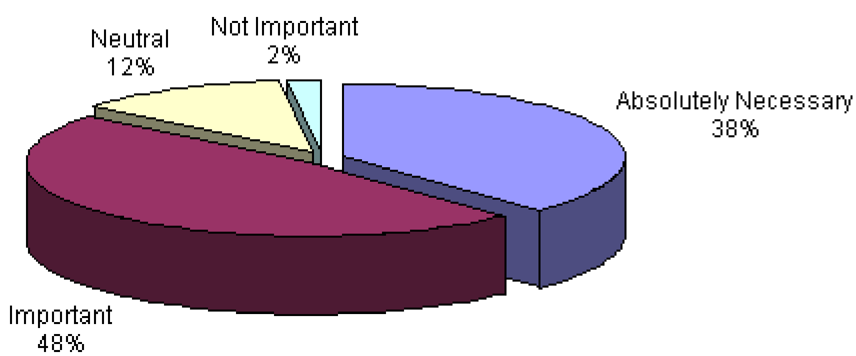
(37.1.2) How important is it in your work to have information on the interim water level measurements in a borehole during the initial site investigation?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



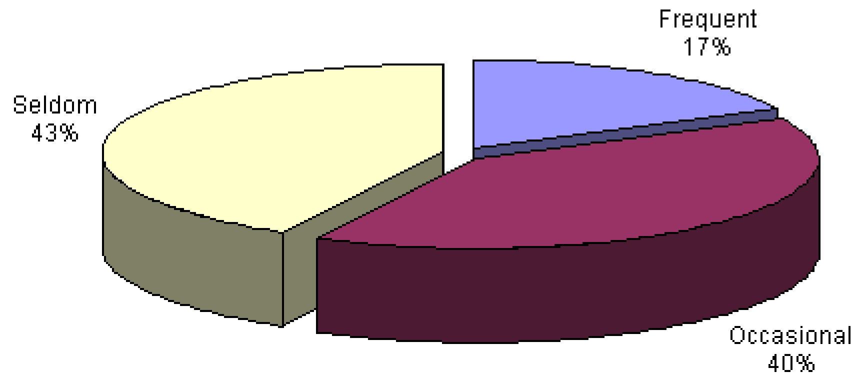
(37.2) How important is it in your work to have information on the date and time of water level measurement(s) in a borehole?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



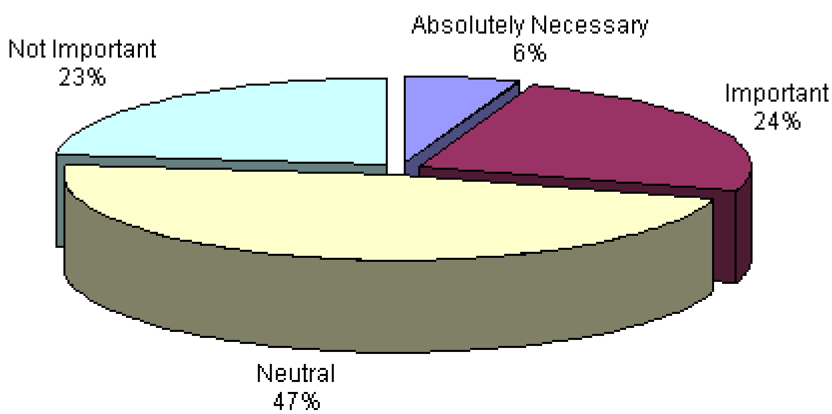
(37.3) How often is the borehole installed for purposes of long term monitoring (months to years) of water level?

- Frequent
- Occasional
- Seldom



(37.4) How important is it in your work to have information on packer tests, pump tests, or other well development tests?

- Absolutely necessary
- Important
- Neutral
- Not important

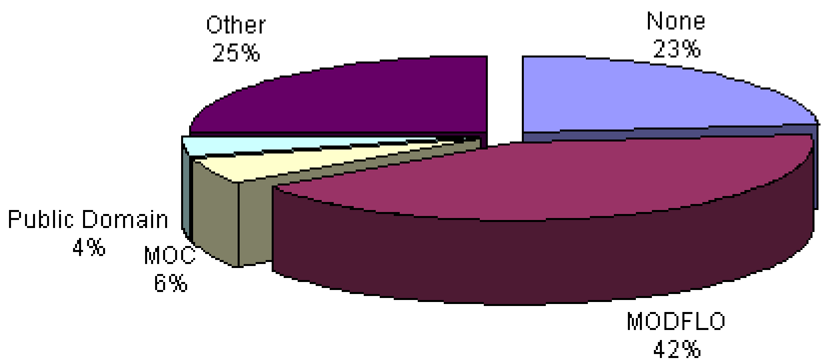


(38) Does your organization perform groundwater modeling?

- Yes (38%)
- No (62%)

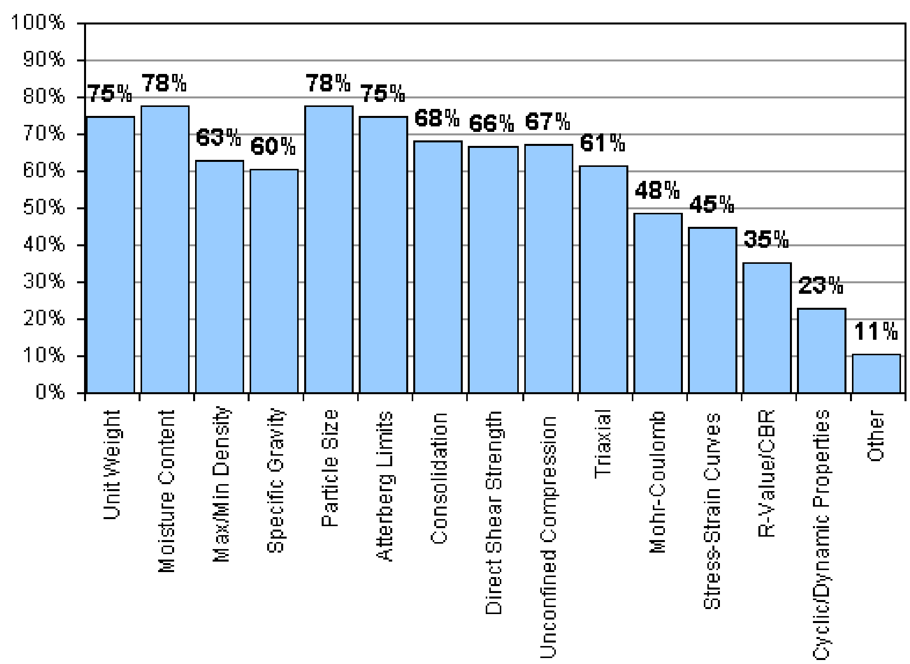
(38.1) What types of groundwater modeling software do you use?

- ❑ None
- ❑ MODFLO
- ❑ MOC
- ❑ Public Domain Software
- ❑ Other



(39) What types of geotechnical lab test data do you use and/or generate? (Please check all that apply):

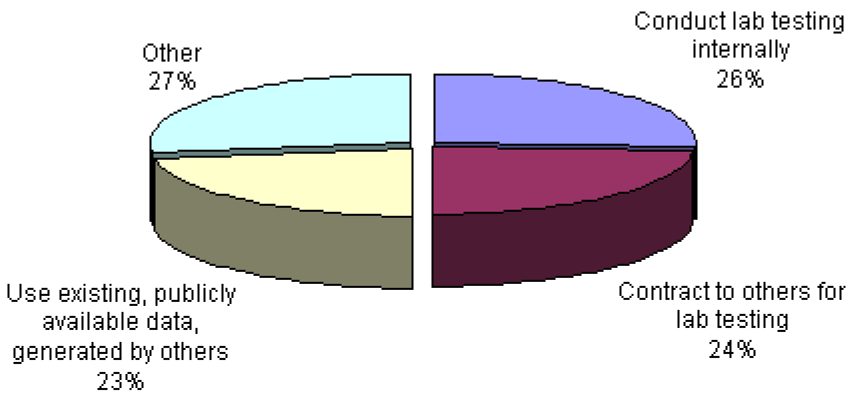
- ❑ Unit Weight
- ❑ Moisture Content
- ❑ Maximum/minimum Density, Relative Density
- ❑ Specific Gravity
- ❑ Particle Size Analysis
- ❑ Atterberg Limits
- ❑ Consolidation
- ❑ Direct Shear Strength (friction angle and cohesion)
- ❑ Unconfined Compressive Strength
- ❑ Triaxial shear strength parameters (friction angle and cohesion)
- ❑ Mohr-Coulomb envelope from triaxial tests
- ❑ Full stress-strain curves from strength tests
- ❑ R-value/CBR
- ❑ Cyclic/Dynamic Properties
- ❑ Other



The above chart shows the percentages of the respondents (that had indicated that they used lab test data in question 16) that checked the particular response. Those that indicated "other" had responses including: permeability, relative compaction, corrosion, dispersion, miniature vane, sensitivity, cyclic/static DSS, ASTM C-97, ASTM C-99, ASTM C-170, ASTM C-241, ASTM C-880, LBR, erosion testing, loss on ignition, hydrometer, double transverse shear, strain at 50% su, and soluble salts.

(40) How does your organization typically acquire lab test data? (Please check all that apply):

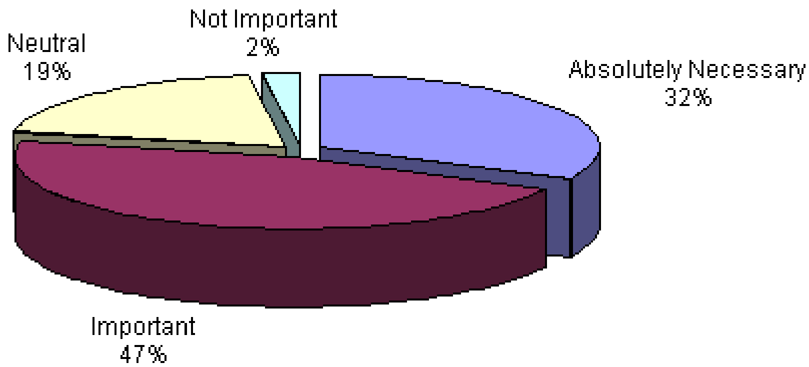
- ❑ Conduct lab testing internally
- ❑ Contract to others for lab testing
- ❑ Use existing, publicly available, data generated by others
- ❑ Other



The above chart shows the percentages of the respondents (that had indicated that they used lab test data in question 16) that checked the particular response. Those that indicated "other" had responses including: use in-house data banks, use data acquired by owner-hired geotechnical engineer, requesting access to private data sets, use existing proprietary data, and consultant files.

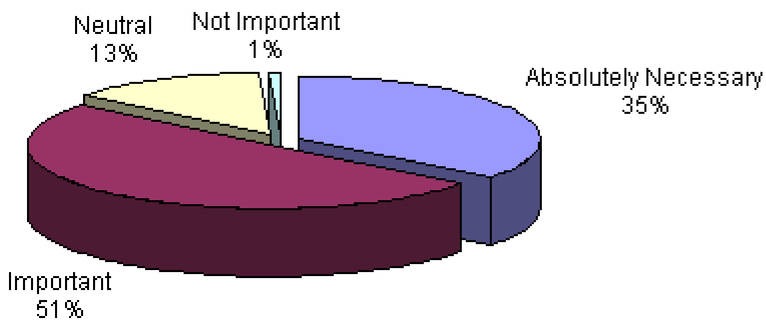
(41) How important is it in your work to have the interpreted data (e.g. Compression Index, Shear Strength, Unit Weight) readily available, as well as information on the methods used to make the interpretations?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important


Not Important
2%
Neutral
19%
Absolutely Necessary
32%
Important
47%

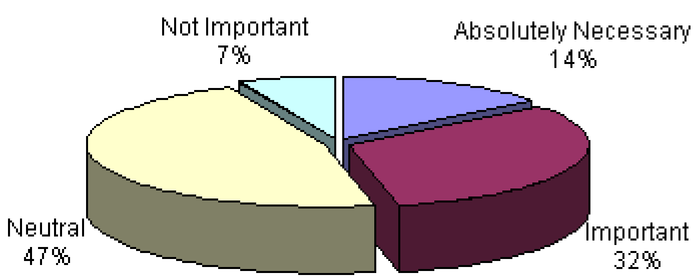
(41.1) How important is it in your work to have the primary data (e.g. calibrated settlement vs. time) readily available, as well as information on the factors and methods used to develop the primary data (e.g. calibration constants, filtering techniques, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



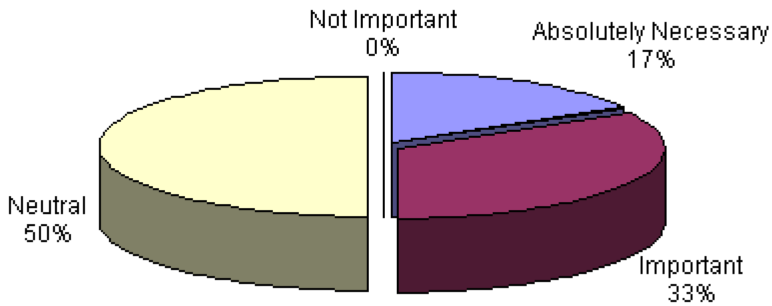
(41.1.1) How important is it in your work to have the raw data readily available (e.g. unprocessed transducer voltages)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



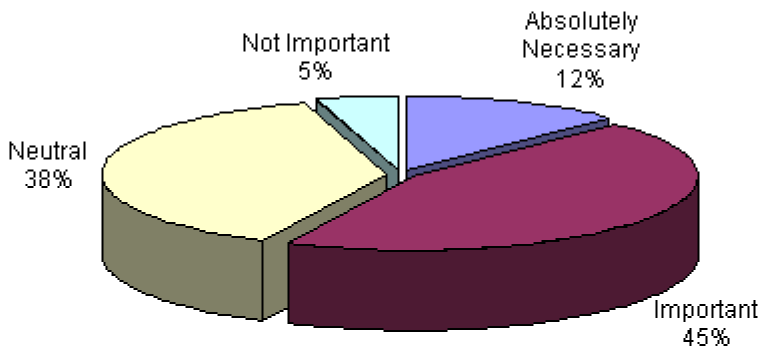
(41.1.1.1) How important is it in your work to have information on transducer calibration data for test equipment?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



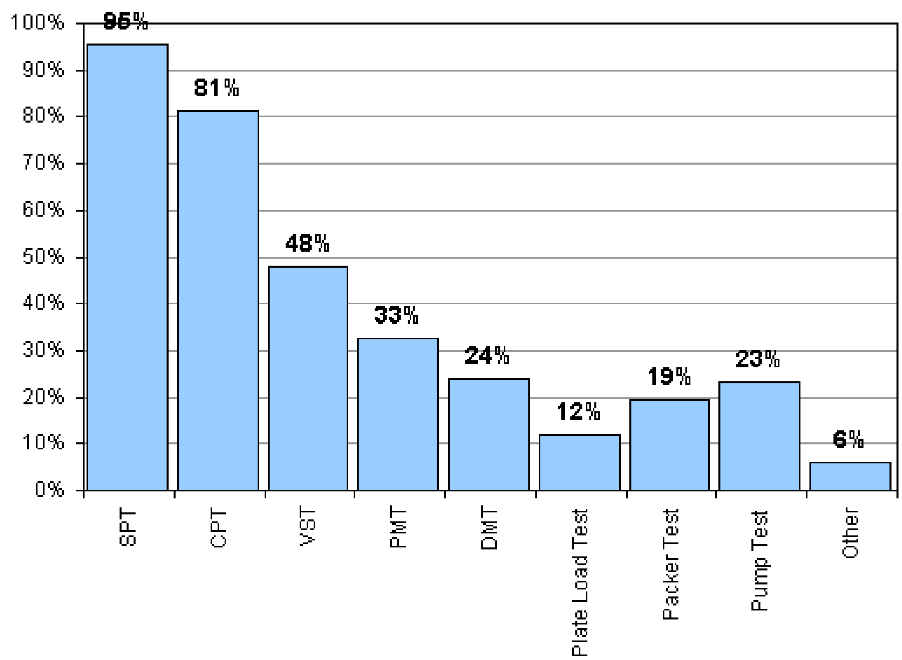
(41.2) How important is it in your work to have information on the lab test equipment (e.g. make, model, type, key dimensions, transducers, etc.), test conditions (e.g. estimated in-situ vertical pressure for a consolidation test), or test specimen (e.g. initial sample thickness for a consolidation test) for a particular test result?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



(42) What types of geotechnical in-situ test data do you use and/or generate? (Please check all that apply):

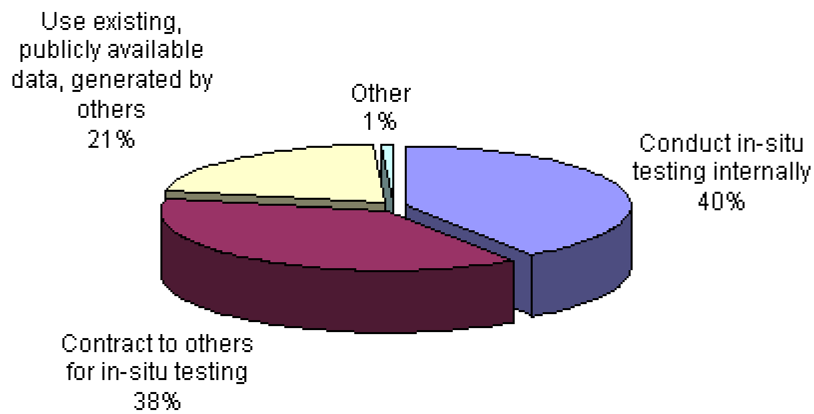
- ❑ Standard Penetration Test (SPT)
- ❑ Cone Penetration Test (CPT)
- ❑ Vane Shear Test (VST)
- ❑ Pressuremeter Test (PMT)
- ❑ Dilatometer Test (DMT)
- ❑ Plate Load Test
- ❑ Packer Test
- ❑ Pump Test
- ❑ Other



The above chart shows the percentages of the respondents (that had indicated that they used in-situ test data in question 16) that checked the particular response. Those that indicated "other" had responses including: blow counts, resilient modulus, shelby tubes for direct shear, air hammer drives, stiffness gauge, point load on rock, and electrical resistivity of soils.

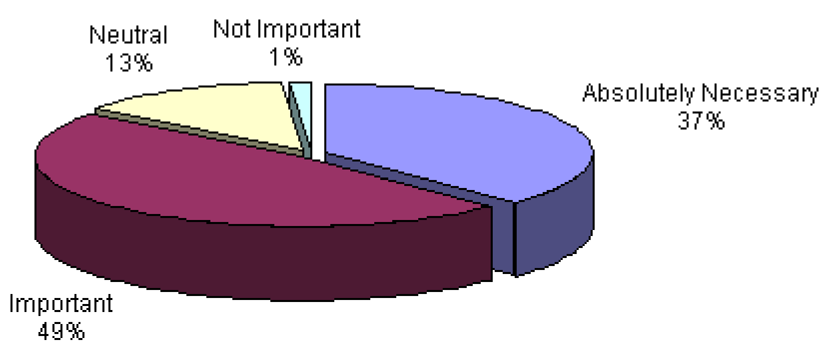
(43) How does your organization typically acquire in-situ test data? (Please check all that apply):

- ❑ Conduct in-situ testing internally
- ❑ Contract to others for in-situ testing
- ❑ Use existing, publicly available, data generated by others
- ❑ Other



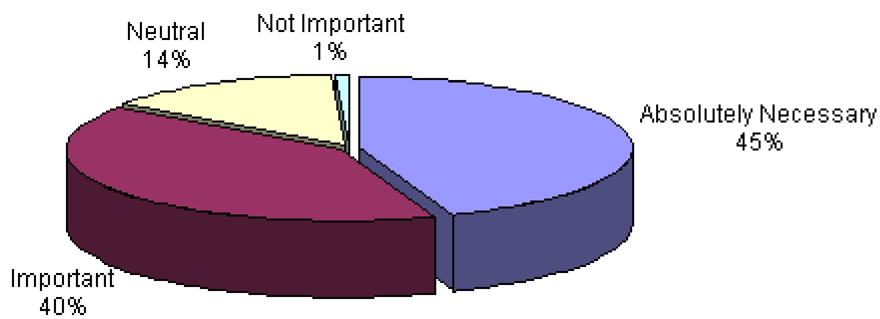
(44) How important is it in your work to have the interpreted data (e.g. CPT-based soil type, undrained shear strength, pressuremeter modulus, corrected N1-60 SPT blow counts) readily available, as well as information on the methods used to make the interpretations (e.g. assumptions of the water level elevation or soil unit weight, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



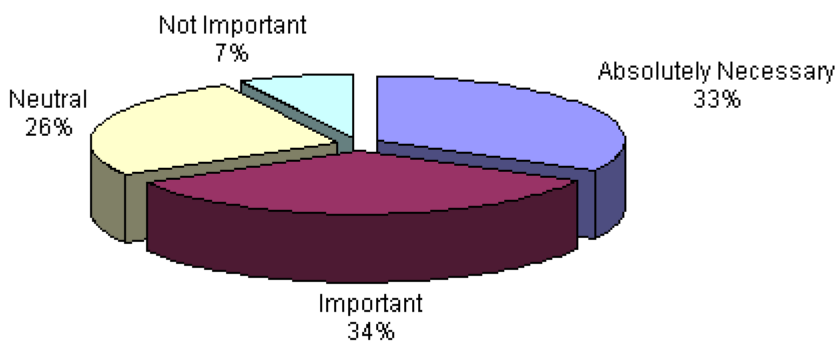
(44.1) How important is it in your work to have the primary data (e.g. CPT tip resistance and sleeve friction, depth, etc.) readily available, as well as information on the factors and methods used to develop the primary data (e.g. calibration constants, filtering techniques, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



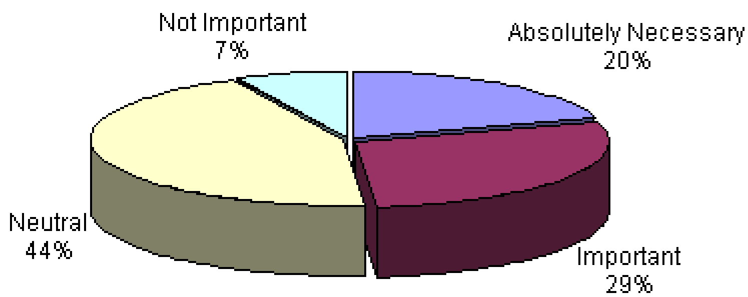
(44.1.1) How important is it in your work to have the raw data readily available (e.g. unprocessed voltages from pressure and load transducers for CPT, uncorrected blow counts for SPT)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



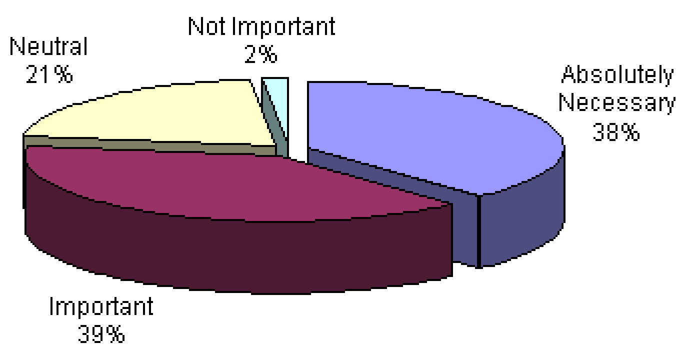
(44.1.1.1) How important is it in your work to have information on transducer calibration data for test equipment (e.g. calibration for a pore pressure transducer on a CPT cone)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



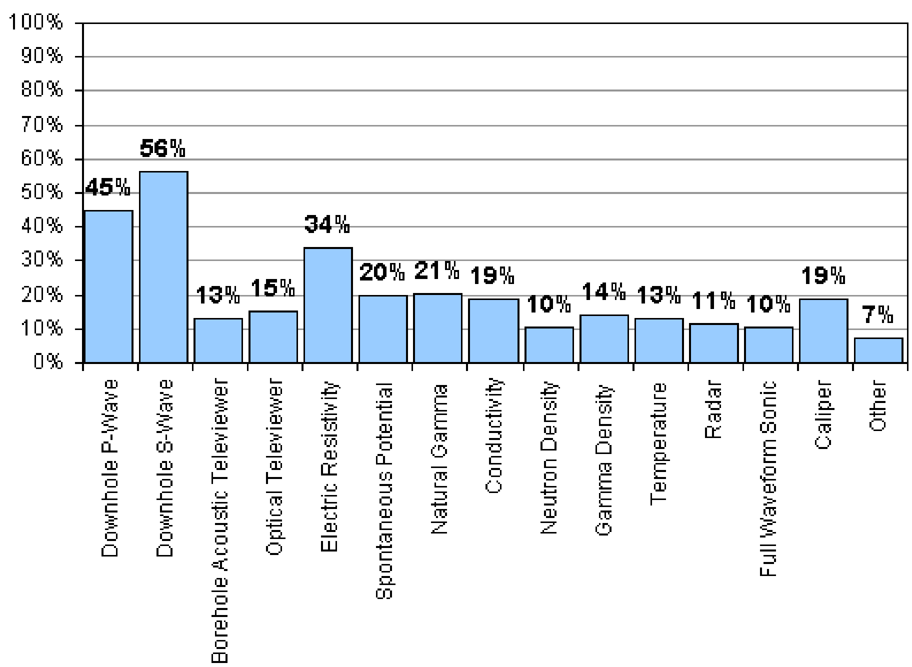
(44.2) How important is it in your work to have information on the in-situ test equipment (e.g. make, model, type, key dimensions, transducers, CPT cone tip size, SPT hammer lifting mechanism, SPT hammer drop weight/length, SPT energy transfer efficiency, etc.) and field test conditions (e.g. setup, layout, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



(70) What types of borehole geophysical test data do you use and/or generate? (Please check all that apply):

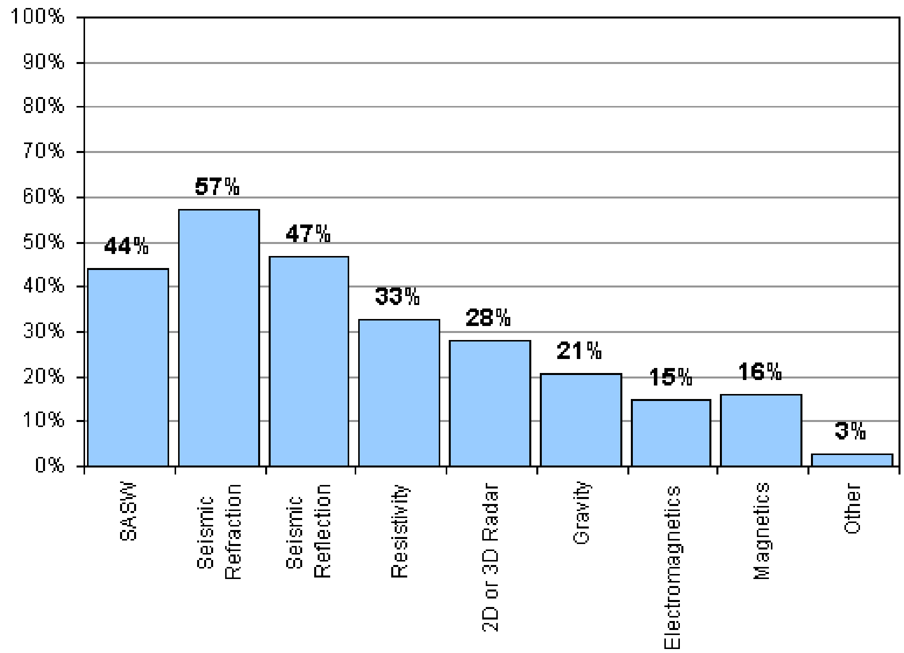
- ❑ Downhole P-wave velocity
- ❑ Downhole S-wave velocity
- ❑ Borehole acoustic televiewer
- ❑ Optical Televiewer
- ❑ Electric Resistivity (e.g. short normal and/or long normal)
- ❑ Spontaneous Potential
- ❑ Natural Gamma
- ❑ Conductivity
- ❑ Neutron Density
- ❑ Gamma Density
- ❑ Temperature
- ❑ Radar
- ❑ Full Waveform Sonic
- ❑ Caliper
- ❑ Other



The above chart shows the percentages of the respondents (that had indicated that they used borehole geophysics data in question 16) that checked the particular response. Those that indicated "other" had responses including: tomography, crosshole S/P, seismic CPT, and heat pulse flow.

(71) Does your organization accept surface geophysical data to supplement borehole geology, SPT, and sample tests, and if so what types do you use (Please check all that apply)?

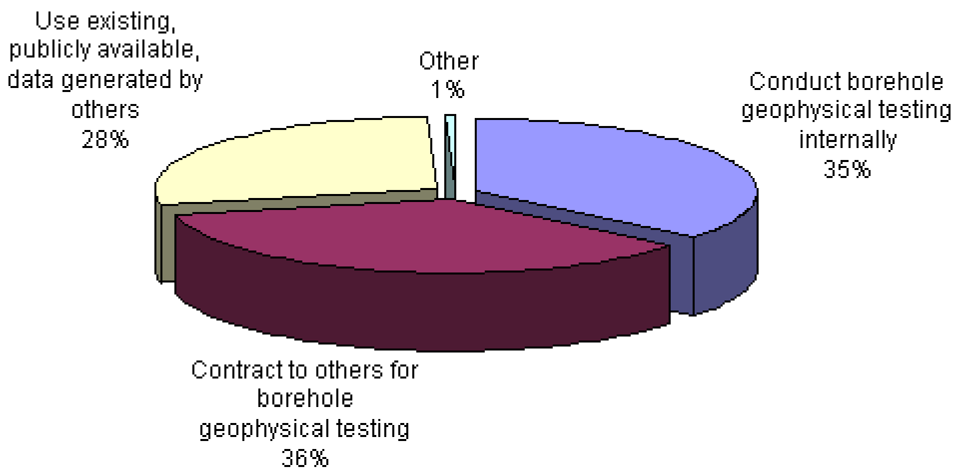
- ❑ SASW Velocity Profile (shear wave velocity with depth)
- ❑ Seismic Refraction (P-wave velocity with depth)
- ❑ Seismic Reflection (either shear-wave or P-wave)
- ❑ Resistivity (1D, 2D, or 3D)
- ❑ 2D or 3D radar
- ❑ Gravity
- ❑ Electromagnetics
- ❑ Magnetics
- ❑ Other



The above chart shows the percentages of the respondents (that had indicated that they used borehole geophysics data in question 16) that checked the particular response. Those that indicated "other" had responses including: magnetotellurics, and ground penetrating radar.

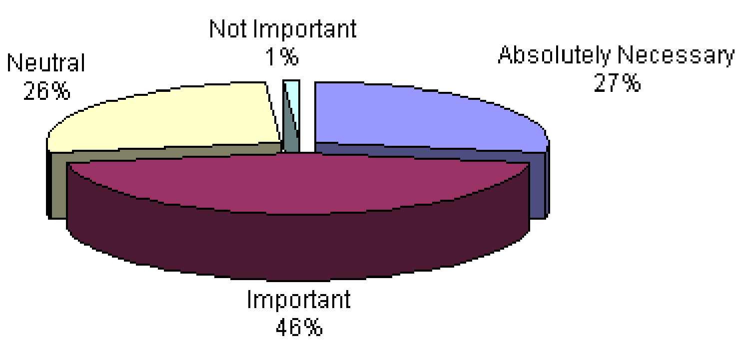
(72) How does your organization typically acquire borehole geophysical test data (Please check all that apply)?

- ❑ Conduct borehole geophysical testing internally
- ❑ Contract to others for borehole geophysical testing
- ❑ Use existing, publicly available, data generated by others
- ❑ Other



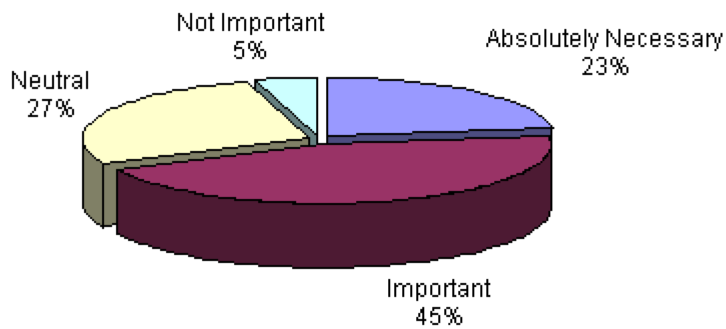
(73) How important is it in your work to have the interpreted data (e.g. Poisson's Ratio, shear modulus, shear wave velocity, etc.) readily available, as well as information on the methods used to make the interpretations (e.g. wave arrival picks, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



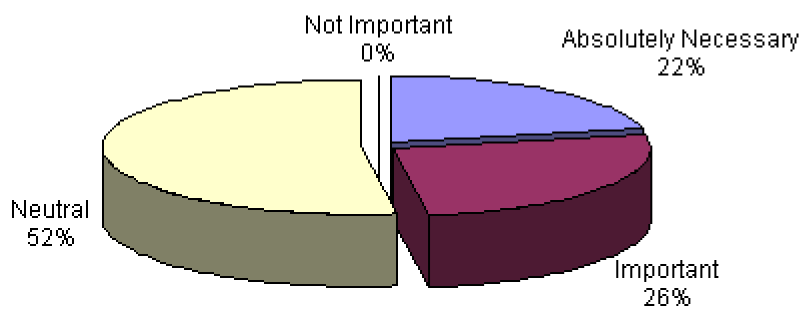
(73.1) How important is it in your work to have the primary data (e.g. calibrated and filtered wave traces, etc.) readily available, as well as information on the factors and methods used to develop the primary data (e.g. calibration constants, filtering techniques, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



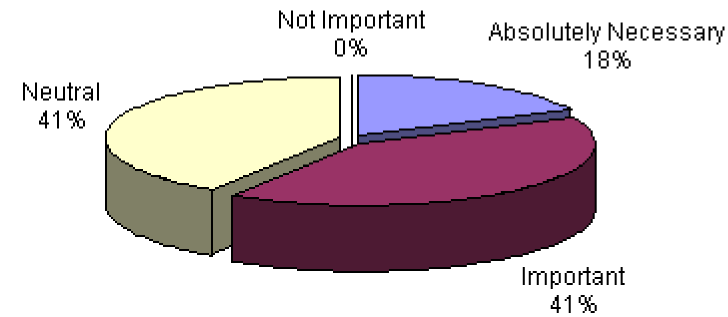
(73.1.1) How important is it in your work to have the raw data readily available (e.g. unprocessed transducer voltages)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



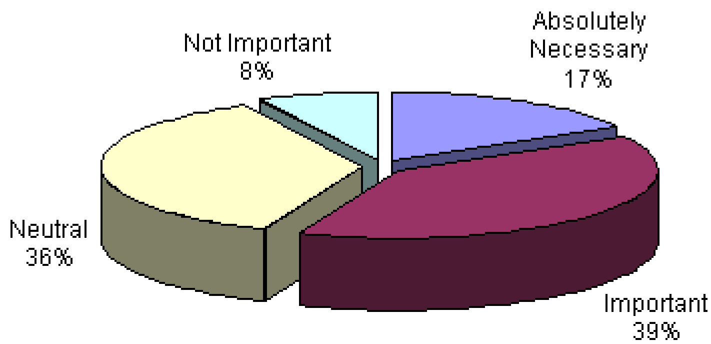
(73.1.1.1) How important is it in your work to have information on transducer calibration data for test equipment?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



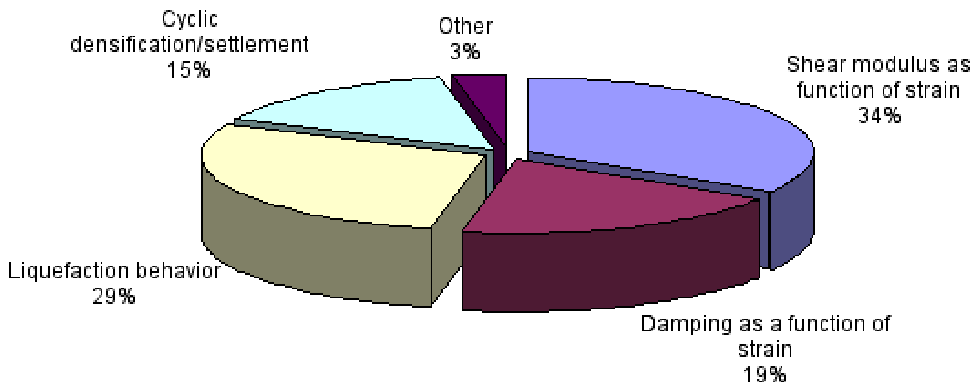
(73.2) How important is it in your work to have information on the test equipment (e.g. make, model, type, key dimensions, transducers, etc.) and field test conditions (e.g. setup, layout, etc.)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



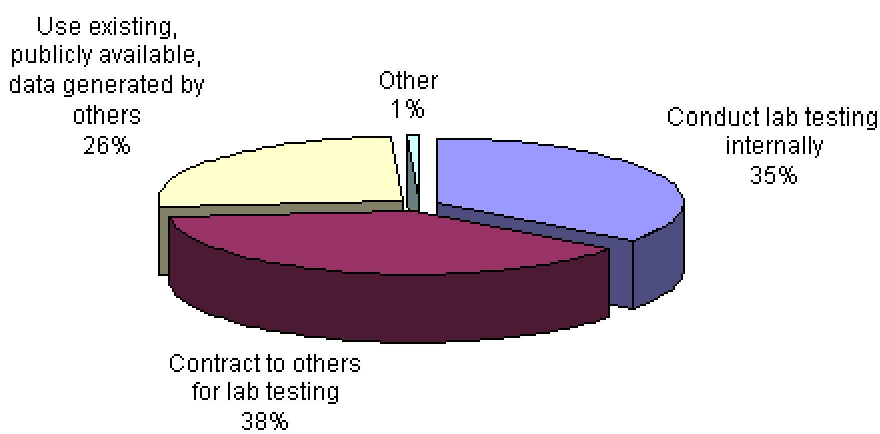
(46) What types of dynamic lab test data do you use or generate? (Please check all that apply):

- ❑ Shear modulus as a function of strain
- ❑ Damping as a function of strain
- ❑ Liquefaction behavior
- ❑ Cyclic densification/settlement
- ❑ Other



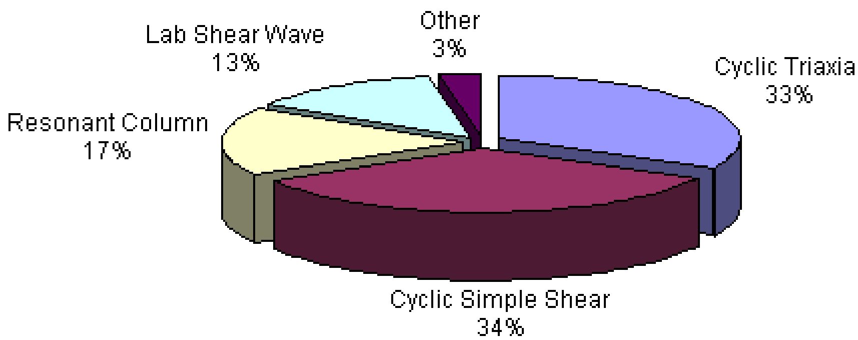
(47) How does your organization typically acquire lab test data? (Please check all that apply):

- ❑ Conduct lab testing internally
- ❑ Contract to others for lab testing
- ❑ Use existing, publicly available, data generated by others
- ❑ Other



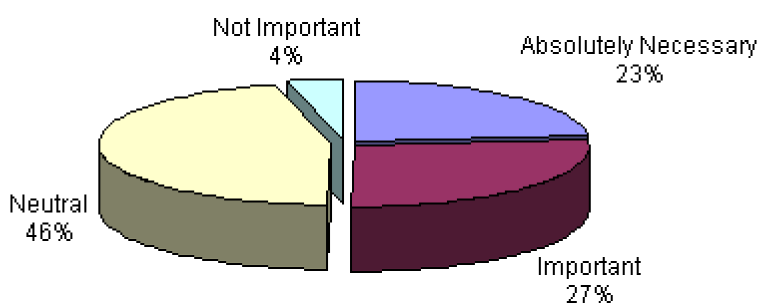
(48) Which test methods are used to obtain these properties? (Please check all that apply):

- ❑ Cyclic triaxial
- ❑ Cyclic simple shear
- ❑ Resonant column torsional shear
- ❑ Laboratory shear wave methods
- ❑ Other



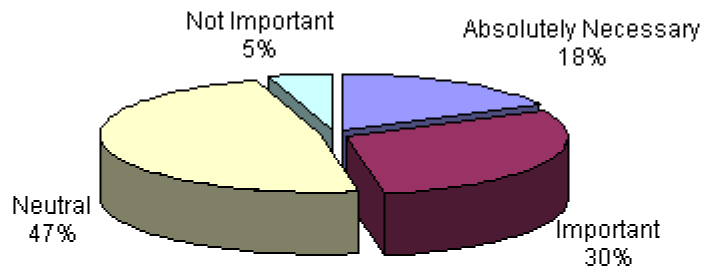
(49) When using this data, how important is it for you to have access to the interpreted data (e.g. number of cycles to liquefaction as a function of cyclic stress ratio)?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



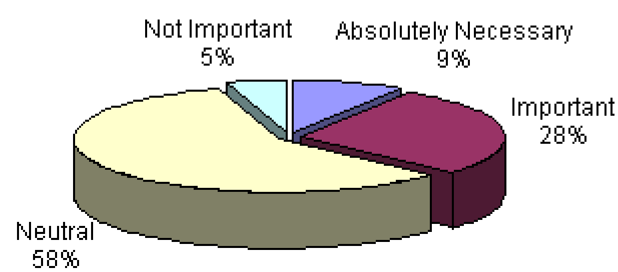
(50) When using this data, how important is it for you to have access to the primary data (e.g. time histories of stress, strain, and pore pressures)?

- Absolutely necessary
- Important
- Neutral
- Not important



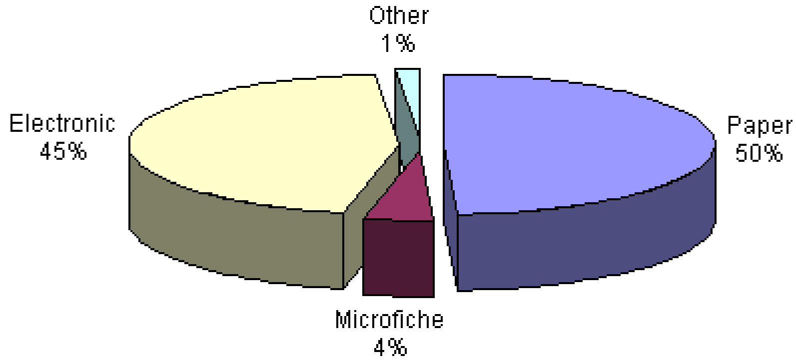
(51) When using this data, how important is it to you to know the detailed test conditions (e.g. locations and types of load and deformation transducers, sequence of steps in procedures, measured B values, consolidation strains, etc.) ?

- Absolutely necessary
- Important
- Neutral
- Not important



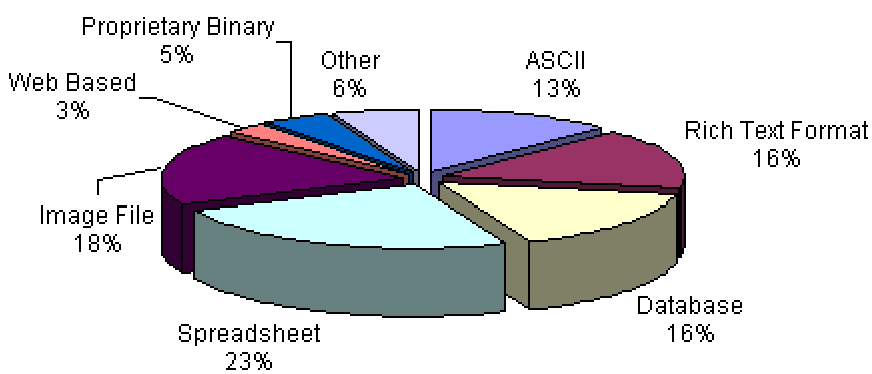
(52) In what form does your organization currently prepare, report, and/or archive geotechnical data? (Please check all that apply):

- ❑ Paper
- ❑ Microfiche
- ❑ Electronic
- ❑ Other



(53) What types of electronic formats do you use to store geotechnical data? (Please check all that apply):

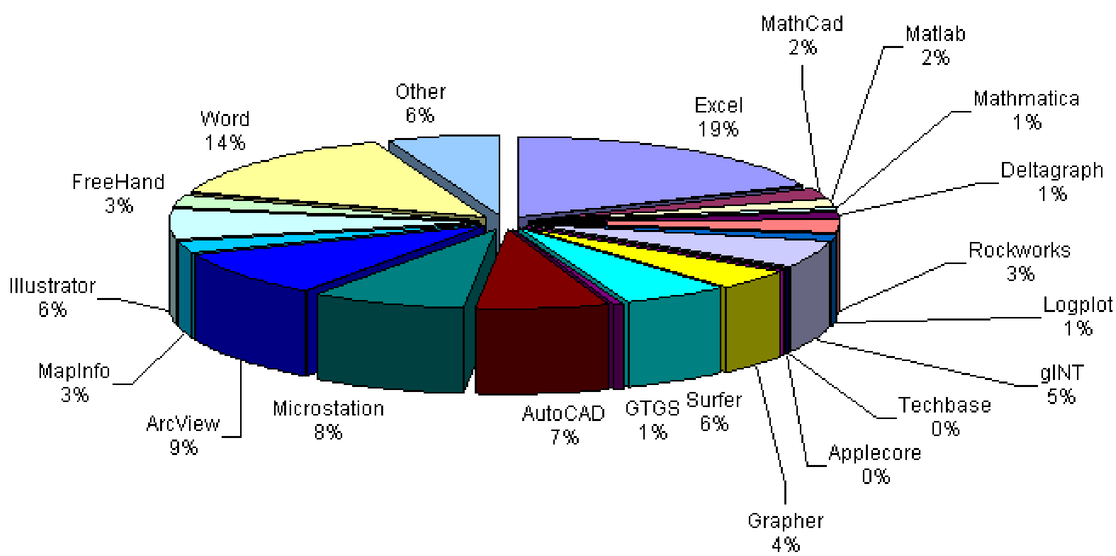
- ❑ ASCII delimited text (e.g. text file with parameters separated by commas, tab, etc.)
- ❑ Rich Text Format (e.g. Word)
- ❑ Database format (e.g. Access, Filemaker Pro, Oracle)
- ❑ Spreadsheet format (e.g. Excel)
- ❑ Image file (e.g. JPEG, TIFF)
- ❑ Web-based Format (e.g. XML)
- ❑ Proprietary binary format for specific software
- ❑ Other



Those that indicated “other” had responses including: GTGS, GIS, LogPlot, ArcView, home made software, Microstation, Adobe PDF, gINT, Blog, DXF, SDE, TIFF, Illustrator, and AGS.

(54) What computer software do you use to prepare geotechnical report products (e.g. plots, charts, graphs, logs, etc.)? (Please check all that apply):

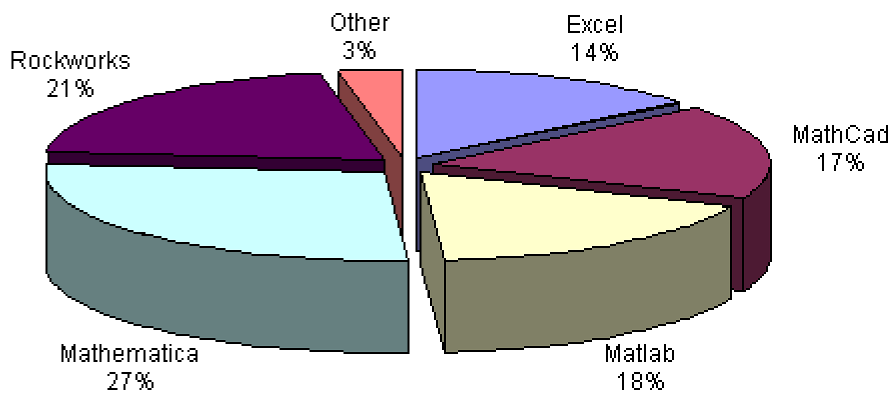
- ❑ Excel
- ❑ MathCad
- ❑ Matlab
- ❑ Mathmatica
- ❑ Deltagraph
- ❑ Rockworks
- ❑ Logplot
- ❑ GINT
- ❑ Techbase
- ❑ Applecore
- ❑ Grapher
- ❑ Surfer
- ❑ GTGS
- ❑ AutoCAD
- ❑ Microstation
- ❑ ArcView
- ❑ MapInfo
- ❑ Adobe Illustrator
- ❑ FreeHand
- ❑ Microsoft Word
- ❑ Other



Those that indicated "other" had responses including: Acrobat, Winlog, Igor, PSIPlot, Paintshop Pro, ArcINFO, Century Logging Display, WordPerfect, CorelDraw, Photoshop, GMT, Geomedia, Access, LogDraft, Blog, proprietary DOT systems, geosystem, stereonet, Kaleidegraph, Origin, Flash, Canvas, Borelog, Coneplot, Visio, Pagemaker, Integraph SGE, ERMA, MS Publisher, SID, Keyhole, and Vulcan.

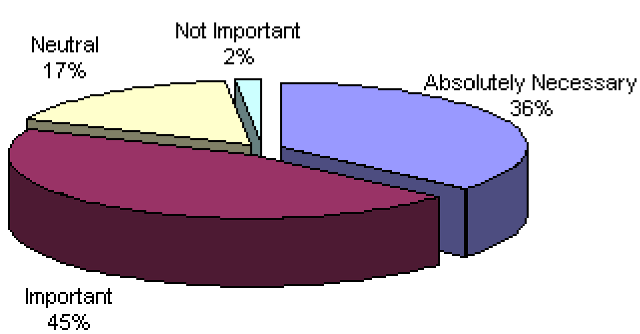
(55) What computer software do you use to process and analyze geotechnical data?

- ❑ Excel
- ❑ MathCad
- ❑ Matlab
- ❑ Mathmatica
- ❑ Rockworks
- ❑ Other



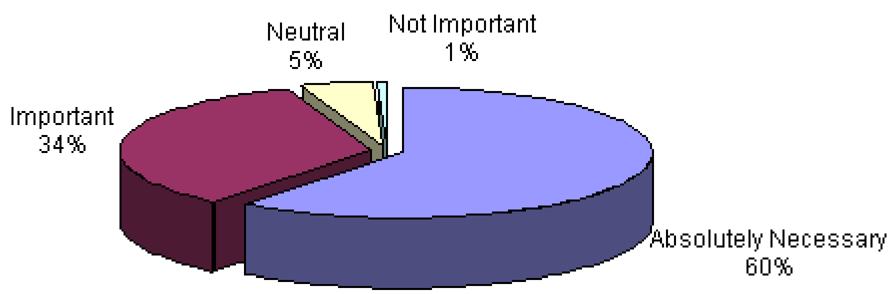
(56) How important is it in your *current work* to have geotechnical data stored in an electronic format?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



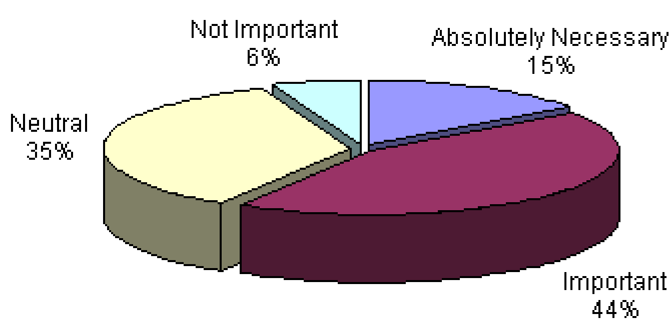
(57) How important do you think it will be for your *future work* to have geotechnical data stored in an electronic format?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



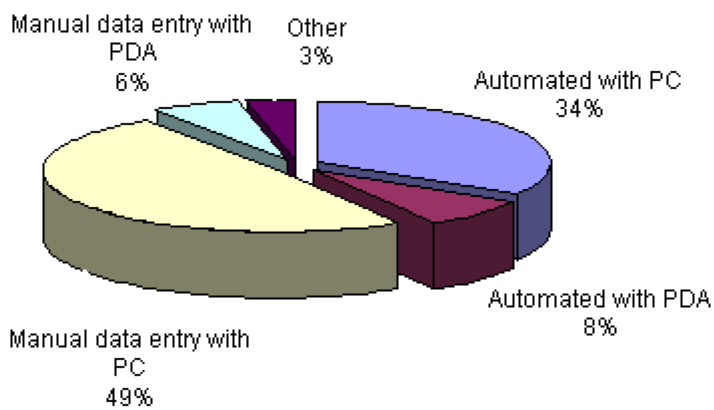
(58) How important is it in your *current work* to have geotechnical data initially collected in an electronic format?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



(58.1) How do you currently collect geotechnical data electronically?

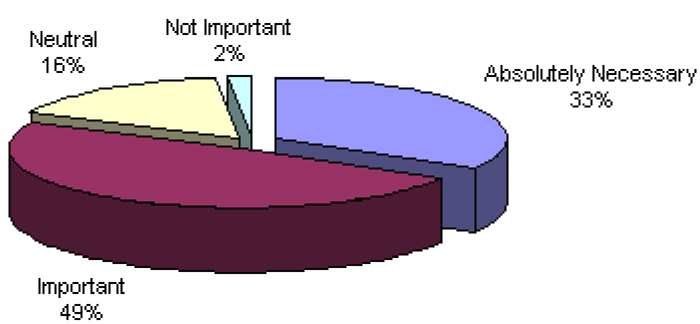
- ❑ Automated data acquisition with PC.
- ❑ Automated data acquisition with PDA (e.g. Palm, PocketPC).
- ❑ Manual data entry on a PC.
- ❑ Manual data entry with PDA (e.g. Palm, PocketPC).
- ❑ Other



Those that indicated "other" had responses including: GPS, and copy and scan.

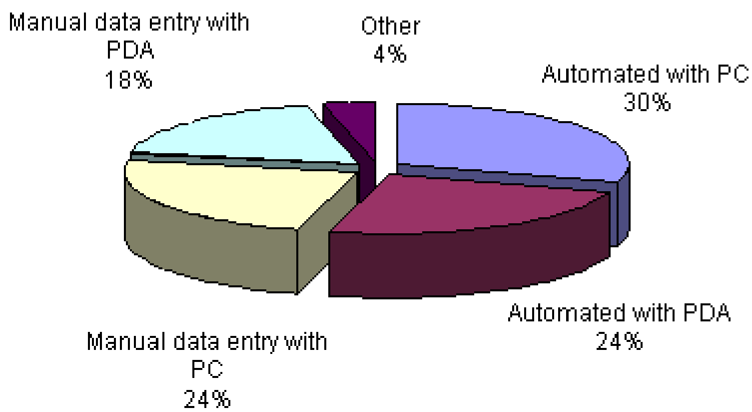
(59) How important do think it will be for your *future work* to have geotechnical data initially collected in an electronic format?

- ❑ Absolutely necessary
- ❑ Important
- ❑ Neutral
- ❑ Not important



(59.1) How would you foresee collecting that geotechnical data? (Please check all that apply):

- ❑ Automated data acquisition with PC.
- ❑ Automated data acquisition with PDA (e.g. Palm, PocketPC).
- ❑ Manual data entry on a PC.
- ❑ Manual data entry with PDA (e.g. Palm, PocketPC).
- ❑ Other



Those that indicated "other" had responses including: data loggers, digital recorder download to PC, not sure how many would be used, future software on PC, unsure, and data transfer in AGS format.

(60) Does your organization *currently* have a system in place that allows you to access your own geotechnical data (not just bitmap images) in an electronic format that is compatible with your current analysis and presentation tools?

- ❑ Yes (37%)
- ❑ No (63%)

Those that indicated "Yes" had responses including: ArcView, Access database, PDF, NGES database, Filemaker Pro FOQUS, Intergraph, Sybase Database, Project-by project Excel spreadsheets and GIS files, Excel, GIS-based database format, spread sheet, gINT, ASCII, LabView, dynamic websites, Foxpro, databases developed by our own staff, Oracle, ArcINFO, plot drill holes and see locations on screen, internal network, Boring Log Automation Program (developed in house), All test results (resilient modulus soil testing), server access to gINT logs and Word, AutoCAD, MapInfo Database, Microstation plots, MGE, Windows Notebook, 60spec, Access DB through our GIS software (MGE), Intergraph, Geofinder, commercial spreadsheet and graphing software, working on a intranet delivery system for geologic data, Acad, Word, SID, and Techbase.

(61) If a *new system* was developed to allow you to access your own geotechnical data in an electronic format compatible with your current analysis and presentation tools, would you use such a tool?

- ❑ Yes (78%)
- ❑ No (22%)

(62) If a *new system* was developed to allow you to access your own geotechnical data, as well as data generated by other organizations/companies, in an electronic format compatible with your current analysis and presentation tools, would you use such a tool?

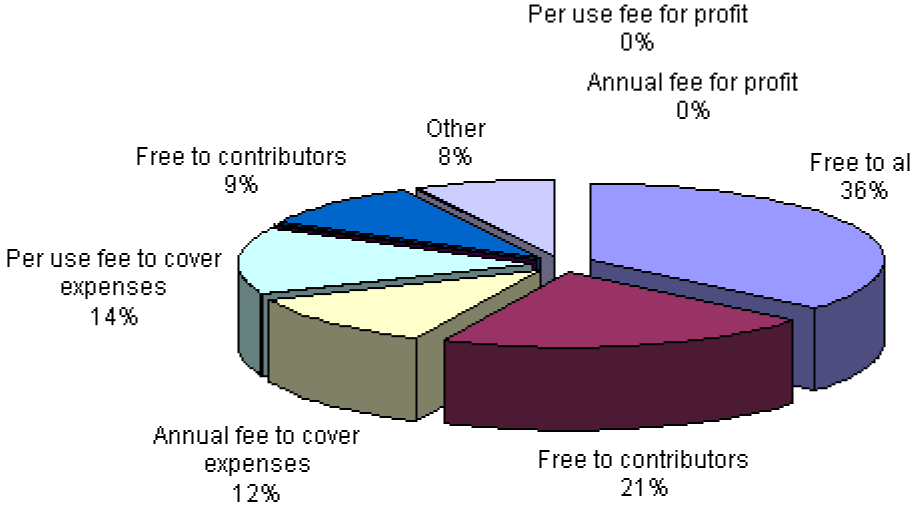
- ❑ Yes (86%)
- ❑ No (14%)

(62.1) Would your organization be interested in contributing data in some standardized format to an information system used by others?

- ❑ Yes (89%)
- ❑ No (11%)

(62.2) In your opinion, how should such data be made available?

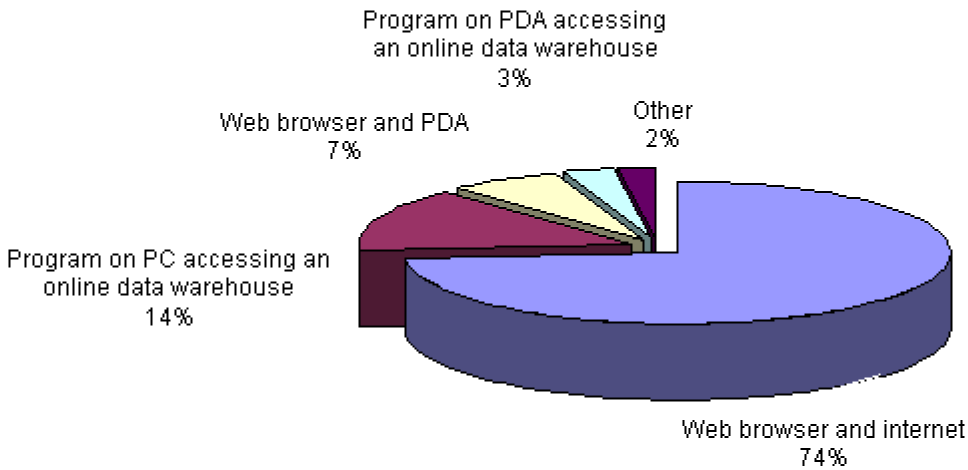
- ❑ Freely available to all
- ❑ Freely available to contributors of data
- ❑ Annual fee for use to cover expenses
- ❑ Per use fee to cover expenses
- ❑ Annual fee for profit
- ❑ Per use fee for profit
- ❑ Freely available only to contributors of data
- ❑ Other



Those that indicated "Other" provided responses including: how would you verify the quality of the contribute?, case by case basis, government supported data should be free, different users have different customer bill, choice is outside my responsibilities, a fee for noncontributors, reasonable fee to cover expenses, at least free for students, undecided, not sure, our data could be available to all, per use fee based on the amount of data, our data is public information, available to licensed geotechnical engineers and geologists, data owned by client not public, Charge non-contributors, big problems with this.

(63) What type(s) of software and hardware tool(s) would you prefer to use to access this data? (Please check all that apply):

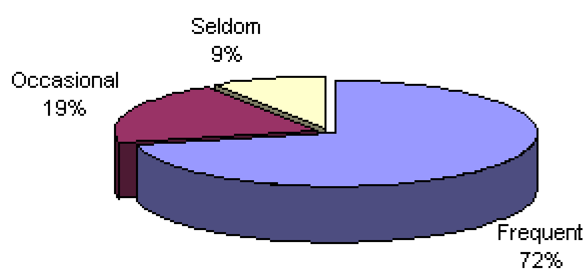
- ❑ Through the internet using a standard web browser (e.g. Netscape, Explorer) on a personal computer.
- ❑ Using a special program installed on your computer that accesses an online data warehouse.
- ❑ Through the internet using a web browser on a personal digital assistant (e.g. Palm, PocketPC).
- ❑ Using a special program installed on your personal digital assistant (e.g. Palm, PocketPC) that accesses an online data warehouse.
- ❑ Other



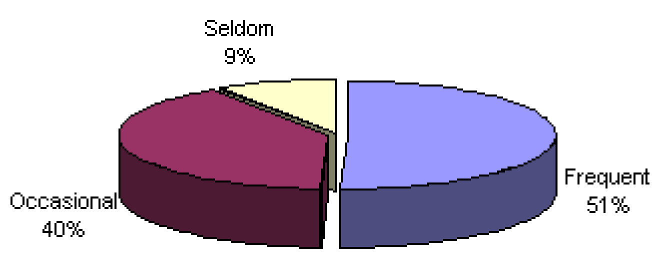
Those that indicated "Other" provided responses including: web-based GIS, tablet PC, and libraries still work well.

(64) Please indicate how often you would use each of the following methods to search for geotechnical data? (Frequent, Occasional, Seldom)

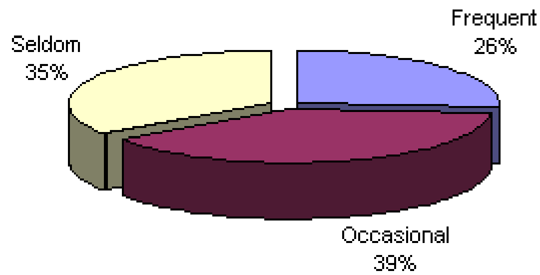
- Location (e.g. map interface, Thomas Bros. Grid, Lat/Long, street address)



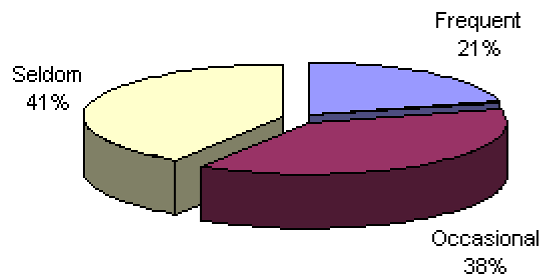
- Data type (e.g. search only for data that contain SPT blow count measurements, search only for monitoring well data, etc.)



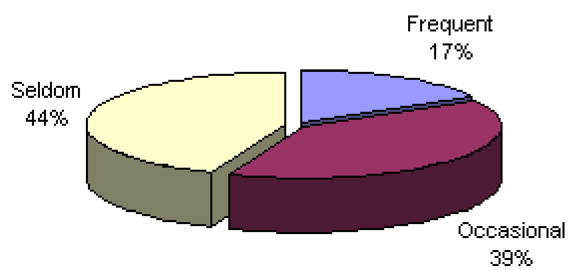
- Data value (e.g. search only for data with SPT blow counts less than 10, search only for boreholes with specific lithologic descriptions, etc.)



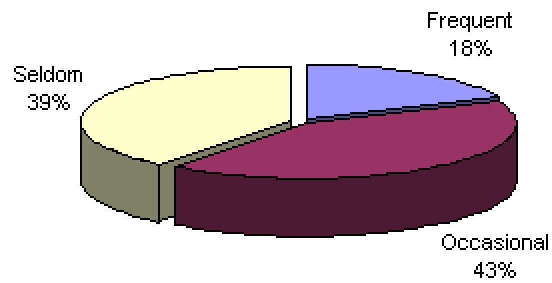
- Quality of Data (e.g. search only for data that contain SPT blow counts with measured transfer efficiency)



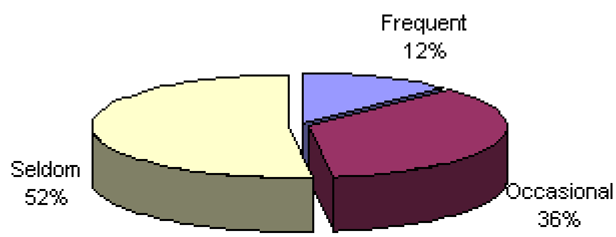
- Source of Data (e.g. search only for data generated by USGS)



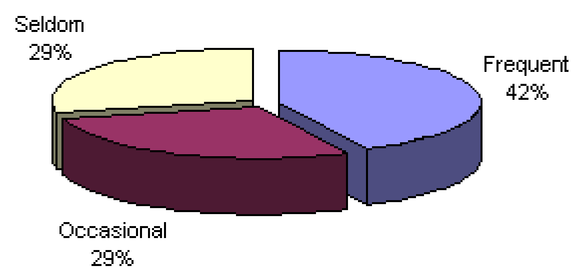
- Date of site investigation



- Date that data was added to the information system.

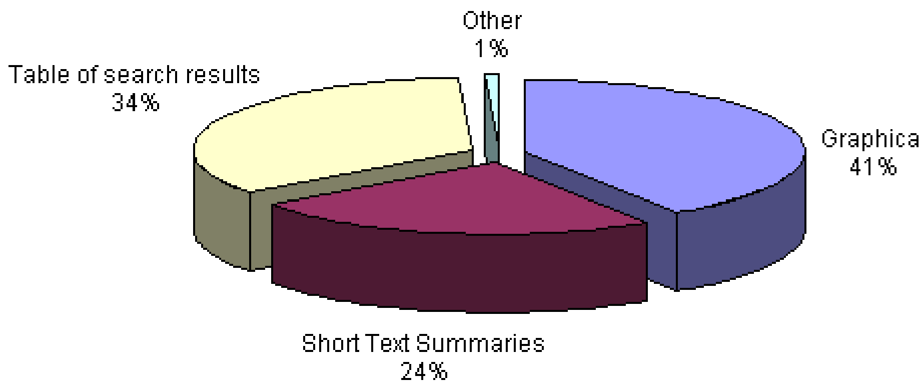


- Search by other parameter. Responses included: stratigraphic units, person, and elevation of data point.



(65) How would you want the results of the search presented to you? (Please check all that apply):

- Graphical (e.g. points on a map)
- Short text summaries of the data sets (e.g. key metadata)
- Table of search results
- Other

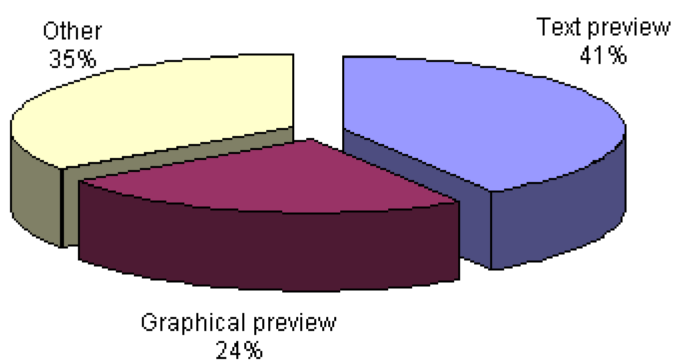


(66) Do you need to have the capability to search/sort through your search results?

- Yes (82%)
- No (18%)

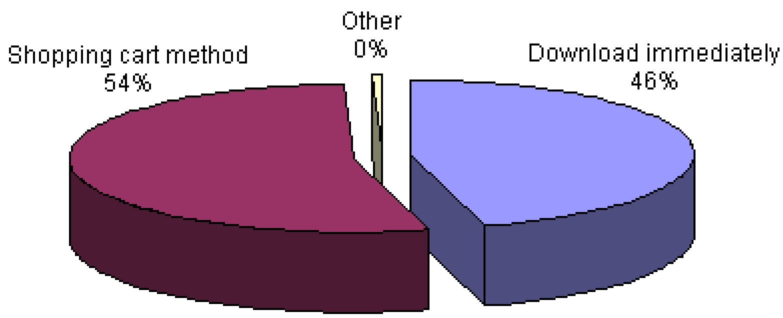
(67) How would you prefer to preview the data resulting from the search? (Please check all that apply):

- Text preview of raw data (e.g. columns of numbers for CPT data)
- Graphical preview of the data set (i.e. CPT data plotted with depth)
- Other



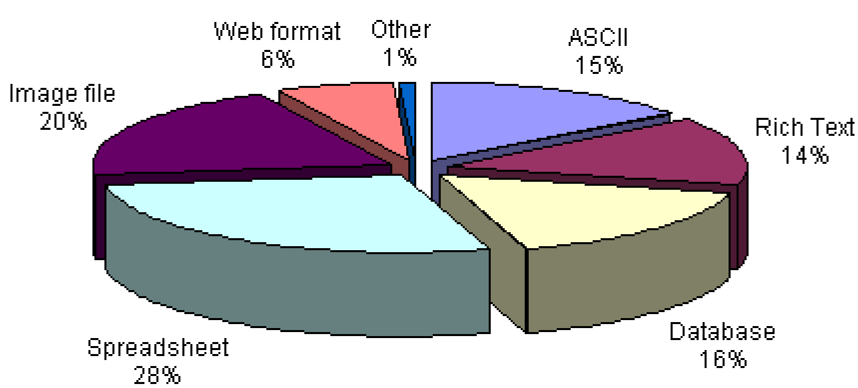
(68) How would you prefer to download and use the geotechnical data? (Please check all that apply):

- ❑ Download immediately based upon the results of the short text summary, text preview, graphical preview, or other form.
- ❑ "Shopping Cart" method; check a box, continue searching, and download everything later.
- ❑ Other



(69) In what format(s) would you prefer to download geotechnical data? (Please check all that apply):

- ❑ ASCII delimited text (e.g. text file with parameters separated by commas, tab, etc.)
- ❑ Rich Text Format (e.g. Word)
- ❑ Database format (e.g. Access, Filemaker Pro, Oracle)
- ❑ Spreadsheet format (e.g. Excel)
- ❑ Image file (e.g. JPEG, TIFF)
- ❑ Web-based Format (e.g. XML)
- ❑ Other



APPENDIX 2

DATA DICTIONARY TABLES AND SAMPLE MAPPING FROM SITE TABLE TO XML

Alias	An alternate name for another object. The alternate name is defined within a context, or naming system.

Name	**Definition**
Aliased Object	The foreign key reference to the object which is aliased.
Name	A name for this object. This name does not need to be unique within the naming system.
Naming System	A list of names, or a method for developing a list of names, from which Name is developed.

Atterberg Limits	The consistency of plastic soils defined in terms of shrinkage, plastic and liquid limits.

Name	**Definition**
Specimen	The specimen, of which these Atterberg limits test results are a part. The Atterberg limits test results must be related to a Specimen. This value is a foreign key that should select an instance of Specimen based on the Id value of the Specimen.
Liquid Limit	The water content of a soil at the arbitrary boundary between the semi-liquid and plastic states, generally expressed in percent.
Liquid Limit Method	The name of the method used to determine the liquid limit. Methods include the Liquid Limit Device and the Fall Cone.
Preparation Method	The name of the method used to prepare the specimen for the liquid limit test. Methods include the Dry and Wet preparation.
Plastic Limit	The water content of a soil at the arbitrary boundary between the plastic and semi-solid states, generally expressed in percent.
Shrinkage Limit	The maximum water content at which a reduction in water content will not cause a decrease in volume of the soil mass, generally expressed in percent.
Shrinkage Limit Method	The name of the method used to determine the shrinkage limit. Methods include the use of mercury or wax.
Natural Water Content	The water content of a soil in it's natural in situ moisture condition, generally expressed in percent.
Remarks	A text descriptor providing additional information relevant to the Atterberg Limit test.

Business Associate	The information about a business associate. The business associate may be a person, company, group, agency, or any other person or collection of persons that is related to the object.

Name	**Definition**
Name	A common name for this business associate. This name does not need to be unique within the naming system.
Naming System	A list of names, or a method for developing a list of names, from which Name is developed.
Type	The type of Business Associate. This should be one of the following: {company, person, consultant, work group, agency, other}.
Street Address	The street portion of the address. This may be multiple lines.
City	The name of the city where the Business Associate address is located.
State	The name of the state where the Business Associate address is located.
Postal Code	The postal code, appropriate to the given country, where the Business Associate address is located.
Country	The name of the country where the Business Associate Address is located.
Phone Number	The phone number of the Business Associate. The phone number is qualified by the type of phone number (eg, fax, voice, voice mail, mobile) and the nature (business or personal).
Email	The email address of a Business Associate.
Associated With	The company or group that this Business Associate is associated with. If the Business Associate is an employee, for example, the associate with would be the company which employs her. This is a foreign key to another instance of business associate. It is not required that the other instance be instantiated.
Contact	A foreign key to another Business Associate who serves as a contact for this Business Associate.

Component	A physical feature or condition observed at a point or within an interval of earth material within a hole, typically described megascopically. A Component may represent a notable textural or lithologic feature within a layer, or some other physical, structural, diagenetic, mineralogical, biological, or geophysical characteristic. It also may represent a condition (temporal or persistent) described at a point or within an interval. A Component may exist within a Layer, or may extend across many Layers.

Name	**Definition**
Hole	The hole, of which this Component is a part. A Component must be related to a hole. This value is a foreign key that should select an instance of Hole based on the Id value of the Hole.
Core	The core, of which this component is a part. A component may or may not be related to a Core. If used, this value should select an instance of Core based on the Id value of the Core.
Layer	The layer, of which this Component is a part. A Component may or may not be related to a layer. If a part of a Layer, this value should select an instance of Layer based on the Id value of the Layer.
Source	The data source or kind of sample used to describe the Component and its location. This should be one of the following:{Core, CPT, Cuttings, Geophysical Log, Estimate, Multiple Sources, Outcrop, Other}.
Component Top	The measured depth at the top of the Component The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Component Base	The measured depth to the base of the Component. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}
Classification System	The name of the classification system used to describe the Component, if applicable (e.g. Munsell color). This is expected to be a foreign key to an instance, however there is no requirement that the instance exist.
Type	The type of Component being described (e.g, color, roundness, sorting, structural, physical, lithologic, diagenetic, mineralogic, fossil). This is expected to be a foreign key to an instance, however there is no requirement that the instance exist.
Description	A name or description of the Component. This can be an element of a classification system, and/or be restricted to a certain type of Component, or be a general text descriptor.
Abundance	A description of the relative pervasiveness of the Component within the interval defined by the Component top and Component base. This is a text descriptor and should provide some definition, such as: {pervasive (>50%), abundant (30-50%), common (15-30%, few (5-15%), rare (1-5%),trace}.

Core	An interval of earth materials, extracted or attempted to be extracted from a hole or site, using a specific type of sampling device, and where the physical locations of the ends of the Core are known in space. This term is used to represent both the sample collected as well as the interval within the hole that is sampled. If a physical sample of material is recovered from the interval, it is contained within the interval and is coherent, meaning that the material represents the relative position and properties of the strata or geological material in its in-situ condition. Material collected from a Core may be a) tested as a whole, b) further sub-sampled for geotechnical lab tests, c) described in detail, or d) subjected to geophysical tests, such as density scans, etc. Cores cannot overlap within a single hole.

Name	**Definition**
Name	A common name for the Core. This name does not need to be unique within the naming system.
Naming System	A list of names or a method for developing a list of names.
Hole	The hole, of which this Core is a part. A Core must be related to a hole. This value is a foreign key that should select an instance of Hole based on the Id value of the Hole.
Core Top	The measured depth to the top of the Core. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Core Base	The measured depth to the lowermost boundary of the Core. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Sample Top	The inferred measured depth to the top of any sample recovered from the Core. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Sample Base	The inferred measured depth to the base of any sample recovered from the Core. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Sampling Method	The name of the sampling method used to obtain a Core. Sampling methods can be one of the following: a) undisturbed sampling by Shelby tube or Piston sampler, b) disturbed sample by split-spoon, c) block sample, d) disturbed sample by other methods, e) rotary drill cored sample, or f) other sampling method.
Date	The date and time when the Core was sampled at the site.
Sample Length	The length of material recovered (solid or unconsolidated) from the cored interval using one of the sampling methods.
Remarks	A text descriptor providing additional information relevant to the Core. Examples of this could be drill rig behavior, driller's comments, and drill time through the layer.

Cone Penetration Test Data	The cone penetration test (CPT) consists in determining the resistance to penetration of a conical pointed penetrometer into subsurface soils. Standard testing procedures are described in ASTM D 5778. Cone Penetration data are presented in this table.

Name	Definition
Cone Penetration Test Parameters	The Cone Penetration Test Parameters, of which these CPT data are a part. The CPT data must be related to a Cone Penetration Test Parameters. This value is a foreign key that should select an instance of Cone Penetration Test Parameters based on the Id value of the Cone Penetration Test Parameters.
Tip Depth	The depth of measurement at the penetrometer tip.
Tip Resistance	The end-bearing component of penetration resistance in units of stress referred to as q_c (uncorrected for net area ratio).
Friction Sleeve Resistance	The friction component of penetration resistance in units of stress developed on a friction sleeve refereed to as f_s.
Penetration Pore Pressure	Fluid pressure measured using the piezocone penetration test.
Inclination	Inclination of the penetrometer during advance in degrees.
Remarks	A text descriptor providing additional information relevant to the CPT data and results.
Date Last Updated	The date of the last update to the data in this table.

Cone Penetration Test Dissipation Data	During cone penetration testing it is possible to conduct dissipation tests to evaluate the hydraulic conductivity of soils. The process consists in stopping the penetrometer advance at the depth of interest and observing the pore pressure decay with time. Standard testing procedures are described in ASTM D 5778. Cone Penetration dissipation data are presented in this table.

Name	Definition
Cone Penetration Test Data	The Cone Penetration Test Data, of which these CPT dissipation data are a part. The CPT dissipation data must be related to a Cone Penetration Test Data. This value is a foreign key that should select an instance of Cone Penetration Test Data based on the Id value of the Cone Penetration Test Data.
Tip Depth	The depth of dissipation measurement at the penetrometer tip.
Penetration Pore Pressure	Fluid pressure measured using the piezocone during the dissipation test.
Elapsed Time	Elapsed time of reading for dissipation measurement.

Remarks	A text descriptor providing additional information relevant to the CPT dissipation data, results and procedures.
Date Last Updated	The date of the last update to the data in this table.

Cone Penetration Test Parameters	The cone penetration test (CPT) consists in determining the resistance to penetration of a conical pointed penetrometer into subsurface soils. Standard testing procedures are described in ASTM D 5778. Relevant testing parameters are described in this table.

Name	**Definition**
Hole	The hole, of which these CPT parameters are a part. The CPT parameters must be related to a hole. This value is a foreign key that should select an instance of Hole based on the Id value of the Hole.
Cone Type	The type of cone penetrometer used for testing. The following provides a list of available cone penetrometers: a) mechanical cone, b) electric cone, c) piezocone, d) seismic piezocone, e) lateral stress cone, f) dynamic cone, g) acoustic cone, h) resistivity cone, i) vibratory cone, j) miniature cone, or k) other.
Cone Manufacturer	The business name of the company manucturing the cone penetrometer. For example, Fugro, Hogentogler, Delft, etc.
Tip Area	The conical base area of the penetrometer tip. Typical values are 10 cm^2 and 15 cm^2
Tip Apex Angle	The apex angle of the conical point of the penetrometer tip. The standard value is 60 degrees.
Friction Sleeve Area	The surface area of the friction sleeve located immediately behind the penetrometer tip. Typical values are 150 cm^2 for the 10 cm^2 and 200 cm^2 for the 15 cm^2.
Distance Tip to Sleeve	The distance between the tip and the center of the friction sleeve.
Piezocone Type	The type of Piezocone is defined in part by the position of the filter element. The types in use are the following: a) Type 1 (on the tip apex or at the midface on the tip), b) Type 2 (at the shoulder or behind the tip), c) Type 3 (above the friction sleeve), or d) other.
Porous Element Type	The type of material used as porous filter element. The following materials are typically used: a) plastic, b) sintered bronze, c) sintered steel, d) ceramic, or e) other.
Saturation Fluid	The fluid used to saturate the porous filter element. The following deaired fluids are typically used: a) water, b) glycerin, c) silicon oil, or d) other.
Saturation Method	A description of the procedure used to saturate the porous filter element.
Net Area Ratio Correction	The correction necessary to adjust the penetration cone resistance due to penetration water pressures acting behind the cone tip. The net area ratio correction, a, is applied to the cone resistance q_c which becomes the corrected total cone resistance q_t. The value a is dimensionless.
Push Rod Type	The type of pushing rods used for CPT penetration. Standard nomenclature can be used such as A-rod or N-rod.
Friction Reducer	A description of the type, size and location of the friction reducer behind the base of the cone should be reported if used.

Penetration Rate	The rate of advance of the penetrometer. Rate should be between 20 +/- 5 mm/second.
Tip Load Cell Capacity	The capacity of the tip load cell.
Sleeve Load Cell Capacity	The capacity of the sleeve load cell.
Surface Load Cell Capacity	The capacity of the surface load cell.
Pore Pressure Load Cell Capacity	The capacity of the pore pressure load cell.
Last Calibration Date	The date of the last calibration of the penetrometer. Specify which components were calibrated.
Remarks	A text descriptor providing additional information relevant to the CPT parameters and equipment especially if those differ from standard requirements.
Date Last Updated	The date of the last update to the data in this table.

CRS	A coordinate reference system for which a set of coordinates is given. This object contains information that will either reference a standard CRS, or will define a local coordinate system particular to a site/ project.

Name	**Definition**
Name	A common name for the CRS. This name does not need to be unique within the naming system.
Naming System	A list of names or a method for developing a list of names.
EPSG Code	The standard code for a well-known CRS, as defined and maintained by the European Petroleum Survey Group (EPSG).
URL	The Uniform Resource Locator for a dictionary entry to the standard CRS.
Type	The type of CRS. Values are {geographic, projected, vertical, engineering}.
Project Origin	A foreign key to the Project for which this CRS is a local, engineering CRS. This value indicates that the Project has defined a Location Reference Point, which is to be used as the origin for this CRS.
Origin	A description of a point which serves as the origin of the CRS. This is an alternative to the Project Origin, which uses a Location Reference Point as the origin.
North Direction	The direction that is assumed to be north in the engineering CRS. This is one of {true north, magnetic north, projected north, unknown}.
X Axis Azimuth	The rotation from the north direction of the X-axis. The rotation is positive clockwise. If the x-axis is due east, the value would be 90 deg.
X Axis Description	A description of the X-axis. If the X Axis Azimuth is not given, then a textual description of the direction of the X-axis should be given.

Y Axis Rotation	The Y axis is assumed to be rotated 90 deg from the X axis. The rotation may either be {clockwise, counter clockwise}. The usual value is counter clockwise.

Hole	A single sampling station, from which earth materials are collected or described, or earth material properties are measured. The sample may be from a core or cuttings from a borehole, surface excavation, or any other highly local sampling method. This term is used to represent the sample collecting activity as well as the sampling station.

Name	**Definition**
Name	A common name for the hole. This name does not need to be unique within the naming system.
Naming System	A list of names or a method for developing a list of names.
Site	The Site of which this hole is a part. A hole must be related to a Site This value is a foreign key that should select in instance of Site based on the Id value of the Site.
Type	The primary or current type of sampling station/hole. This is used to supply more specificity to the Site Type. Value should be one of the following: {see Hole Type sheet}.
Driller	The business associate that drilled the hole. This is intended to be a foreign key to a possible database entry, although there is no expectation that this entry will actually exist.
Logger	The business associate that logged the hole. This is intended to be a foreign key to a possible database entry, although there is no expectation that this entry will actually exist.
Start Date	The starting date of the collection activity for this hole.
End Date	The ending date of the collection activity for this hole.
Elevation	Elevation of the hole at the depth datum. Elevations are positive upward, measured from the elevation datum.
Elevation Datum	The name of the elevation datum.
Map Projection	The map projection used to give the X and Y locations of the location reference point.
Location X	The first coordinate for the location of the location reference point. In the US, this would be the Easting.
Location Y	The second coordinate for the location of the location reference point. In the US, this would be the Northing.
Local CRS	A description of the local coordinate system which applies to local x,y coordinates. This is expected to be a foreign key to an instance, however there is no requirement that the instance exist.
Geodetic Datum	The geographic coordinate system used to give the latitude and longitude of the location reference point.

Latitude	The latitude of the location reference point, given in the Geodetic Datum CRS.
Longitude	The longitude of the location reference point, given in the Geodetic Datum CRS.
Local X	The X location (first coordinate value) in the local CRS.
Local Y	The Y location (second coordinate value) in the local CRS.
Depth Datum	The datum from which depths are measured. If no value is given, it is assumed that the datum is the ground level.
Bottomhole depth	The measured depth of the hole at its deepest point. The depth is measured from the depth datum, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Inclination	The variation from the vertical of the hole. The inclination must be a positive value. If no inclination is given, the hole is interpreted to be vertical, or a hole survey object (not yet defined) exists which describes the path of the hole.
Surface Geology	The surficial geologic unit at the location of this hole. This is intended to be a foreign key to a possible database entry, although there is no expectation that this entry will actually exist.
Location Method	A description of the method by which the location reference point coordinates were obtained. This should be one of the following: {DGPS, Estimated from Well ID, GPS, Digitized from existing map, LORAN, Posted to map from description, Unknown - from owner/operator, Unknown - from 3rd party}.
Location Accuracy	An estimate of the accuracy of the location reference point. This should be one of the following: {0.3 m (~1/100 sec), 3 m (~1/10 sec), 15 m (~1/2 sec), 30 m (~1 sec), 90 m (~3 sec), <150 m (~5 sec), 300 m (~10 sec), 800 m (~1 min), >800 m (>~1 min)}.

Hole_Test_Assoc	The studies and analyses that are performed at a Hole and that may be available for direct access through the Geotechnical Virtual Data Center.

Name	**Definition**
Hole	The hole, of which this Hole Data is a part. Hole Data must be related to a hole. This value is a foreign key that should select an instance of Hole based on the Id value of the Hole.
Hole Tests	The Hole Tests of which this Hole Data is a part. Test must be related to a Hole Tests. This value is a foreign key that should select an instance of Hole Tests based on the Id value of the Hole Tests.
Parent	The Parent Hole Tests of which this Hole Data is a part. Parent must be related to a Hole Tests. This value should be the Parent attribute of the Hole Tests associated with this instance of Hole Data.
Grandparent	The Grandparent Hole Tests of which this Hole Data is a part. Grandparent must be related to a Hole Tests. This value should be the Grandparent attribute of the Hole Tests associated with this instance of Hole Data.

Top Depth	The measured depth to the uppermost or shallowest extent of the Hole Data. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Bottom Depth	The measured depth to the lowermost extent of the Hole Data. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
XML File Name	A URL of the XML file that contains the results of this hole data that resides with the data provider. If this attribute is NULL, then the hole data exists, but is not available for download from the data provider.
Reference	A reference to a publication or publications, and/or to a URL that reports the hole data results, its implications, and the methods by which the data were obtained.
Contact	The business associate to which inquiries about this Hole Data may be addressed. This is intended to be a foreign key to a possible database entry, although there is no expectation that this entry will actually exist.
Remarks	

Hole Tests	The studies and analyses that are performed at a Hole and that may be available for direct access through the Geotechnical Virtual Data Center.

Name	**Definition**
ID	A simple name for the Hole Test. This value is intended to be a primary key for referencing this data instance.
Parent	A higher-level classification to which this Study Type belongs.
Grandparent	A higher-level classification to which the Parent belongs.
Description	A description of the Study Type.
Reference	A reference to a publication or publications, and/or to a URL that describe the study or analysis and/or provides standard procedures for performing the study or analysis.
InQuery	A flag that signifies whether the Geotechnical Virtual Data Center web site will query on this field.

Layer	An interval of earth material in which the texture and physical character of the material are described. The layer is usually defined in terms of a scientific or vernacular classification system. No layers in a given hole defined within one classification system may overlap.

Name	**Definition**
Hole	The hole, of which this layer is a part. A layer must be related to a hole. This value is a foreign key that should select an instance of Hole based on the Id value of the Hole.
Core	The core, of which this layer is a part. A layer may or may not be related to a core. If used, this value should select an instance of Core based on the Id value of the Core.
Source	The data source or kind of sample used to describe the layer and define its boundaries. This should be one of the following:{Core, CPT, cuttings, Geophysical Log, Estimate, Multiple Sources, Outcrop, Other}.
Layer Top	The measured depth to the top of the layer. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Layer Base	The measured depth to the lowermost boundary of the layer. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers}.
Classification System	The name of the classification system used to describe the layer. This can be a scientific system such as USCS, USDA, or AASHTO, or a local, custom system. This is expected to be a foreign key to an instance, however there is no requirement that the instance exist.
Primary Classification	The value used as a primary description for the layer. This is intended to be an element of the classification system.
Secondary Classification	The value used to describe a part of the layer considered to be a secondary component of the layer. This is intended to be an element of the classification system and is only relevant if the primary classification attribute exists. The value may be qualified by the measured or estimated percentage of the layer for which this classification is relevant.
Tertiary Classification	The value used to describe a portion of the layer considered to be a minor component of the layer. This is intended to be an element of the classification system and is only relevant if the secondary classification attribute exists. The value may be qualified by the measured or estimated percentage of the layer for which this classification is relevant.
Description	A text descriptor for the layer. This can be used to provide additional descriptive information about the layer, or can be used In lieu of the primary, secondary, or tertiary classifications.
Remarks	A text descriptor providing information relevant to the layer interval, but not specifically relevant to a description of the layer itself. Examples of this could be drill rig behavior, driller's comments, and drill time through the layer.
Grain Size	The average or representative grain size of the material in the layer. This can be represented as a quantity of grain diameter (usually mm or phi), or as a text descriptor. If a text descriptor, a definition or reference to a classification system should be defined.

Bedding	A description of the representative bedding thickness and character within the layer, if observed. This is a text descriptor and should provide a definition of the descriptor as: massive, thickly bedded (> dm), medium bedded (cm-dm), thinly bedded (< cm), laminated}.
Basal Contact	A description of the nature of the lowermost boundary of the layer, if observed. This can be a text descriptor or member of a list as: {sharp, broken, clear, diffuse, erosional, gradational, irregular, wavy, undulating, inclined, angular unconformity, faulted, uncertain, incised}.

Natural Moisture Content	The in situ natural moisture or water content of geologic materials.

Name	**Definition**
Specimen	The specimen, of which this Natural Moisture Content is a part. The Natural Moisture Content must be related to a Specimen. This value is a foreign key that should select an instance of Specimen based on the Id value of the Specimen.
Natural Moisture Content	The water content of a soil in it's natural in situ moisture condition. The water content is the ratio of the mass of water contained in the pore spaces of soil or rock material, to the solid mass of particles in that material, generally expressed in percent.
Remarks	A text descriptor providing additional information relevant to the moisture content determination.

Particle Size Data	The distribution of particle sizes in soils as determined by sieve analysis and/or hydrometer analysis.

Name	**Definition**
Specimen	The specimen, of which this Particle Size Data analysis is a part. The Particle Size analysis must be related to a Specimen. This value is a foreign key that should select an instance of Specimen based on the Id value of the Specimen.
Particle Size Parameters	The Particle Size Parameters, of which these Particle Size Data are a part. The Particle Size Data must be related to the Particle Size Parameters. This value is a foreign key that should be an instance of Particle Size Parameters based on the Id value of the Particle Size Parameters.
Sieve or Particle Size	The sieve opening or the size of the soil particles.
Percent Passing	The percentage of soil passing or finer by weight or mass for each sieve or size of soil particle.
Remarks	A text descriptor providing additional information relevant to the particle size analysis of the soil specimen.

Particle Size Parameters	The distribution of particle sizes in soils as determined by sieve analysis and/or hydrometer analysis. Relevant parameters and summary results are presented in this table.

Name	**Definition**
Specimen	The specimen, of which this Particle Size analysis is a part. The Particle Size analysis must be related to a Specimen. This value is a foreign key that should select an instance of Specimen based on the Id value of the Specimen.
D10	Grain diameter corresponding to 10 percent passing.
D50	Grain diameter corresponding to 50 percent passing.
Uniformity	A coefficient describing the degree of uniformity of the grain size distribution. This coefficient is defined as the ratio of D60 over D10.
Curvature	A coefficient describing the degree of curvature of the grain size distribution. This coefficient is defined as the ratio of (D30)2 over (D60 times D10).
Percent Fines	The percentage of fines by weight passing the No. 200 sieve (finer than 0.075 mm).
Remarks	A text descriptor providing additional information relevant to the particle size analysis of the soil specimen.

Site	A collection of holes and samples obtained at a common place.

Name	**Definition**
Name	A common name for the Site. This name does not need to be unique within the naming system.
Naming System	A list of names or a method for developing a list of names.
Type	Primary purpose for data collection at the Site. This should be one of the following: {see Site Types sheet}
Address	The physical address for the site.
City	The name of the city where the site is located.
State	The name of the state where the site is located.
Zip	The zip (or postal code) where the site is located.
County	The name of the county where the site is located.
Country	The name of the country where the site is located.

Quadrangle	The name of the USGS 7.5' quadrangle where the site is located.
PLSS	The Public Land Survey System township, range, section, and quarter-quarter section where the site is located.
Organization	The manager, operator or owner of the Site. This is intended to be a foreign key to a possible database entry, although there is no expectation that this entry will actually exist.
Contact	A name to contact for more information about the Site. This is intended to be a foreign key to a possible database entry, although there is no expectation that this entry will actually exist.
Location Reference Point	A description of a point at the Site which represents the location of the Site. The location given in other attributes will be the location of this point. In general, a local CRS (coordinate reference system) for locating other objects at the site will use this as the origin.
Map Projection	The map projection used to give the X and Y locations of the location reference point
Location X	The first coordinate for the location of the location reference point. In the US, this would be the Easting.
Location Y	The second coordinate for the location of the location reference point. In the US, this would be the Northing.
Geodetic Datum	The geographic coordinate reference system used to give the latitude and longitude of the location reference point.
Latitude	The latitude of the location reference point, given in the Geodetic Datum CRS.
Longitude	The longitude of the location reference point, given in the Geodetic Datum CRS.
Location Method	A description of the method by which the location reference point coordinates were obtained. This should be one of the following: {DGPS, Estimated from Well ID, GPS, Digitized from existing map, LORAN, Posted to map from description, Unknown - from owner/operator, Unknown - from 3rd party}.
Location Accuracy	An estimate of the accuracy of the location reference point. This should be one of the following: {0.3 m (~1/100 sec), 3 m (~1/10 sec), 15 m (~1/2 sec), 30 m (~1 sec), 90 m (~3 sec), <150 m (~5 sec), 300 m (~10 sec), 800 m (~1 min), >800 m (>~1 min)}.
Data Source	The name of the original source of data obtained for this Site. This could be the data provider itself, or another business associate that released the information to the data provider. This is intended to be a foreign key to a possible database entry, although there is no expectation that this entry will actually exist.

Specimen	A sample of earth material collected for the purpose of description or testing. A specimen may be collected directly from a site or hole, collected from the same Specimen material or from another Specimen.

Name	**Definition**
Name	A common name for the Specimen. This name does not need to be unique within the naming system.
Naming System	A list of names or a method for developing a list of names.
Hole	The hole, of which this Specimen is a part. A specimen must be related to a hole, either through this attribute or through Core. This value should select an instance of Hole based on the Id value of the Hole. Note: if Specimen comes from a Core, then the Core attribute must be populated and a value for Hole is not required.
Core	The Core, of which this Specimen is a part. A Specimen may or may not be related to a Core. If used, this value should select an instance of Core based on the Id value of the Core.
Layer	The layer, of which this Specimen is a part. A Specimen may or may not be related to a Layer. If a part of a Layer, this value should select an instance of Layer based on the Id value of the Layer.
Part of Specimen	The Specimen of which this Specimen is a part. If this Specimen is a split of a previously collected Speciment or resampled for a different test, this attribute should be populated. If used, this value should select an instance of Specimen based on the Id value of the Specimen.
Specimen Top	The measured depth to the top of the Specimen. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers, lab technicians}.
Specimen Base	The measured depth to the lowermost boundary of the Specimen. The depth is measured from the depth datum of the hole, and is positive downward, as measured along the hole alignment. The value may also be qualified by who measured the depth {loggers, drillers, lab technicians}.
Sampling Method	The name of the sampling method used to obtain a Specimen. Sampling methods should be one of the following: {Block sample, Bulk sample, Core plug, Other, Split-core section, Whole-core section}.
Lithology Classification System	The name of the classification system used to describe the lithology of the Sample. This can be a scientific system such as USCS, USDA, or AASHTO, or a local, custom system. This is expected to be a foreign key to an instance, however there is no requirement that the instance exist.
Primary Lithology	The value that describes the primary lithology of the Specimen. This is intended to be an element of the classification system.
Test	The name of the test for which the Specimen was collected. This is intended to be a name from an enumerated list, and should be one of those listed on the Tests worksheet.
Collector	The business associate that collected the Specimen. This is intended to be a foreign key to a possible database entry, although there is no expectation that this entry will actually exist.

Date	The date and time when the Specimen was obtained from the cored interval or other specimens.
Remarks	A text descriptor providing additional information relevant to the Specimen.

Standard Penetration Test Data	The standard penetration test (SPT) involves driving a split-spoon sample barrel into the ground from the bottom of a borehole by dropping a 140 lb (63.5 kg) hammer a height of 30 inches (0.76 m). From the test, a penetration resistance or blowcount (N) is obtained which equals the number of blows to drive the sampler over the depth interval between 6 and 18 inches (150 to 450 mm). The N-value is reported in blows per foot (blows per 300 mm). Standard testing procedures are described in ASTM D 1586. SPT results are presented in this table.

Name	**Definition**
Hole	The hole, of which these SPT data are a part. The SPT data must be related to a hole. This value is a foreign key that should select an instance of Hole based on the Id value of the Hole.
Core	The core, of which these SPT are a part. The SPT data must be related to a Core. This value is a foreign key that should select an instance of Core based on the Id value of the Core.
SPT Parameters	The SPT Parameters, of which these SPT data are a part. The SPT data must be related to the SPT Parameters. This value is a foreign key that should select an instance of SPT Parameters based on the Id value of the SPT Parameters.
Blows First	The number of blows required to drive the split-spoon sampler for the first 6 inch (150 mm) increment. This first increment is considered the seating drive. Penetration is stopped and often noted as "refusal" if the number of blows reaches 50 for any of the 6 inch (150 mm) increment or if there is no observed advance during the application of 10 successive blows or if the total number of blows have reached 100.
Blows First Penetration	Penetration for first increment. Complete increment is 6 inch (150 mm). Partial increment should be recorded to the nearest inch (25 mm).
Blows Second	The number of blows required to drive the split-spoon sampler for the second 6 inch (150 mm) increment. Penetration is stopped and often noted as "refusal" if the number of blows reaches 50 for any of the 6 inch (150 mm) increment or if there is no observed advance during the application of 10 successive blows or if the total number of blows have reached 100.
Blows Second Penetration	Penetration for second increment. Complete increment is 6 inch (150 mm). Partial increment should be recorded to the nearest inch (25 mm).
Blows Third	The number of blows required to drive the split-spoon sampler for the third 6 inch (150 mm) increment. Penetration is stopped and often noted as "refusal" if the number of blows reaches 50 for any of the 6 inch (150 mm) increment or if there is no observed advance during the application of 10 successive blows or if the total number of blows have reached 100.
Blows Third Penetration	Penetration for third increment. Complete increment is 6 inch (150 mm). Partial increment should be recorded to the nearest inch (25 mm).

Blows Fourth	The number of blows required to drive the split-spoon sampler for the fourth 6 inch (150 mm) increment if a 24 inch (600 mm) sampler is used. Penetration is stopped and often noted as "refusal" if the number of blows reaches 50 for any of the 6 inch (150 mm) increment or if there is no observed advance during the application of 10 successive blows or if the total number of blows have reached 100.
Blows Fourth Penetration	Penetration for fourth increment. Complete increment is 6 inch (150 mm). Partial increment should be recorded to the nearest inch (25 mm).
N Value	The uncorrected SPT N-Value is defined as the sum of second and third increments (from 6 to 18 inches - 150 to 450 mm). Deviation from this definition occurs if penetration is stopped due to any of the 6 inch (150 mm) increment reaching 50 blows or if there is no observed advance during the application of 10 successive blows or the total number of blows have reached 100. Such deviations should be reported as number of blows for each complete 6 inch increment or number of blows for each partial increment. Partial increments should be reported to the nearest inch (25 mm).
N Value Top Depth	The measured depth associated with the beginning of the interval of penetration for the reported N Value.
N Value Base Depth	The measured depth associated with the end of the interval of penetration for the reported N Value.
Measured Energy	The measured energy ratio expressed as a percentage.
Remarks	A text descriptor providing additional information relevant to the Standard Penetration Test of the soil specimen.
Date Last Updated	The date of the last update to the data in this table.

Standard Penetration Test Parameters	The standard penetration test (SPT) involves driving a split-spoon sample barrel into the ground from the bottom of a borehole by dropping a 140 lb (63.5 kg) hammer a height of 30 inches (0.76 m). From the test, a penetration resistance or blowcount (N) is obtained which equals the number of blows to drive the sampler over the depth interval between 6 and 18 inches (150 to 450 mm). The N-value is reported in blows per foot (blows per 300 mm). Standard testing procedures are described in ASTM D 1586. Relevant testing parameters are described in this table.

Name	**Definition**
Sampler Length	The length of the split-spoon sampler barrel. Standard lengths are 18 inches (450 mm) and 24 inches (600 mm).
Sampler Internal Diameter	The inside diameter of the split-spoon sampler.
Liner	The use of a liner to produce a constant inside diameter is permitted and should be noted.
Basket	The use of a basket retainer is permitted and should be noted.

Hammer Mass	The hammer mass used to drive the split-spoon sampler. The standard mass is 140 lb (63.5 kg).
Hammer type	The type of hammer or drive-weight assembly used for the sampling and penetration. Typical hammer types include the following: a) donut, b) safety, or c) other.
Hammer Release	The mechanism used to lift and drop the hammer or drive-weight assembly. Typical hammer release mechanisms include the following: a) rope and cathead, b) trip, c) semi-automatic, d) automatic, or e) other.
Drop Height	The hammer drop height for SPT penetration. The standard procedure requires a drop of 30 inches (0.76 m).
Rod Type	The type of sampling rods used for SPT penetration. Standard nomenclature can be used such as A-rod or N-rod.
Rod External Diameter	The external diameter of the sampling rods used for SPT penetration.
Rod Weight	The drive rod weight per unit length (typically given per meter or per foot).
Cathead diameter	The diameter of the cathead used to pull the rope attached to the hammer. Typical diameters range from 6 to 10 inches (150 to 250 mm).
Rope Turns Number	The number of rope turns on the cathead for performing the SPT. Maximum allowed number of turns is 2 1/4.
Energy	A description of the equipment used to measure energy during the SPT penetration.
Remarks	A text descriptor providing additional information relevant to the SPT parameters and equipment especially if those differ from standard requirements.
Date Last Updated	The date of the last update to the data in this table.

Sample Mapping: Site Table to XML

An example mapping is shown that takes the information from the Site table, and encodes it into XML schema, and is expressed in an XML file.

The schema is shown below:

```
<xsd:element name="Site" type="siteTableType">
              <xsd:annotation>
                <xsd:documentation>
The Site is a collection of holes and samples obtained at a common place.
It is a direct parent of Hole, and offers the top level of the context
hierarchy.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>

<xsd:complexType name="siteTableType">
              <xsd:annotation>
                <xsd:documentation>
The Site is a collection of holes and samples obtained at a common place.
It is a direct parent of Hole, and offers the top level of the context
hierarchy.
                </xsd:documentation>
              </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="ID" type="codeSysElAttType">
              <xsd:annotation>
                <xsd:documentation>
A code or simple name for a Site. This value is intended to be a foreign
key for referencing this data instance.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
    <xsd:element name="Name" type="nameSysElAttType" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
A common name for the Site. This name does not need to be unique within
the naming system.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
    <xsd:element name="Alias" type="nameSysElAttType" minOccurs="0"
maxOccurs="unbounded">
              <xsd:annotation>
                <xsd:documentation>
Zero or more alternate names for the Site. This name does not need to be
unique within the naming system. This element is useful if the Site has
different names in different databases, or if it is known in the industry
by different names.
                </xsd:documentation>
```

```
              </xsd:annotation>
      </xsd:element>
    <xsd:element name="Type" type="extSiteTypeEnum" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
Primary purpose for data collection at the Site. These values are from an
enumerated list, and may be extended using Other: xx method.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
    <xsd:element name="Organization" type="simpleRefType" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
A reference to a business associate that is the owner at the Site.
Details about the business associate may, if desired, be carried in the
dictionary portion or this exchange file, or may obtainable through a
service.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
    <xsd:element name="Contact" type="simpleRefType" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
A reference to a business associate that is the contact at the site, at
the time of data collection. There is no expectation that the site
contact will be the same at a later date.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
<xsd:element name="SiteAddressLocation" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
The geopolitical location (state, city, county, country) of the Site,
with the address added to the sequence of values. In geotechnical
sampling, a site can often be located with a simple address.
                </xsd:documentation>
              </xsd:annotation>
 <xsd:complexType>
  <xsd:sequence>
    <xsd:element name="Address" type="xsd:string" minOccurs="0"
maxOccurs="unbounded">
              <xsd:annotation>
                <xsd:documentation>
The physical address for the site. The site may be located by giving an
address.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
    <xsd:element name="City" type="xsd:string" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
The name of the city where the site is located.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
```

```
    <xsd:element name="State" type="stateCodeEnum" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
The name of the state where the site is located. The state is given as
the two character postal code.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
    <xsd:element name="County" type="xsd:string" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
The name of the county where the site is located.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
    <xsd:element name="Country" type="countryCodeEnum" minOccurs="0">
              <xsd:annotation>
                <xsd:documentation>
The name of the country where the site is located. Either the two or
three character ISO code may be used. For the United States, the
appropriate codes would be US or USA.
                </xsd:documentation>
              </xsd:annotation>
      </xsd:element>
  </xsd:sequence>
 </xsd:complexType>
```

A sample of an XML file instantiated from the above schema is shown below:


```
 <Site>
    <ID codeSpace="USGS_ID">Lonr C_31861788_bD19</ID>
    <Name namingSystem="USGS_PostgreSQL_name">15</Name>
    <Name namingSystem="USGS_common_name">Long Beach - Pier C</Name>
    <Alias namingSystem="USGS_Abbreviation">LBPC</Alias>
    <Alias namingSystem="USGS_Other_ID">Long Beach-4</Alias>
    <Type>geotechnical</Type>
    <Organization>CalWaterRep</Organization>
    <Contact>Dan Ponti</Contact>
    <SiteAddressLocation>
      <Address>Street address if known</Address>
      <City>Long Beach</City>
      <State>CA</State>
      <County>Los Angeles</County>
      <Country>US</Country>
    </SiteAddressLocation>
    <LocationReferencePoint>Western end of Pier C Container facility,
adjacent to Channel Two</LocationReferencePoint>
    <Quadrangle>LONG BEACH</Quadrangle>
    <PLSS xsi:type="USLegal">
      <Township>5S</Township>
      <Range>13W</Range>
      <Section>3</Section>
      <PrincipalMeridian>San Bernardino Base and
Meridian</PrincipalMeridian>
    </PLSS>
```

```
    <Location>
      <CRS>NAD83</CRS>
      <LatitudeValue uom="deg">33.77095</LatitudeValue>
      <LongitudeValue uom="deg">-118.22052</LongitudeValue>
    </Location>
         <!--  Can also include a non-lat/lon location, if desired.
    <Location>
      <CRS>UTM 11N / NAD83</CRS>
      <Easting uom="m">386982.7</Easting>
      <Northing uom="m">3737429</Northing>
    </Location>
          -->
    <LocationMethod>GPS</LocationMethod>
    <LocationAccuracy>3 m</LocationAccuracy>
    <DataSource>USGS</DataSource>
    <LastUpdated>2002-08-29</LastUpdated>
    <Hole>. . .
      information about Holes, Cores, Specimen, etc are also included.
</Site>
```

APPENDIX 3

COSMOS/PEER-LL XML SCHEMA, DETAILED SYSTEM ARCHITECHTURE DESCRIPTION, AND WORKFLOWS

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[5] California Geological Survey, 801 K. Street MS 12-31, Sacramento, CA 95914; Email: creal@consrv.ca.gov
[6] Geotechnology Implementation Branch Division of Research & Innovation, California Department of Transportation, 5900 Folsom Blvd.MS-5, Sacramento, CA 95819; Email: Paul_Grimes@dot.ca.gov
[7] Farallon Geographics, Inc., 609 Mission St. 2nd Floor, San Francisco, CA 94105; Email: apeters@fargeo.com
[8] Internovations, 7071 Warner Ave., #F-372, Huntington Beach, CA 92647; Email: josephc@internovations.com
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1.0 INTRODUCTION

This Appendix is intended as a companion to Chapter 4 entitled "Pilot Geotechnical Data System Architecture and Databases" (Swift et al., this report). The purpose of this appendix is to assist in the understanding of the methodology used in constructing the COSMOS/PEER-LL Geotechnical Virtual Data Center (GVDC) demo data center as well as the logic behind its development.

The GVDC data center consists of data provider's data sets and supporting applications, a centralized metadata database supporting end-user search capabilities, an end-user front end website and an administrative website (see Chapter 4, Figure 11, Swift et al., this report). This appendix contains detailed documentation on the Geotechnical XML Schema developed for the COSMOS/PEER-LL 2L02 project, the server-side and client-side GVDC architectures, and workflow instructions for installing, maintaining and updating parts of the system. This document is organized in the following general sections:

- COSMOS/PEER-LL Geotechnical Extensible Stylesheet Language (XML) Schema
- GVDC Database Structure
- Client Side Data Preparation and Exchange Protocol
- Server Side Back End System Architecture
- Server Side Front End Website
- Server Side Administrative Website
- Workflows

Information of primary significance to GVDC data providers can be found in sections "Client Side Data Preparation and Exchange Protocol" and "Workflows".

Integrating all of the applications described in this appendix into a centralized, efficient data center presented special challenges, as the various applications were for the most part coded in different programming languages by different individuals at different institutions. The GVDC data center presents a unique success story of academic, industry and agency collaboration. Contact information for project participants who contributed to the various code development and documentation efforts is provided at the end of this appendix.

2.0 COSMOS/PEER-LL GEOTECHNICAL XML SCHEMA

As part of the COSMOS/PEER-LL 2L02 project, the geotechnical data dictionary described in Chapter 3 and Appendix 2 (Benoit, et al., this report) was mapped to Extensible Markup Language (XML) schema, a data exchange structure which can be easily integrated with the GVDC system architecture code (Bobbitt, 2004a; Bobbitt et al., 2004; DSTC, 2004).

The Data Dictionary Work Group (DDWG) first defined structures for Site, Hole, Core, Specimen Layer, and Component (Figure 1). Data structures for five geotechnical

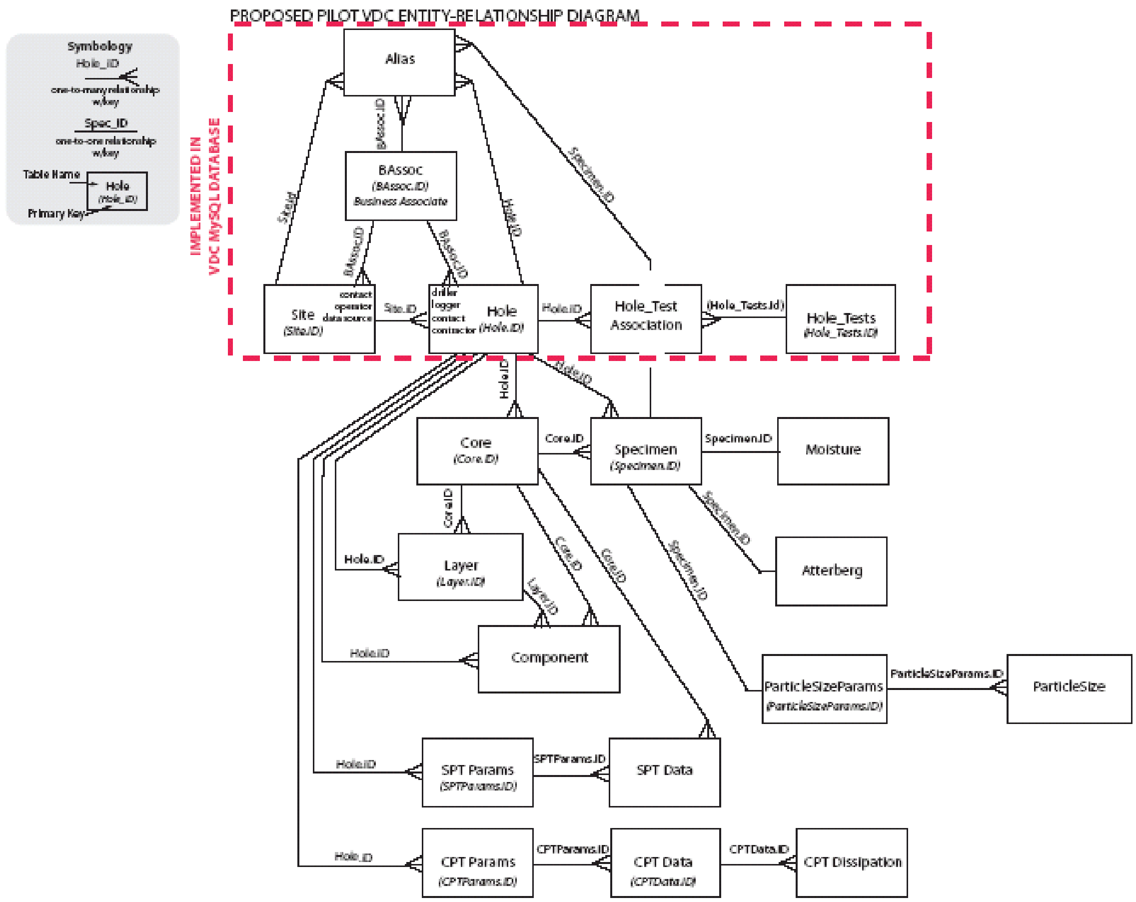


Figure 1. Geotechnical Data Dictionary entity relationship Entity Relationship (ER) Diagram (Benoit et al., this report).

engineering tests were also defined, including moisture, Atterburg, particle size, SPT and CPT tests (Bobbitt, 2004b). These and other supplemental structures described below were mapped to XML schema, as slots of the same names. Mapping the data dictionary to the relational model and to the XML schema was done by looking at the various types of information that needed to be defined, and mapping (Bobbitt, 2004a; Bobbitt, 2004c):

- Every data type in a definition
- Instances
- Aggregates
- Multiplicities

Current working versions of the data dictionary are available online (Bobbitt, et al., 2004; i.e. see "Geotechnical Data Dictionary and Entity Relationship Diagram Version 3").

The reasons for selecting the five tests were that they are widely used and requested, and straightforward enough to model in the pilot stage of the project. It was fully recognized that additional tests need to be modeled, and added to the XML standard data exchange structure in future revisions of the schema. Experience has shown that it takes approximately 1 to 2 years before these additional tests would actually make their way into the GVDC system. Thus the tests were designed as independent objects within the schema, so that they can be developed without regard to the overall satellite schema. The “Tests” structure has a “choice” that is unbounded, meaning a developer can pick any test and utilize the XML (Bobbitt, 2004d). Since the “choice” is unbounded, this procedure can be repeated as necessary.

It may also be necessary for data suppliers to send additional data by defining their own data structures for additional tests. Data providers must be able to add an additional test (i.e. one not included in the original five) on their own, without going through the standard specification process (Bobbitt, 2004b). This may be because there is an immediate need to exchange the data, or that the full group does not wish to consider such a test, or that the data provider has a simple subset of a more complicated test that does not need the full modeling. These additional tests can be added, as long as they are identified as non-standard additions to the schema. The meaning of a non-standard addition is that there will be no attempt by the COSMOS/PEER-LL standards group to maintain backward compatibility so that the schema for a test might change abruptly from one month to the next. Thus a slot for additional tests was added to the schema. This structure allows for any group to work independently of the overall COSMOS/PEER-LL project.

The DDWG also created supporting data structures including Associate, Alias and CRS (Coordinate Reference System; Benoit et al., this report). These were designed to (a) resolve references to objects or attributes, and (b) allow developers and a user to include supplemental information about attributes (Bobbitt, 2004e). This allows a lot of information normally attached to the basic Site table to be contained in another section of the schema. Other types of supporting data can be added in the future. The supporting data portion of the schema is optional, allowing the data sender to fill in more information if desired.

The Geotechnical XML Schema documents are provided in the root:/ Geotechnical_XML_Schema/-level directory of the report CD. The schema is described below in the following breakdown (Bobbitt et al., 2004):

- Schema Document Properties
    - Declared Namespaces
    - Schema Component Representation
- Global Schema Components
    - Elements
        - XML Instance Representation
        - Schema Component Representation
        - Complex and Simple Types

2.1 Schema Document Properties

Target Namespace	http://www.cosmos.org/v10
Element and Attribute Namespaces	• Global element and attribute declarations belong to this schema's target namespace. • By default, local element declarations belong to this schema's target namespace. • By default, local attribute declarations have no namespace.

Schema Composition	• This schema imports schema(s) from the following namespace(s):
	  o *http://www.posc.org/schemas* (DocumentInfo.xsd – see the root:/geotech_schema/ directory of the report CD)
	• This schema includes components from the following schema document(s) (see the root:/geotech_schema/ directory of the report CD):
	  o Tests.xsd
	  o Location.xsd

2.1.1 Declared Namespaces

Prefix	Namespace
Default namespace	http://www.cosmos.org/v10
xml	http://www.w3.org/XML/1998/namespace
xsd	http://www.w3.org/2001/XMLSchema
posc	http://www.posc.org/schemas
xsi	http://www.w3.org/2001/XMLSchema-instance

<u>Schema Component Representation</u>

```
<xsd:schema targetNamespace="http://www.cosmos.org/v10"
elementFormDefault="qualified">
<xsd:include schemaLocation="Tests.xsd"/>
<xsd:include schemaLocation="Location.xsd"/>
<xsd:import namespace="http://www.posc.org/schemas"
schemaLocation="DocumentInfo.xsd"/>
...
</xsd:schema>
```

2.2 Global Schema Components

2.2.1 Element: GeotechnicalData

Name	GeotechnicalData
Type	geotechDataType
Nillable	no
Abstract	no
Documentation	The root element for the application schema.

XML Instance Representation

<GeotechnicalData>
<posc:DocumentInformation> ... </posc:DocumentInformation> [0..1]
<Site> ... </Site> [1] ?
<_Tests> ... </_Tests> [0..*] ?
<_Dictionaries> ... </_Dictionaries> [0..*] ?
</GeotechnicalData>

Schema Component Representation

<xsd:element name="GeotechnicalData" type=" geotechDataType "/>

2.2.2 Element: _Dictionaries

- *The following elements can be used wherever this element is referenced:*
  - SupportingData

Name	_Dictionaries
Type	abstractBasicType
Nillable	no
Abstract	yes
Documentation	An abstract placeholder for delivering dictionaries, and resolving references.

XML Instance Representation

<_Dictionaries/>

Schema Component Representation

<xsd:element name="_Dictionaries" type=" abstractBasicType " abstract="true"/>

Complex Type: geotechDataType

Parent type: None
Direct sub-types: None

Name	geotechDataType
Abstract	no
Documentation	The root element contains four parts. The first part is basic document information, imported from POSC. The second is the context, which consists of the Site, Hole, Layers, Cores, etc, all put in their proper place. The next part is a container for all the Tests. Finally, there is a holding position for dictionaries and resolution of references.

<u>XML Instance Representation</u>

```
<...>
<posc:DocumentInformation> ... </posc:DocumentInformation> [0..1]
<Site> ... </Site> [1] ?
<_Tests> ... </_Tests> [0..*] ?
<_Dictionaries> ... </_Dictionaries> [0..*] ?
</...>
```

<u>Schema Component Representation</u>

```
<xsd:complexType name="geotechDataType">
<xsd:sequence>
<xsd:element ref=" posc:DocumentInformation " minOccurs="0"/>
<xsd:element ref=" Site "/>
<xsd:element ref=" _Tests " minOccurs="0" maxOccurs="unbounded"/>
<xsd:element ref=" _Dictionaries " minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
</xsd:complexType>
```

2.2.3 Element: Site

Name	Site
Type	siteTableType
Nillable	no
Abstract	no
Documentation	The Site is a collection of holes and samples obtained at a common place. It is a direct parent of Hole, and offers the top level of the context hierarchy.

<u>XML Instance Representation</u>

```
<Site
id=" keyid [0..1] ?"
modver="1.0 [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<Name> nameSysElAttType </Name> [0..1] ?
<Alias> nameSysElAttType </Alias> [0..*] ?
<Type> extSiteTypeEnum </Type> [0..1] ?
<Organization> simpleRefType </Organization> [0..1] ?
```

<Contact> simpleRefType </Contact> [0..1] ?
<SiteAddressLocation> [0..1] ?
<Address> xsd:string </Address> [0..*] ?
<City> xsd:string </City> [0..1] ?
<State> stateCodeEnum </State> [0..1] ?
<County> xsd:string </County> [0..1] ?
<Country> countryCodeEnum </Country> [0..1] ?
</SiteAddressLocation>
<LocationReferencePoint> xsd:string </LocationReferencePoint> [0..1] ?
<Quadrangle> xsd:string </Quadrangle> [0..1] ?
<PLSS> legalLocType </PLSS> [0..1] ?
<Location> survLocType </Location> [0..*] ?
<LocationMethod> extLocMethodEnum </LocationMethod> [0..1] ?
<LocationAccuracy> extLocAccuracyEnum </LocationAccuracy> [0..1] ?
<DataSource> xsd:string </DataSource> [0..1] ?
<LastUpdated> xsd:string </LastUpdated> [0..1] ?
<Hole> holeTableType </Hole> [1..*] ?
</Site>

<u>Schema Component Representation</u>
<xsd:element name="Site" type=" siteTableType "/>

Complex Type: siteTableType

<u>Parent type:</u> None
<u>Direct sub-types:</u> None

Name	siteTableType
Abstract	no
Documentation	The Site is a collection of holes and samples obtained at a common place. It is a direct parent of Hole, and offers the top level of the context hierarchy.

<u>XML Instance Representation</u>
<...
id=" keyid [0..1] ?"
modver="1.0 [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<Name> nameSysElAttType </Name> [0..1] ?
<Alias> nameSysElAttType </Alias> [0..*] ?
<Type> extSiteTypeEnum </Type> [0..1] ?
<Organization> simpleRefType </Organization> [0..1] ?
<Contact> simpleRefType </Contact> [0..1] ?
<SiteAddressLocation> [0..1] ?
<Address> xsd:string </Address> [0..*] ?
<City> xsd:string </City> [0..1] ?

```
<State> stateCodeEnum </State> [0..1] ?
<County> xsd:string </County> [0..1] ?
<Country> countryCodeEnum </Country> [0..1] ?
</SiteAddressLocation>
<LocationReferencePoint> xsd:string </LocationReferencePoint> [0..1] ?
<Quadrangle> xsd:string </Quadrangle> [0..1] ?
<PLSS> legalLocType </PLSS> [0..1] ?
<Location> survLocType </Location> [0..*] ?
<LocationMethod> extLocMethodEnum </LocationMethod> [0..1] ?
<LocationAccuracy> extLocAccuracyEnum </LocationAccuracy> [0..1] ?
<DataSource> xsd:string </DataSource> [0..1] ?
<LastUpdated> xsd:string </LastUpdated> [0..1] ?
<Hole> holeTableType </Hole> [1..*] ?
</...>
```

Schema Component Representation

```
<xsd:complexType name="siteTableType">
<xsd:sequence>
<xsd:element name="ID" type=" codeSysElAttType "/>
<xsd:element name="Name" type=" nameSysElAttType " minOccurs="0"/>
<xsd:element name="Alias" type=" nameSysElAttType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="Type" type=" extSiteTypeEnum " minOccurs="0"/>
<xsd:element name="Organization" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="Contact" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="SiteAddressLocation" minOccurs="0">
<xsd:complexType>
<xsd:sequence>
<xsd:element name="Address" type=" xsd:string " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="City" type=" xsd:string " minOccurs="0"/>
<xsd:element name="State" type=" stateCodeEnum " minOccurs="0"/>
<xsd:element name="County" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Country" type=" countryCodeEnum " minOccurs="0"/>
</xsd:sequence>
</xsd:complexType>
</xsd:element>
<xsd:element name="LocationReferencePoint" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Quadrangle" type=" xsd:string " minOccurs="0"/>
<xsd:element name="PLSS" type=" legalLocType " minOccurs="0"/>
<xsd:element name="Location" type=" survLocType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="LocationMethod" type=" extLocMethodEnum " minOccurs="0"/>
<xsd:element name="LocationAccuracy" type=" extLocAccuracyEnum "
minOccurs="0"/>
<xsd:element name="DataSource" type=" xsd:string " minOccurs="0"/>
```

```
<xsd:element name="LastUpdated" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Hole" type=" holeTableType " maxOccurs="unbounded"/>
</xsd:sequence>
<xsd:attribute name="id" type=" keyid " use="optional"/>
<xsd:attribute name="modver" type=" xsd:string " fixed="1.0"/>
</xsd:complexType>
```

2.2.4 Element: _Tests

- *The following elements can be used wherever this element is referenced:*
  - Tests

Name	_Tests
Type	abstractBasicType
Nillable	no
Abstract	yes
Documentation	An abstract element that allows one or more test instances to be inserted. A nonabstract element is defined, which contains six test descriptions. This may be readily extended by the main schema, or by satellite groups, if they wish to add their own test definitions.

<u>XML Instance Representation</u>

```
<_Tests/>
```

<u>Schema Component Representation</u>

```
<xsd:element name="_Tests" type=" abstractBasicType " abstract="true"/>
```

2.2.5 Element: Tests

- *This element can be used wherever the following element is referenced:*
  - _Tests

Name	Tests
Type	testsType
Nillable	no
Abstract	no
Documentation	A non-abstract test container, which may be substituted for the Abstract _Tests. This contains the initial five tests that have been defined by the pilot project, along with a sixth which allows the listing of additional tests.

<u>XML Instance Representation</u>

```
<Tests>
Start Choice [1..*] ?
<Atterberg> atterbergTableType </Atterberg> [1] ?
<ConePenetration> cptTableType </ConePenetration> [1] ?
<Moisture> moistureTableType </Moisture> [1] ?
<ParticleSize> partSizeTableType </ParticleSize> [1] ?
```

```
<StandardPenetration> sptTableType </StandardPenetration> [1] ?
<AdditionalTests> additionalType </AdditionalTests> [1] ?
End Choice
</Tests>
```

Schema Component Representation

```
<xsd:element name="Tests" type=" testsType " substitutionGroup="_Tests"/>
```

Complex Type: testsType

Parent type:	abstractBasicType (derivation method: extension)
Direct sub-types:	None

Name	testsType
Abstract	no
Documentation	A container type. It allows an unlimited choice of the six test types. This allows the instance writer to deliver the tests in any order.

XML Instance Representation

```
<...>
Start Choice [1..*] ?
<Atterberg> atterbergTableType </Atterberg> [1] ?
<ConePenetration> cptTableType </ConePenetration> [1] ?
<Moisture> moistureTableType </Moisture> [1] ?
<ParticleSize> partSizeTableType </ParticleSize> [1] ?
<StandardPenetration> sptTableType </StandardPenetration> [1] ?
<AdditionalTests> additionalType </AdditionalTests> [1] ?
End Choice
</...>
```

Schema Component Representation

```
<xsd:complexType name="testsType">
<xsd:complexContent>
<xsd:extension base=" abstractBasicType ">
<xsd:choice maxOccurs="unbounded">
<xsd:element name="Atterberg" type=" atterbergTableType "/>
<xsd:element name="ConePenetration" type=" cptTableType "/>
<xsd:element name="Moisture" type=" moistureTableType "/>
<xsd:element name="ParticleSize" type=" partSizeTableType "/>
<xsd:element name="StandardPenetration" type=" sptTableType "/>
<xsd:element name="AdditionalTests" type=" additionalType "/>
</xsd:choice>
</xsd:extension>
</xsd:complexContent>
</xsd:complexType>
```

2.2.6 Element: SupportingData

- *This element can be used wherever the following element is referenced:*
    - _Dictionaries

Name	SupportingData
Type	dictionariesType
Nillable	no
Abstract	no
Documentation	A nonabstract element that substitutes for the abastract _Dictionaries. This includes the two dictionaries, Business Associate, and Coordinate Reference Systems. The using groups may extend this by adding their own dictionary types.

<u>XML Instance Representation</u>

<SupportingData>
Start Choice [1..*]
<BusinessAssociate> busAssocType </BusinessAssociate> [1] ?
<CoordReferenceSystem> crsDictType </CoordReferenceSystem> [1] ?
End Choice
</SupportingData>

<u>Schema Component Representation</u>

<xsd:element name="SupportingData" type=" dictionariesType "
substitutionGroup="_Dictionaries"/>

Complex Type: dictionariesType

<u>Parent type:</u> abstractBasicType (derivation method: extension)
<u>Direct sub-types:</u> None

Name	dictionariesType
Abstract	no
Documentation	The inclusion of two dictionaries: BusinessAssociate and CoordReferenceSystem. These may be instantiated in any order, as often as needed.

<u>XML Instance Representation</u>

<...>
Start Choice [1..*]
<BusinessAssociate> busAssocType </BusinessAssociate> [1] ?
<CoordReferenceSystem> crsDictType </CoordReferenceSystem> [1] ?
End Choice
</...>

<u>Schema Component Representation</u>

<xsd:complexType name="dictionariesType">

```
<xsd:complexContent>
<xsd:extension base=" abstractBasicType ">
<xsd:choice maxOccurs="unbounded">
<xsd:element name="BusinessAssociate" type=" busAssocType "/>
<xsd:element name="CoordReferenceSystem" type=" crsDictType "/>
</xsd:choice>
</xsd:extension>
</xsd:complexContent>
</xsd:complexType>
```

Complex Type: busAssocType

<u>Parent type:</u> None
<u>Direct sub-types:</u> None

Name	busAssocType
Abstract	no
Documentation	The information about a business associate. The business associate may be a person, company, group, agency, or any other person or collection of persons that is related to the object.

<u>XML Instance Representation</u>

```
<...
id=" keyid [0..1]"
modver="1.0 [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<Name> nameSysElAttType </Name> [0..1] ?
<Alias> nameSysElAttType </Alias> [0..*] ?
<Type> xsd:string </Type> [0..1] ?
<Address> xsd:string </Address> [0..*] ?
<City> xsd:string </City> [0..1] ?
<State> stateCodeEnum </State> [0..1] ?
<PostalCode> xsd:string </PostalCode> [0..1] ?
<Country> countryCodeEnum </Country> [0..1] ?
<PhoneNumber> att1Type </PhoneNumber> [0..*] ?
<Email> att2Type </Email> [0..*] ?
<URL> xsd:anyURI </URL> [0..*] ?
<AssociatedWith> xsd:string </AssociatedWith> [0..1] ?
<BAContact> xsd:string </BAContact> [0..1] ?
<Comment> xsd:string </Comment> [0..1] ?
</...>
```

Schema Component Representation

```
<xsd:complexType name="busAssocType">
<xsd:sequence>
<xsd:element name="ID" type=" codeSysElAttType "/>
<xsd:element name="Name" type=" nameSysElAttType " minOccurs="0"/>
<xsd:element name="Alias" type=" nameSysElAttType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="Type" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Address" type=" xsd:string " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="City" type=" xsd:string " minOccurs="0"/>
<xsd:element name="State" type=" stateCodeEnum " minOccurs="0"/>
<xsd:element name="PostalCode" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Country" type=" countryCodeEnum " minOccurs="0"/>
<xsd:element name="PhoneNumber" type=" att1Type " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="Email" type=" att2Type " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="URL" type=" xsd:anyURI " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="AssociatedWith" type=" xsd:string " minOccurs="0"/>
<xsd:element name="BAContact" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Comment" type=" xsd:string " minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="id" type=" keyid " use="optional"/>
<xsd:attribute name="modver" type=" xsd:string " fixed="1.0"/>
</xsd:complexType>
```

Complex Type: crsDictType

Parent type: None
Direct sub-types: None

Name	crsDictType
Abstract	no
Documentation	A coordinate reference system for which a set of coordinates is given. This object contains information that will either reference a standard CRS, or will define a local coordinate system particular to a site/ project.

XML Instance Representation

```
<...
id=" keyid [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<Name> nameSysElAttType </Name> [0..1] ?
<EPSGCode> xsd:string </EPSGCode> [0..1] ?
```

```
<URL> xsd:anyURI </URL> [0..1] ?
<Type> extCRSEnum </Type> [0..1] ?
Start Choice [0..1] ?
<UsesSiteOrigin> simpleRefType </UsesSiteOrigin> [1] ?
<OriginDescription> xsd:string </OriginDescription> [1] ?
End Choice
<NorthDirection> extNorthDirEnum </NorthDirection> [0..1] ?
<XAxisAzimuth> QuantityType </XAxisAzimuth> [0..1] ?
<XAxisDescription> xsd:string </XAxisDescription> [0..1] ?
<YAxisRotation> rotationEnum </YAxisRotation> [0..1] ?
</...>
```

<u>Schema Component Representation</u>

```
<xsd:complexType name="crsDictType">
<xsd:sequence>
<xsd:element name="ID" type=" codeSysElAttType "/>
<xsd:element name="Name" type=" nameSysElAttType " minOccurs="0"/>
<xsd:element name="EPSGCode" type=" xsd:string " minOccurs="0"/>
<xsd:element name="URL" type=" xsd:anyURI " minOccurs="0"/>
<xsd:element name="Type" type=" extCRSEnum " minOccurs="0"/>
<xsd:choice minOccurs="0">
<xsd:element name="UsesSiteOrigin" type=" simpleRefType "/>
<xsd:element name="OriginDescription" type=" xsd:string "/>
</xsd:choice>
<xsd:element name="NorthDirection" type=" extNorthDirEnum " minOccurs="0"/>
<xsd:element name="XAxisAzimuth" type=" QuantityType " minOccurs="0"/>
<xsd:element name="XAxisDescription" type=" xsd:string " minOccurs="0"/>
<xsd:element name="YAxisRotation" type=" rotationEnum " minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="id" type=" keyid " use="optional"/>
</xsd:complexType>
```

Complex Type: holeTableType

<u>Parent type:</u> None
<u>Direct sub-types:</u> None

Name	holeTableType
Abstract	No
Documentation	A single sampling station, from which earth materials are collected or described, or earth material properties are measured. The sample may be from a core or cuttings from a borehole, surface excavation, or any other highly local sampling method. This term is used to represent the sample collecting activity as well as the sampling station.

XML Instance Representation

```
<...
id=" keyid [0..1]"
modver="1.0 [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<Name> nameSysElAttType </Name> [0..1] ?
<Alias> nameSysElAttType </Alias> [0..*] ?
<SiteID> simpleRefType </SiteID> [1] ?
<Type> holeEnum </Type> [0..1] ?
<Driller> simpleRefType </Driller> [0..1] ?
<Logger> simpleRefType </Logger> [0..1] ?
<StartDate> anyDate </StartDate> [0..1] ?
<EndDate> anyDate </EndDate> [0..1] ?
<ElevationDatum> xsd:string </ElevationDatum> [0..1] ?
<Elevation> QuantityType </Elevation> [0..1] ?
<Location> survLocType </Location> [0..*] ?
<LocalLocation> locOffsetType </LocalLocation> [0..1] ?
<DepthDatum> extElevCodeEnum </DepthDatum> [0..1] ?
<Depth> QualifiedQuanType </Depth> [0..1] ?
<Inclination> QuantityType </Inclination> [0..1] ?
<SurfaceGeology> xsd:string </SurfaceGeology> [0..1] ?
<LocationMethod> extLocMethodEnum </LocationMethod> [0..1] ?
<LocationAccuracy> extLocAccuracyEnum </LocationAccuracy> [0..1] ?
<DataSource> xsd:string </DataSource> [0..1] ?
<LastUpdated> xsd:string </LastUpdated> [0..1] ?
<Core> coreTableType </Core> [0..*] ?
<Specimen> specimenTableType </Specimen> [0..*] ?
<Layer> layerTableType </Layer> [0..*] ?
<Component> componentTableType </Component> [0..*] ?
</...>
```

Schema Component Representation

```
<xsd:complexType name="holeTableType">
<xsd:sequence>
<xsd:element name="ID" type=" codeSysElAttType "/>
<xsd:element name="Name" type=" nameSysElAttType " minOccurs="0"/>
<xsd:element name="Alias" type=" nameSysElAttType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="SiteID" type=" simpleRefType "/>
<xsd:element name="Type" type=" holeEnum " minOccurs="0"/>
<xsd:element name="Driller" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="Logger" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="StartDate" type=" anyDate " minOccurs="0"/>
<xsd:element name="EndDate" type=" anyDate " minOccurs="0"/>
<xsd:element name="ElevationDatum" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Elevation" type=" QuantityType " minOccurs="0"/>
```

```
<xsd:element name="Location" type=" survLocType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="LocalLocation" type=" locOffsetType " minOccurs="0"/>
<xsd:element name="DepthDatum" type=" extElevCodeEnum " minOccurs="0"/>
<xsd:element name="Depth" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="Inclination" type=" QuantityType " minOccurs="0"/>
<xsd:element name="SurfaceGeology" type=" xsd:string " minOccurs="0"/>
<xsd:element name="LocationMethod" type=" extLocMethodEnum " minOccurs="0"/>
<xsd:element name="LocationAccuracy" type=" extLocAccuracyEnum "
minOccurs="0"/>
<xsd:element name="DataSource" type=" xsd:string " minOccurs="0"/>
<xsd:element name="LastUpdated" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Core" type=" coreTableType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="Specimen" type=" specimenTableType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="Layer" type=" layerTableType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="Component" type=" componentTableType " minOccurs="0"
maxOccurs="unbounded"/>
</xsd:sequence>
<xsd:attribute name="id" type=" keyid " use="optional"/>
<xsd:attribute name="modver" type=" xsd:string " fixed="1.0"/>
</xsd:complexType>
```

Complex Type: coreTableType

<u>Parent type:</u> None
<u>Direct sub-types:</u> None

Name	coreTableType
Abstract	no
Documentation	An interval of earth materials, extracted or attempted to be extracted from a hole or site, using a specific type of sampling device, and where the physical locations of the ends of the Core are known in space. This term is used to represent both the sample collected as well as the interval within the hole that is sampled. If a physical sample of material is recovered from the interval, it is contained within the interval and is coherent, meaning that the material represents the relative position and properties of the strata or geological material in its in-situ condition. Material collected from a Core may be a) tested as a whole, b) further sub-sampled for geotechnical lab tests, c) described in detail, or d) subjected to geophysical tests, such as density scans, etc. Cores cannot overlap within a single hole.

XML Instance Representation

```
<...
id=" keyid [0..1]"
modver="1.0 [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<Name> nameSysElAttType </Name> [0..1] ?
<Alias> nameSysElAttType </Alias> [0..*] ?
<HoleID> simpleRefType </HoleID> [0..1] ?
<Top> QualifiedQuanType </Top> [0..1] ?
<Base> QualifiedQuanType </Base> [0..1] ?
<SampleTop> QualifiedQuanType </SampleTop> [0..1] ?
<SampleBase> QualifiedQuanType </SampleBase> [0..1] ?
<SamplingMethod> extSampMethEnum </SamplingMethod> [0..1] ?
<SamplingDate> anyDate </SamplingDate> [0..1] ?
<SampleRecovery> QuantityType </SampleRecovery> [0..1] ?
<Remarks> xsd:string </Remarks> [0..1] ?
<DataSource> xsd:string </DataSource> [0..1] ?
<LastUpdated> xsd:string </LastUpdated> [0..1] ?
<Layer> layerTableType </Layer> [0..*] ?
<Specimen> specimenTableType </Specimen> [0..*] ?
<Component> componentTableType </Component> [0..*] ?
</...>
```

Schema Component Representation

```
<xsd:complexType name="coreTableType">
<xsd:sequence>
<xsd:element name="ID" type=" codeSysElAttType "/>
<xsd:element name="Name" type=" nameSysElAttType " minOccurs="0"/>
<xsd:element name="Alias" type=" nameSysElAttType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="HoleID" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="Top" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="Base" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="SampleTop" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="SampleBase" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="SamplingMethod" type=" extSampMethEnum " minOccurs="0"/>
<xsd:element name="SamplingDate" type=" anyDate " minOccurs="0"/>
<xsd:element name="SampleRecovery" type=" QuantityType " minOccurs="0"/>
<xsd:element name="Remarks" type=" xsd:string " minOccurs="0"/>
<xsd:element name="DataSource" type=" xsd:string " minOccurs="0"/>
<xsd:element name="LastUpdated" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Layer" type=" layerTableType " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="Specimen" type=" specimenTableType " minOccurs="0"
maxOccurs="unbounded"/>
```

<xsd:element name="Component" type=" componentTableType " minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
<xsd:attribute name="id" type=" keyid " use="optional"/>
<xsd:attribute name="modver" type=" xsd:string " fixed="1.0"/>
</xsd:complexType>

Complex Type: specimenTableType

Parent type: None
Direct sub-types: None

Name	specimenTableType
Abstract	No
Documentation	A sample of earth material collected for the purpose of description or testing. A specimen may be collected directly from a site or hole, collected from the same Specimen material or from another Specimen.

XML Instance Representation
<...
id=" keyid [0..1]"
modver="1.0 [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<Name> nameSysElAttType </Name> [0..1] ?
<HoleID> simpleRefType </HoleID> [0..1] ?
<CoreID> simpleRefType </CoreID> [0..1] ?
<PartOfSpecimen> simpleRefType </PartOfSpecimen> [0..1] ?
<Top> QualifiedQuanType </Top> [0..1] ?
<Base> QualifiedQuanType </Base> [0..1] ?
<SamplingMethod> extSpecSampEnum </SamplingMethod> [0..1] ?
<ClassificationSystem> xsd:string </ClassificationSystem> [0..1] ?
<PrimaryLithology> xsd:string </PrimaryLithology> [0..1] ?
<Test> specimenTestEnum </Test> [0..1] ?
<Collector> simpleRefType </Collector> [0..1]?
<Date> anyDate </Date> [0..1] ?
<Remarks> xsd:string </Remarks> [0..1] ?
<DataSource> xsd:string </DataSource> [0..1] ?
<LastUpdated> xsd:string </LastUpdated> [0..1] ?
</...>

Schema Component Representation
<xsd:complexType name="specimenTableType">
<xsd:sequence>
<xsd:element name="ID" type=" codeSysElAttType "/>
<xsd:element name="Name" type=" nameSysElAttType " minOccurs="0"/>
<xsd:element name="HoleID" type=" simpleRefType " minOccurs="0"/>

```
<xsd:element name="CoreID" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="PartOfSpecimen" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="Top" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="Base" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="SamplingMethod" type=" extSpecSampEnum " minOccurs="0"/>
<xsd:element name="ClassificationSystem" type=" xsd:string " minOccurs="0"/>
<xsd:element name="PrimaryLithology" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Test" type=" specimenTestEnum " minOccurs="0"/>
<xsd:element name="Collector" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="Date" type=" anyDate " minOccurs="0"/>
<xsd:element name="Remarks" type=" xsd:string " minOccurs="0"/>
<xsd:element name="DataSource" type=" xsd:string " minOccurs="0"/>
<xsd:element name="LastUpdated" type=" xsd:string " minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="id" type=" keyid " use="optional"/>
<xsd:attribute name="modver" type=" xsd:string " fixed="1.0"/>
</xsd:complexType>
```

Complex Type: layerTableType

Parent type: None
Direct sub-types: None

Name	layerTableType
Abstract	No
Documentation	An interval of earth material in which the texture and physical character of the material are described. The layer is usually defined in terms of a scientific or vernacular classification system. No layers in a given hole defined within one classification system may overlap.

XML Instance Representation

```
<...
id=" keyid [0..1]"
modver="1.0 [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<HoleID> simpleRefType </HoleID> [0..1] ?
<CoreID> simpleRefType </CoreID> [0..1] ?
<Source> extLayerSourceEnum </Source> [0..*] ?
<Top> QualifiedQuanType </Top> [0..1] ?
<Base> QualifiedQuanType </Base> [0..1] ?
<ClassificationSystem> xsd:string </ClassificationSystem> [0..1] ?
<PrimaryClass> xsd:string </PrimaryClass> [0..1] ?
<SecondaryClass> classPercentType </SecondaryClass> [0..1] ?
<TertiaryClass> classPercentType </TertiaryClass> [0..1] ?
<Description> xsd:string </Description> [0..1] ?
<Remarks> xsd:string </Remarks> [0..1] ?
```

Start Choice [0..1] ?
<GrainSize> QuantityType </GrainSize> [1] ?
<GrainSizeText> xsd:string </GrainSizeText> [1]?
End Choice
<Bedding> xsd:string </Bedding> [0..1] ?
<BasalContact> xsd:string </BasalContact> [0..1] ?
<DataSource> xsd:string </DataSource> [0..1] ?
<LastUpdated> xsd:string </LastUpdated> [0..1] ?
<Component> componentTableType </Component> [0..*] ?
</...>

Schema Component Representation
<xsd:complexType name="layerTableType">
<xsd:sequence>
<xsd:element name="ID" type=" codeSysElAttType "/>
<xsd:element name="HoleID" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="CoreID" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="Source" type=" extLayerSourceEnum " minOccurs="0" maxOccurs="unbounded"/>
<xsd:element name="Top" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="Base" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="ClassificationSystem" type=" xsd:string " minOccurs="0"/>
<xsd:element name="PrimaryClass" type=" xsd:string " minOccurs="0"/>
<xsd:element name="SecondaryClass" type=" classPercentType " minOccurs="0"/>
<xsd:element name="TertiaryClass" type=" classPercentType " minOccurs="0"/>
<xsd:element name="Description" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Remarks" type=" xsd:string " minOccurs="0"/>
<xsd:choice minOccurs="0">
<xsd:element name="GrainSize" type=" QuantityType "/>
<xsd:element name="GrainSizeText" type=" xsd:string "/>
</xsd:choice>
<xsd:element name="Bedding" type=" xsd:string " minOccurs="0"/>
<xsd:element name="BasalContact" type=" xsd:string " minOccurs="0"/>
<xsd:element name="DataSource" type=" xsd:string " minOccurs="0"/>
<xsd:element name="LastUpdated" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Component" type=" componentTableType " minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
<xsd:attribute name="id" type=" keyid " use="optional"/>
<xsd:attribute name="modver" type=" xsd:string " fixed="1.0"/>
</xsd:complexType>

Complex Type: componentTableType

Parent type: None
Direct sub-types: None

Name componentTableType
Abstract no
Documentation A physical feature or condition observed at a point or within an interval of earth material within a hole, typically described megascopically. A Component may represent a notable textural or lithologic feature within a layer, or some other physical, structural, diagenetic, mineralogical, biological, or geophysical characteristic. It also may represent a condition (temporal or persistent) described at a point or within an interval. A Component may exist within a Layer, or may extend across many Layers.

XML Instance Representation

```
<...
id=" keyid [0..1]"
modver="1.0 [0..1]">
<ID> codeSysElAttType </ID> [1] ?
<HoleID> simpleRefType </HoleID> [0..1] ?
<CoreID> simpleRefType </CoreID> [0..1] ?
<LayerID> simpleRefType </LayerID> [0..1] ?
<Source> extCompSourceEnu </Source> [0..*] ?
<Top> QualifiedQuanType </Top> [0..1] ?
<Base> QualifiedQuanType </Base> [0..1] ?
<ClassificationSystem> xsd:string </ClassificationSystem> [0..1] ?
<Type> xsd:string </Type> [0..1] ?
<Description> xsd:string </Description> [0..1] ?
<Abundance> abundanceEnum </Abundance> [0..1] ?
<AbundanceDescription> xsd:string </AbundanceDescription> [0..1] ?
<Remarks> xsd:string </Remarks> [0..1] ?
<DataSource> xsd:string </DataSource> [0..1] ?
<LastUpdated> xsd:string </LastUpdated> [0..1]
</...>
```

Schema Component Representation

```
<xsd:complexType name="componentTableType">
<xsd:sequence>
<xsd:element name="ID" type=" codeSysElAttType "/>
<xsd:element name="HoleID" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="CoreID" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="LayerID" type=" simpleRefType " minOccurs="0"/>
<xsd:element name="Source" type=" extCompSourceEnum " minOccurs="0"
maxOccurs="unbounded"/>
<xsd:element name="Top" type=" QualifiedQuanType " minOccurs="0"/>
<xsd:element name="Base" type=" QualifiedQuanType " minOccurs="0"/>
```

```
<xsd:element name="ClassificationSystem" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Type" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Description" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Abundance" type=" abundanceEnum " minOccurs="0"/>
<xsd:element name="AbundanceDescription" type=" xsd:string " minOccurs="0"/>
<xsd:element name="Remarks" type=" xsd:string " minOccurs="0"/>
<xsd:element name="DataSource" type=" xsd:string " minOccurs="0"/>
<xsd:element name="LastUpdated" type=" xsd:string " minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="id" type=" keyid " use="optional"/>
<xsd:attribute name="modver" type=" xsd:string " fixed="1.0"/>
</xsd:complexType>
```

Simple Type: anyDate

Parent type: None
Direct sub-types: None

Name anyDate
Content
- Union of following types:
    - xsd:dateTime
    - xsd:date
    - xsd:gYearMonth
    - xsd:gYear

Schema Component Representation
```
<xsd:simpleType name="anyDate">
<xsd:union memberTypes=" xsd:dateTime xsd:date xsd:gYearMonth xsd:gYear"/>
</xsd:simpleType>
```

Complex Type: QualifiedQuanType

Parent type: QuantityType (derivation method: extension)
Direct sub-types: None

Name QualifiedQuanType
Abstract no

XML Instance Representation
```
<...
uom=" xsd:anyURI [0..1]"
qualifier=" xsd:string [0..1]">
QuantityType
</...>
```

Schema Component Representation

```
<xsd:complexType name="QualifiedQuanType">
<xsd:simpleContent>
<xsd:extension base=" QuantityType ">
<xsd:attribute name="qualifier" type=" xsd:string "/>
</xsd:extension>
</xsd:simpleContent>
</xsd:complexType>
```

Complex Type: nameSysElAttType

Parent type:	xsd:string (derivation method: extension)
Direct sub-types:	None

Name	nameSysElAttType
Abstract	no

XML Instance Representation

```
<...
namingSystem=" xsd:string [0..1]"
version=" xsd:string [0..1]">
xsd:string
</...>
```

Schema Component Representation

```
<xsd:complexType name="nameSysElAttType">
<xsd:simpleContent>
<xsd:extension base=" xsd:string ">
<xsd:attribute name="namingSystem" type=" xsd:string " use="optional"/>
<xsd:attribute name="version" type=" xsd:string " use="optional"/>
</xsd:extension>
</xsd:simpleContent>
</xsd:complexType>
```

Complex Type: att1Type

Parent type:	xsd:string (derivation method: extension)
Direct sub-types:	None

Name	att1Type
Abstract	no

XML Instance Representation

```
<...
type=" extPhoneEnum [1]"
qualifier=" extQualifierEnum [0..1]">
```

```
xsd:string
</...>
```

Schema Component Representation

```
<xsd:complexType name="att1Type">
<xsd:simpleContent>
<xsd:extension base=" xsd:string ">
<xsd:attribute name="type" type=" extPhoneEnum " use="required"/>
<xsd:attribute name="qualifier" type=" extQualifierEnum " use="optional"/>
</xsd:extension>
</xsd:simpleContent>
</xsd:complexType>
```

Complex Type: att2Type

Parent type:	xsd:string (derivation method: extension)
Direct sub-types:	None

Name	att2Type
Abstract	no

XML Instance Representation

```
<...
qualifier=" extQualifierEnum [0..1]">
xsd:string
</...>
```

Schema Component Representation

```
<xsd:complexType name="att2Type">
<xsd:simpleContent>
<xsd:extension base=" xsd:string ">
<xsd:attribute name="qualifier" type=" extQualifierEnum " use="optional"/>
</xsd:extension>
</xsd:simpleContent>
</xsd:complexType>
```

Complex Type: classPercentType

Parent type:	xsd:string (derivation method: extension)
Direct sub-types:	None

Name	classPercentType
Abstract	no

XML Instance Representation

```
<...
percent=" xsd:decimal [0..1]">
xsd:string
</...>
```

Schema Component Representation

```
<xsd:complexType name="classPercentType">
<xsd:simpleContent>
<xsd:extension base=" xsd:string ">
<xsd:attribute name="percent" type=" xsd:decimal "/>
</xsd:extension>
</xsd:simpleContent>
</xsd:complexType>
```

Complex Type: abstractBasicType

Parent type: None

- Direct sub-types: testsType (by extension)
- dictionariesType (by extension)

Name	abstractBasicType
Abstract	no

XML Instance Representation

```
<.../>
```

Schema Component Representation

```
<xsd:complexType name="abstractBasicType">
<xsd:sequence/>
</xsd:complexType>
```

Simple Type: otherNameType

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name	otherNameType
Content	• Built-in XSD Type: string • *pattern* = Other: [A-Za-z0-9()%/. -]{1,54}
Documentation	A pattern that is used to make an enumerate list extendable. It adds the capability to give an additional value of 'Other: xx', where xx is two or more alphanumeric characters. It's main use is as follows. An enumerated list is developed. Then, a new extendable list is developed by making a union of this type with the list. The same may be accomplished by creating the extendable list directly by adding the pattern to the end of the list of values.

Schema Component Representation

```
<xsd:simpleType name="otherNameType">
<xsd:restriction base=" xsd:string ">
<xsd:pattern value="Other: [A-Za-z0-9()%/. -]{1,54}"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extSiteTypeEnum

Parent type: None
Direct sub-types: None

Name	extSiteTypeEnum

Content	• Union of following types:
	    ○ otherNameType
	    ○ siteTypeEnum

Schema Component Representation

```
<xsd:simpleType name="extSiteTypeEnum">
<xsd:union memberTypes=" otherNameType siteTypeEnum "/>
</xsd:simpleType>
```

Simple Type: siteTypeEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name	siteTypeEnum
Content	• Built-in XSD Type: string • *value* = {'environmental'|'excavation'|'geophysical'|'geotechnical'|'geothermal'|'mixed or other'|'oil or gas'|'outcrop'|'ocean or lake'|'water'}

Schema Component Representation
```
<xsd:simpleType name="siteTypeEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="environmental"/>
<xsd:enumeration value="excavation"/>
<xsd:enumeration value="geophysical"/>
<xsd:enumeration value="geotechnical"/>
<xsd:enumeration value="geothermal"/>
<xsd:enumeration value="mixed or other"/>
<xsd:enumeration value="oil or gas"/>
<xsd:enumeration value="outcrop"/>
<xsd:enumeration value="ocean or lake"/>
<xsd:enumeration value="water"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: rotationEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name	rotationEnum
Content	• Built-in XSD Type: string • *value* = {'clockwise'|'counter clockwise'|'counter-clockwise'}

Schema Component Representation
```
<xsd:simpleType name="rotationEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="clockwise"/>
<xsd:enumeration value="counter clockwise"/>
<xsd:enumeration value="counter-clockwise"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extLocAccuracyEnum

Parent type: None
Direct sub-types: None

Name	extLocAccuracyEnum

Content	• Union of following types:
	  ○ otherNameType
	  ○ locAccuracyEnum

Schema Component Representation

```
<xsd:simpleType name="extLocAccuracyEnum">
<xsd:union memberTypes=" otherNameType locAccuracyEnum "/>
</xsd:simpleType>
```

Simple Type: locAccuracyEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name locAccuracyEnum

Content
- Built-in XSD Type: string
- *value* = {'0.3 m'|'3 m'|'15 m'|'30 m'|'90 m'|'150 m'|'300 m'|'800 m'|'above 800 m'}

Schema Component Representation

```
<xsd:simpleType name="locAccuracyEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="0.3 m"/>
<xsd:enumeration value="3 m"/>
<xsd:enumeration value="15 m"/>
<xsd:enumeration value="30 m"/>
<xsd:enumeration value="90 m"/>
<xsd:enumeration value="150 m"/>
<xsd:enumeration value="300 m"/>
<xsd:enumeration value="800 m"/>
<xsd:enumeration value="above 800 m"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extCRSEnum

Parent type: None
Direct sub-types: None

Name extCRSEnum

Content
- Union of following types:
  - otherNameType
  - crsEnum

Schema Component Representation

```
<xsd:simpleType name="extCRSEnum">
<xsd:union memberTypes=" otherNameType crsEnum "/>
</xsd:simpleType>
```

Simple Type: crsEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name	crsEnum
Content	• Built-in XSD Type: string • *value* = {'geographic'|'projection'|'vertical'|'engineering'}

Schema Component Representation

```
<xsd:simpleType name="crsEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="geographic"/>
<xsd:enumeration value="projection"/>
<xsd:enumeration value="vertical"/>
<xsd:enumeration value="engineering"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: stateCodeEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name	stateCodeEnum
Content	• Built-in XSD Type: string • *value* = {'AL'|'AK'|'AS'|'AR'|'AZ'|'CA'|'CO'|'CT'|'DE'|'DC'|'FM'|'FL'|'GA'|'GU'|'HI'|'ID'|'IL'|'IN'|'IA'|'KS'|'KY'|'LA'|'ME'|'MH'|'MD'|'MA'|'MI'|'MN'|'MS'|'MO'|'MT'|'NE'|'NV'|'NH'|'NJ'|'NM'|'NY'|'NC'|'ND'|'MP'|'OH'|'OK'|'OR'|'PW'|'PA'|'PR'|'RI'|'SC'|'SD'|'TN'|'TX'|'UT'|'VT'|'VI'|'VA'|'WA'|'WV'|'WI'|'WY'}

Schema Component Representation

```
<xsd:simpleType name="stateCodeEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="AL"/>
<xsd:enumeration value="AK"/>
<xsd:enumeration value="AS"/>
<xsd:enumeration value="AR"/>
<xsd:enumeration value="AZ"/>
<xsd:enumeration value="CA"/>
<xsd:enumeration value="CO"/>
<xsd:enumeration value="CT"/>
<xsd:enumeration value="DE"/>
<xsd:enumeration value="DC"/>
<xsd:enumeration value="FM"/>
```

```
<xsd:enumeration value="FL"/>
<xsd:enumeration value="GA"/>
<xsd:enumeration value="GU"/>
<xsd:enumeration value="HI"/>
<xsd:enumeration value="ID"/>
<xsd:enumeration value="IL"/>
<xsd:enumeration value="IN"/>
<xsd:enumeration value="IA"/>
<xsd:enumeration value="KS"/>
<xsd:enumeration value="KY"/>
<xsd:enumeration value="LA"/>
<xsd:enumeration value="ME"/>
<xsd:enumeration value="MH"/>
<xsd:enumeration value="MD"/>
<xsd:enumeration value="MA"/>
<xsd:enumeration value="MI"/>
<xsd:enumeration value="MN"/>
<xsd:enumeration value="MS"/>
<xsd:enumeration value="MO"/>
<xsd:enumeration value="MT"/>
<xsd:enumeration value="NE"/>
<xsd:enumeration value="NV"/>
<xsd:enumeration value="NH"/>
<xsd:enumeration value="NJ"/>
<xsd:enumeration value="NM"/>
<xsd:enumeration value="NY"/>
<xsd:enumeration value="NC"/>
<xsd:enumeration value="ND"/>
<xsd:enumeration value="MP"/>
<xsd:enumeration value="OH"/>
<xsd:enumeration value="OK"/>
<xsd:enumeration value="OR"/>
<xsd:enumeration value="PW"/>
<xsd:enumeration value="PA"/>
<xsd:enumeration value="PR"/>
<xsd:enumeration value="RI"/>
<xsd:enumeration value="SC"/>
<xsd:enumeration value="SD"/>
<xsd:enumeration value="TN"/>
<xsd:enumeration value="TX"/>
<xsd:enumeration value="UT"/>
<xsd:enumeration value="VT"/>
<xsd:enumeration value="VI"/>
<xsd:enumeration value="VA"/>
<xsd:enumeration value="WA"/>
<xsd:enumeration value="WV"/>
```

```
<xsd:enumeration value="WI"/>
<xsd:enumeration value="WY"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: holeEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name	holeEnum
Content	• Built-in XSD Type: string • *value* = {'environmental'|'excavation'|'geophysical'|'geotechnical'|'ocean/lake'|'oil or gas'|'outcrop'|'water'|'destroyed/abandoned'|'observation'|'test/exploratory boring'|'mine'|'pit'|'trench'|'tunnel'|'potential field'|'seismic reflection/refraction'|'borehole array'|'observation'|'seismic velocity'|'test/exploratory boring'|'pit'|'potential field'|'seismic reflection/refraction'|'surface sample'|'test/exploratory boring'|'air injection'|'CO2'|'dry hole - abandoned'|'dual oil and disposal'|'dual oil and gas'|'dual oil and waterflood'|'fireflood'|'gas'|'gas injection'|'gas storage-injection/withdrawal'|'gas-open to oil zone'|'idle'|'LPG injection'|'oil'|'oil producing and gas injection'|'repressurize'|'steamflood'|'waste'|'water disposal'|'water source'|'waterflood'|'surface sample'|'anode'|'destroyed/abandoned'|'dewatering'|'domestic'|'domestic and irrigation'|'drain'|'ground water barrier regulation'|'industrial supply'|'injection/recharge'|'irrigation'|'municipal (public supply)'|'observation'|'standby emergency supply'|'stock'}

Schema Component Representation

```
<xsd:simpleType name="holeEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="environmental"/>
<xsd:enumeration value="excavation"/>
<xsd:enumeration value="geophysical"/>
<xsd:enumeration value="geotechnical"/>
<xsd:enumeration value="ocean/lake"/>
<xsd:enumeration value="oil or gas"/>
<xsd:enumeration value="outcrop"/>
<xsd:enumeration value="water"/>
<xsd:enumeration value="destroyed/abandoned"/>
<xsd:enumeration value="observation"/>
<xsd:enumeration value="test/exploratory boring"/>
<xsd:enumeration value="mine"/>
```

```
<xsd:enumeration value="pit"/>
<xsd:enumeration value="trench"/>
<xsd:enumeration value="tunnel"/>
<xsd:enumeration value="potential field"/>
<xsd:enumeration value="seismic reflection/refraction"/>
<xsd:enumeration value="borehole array"/>
<xsd:enumeration value="observation"/>
<xsd:enumeration value="seismic velocity"/>
<xsd:enumeration value="test/exploratory boring"/>
<xsd:enumeration value="pit"/>
<xsd:enumeration value="potential field"/>
<xsd:enumeration value="seismic reflection/refraction"/>
<xsd:enumeration value="surface sample"/>
<xsd:enumeration value="test/exploratory boring"/>
<xsd:enumeration value="air injection"/>
<xsd:enumeration value="CO2"/>
<xsd:enumeration value="dry hole - abandoned"/>
<xsd:enumeration value="dual oil and disposal"/>
<xsd:enumeration value="dual oil and gas"/>
<xsd:enumeration value="dual oil and waterflood"/>
<xsd:enumeration value="fireflood"/>
<xsd:enumeration value="gas"/>
<xsd:enumeration value="gas injection"/>
<xsd:enumeration value="gas storage-injection/withdrawal"/>
<xsd:enumeration value="gas-open to oil zone"/>
<xsd:enumeration value="idle"/>
<xsd:enumeration value="LPG injection"/>
<xsd:enumeration value="oil"/>
<xsd:enumeration value="oil producing and gas injection"/>
<xsd:enumeration value="repressurize"/>
<xsd:enumeration value="steamflood"/>
<xsd:enumeration value="waste"/>
<xsd:enumeration value="water disposal"/>
<xsd:enumeration value="water source"/>
<xsd:enumeration value="waterflood"/>
<xsd:enumeration value="surface sample"/>
<xsd:enumeration value="anode"/>
<xsd:enumeration value="destroyed/abandoned"/>
<xsd:enumeration value="dewatering"/>
<xsd:enumeration value="domestic"/>
<xsd:enumeration value="domestic and irrigation"/>
<xsd:enumeration value="drain"/>
<xsd:enumeration value="ground water barrier regulation"/>
<xsd:enumeration value="industrial supply"/>
<xsd:enumeration value="injection/recharge"/>
<xsd:enumeration value="irrigation"/>
```

```
<xsd:enumeration value="municipal (public supply)"/>
<xsd:enumeration value="observation"/>
<xsd:enumeration value="standby emergency supply"/>
<xsd:enumeration value="stock"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extElevCodeEnum

Parent type: None
Direct sub-types: None

Name	extElevCodeEnum

Content	• Union of following types:
	  ○ otherNameType
	  ○ elevCodeEnum

Schema Component Representation

```
<xsd:simpleType name="extElevCodeEnum">
<xsd:union memberTypes=" otherNameType elevCodeEnum "/>
</xsd:simpleType>
```

Simple Type: elevCodeEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name	elevCodeEnum
Content	• Built-in XSD Type: string • *value* = {'CF'|'CV'|'KB'|'RB'|'GL'|'DF'|'RT'|'SF'|'LAT'|'KO'|'SL'|'UN'}

Schema Component Representation

```
<xsd:simpleType name="elevCodeEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="CF"/>
<xsd:enumeration value="CV"/>
<xsd:enumeration value="KB"/>
<xsd:enumeration value="RB"/>
<xsd:enumeration value="GL"/>
<xsd:enumeration value="DF"/>
<xsd:enumeration value="RT"/>
<xsd:enumeration value="SF"/>
<xsd:enumeration value="LAT"/>
<xsd:enumeration value="KO"/>
<xsd:enumeration value="SL"/>
<xsd:enumeration value="UN"/>
```

```
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extLocMethodEnum

<u>Parent type:</u> None
<u>Direct sub-types:</u> None

Name	extLocMethodEnum

Content	• Union of following types:
	    o otherNameType
	    o locMethodEnum

<u>Schema Component Representation</u>

```
<xsd:simpleType name="extLocMethodEnum">
<xsd:union memberTypes=" otherNameType locMethodEnum "/>
</xsd:simpleType>
```

Simple Type: locMethodEnum

<u>Parent type:</u> xsd:string (derivation method: restriction)
<u>Direct sub-types:</u> None

Name	locMethodEnum
Content	• Built-in XSD Type: string • *value* = {'DGPS'|'GPS'|'estimated from Well ID'|'digitized from existing map'|'LORAN'|'posted to map from description'|'unknown'|'unknown - from owner, operator'|'unknown - from 3rd party'}

<u>Schema Component Representation</u>

```
<xsd:simpleType name="locMethodEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="DGPS"/>
<xsd:enumeration value="GPS"/>
<xsd:enumeration value="estimated from Well ID"/>
<xsd:enumeration value="digitized from existing map"/>
<xsd:enumeration value="LORAN"/>
<xsd:enumeration value="posted to map from description"/>
<xsd:enumeration value="unknown"/>
<xsd:enumeration value="unknown - from owner, operator"/>
<xsd:enumeration value="unknown - from 3rd party"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extSampMethEnum

Parent type: None
Direct sub-types: None

Name extSampMethEnum
Content
- Union of following types:
  - otherNameType
  - sampMethEnum

Schema Component Representation

```
<xsd:simpleType name="extSampMethEnum">
<xsd:union memberTypes=" otherNameType sampMethEnum "/>
</xsd:simpleType>
```

Simple Type: sampMethEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name sampMethEnum
Content
- Built-in XSD Type: string
- *value* = {'undisturbed'|'Shelby tube'|'Piston sampler'|'split-spoon'|'block sample'|'disturbed'|'rotary drill'|'unknown'}

Schema Component Representation

```
<xsd:simpleType name="sampMethEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="undisturbed"/>
<xsd:enumeration value="Shelby tube"/>
<xsd:enumeration value="Piston sampler"/>
<xsd:enumeration value="split-spoon"/>
<xsd:enumeration value="block sample"/>
<xsd:enumeration value="disturbed"/>
<xsd:enumeration value="rotary drill"/>
<xsd:enumeration value="unknown"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extSpecSampEnum

Parent type: None
Direct sub-types: None

Name extSpecSampEnum
Content
- Union of following types:
    - otherNameType
    - specSampEnum

<u>Schema Component Representation</u>

```
<xsd:simpleType name="extSpecSampEnum">
<xsd:union memberTypes=" otherNameType specSampEnum "/>
</xsd:simpleType>
```

Simple Type: specSampEnum

<u>Parent type:</u> xsd:string (derivation method: restriction)
<u>Direct sub-types:</u> None

Name specSampEnum
Content
- Built-in XSD Type: string
- *value* = {'block sample'|'bulk sample'|'core plug'|'split-core section'|'whole-core section'|'unknown'}

<u>Schema Component Representation</u>

```
<xsd:simpleType name="specSampEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="block sample"/>
<xsd:enumeration value="bulk sample"/>
<xsd:enumeration value="core plug"/>
<xsd:enumeration value="split-core section"/>
<xsd:enumeration value="whole-core section"/>
<xsd:enumeration value="unknown"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: specimenTestEnum

<u>Parent type:</u> xsd:string (derivation method: restriction)
<u>Direct sub-types:</u> None

Name specimenTestEnum
Content
- Built-in XSD Type: string
- *value* = {'acid volatile sulfide'|'amino acid'|'argon-argon'|'Atterberg limits'|'biomarker'|'cesium-137'|'consolidation tests'|'core P-wave velocity'|'cyclic engineering tests'|'cyclic torsional shear'|'cyclic triaxial shear'|'dendrochronology'|'electron probe'|'electron spin resonance'|'engineering classification'|'fission track'|'grain size distribution'|'hydraulic conductivity'|'instrumental neutron activation'|'ionium-thorium-

protactinium'|'ionium-uranium-protactinium'|'lead isotopes'|'lead-210'|'large strain simple shear'|'medium strain cyclic simple shear'|'megafossil paleontology'|'mercury methylation + demethylation potential'|'methylmercury + total mercury'|'micropaleontology'|'moisture content'|'nanofossils'|'obsidian hydration'|'organic carbon'|'redox potential'|'paleobotany'|'paleomagnetics'|'palynology'|'petrography'|'pH'|'phosopholipid/fatty acid'|'pocket penetrometer'|'point/selective sample'|'pore water chemistry'|'potassium-argon'|'radiocarbon'|'repeatedly sheared direct shear'|'resonant column'|'ring shear'|'rubidium-strontium'|'SEM photo'|'small-strain cyclic simple shear'|'smear slide'|'soil chemistry'|'specific gravity'|'stratigraphy/sedimentology'|'stratigraphic chronology'|'strontium isotopes'|'tephronology'|'bulk density, porosity'|'thermal conductivity'|'thermal/optical luminescence'|'thin section'|'trovane'|'trace metals'|'triaxial shear'|'undetermined'|'uranium isotopes'|'uranium-helium'|'uranium-lead'|'vane shear'|'weathering'|'x-ray analysis'}

<u>Schema Component Representation</u>

```
<xsd:simpleType name="specimenTestEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="acid volatile sulfide"/>
<xsd:enumeration value="amino acid"/>
<xsd:enumeration value="argon-argon"/>
<xsd:enumeration value="Atterberg limits"/>
<xsd:enumeration value="biomarker"/>
<xsd:enumeration value="cesium-137"/>
<xsd:enumeration value="consolidation tests"/>
<xsd:enumeration value="core P-wave velocity"/>
<xsd:enumeration value="cyclic engineering tests"/>
<xsd:enumeration value="cyclic torsional shear"/>
<xsd:enumeration value="cyclic triaxial shear"/>
<xsd:enumeration value="dendrochronology"/>
<xsd:enumeration value="electron probe"/>
<xsd:enumeration value="electron spin resonance"/>
<xsd:enumeration value="engineering classification"/>
<xsd:enumeration value="fission track"/>
<xsd:enumeration value="grain size distribution"/>
<xsd:enumeration value="hydraulic conductivity"/>
<xsd:enumeration value="instrumental neutron activation"/>
<xsd:enumeration value="ionium-thorium-protactinium"/>
<xsd:enumeration value="ionium-uranium-protactinium"/>
<xsd:enumeration value="lead isotopes"/>
<xsd:enumeration value="lead-210"/>
<xsd:enumeration value="large strain simple shear"/>
<xsd:enumeration value="medium strain cyclic simple shear"/>
<xsd:enumeration value="megafossil paleontology"/>
<xsd:enumeration value="mercury methylation + demethylation potential"/>
```

```
<xsd:enumeration value="methylmercury + total mercury"/>
<xsd:enumeration value="micropaleontology"/>
<xsd:enumeration value="moisture content"/>
<xsd:enumeration value="nanofossils"/>
<xsd:enumeration value="obsidian hydration"/>
<xsd:enumeration value="organic carbon"/>
<xsd:enumeration value="redox potential"/>
<xsd:enumeration value="paleobotany"/>
<xsd:enumeration value="paleomagnetics"/>
<xsd:enumeration value="palynology"/>
<xsd:enumeration value="petrography"/>
<xsd:enumeration value="pH"/>
<xsd:enumeration value="phosopholipid/fatty acid"/>
<xsd:enumeration value="pocket penetrometer"/>
<xsd:enumeration value="point/selective sample"/>
<xsd:enumeration value="pore water chemistry"/>
<xsd:enumeration value="potassium-argon"/>
<xsd:enumeration value="radiocarbon"/>
<xsd:enumeration value="repeatedly sheared direct shear"/>
<xsd:enumeration value="resonant column"/>
<xsd:enumeration value="ring shear"/>
<xsd:enumeration value="rubidium-strontium"/>
<xsd:enumeration value="SEM photo"/>
<xsd:enumeration value="small-strain cyclic simple shear"/>
<xsd:enumeration value="smear slide"/>
<xsd:enumeration value="soil chemistry"/>
<xsd:enumeration value="specific gravity"/>
<xsd:enumeration value="stratigraphy/sedimentology"/>
<xsd:enumeration value="stratigraphic chronology"/>
<xsd:enumeration value="strontium isotopes"/>
<xsd:enumeration value="tephronology"/>
<xsd:enumeration value="bulk density, porosity"/>
<xsd:enumeration value="thermal conductivity"/>
<xsd:enumeration value="thermal/optical luminescence"/>
<xsd:enumeration value="thin section"/>
<xsd:enumeration value="trovane"/>
<xsd:enumeration value="trace metals"/>
<xsd:enumeration value="triaxial shear"/>
<xsd:enumeration value="undetermined"/>
<xsd:enumeration value="uranium isotopes"/>
<xsd:enumeration value="uranium-helium"/>
<xsd:enumeration value="uranium-lead"/>
<xsd:enumeration value="vane shear"/>
<xsd:enumeration value="weathering"/>
<xsd:enumeration value="x-ray analysis"/>
</xsd:restriction>
```

</xsd:simpleType>

Simple Type: extLayerSourceEnum

Parent type:	None
Direct sub-types:	None

Name	extLayerSourceEnum
Content	• Union of following types: ◦ otherNameType ◦ layerSourceEnum

Schema Component Representation

```
<xsd:simpleType name="extLayerSourceEnum">
<xsd:union memberTypes=" otherNameType layerSourceEnum "/>
</xsd:simpleType>
```

Simple Type: layerSourceEnum

Parent type:	xsd:string (derivation method: restriction)
Direct sub-types:	None

Name	layerSourceEnum
Content	• Built-in XSD Type: string • *value* = {'core'|'CPT'|'cuttings'|'geophysical log'|'estimate'|'outcrop'|'unknown'}

Schema Component Representation

```
<xsd:simpleType name="layerSourceEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="core"/>
<xsd:enumeration value="CPT"/>
<xsd:enumeration value="cuttings"/>
<xsd:enumeration value="geophysical log"/>
<xsd:enumeration value="estimate"/>
<xsd:enumeration value="outcrop"/>
<xsd:enumeration value="unknown"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: abundanceEnum

Parent type:	xsd:string (derivation method: restriction)
Direct sub-types:	None

Name abundanceEnum
Content
- Built-in XSD Type: string
- *value* = {'pervasive'|'abundant'|'common'|'few'|'rare'|'trace'}

Schema Component Representation

```
<xsd:simpleType name="abundanceEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="pervasive"/>
<xsd:enumeration value="abundant"/>
<xsd:enumeration value="common"/>
<xsd:enumeration value="few"/>
<xsd:enumeration value="rare"/>
<xsd:enumeration value="trace"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extCompSourceEnum

Parent type: None
Direct sub-types: None

Name extCompSourceEnum
Content
- Union of following types:
  - otherNameType
  - compSourceEnum

Schema Component Representation

```
<xsd:simpleType name="extCompSourceEnum">
<xsd:union memberTypes=" otherNameType compSourceEnum "/>
</xsd:simpleType>
```

Simple Type: compSourceEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name compSourceEnum
Content
- Built-in XSD Type: string
- *value* = {'core'|'CPT'|'cuttings'|'geophysical log'|'estimate'|'outcrop'|'unknown'}

Schema Component Representation

```
<xsd:simpleType name="compSourceEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="core"/>
<xsd:enumeration value="CPT"/>
<xsd:enumeration value="cuttings"/>
<xsd:enumeration value="geophysical log"/>
<xsd:enumeration value="estimate"/>
<xsd:enumeration value="outcrop"/>
<xsd:enumeration value="unknown"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extQualifierEnum

Parent type: None
Direct sub-types: None

Name extQualifierEnum
Content
- Union of following types:
    - otherNameType
    - qualifierEnum

Schema Component Representation

```
<xsd:simpleType name="extQualifierEnum">
<xsd:union memberTypes=" otherNameType qualifierEnum "/>
</xsd:simpleType>
```

Simple Type: qualifierEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name qualifierEnum
Content
- Built-in XSD Type: string
- *value* = {'personal'|'work'|'permanent'}

Schema Component Representation

```
<xsd:simpleType name="qualifierEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="personal"/>
<xsd:enumeration value="work"/>
<xsd:enumeration value="permanent"/>
</xsd:restriction>
</xsd:simpleType>
```

Simple Type: extPhoneEnum

Parent type: None
Direct sub-types: None

Name extPhoneEnum
Content
- Union of following types:
  - otherNameType
  - phoneEnum

Schema Component Representation

```
<xsd:simpleType name="extPhoneEnum">
<xsd:union memberTypes=" otherNameType phoneEnum "/>
</xsd:simpleType>
```

Simple Type: phoneEnum

Parent type: xsd:string (derivation method: restriction)
Direct sub-types: None

Name phoneEnum
Content
- Built-in XSD Type: string
- *value* = {'voice'|'fax'|'mobile'|'voice/fax'|'voicemail'}

Schema Component Representation

```
<xsd:simpleType name="phoneEnum">
<xsd:restriction base=" xsd:string ">
<xsd:enumeration value="voice"/>
<xsd:enumeration value="fax"/>
<xsd:enumeration value="mobile"/>
<xsd:enumeration value="voice/fax"/>
<xsd:enumeration value="voicemail"/>
</xsd:restriction>
</xsd:simpleType>
```

3.0 GVDC DATABASE STRUCTURE

An index of available geotechnical borehole data from participating data providers is contained in one MySQL database, which is integrated with the GVDC harvester system architecture (MySQL, 2004a). MySQL was chosen because of the following advantages:

- MySQL is a client/server system that consists of a multi-threaded SQL server that supports different backends, several different client programs and libraries, administrative tools, and a wide range of application programming interfaces (APIs)
- Open Source, thus it is possible for anyone to use and modify the software

- Successful previous implementations of MySQL have been integrated with OAIB (Open Archives IN-A-Box; NCSA, 2004a)
- ODBC compliant, therefore can be easily integrated with the Internet Map Services (IMS) interface required for the user front-end website

MySQL software users can choose to use the MySQL software as an Open Source/Free Software product under the terms of the GNU General Public License. The MySQL website provides the latest information about the MySQL software (MySQL, 2004a).

Mapping the COSMOS/PEER-LL geotechnical data dictionary (Benoit et al., this report) to the relational database model was accomplished by converting the data dictionary into MySQL tables, attribute by attribute, definition by definition, according to the information in the data dictionary spreadsheets contained in the root:\ Original_Data_Dictionary_Spreadsheets\-level directory on the report CD (current working versions of the data dictionary are available online, see Bobbitt, et al., 2004, i.e. see "Geotechnical Data Dictionary and Entity Relationship Diagram Version 3"). Therefore the geotechnical data structures described in Benoit, et al. (this report) are for nearly identical to the corresponding tables in the MySQL database model. Additional reference tables were added to the relational model, consisting of extensible, enumerated lists of information defining original data dictionary elements. Thouh the reference tables should be considered static, their content will be updated according to subsequent releases (versions) of the data dictionary and GVDC system architechture. During the development of the GVDC system architecture and data center, ancillary tables required to support the admin and front-end website functionalities were also added to the MySQL database model. Thus the MySQL database named "gvdc" currently includes the tables shown in Table 1:

Table 1. MySQL "gvdc" database tables supporting the GDVC system architecture.

Geotechnical Borehole Information	Reference Lists	Ancillary System Architecture Support
Alias	Datatypes	adminhelpfaq
Bassoc	Parentkey	adminusers
Crs	r_crs_direction	coreproviders
Hole	r_crs_type	Countries
hole_test_assoc	r_depth_datum	deletedrecords
hole_tests	r_depth_qualifier	Mvals
Site	r_hole_type	Providers
	r_inquiry	subscriberdownloads
	r_layer_source	subscriberlogins
	r_location_accuracy	subscribers
	r_location_method	States
	r_site_trype	updatetimings
	r_specimen_samplingmethod	useraccounts
	r_specimen_tests	Usraccts
	r_y_axis_rotation	

	Studytype	

The GVDC geotechnical database was initially constructed in MS Access in order to test the model prior to constructing the database in MySQL, and to build the necessary tables required to support data providers desiring to work in MS Access (Figure 2). An example GVDC-compliant Access database is provided in the root:\Example_Access_GVDC_Database\-level directory on the report CD. Though this Access database doesn't contain any geotechnical data, the reference tables are populated with the original static data dictionary elements referred to above.

Figure 3 displays the relationships between the original geotechnical data and reference tables, attributes and keys. The MySQL "gvdc" database was built and maintained using MySQL command line functionality, and MySQL Control Center version 0.9.4-beta (MySQL, 2004b). MySQL Control Center is a platform-independent graphical user interface (GUI) administration client for the MySQL database server client. MySQL Control Center makes it easy to create and manage databases and tables, including views for table and field attributes, and to check, repair, and optimize tables. MySQL Control Center is currently used to maintain the GVDC database (Figure 4). Figure 4 shows the MySQL Control Center and the "gvdc" database tables, displaying geotechnical data tables and other ancillary tables that support the website user interfaces.

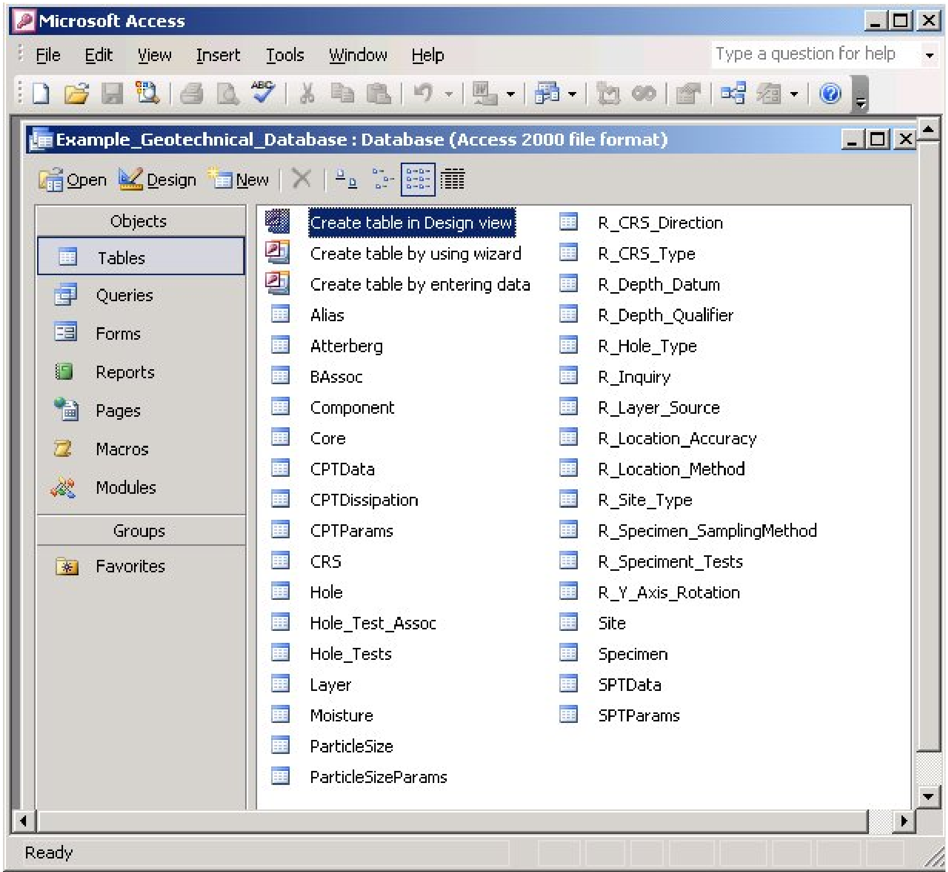


Figure 2. Example Access database constructed for testing the proposed geotechnical database model, equivalent to the data dictionary (Benoit et al., this report).

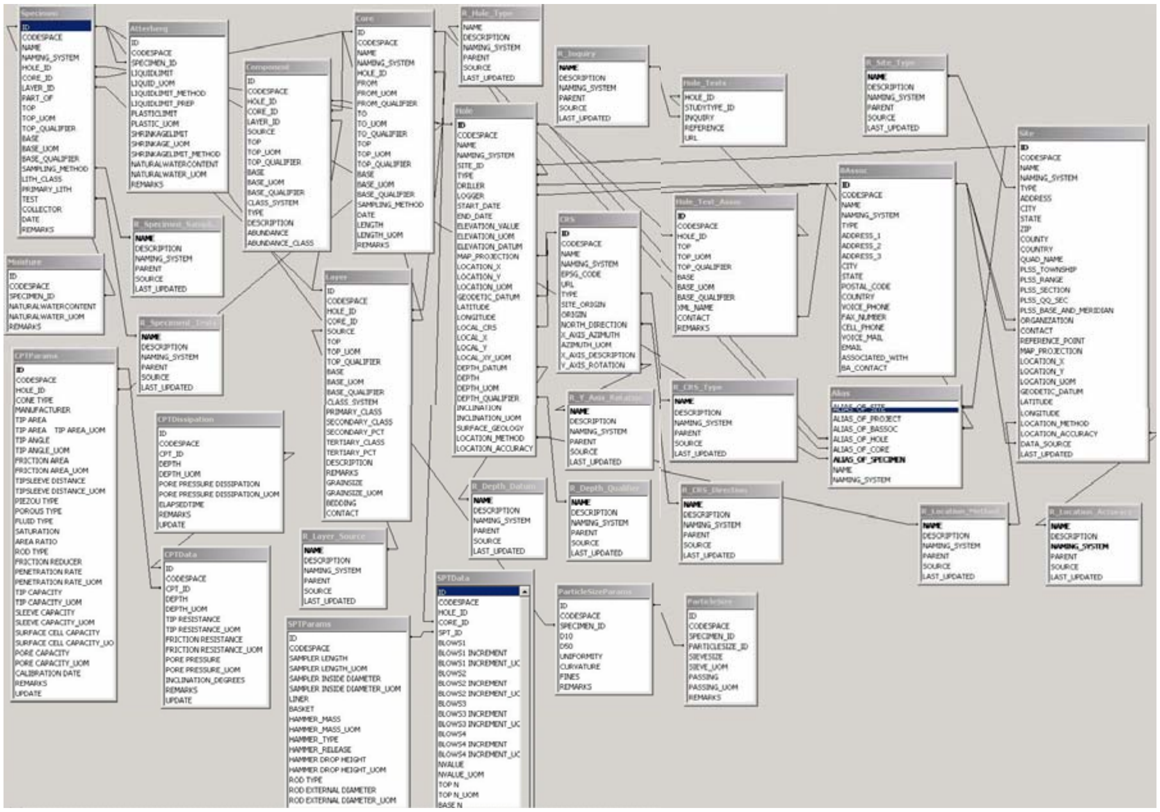


Figure 3. Relationship diagram of geotechnical and reference relational data structures (MS Access).

At present the MySQL tables are populated with example data sets from three of the four data providers, which include the California Department of Transportation (Caltrans), California Geological Survey (CGS), the United States Geological Survey (USGS), and Pacific Gas & Electric (PG&E). Caltrans, CGS, and USGS data sets were harvested in repeated trials during the initial setup and testing phase of developing the harvester backend system. At present the PG&E dataset is being upgraded and will be also available in early 2005. The details of this effort as well as the ancillary tables supporting the backend and front-end applications are described in subsequent sections of this Appendix.

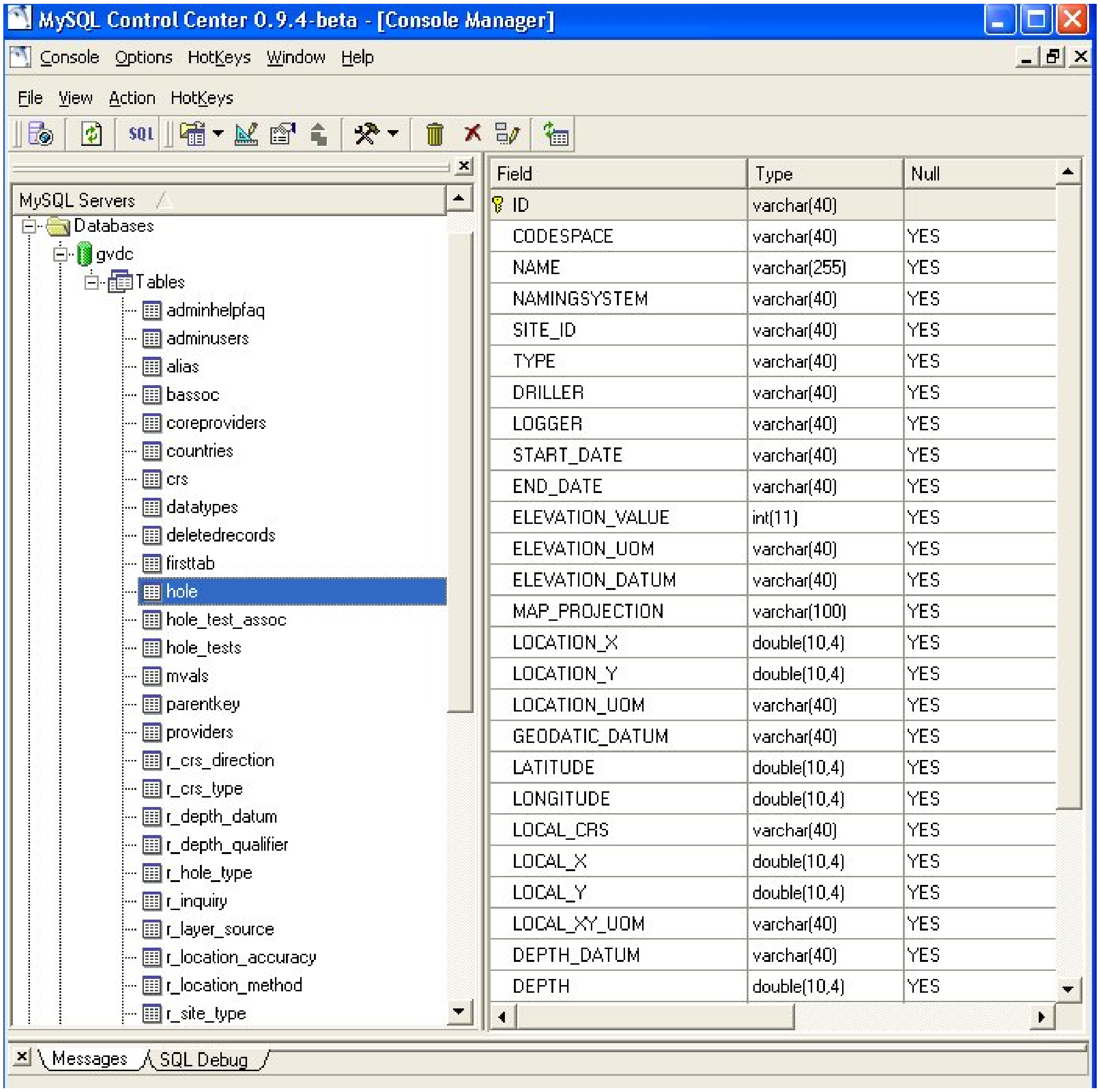


Figure 4. The "gvdc" MySQL relational database, viewed using MySQL Control Center.

4.0 CLIENT SIDE DATA PREPARATION AND EXCHANGE PROTOCOL

Caltrans, CGS, the USGS, and PG&E provided example data sets for the GVDC project. The Caltrans, CGS, and USGS data sets are currently in use and available online through the GVDC website. Presently the PG&E dataset is being upgraded and will be also available online in early 2005. This Appendix is intended to serve as a loose guideline for data providers. The procedures outlined herein are specific to Caltrans, CGS, the USGS, and PG&E experiences as GVDC data providers. The process of integrating new data sets from other data providers into the GVDC will probably vary from this Appendix.

The details for the pilot project data providers' systems are described and illustrated below. Each data provider maintains: 1) a native geotechnical data set or database including the searchable parameters for the GVDC front end; 2) a data translator for exporting data from it's respective native format (such as Microsoft Access, MySQL or PostgreSQL databases) into the COSMOS/PEER-LL XML Schema format (Benoit et al., 2004); and 3) an OAIB installation which allows the GVDC to harvest the search parameter data from the native database or data set (NCSA, 2004a).

To participate in the GVDC, a data provider's data set must include geotechnical test data as well as relevant, associated borehole information required by the GVDC harvester system. The steps for mapping data providers' native data types inlcude:

1) Correlating native geotechnical data types to the COMOS/PEER-LL XMLSchema data types, in order to translate the data sets into XML compliant with the XML schema (Figure 5)
2) Correlating (and/or generating) native geotechnical data to OAIB-compliant borehole metadata, such as location and contact information, to satisfy the GVDC website front-end search page requirments, and the OAI specifications for metadata harvesting

At present, data mapping is a manual process of carefully comparing and matching the orginal data providers' data sets (attributes) with the data dictionary and XML schema (Figure 5). One of the most time-consuming elements of this effort is assembling and agreeing upon the respective attribute definitions. Automation of the data mapping process is currently being proposed as part of a future phase of this project.

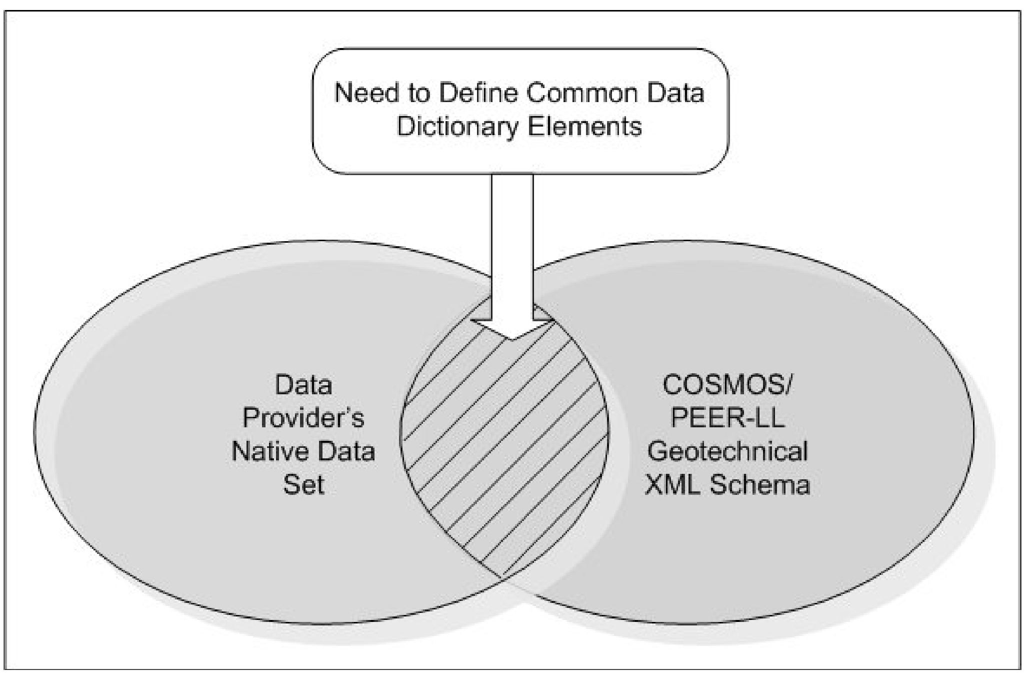


Figure 5. General schematic of the "Data Mapping" process.

Data translators are required to convert the data provider's detailed geotechnical borehole test information into valid XML (W3C, 2004a) files, as defined by the COSMOS Geotechnical Data XMLSchema version 1.0 (Chapter 3, Benoit et al., this report). The translators created during this project are coded in different programming languages, including VB.NET (Visual Basic.NET), Visual Basic, and Java. The publically available source code for the data translators and example XML output files for each data provider are contained in the root:\translators_XML_examples\-level directories of the report CD. Contact information is also indicated in the discussions below, for obtaining more information of these applications.

The GVDC end-user website design allows the end user to download the XML files containing detailed geotechnical test data, via a URL for each borehole passed to the search results pages (see section "COSMOS/PEER-LL Geotechnical Xml Schema" for details on XML data attributes and relations). The URL is a path plus the XML filename specified by the data providers at the time of translation. The URL's are maintained in the data providers' database. Two different coding options are available to the data providers, depending on how the data provider wishes XML files to be generated, stored and delivered:

1) The URL path points to static XML files maintained by the data provider on a remote server under their control, or
2) The URL points to an application installed on the GVDC, which dynamically queries the data provider's remote database and streams the results back to the GVDC; i.e. in a Hypertext Transfer Protocol (HTTP; W3C, 2004b)

In an HTTP request/response environment, the XML data is appended to the HTTP output stream to the end user. Since the data display is dynamic, no XML is actually stored anywhere unless the end user saves the data to another media.

The decision as to which download method to implement is solely at the discretion of the data providers, as both options can be supported by the current GVDC system architecture. The first option allows the data provider complete control over all static XML files generated and updated in-house by their translator. The translator and files will be updated and maintained by the data provider. Note that this requires particular attention to potentially long-term storage and maintenance issues for the data provider Database Administrator (DBA). The second option frees the data provider from having to periodically generate, update, store, and maintain XML files over the long term. Nevertheless, the latter option requires the data providers to write and maintain their own dynamic translators. Based on the current technology used in this project, such applications will be installed on the GVDC. The GVDC administrator will assist the data providers in installation and debugging of dynamic translators, but will not be responsible for updating and recompiling the translator source code. Updating of the source code would be required if, for instance:

1) The data dictionary and thus the XML Schema are updated in a new release
2) Data providers make changes to their own geotechnical database structure

4.1 Data Mapping, Static XML Translation, and OAIB Customization

4.1.1 California Geological Survey (CGS)

CGS provided a comprehensivegeotechnical borehole dataset in MS Access format for use in this project. Figure 6 displays this native CGS Access database structure. This data set contains 629 boreholes and associated test results (Tabe A2). The same CGS database structure also currently supports the CGS Seismic Hazards Mapping Program (SHMP) website "borehole data report" feature (CGS, 2004). The primary focus of the CGS SHMP website is to provide extensive map-based vewing and download functionalities for SHMP zone maps, reports and Geographic Information System (GIS) data.

In order for the the GVDC system to communicate with the CGS geotechnical database remotely, the CGS geotechnical database was customized to:

- Compile and/or generate parameters required for the CGS database to be searchable through the GVDC
- Translate geotechnical data in the native Access tables into XML files
- Enable communication between the GVDC harvester and the database, utilizing OAIB

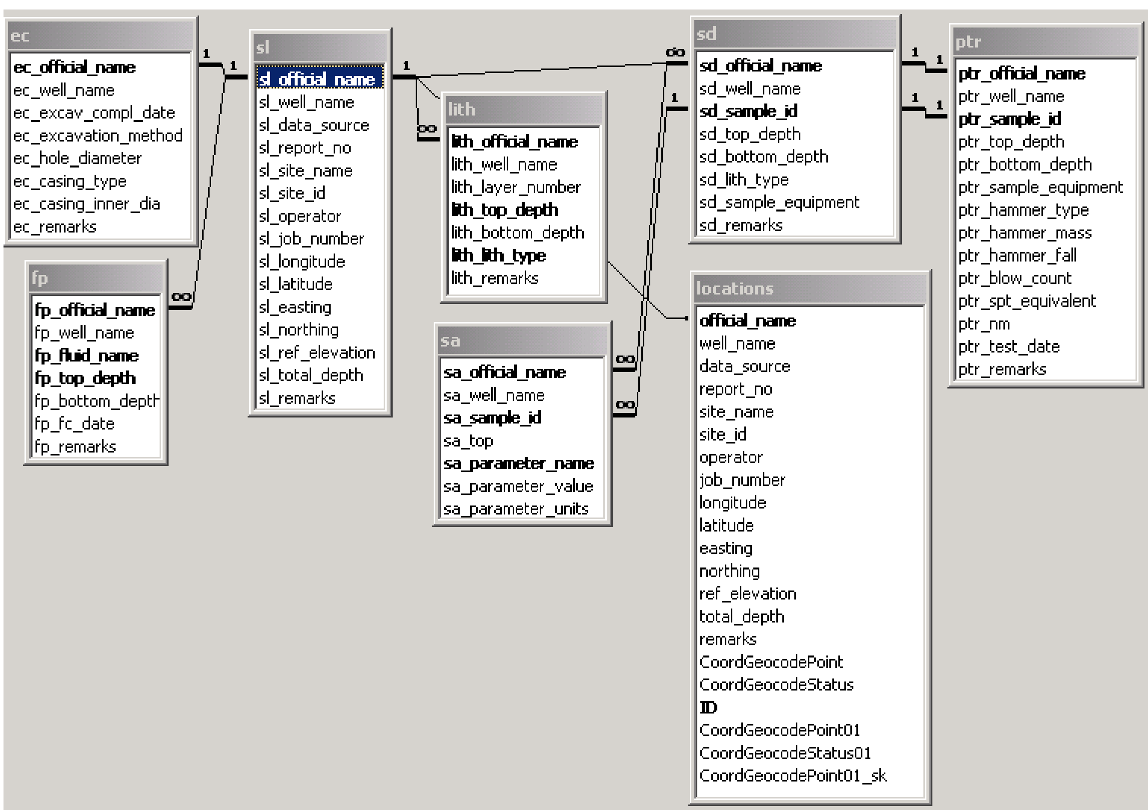


Figure 6. Relationship diagram of native CGS database tables and keys (MS Access). See Table 2 for more information on tables.

Table 2. Geotechnical Information and types of in-situ and laboratory test results included in the CGS borehole data set provided for this project. Corresponding table names (Figure 6) are in parentheses ().

Information Associated with Boreholes in CGS Data Set	
Bulk density (sa)	Percent grains passing #200 sieve (sa)
Coefficient of internal friction (sa)	Percent grains passing #4 sieve (sa)
Cohesion intercept (sa)	Percent grains passing #400 sieve (sa)
Depth to top contact w/fluid (fp)	Permeability (sa)
Dry density (sa)	Plastic limit (sa)
Grain size standard deviation (sa)	Plasticity index (sa)
Kurtosis (sa)	Relative density (sa)
Liquid limit (sa)	Shear strength (sa)
Lithology (lith and sd)	Skewness (sa)
Median grain size (sa)	Specific gravity (sa)
Mode grain size (sa)	SPT (Standard Penetration Tests) (ptr)
Moisture content (%)(sa)	Unit weight (sa)
Percent clay (sa)	Void ratio (sa)
Percent grains passing #10 sieve (sa)	

A generalized illustration of how the CGS data set is integrated with the GVDC is provided in Figure 7.

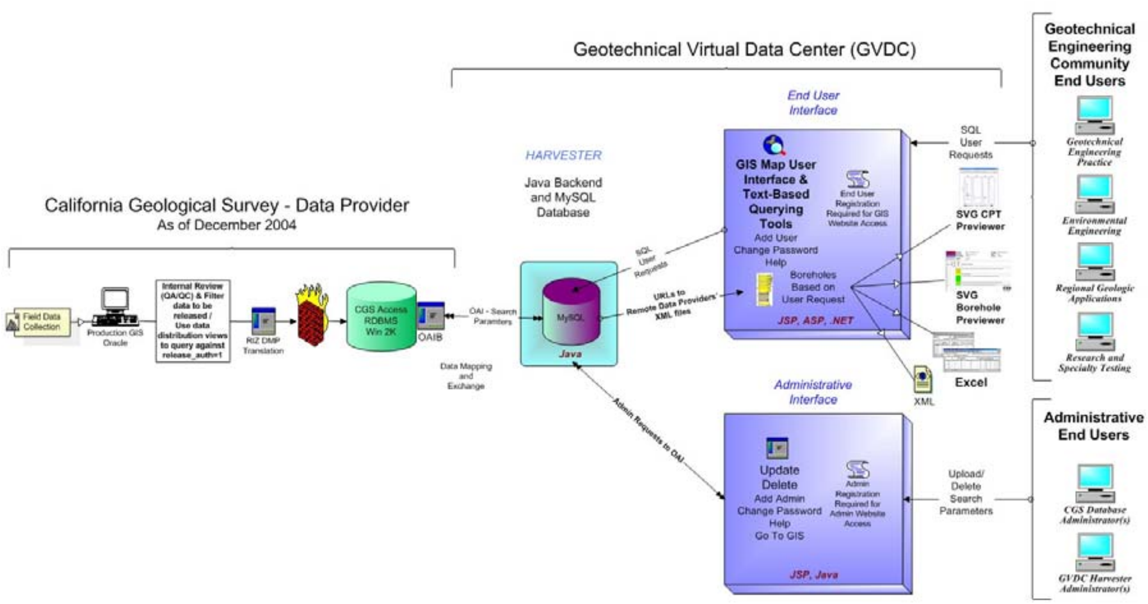


Figure 7. Schematic overview of CGS remote database and GVDC system architecture.

Static VBA XML Translator for Access

Static Visual Basic Applications (VBAs) within the CGS geotechnical Access database directly translate data from the tables into digital XML files. The VBAs reside within the Access database (.mdb file) under "Modules". The newly generated XML files are formatted according to the COSMOS Geotechnical Data XMLSchema (Chapter 3, Benoit et al., this report; see Contact Information: J. Hu). The VBA's perform the following functions:

1) Updates native Access database tables to include information required by the GVDC (see Table 4 for required metadata)
2) Converts geotechnical borehole test data and associated metadata into XML files
3) Stores the XML files' URLs within a table in the Access database
4) Saves the XML files to a permanent directory on a hard drive

Based on the example data set provided by CGS for this project, Table 3 displays the CGS data types that are currently being mapped to the existing XML schema data types (see section "COSMOS/PEER-LL Geotechnical Xml Schema"):

Table 3. Correlation of native CGS database tables (data types) with COSMOS/PEER-LL XML Schema data types. The corresponding GVDC "DataTypes" acronyms (utilized on the GVDC website) are shown in parenthese ().

Native CGS Geotechnical Data -> XMLSchema Data Types
Atterburg Limits (ATL)
Basic Lithology (BLG)
Detailed Lithology (DGC)
Fluid Level, In-Situ Hydologic Test (FLL)
Moisture Content (MSC)
Particle Size Analysis (PSA)
Standard Penetration Tests (SPT)
Unit Weight (UWT)

As new data types are added to the COSMOS geotechnical data dictionary and subsequently to the XML schema, the CGS data mapping can be expanded to include more data types (see Table 2). Thus in the future, more CGS geotechnical data types will be available through the GVDC.

Prior to running the VBA translator, the following attributes were manually added to the CGS Access database table sl (sample location), to enable users to search the GVDC website for CGS geotechnical data:

- start_date: The starting date of the collection activity for a given borehole.
- end_date: The ending date of the collection activity for a given borehole.
- date_last_updated: Date of data entry, or most recent update of exsting record.
- geodetic_datum: The geographic coordinate system used to give the latitude and longitude of the location reference poin. Although this metadata is highly

recommended, it is not necessary in order to comply with the current pilot project data harvesting requirements.
- depth_uom : The unit of measure of the measured depth.

Also, the Data Types for attributes sl.latitude, sl.longitude and sl.depth must be changed to Text. This is an OAIB issue that will be fixed in the next release of OAIB and upgrade of the GVDC system architecture, in early 2005.

Secondly, several tables of project-specific metadata were manually added to the CGS database in order for the data set to be searchable through the GVDC website:

- contact: Equivalent to COSMOS data dictionary table BAssoc. The information about a business associate. The business associate may be a person, company, group, agency, or any other person or collection of persons that is related to the object. This information must be contributed by the CGS database administrator.
- study_type: Equivalent to the static, COSMOS data dictionary refernce table StudyType. Data types and descriptions which are part of the GVDC system.
- study_type_assoc: Data mapping between the native CGS data types and the COSMOS/PEER-LL XML Schema data types (see Table 3). This information must be maintained by the CGS database administrator, with technical oversight.

A simple Access query was designed to support the OAIB installtion on the CGS server (see section "CGS OAIB customization"). This query assimilates all of the data required for the GVDC search webpage. The OAIB Access query includes the following parameters (Table 4):

Table 4. The customized CGS Access query attributes that satisfy the OAIB requirements for metadata harvesting.

Field Name	Data Type	Description
official_name	Text	Table sl – Unique CGS internal ID for each borehole
longitude	Text	Table sl – The longitude of the borehole, given in the Geodetic Datum CRS. Changed from type Number for OAIB.
latitude	Text	Table sl - The latitude of the borehole, given in the Geodetic Datum CRS. Changed from type Number for OAIB.
site_id	Text	Table sl – Unique ID for each site generated by VBA = CGS + - + offical_name – required by OAIB
data_source	Text	Table sl – Name of the original source (agency, institution, etc.) of borehole data.
start_date	Date/Time	Table sl - Starting date of the collection activity for a given borehole. Format: Month/Day/Year.
end_date	Date/Time	Table sl - Ending date of the collection activity for a given borehole. Format: Month/Day/Year.
date_last_updated	Date/Time	Table sl - Date of data entry, or most recent update of

Field Name	Data Type	Description
		exsting record. Format: Month/Day/Year.
site_name	Text	Table sl – CGS internal site names. Null values allowed by CGS. The name of the site of which this borehole is a part. A borehhole must be related to a site.
total_depth	Text	Table sl - Date of data entry, or most recent update of exsting record. Changed from type Number for OAIB.
depth_uom	Text	Table sl - The unit of measure of the measured depth.
xml_name	Text	Table hole_test_assoc – Path + filename of URL for static XML files containing geotechnical test data, generated by custom VBA in database.
id	Text	Table Contact - A code or simple name for the Business Associate. This value is intended to be a foreign key for referencing this data instance.
name	Text	Table Contact - A common name for this Business Associate. This name does not need to be unique within the naming system.
naming_system	Text	Table Contact - A list of names or a method for developing a list of names.
type	Text	Table Contact - The type of Business Associate. This should be one of the following: {company, person, consultant, work group, agency, other}
address_1	Text	Table Contact - The street portion of the address. This may be multiple lines.
city	Text	Table Contact - The name of the city where the Business Associate address is located.
state	Text	Table Contact - The name of the state where the Business Associate address is located.
postal_code	Text	Table Contact - The postal code, appropriate to the given country, where the Business Associate address is located.
country	Text	Table Contact - The name of the country where the Business Associate Address is located.
voice_phone	Text	Table Contact - The voice phone number of the Business Associate.
email	Text	Table Contact - The email address of a Business Associate.
associated_with	Text	Table Contact - The company or group that this Business Associate is associated with. If the Business Associate is an employee, for example, the associate with would be the company which employs her.
ba_contact	Text	Table Contact - A foreign key to another Business Associate who serves as a Business Associate for this Business Associate.
id_key	Text	Table hole_tests – The ID or acronym for the study

Field Name	Data Type	Description
		type. Primary key to table study_type.id.
inquiry	Text	Table hole_tests - Whether or not Data is avalable. See reference table R_Inquiry.name, should be one of the following: {Data Collected - refer to data provider for availability, Data Downloadable, or Data not yet available through VDC}.
Status	Text	Table hole_test_assoc – Status of a record; should be one of the following: {Active (or other similar word indicating that the record is available), or "Deleted"; the latter is required to indicate a record to be deleted from the GVDC}.
sldatelastupdated	Date/Time	Table hole_tests – Same value as date_last_updated. Format: Year-Month-Day. OAIB issue – to be debugged next OAIB release, early 2005.

These parameters are mandatory in the CGS OAIB data configuration file, disussed below in section "CGS OAIB customization". The CGS OAIB data configuration file can be found in the root:\OAIB_Configuration_Files\CGS\-level directory on the report CD.

The VBA source code for the CGS XML translator application are contained in the root:\translators_XML_examples\CGS\-level directory of the report CD. The applications can be summarized as follows:

- <u>Main Program.bas</u>: Calls the hole test compilation and XML translator applications
- <u>Hole Test.bas</u>: Hole test information compilation application. Assembles the different tests performed on each hole into a new hole_test table, required for the website search functionality.
- <u>CGS XML.bas</u>: XML translator application. This application has three basic functions: 1. updates parameters required by the current version of OAIB and GVDC website search criteria, including population of hole_tests and hole_test_assoc tables; 2. converts geotechnical data that has been mapped to the current version of the XML schema into COSMOS XML format; and 3. prompts the user to input a directory for storing the XML files.

Running the VBA application within Access updates the relevant tables within the database and generates and stores the XML files on a user-designated media. The resulting customized, OAIB-compliant CGS Access database is shown in Figure 8. When a new version of the native Access database is generated by the CGS database administrator for use on the CGS production server, the contact, study_type, hole_tests, hole_test_assoc and study_type_assoc tables and the OAIB query can be easily imported from the old database into the new database. The combination of metadata from the pre-exisitng sl table with an updated sl table may require running an append query. All records within tables hole_tests and hole_test_assoc should be deleted, without alteration of the table structures. Lastly, the VBA applications should be imported as-is into the new Access database, and re-run in order to update both the database and the XML files.

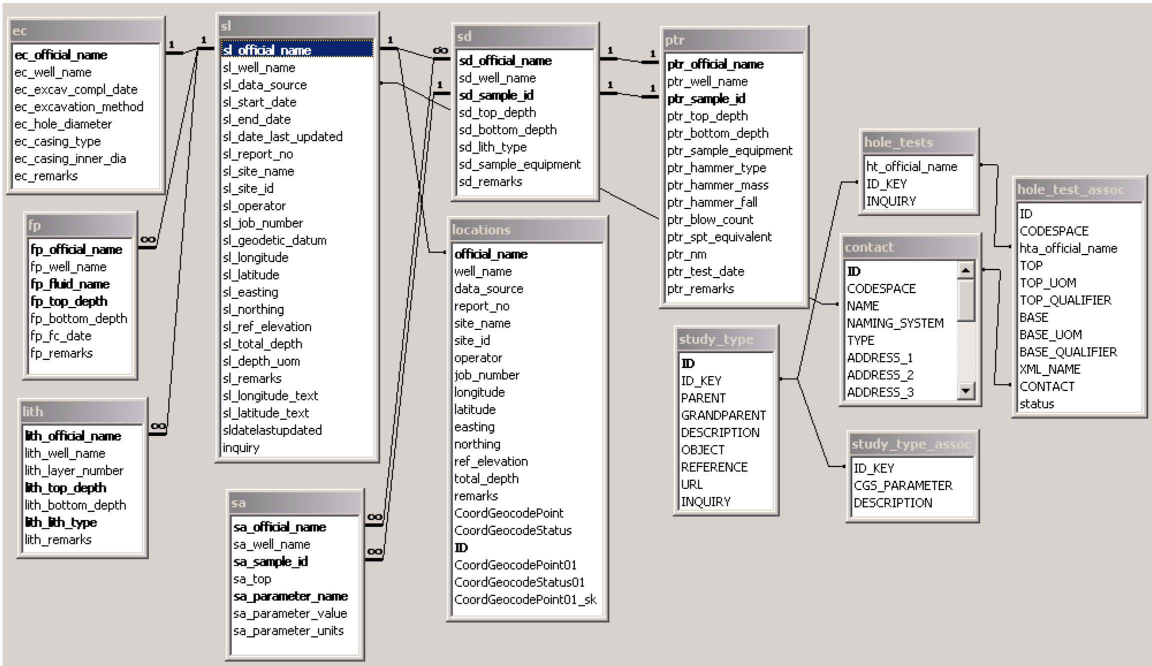


Figure 8. Relationship diagram of customized CGS database tables and keys (MS Access).

The CGS database structure, excluding data, can be found in the root:\Data Sets\CGS\-level directory on the report CD. This OAIB-compliant example database includes the XML translator VBA applications. To obtain a copy of the CGS pilot geotechnical data set as well, please contact CGS directly:

Diane Vaughan , GIS and SHMP Web Manager
California Geological Survey
dvaughah@consrv.ca.gov

Figure 9 shows how the same database structure utilized by the GVDC, could be integrated within the CGS SHMP website. Customization of the GVDC SVG Previewer for Boreholes (see section "SVG Previewer for Borehole") source code would be one method for providing dynamic views of the CGS geotechnical borehole data through the SHMP website, as well as through the GVDC.

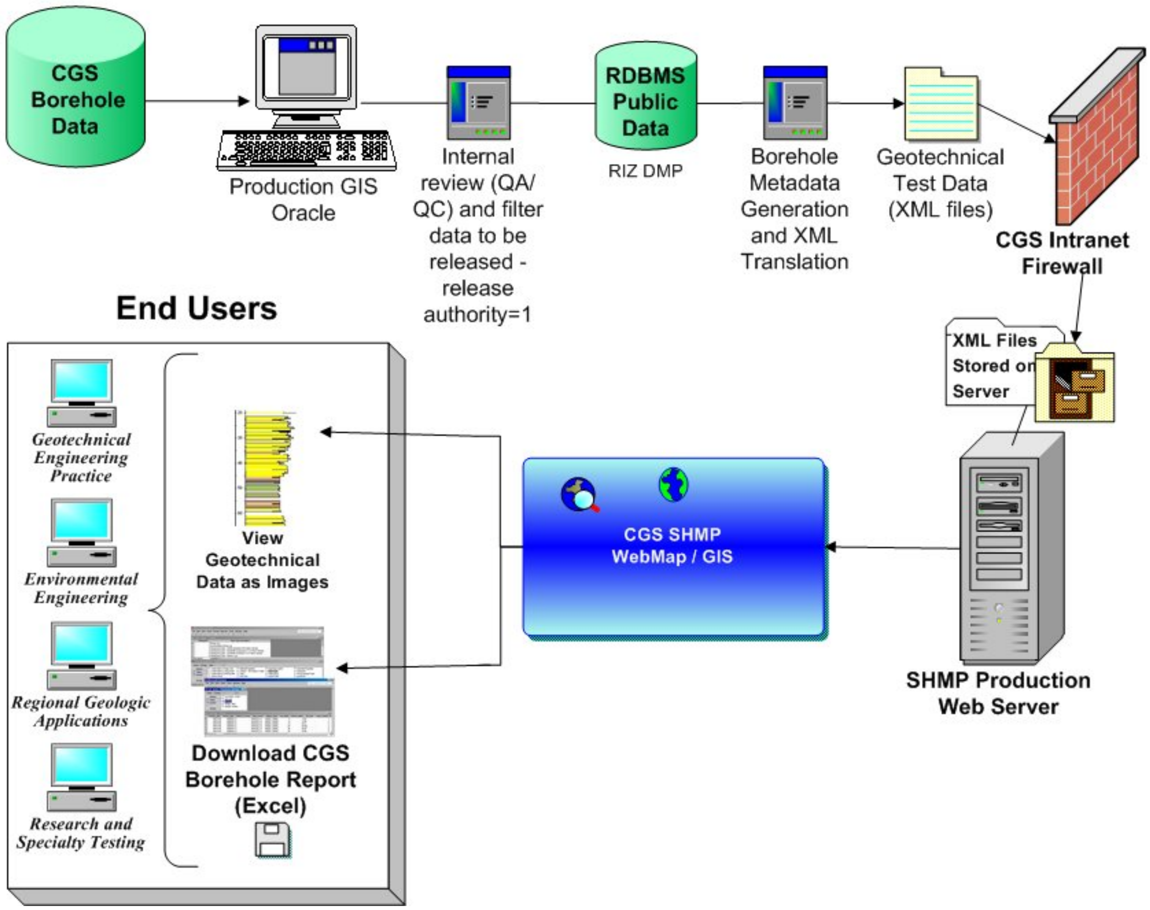


Figure 9. Schematic view of how the CGS database customized to interoperate with the GVDC can be integrated with the SHMP website.

CGS OAIB Customization

OAIB is an application which provides an interface between a JDBC-capable database and an OAI server (NCSA, 2004a; OAI, 2004). The technical details of this application, downloading and installation instructions are provided in sections "OAIB – Open Archives in a Box" and "OAI – Open Archives Initiative". To summarize, the following steps are required in order to install OAIB on the CGS production server:

1) Install Java 2 SDK version 1.4.1_02
2) Install Jakarta Tomcat release 4.1.18
3) Set environment variables for JAVA_HOME and CATALINA_HOME, such as C:\j2sdk1.4.1_02
4) Create a system DSN (ODBC Sytsem Data Source) to the customized Access database, residing on the same server; make sure to use the same name as in the OAIB data configuration file (discussed below)
5) Install OAIB verion 0.7, cocoa.jar file
6) Prepare CGS-data-specific configuration files:
    - OAIB data configuration file; should be placed in: ..\jakarta-tomcat-4.1.18\webapps\oaibdir\WEB-INF\
    - OAI configuration file; should be placed in:

..\jakarta-tomcat-4.1.18\webapps\oaibdir\WEB-INF\classes\

The OAIB-specific configuration files are required on the CGS production server, and should be maintained by the CGS database administrator. The pilot project CGS configuration files provided in the root:\OAIB_Configuration_Files\CGS\-level directory on the report CD are summarized as follows:

- test_oaib_cgs.xml: CGS OAIB data configuration file. Provides data mapping between the JDBC-capable dataset (data providers' customized data sets) and the COSMOS/PEER-LL Geotechnical XML Schema. Make sure that <connection> points to the DSN, and <id-column name="sl_official_name" table="myquery"/> or the name of the OAIB query (discussed above).
- web.xml: OAI configuration file. Identifies the OAI-JDBC interface servlet, OAI server, OAIB data configuration file, and JDBC target class.

Tabe A4 (above) shows the correlation of CGS borehole data to OAIB-compliant metadata (the XML Schema), which satisfies the GVDC front-end website search page requirements. The portion of the OAIB data configuration file (test_oaib_cgs.xml) including the data mapping is as follows:

XML Instance Representation

```
<result>
<md-format namespaceLocation="http://geodata.usc.edu/schema/" prefix="oai_dc"
schemaLocation="http://geodata.usc.edu/schema/
http://geodata.usc.edu/schema/harvester_geotech.xsd">
<geotechData>
<identifier><column name="sl_official_name"/></identifier>
<longitude><column name="sl_longitude"/></longitude>
<latitude><column name="sl_latitude"/></latitude>
<id_key><column name="id_key"/></id_key>
<data_source><column name="sl_data_source"/></data_source>
<start_date><column name="sl_start_date"/></start_date>
<end_date><column name="sl_end_date"/></end_date>
<last_updated><column name="sl_date_last_updated"/></last_updated>
<site_name><column name="sl_site_name"/></site_name>
<depth><column name="sl_total_depth"/></depth>
<depth_uom><column name="sl_depth_uom"/></depth_uom>
<xml_name><column name="xml_name"/>
</xml_name><id2><column name="id"/></id2>
<name><column name="name"/></name>
<naming_system><column name="naming_system"/></naming_system>
<type><column name="type"/></type>
<address_1><column name="address_1"/></address_1>
<city><column name="city"/></city>
<state><column name="state"/></state>
<postal_code><column name="postal_code"/></postal_code>
```

```
<country><column name="country"/></country>
 <voice_phone><column name="voice_phone"/></voice_phone>
 <email><column name="email"/></email>
<associated_with><column name="associated_with"/></associated_with>
<ba_contact><column name="ba_contact"/></ba_contact>
<date><column name="sldatelastupdated"/></date>
<inquiry><column name="inquiry"/></inquiry>
<site_id><column name="sl_site_id"/> </site_id>
<source>delrec=<column name="delrec"/></source>
<sourcename>cgs</sourcename>
</geotechData>
</md-format>
</result>
```


At present, the OAIB application requires that all these fields be filled - none may return a null value. The value of <deleted-column name="delrec"/> should always be maintained, which corresponds to a MySQL data entry and is required by the Java Harvester application. Also it is not recommended to change any tag in the md-format XML. Notice that the last source name is the name of organization (such as CGS, USGS, etc.). If the attribute names are ever changed in the CGS customized database, only the database column names shown in this configuration file should be updated.

Whenever the CGS geotechnical database administrator initiates an update of the CGS data set into the GVDC (see section "Server Side Back End System Architechture"), the GVDC harvester communicates with the OAIB installation on the remote CGS production server. The CGS XML file URL's are harvested concurrently with the other borehole metadata from the customized CGS database utilizing the OAIB query, accoding to the configuration file mapping shown above. The metadata are then stored on the GVDC server in the GVDC MySQL database. When an end user searches the GVDC website, the user only has access to metadata contained in the MySQL database. If the user decides to download specific borehole test data:

1) The user first must agree to CGS data usage and privacy policies, then
2) May download a dynamically zipped file containing the borehole data files they requested, in XML and/or Excel formats

Though the XML files on the remote CGS production server are streamed to the GVDC then zipped on-the-fly for the user, this action is invisible to the end user. The downloading process outlined above is presented in detail in section "Front End Website".

4.1.2 California Department of Transportation (Caltrans)

Caltrans provided a highly detailed pilot data set consiting of geotechnical test information from 50 holes. The natve CPT files are originally generated in the field using a Hogentoggler. The archive at Caltrans now contains a few thousand CPT files, each of which includes data relevant to the particular CPT (Grimes, 2004a). The intention is that the entire archive (not just the 50 example files) will eventually be made available through the GVDC.

Caltrans CPT files are named using a test number and a ".CPD" extension. The files are formatted in plain text. These files are organized in a top-level directory structure according to year and the Caltrans job number. The next level of subdirectories contain the CPT files, and are named in accordance with the Catrans Expenditure Authorization (EA) and job number. Frequently, the location and/or test number is also used to name the subdirectories, in addition to the EA and job number (Figure 10).

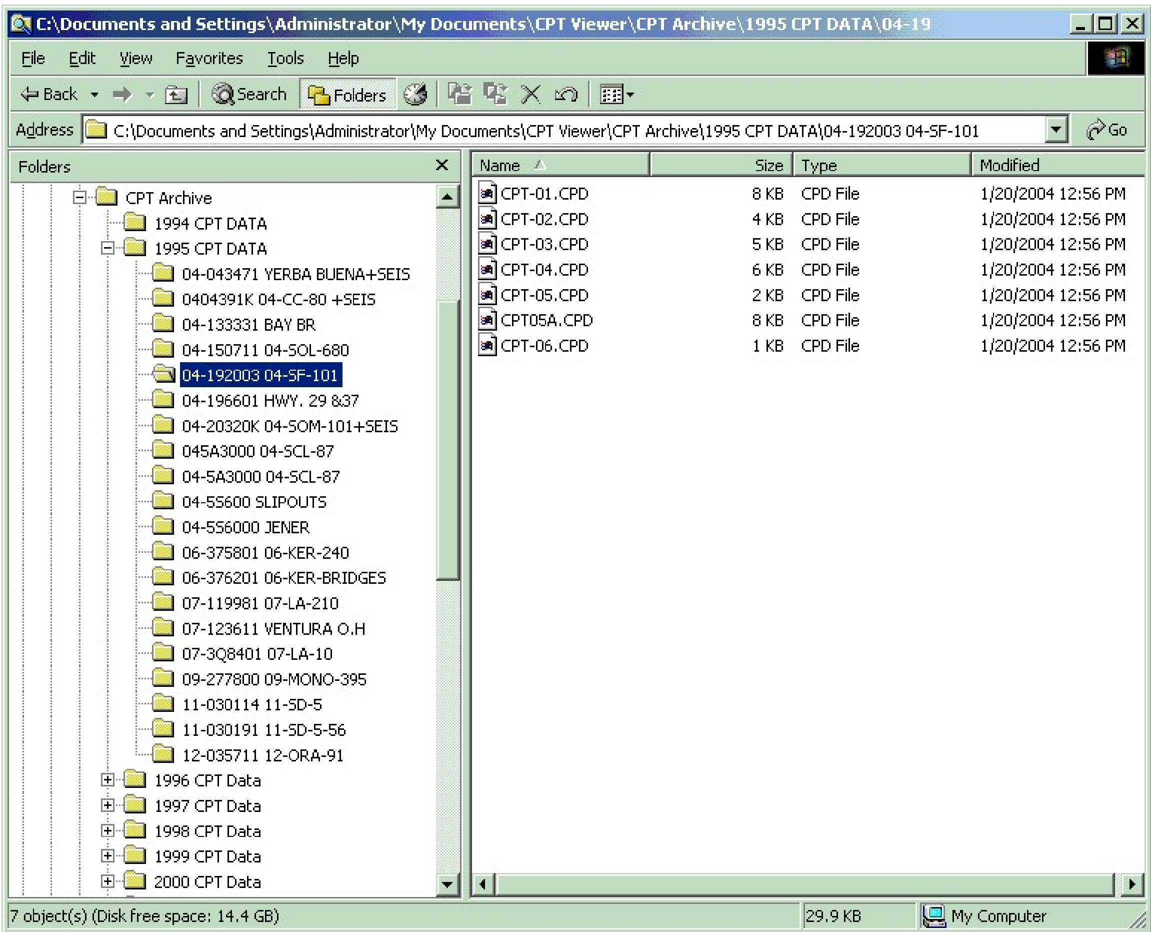


Figure 10. CPT data file archive at Caltrans.

The native tab delimited CPT text files are organized as follows:

The first two rows contain the following metadata:

- Row 1 Text:
  Test number, Date, Time (one field "xx-xxxmm-dd-yy hh:mm")
  Operator(s)

Units of measurement
- Row 2 Text:
  Test number
  Cone tip ID
  EA-job number (xx-xxxxxx)
- Row 2 Numeric:
  Soil behavior rolling avg. interval (# of readings)
  Pore pressure time step
  Active data collection channels

An example of metadata contained in the first two rows of a Caltrans CPT data file:

```
CP96B109-25-96 09:55 R.FITZPATRICK   English
SF BAY BR BNT B 577 T.C.       04-043551       3  3.5  .05  .1  1  2  3  4
```

Following this header section, CPT test information is organized in tab delimited columns as follows:

- Column 1: Depth – Measurement (meters) of the depth reached by the cone tip.
- Column 2: Tip resistance – Measurement (TSF) of resistance against the cone tip.
- Column 3: Sleeve resistance – Measurement (TSF) of resistance against the cone sleeve.
- Column 4 (optional): Pore pressure – Measurement of pore water pressure.
- Column 4/5: Inclination – Measurement (degrees) of how much the cone tip varies from verticle as it is pushed into the soil.

It is important to note that each measurement is recorded at and corresponds to the depth value in the same row.

A complete example of a native Caltrans CPT data file may look like this:

```
CP96B109-25-96 09:55 R.FITZPATRICK   English
SF BAY BR BNT B 577 T.C.       04-043551       3  3.5  .05  .1  1  2  3  4
0.95    38.8   0.440   -0.28    0.16
1.00    28.7   0.265   -0.12    0.16
1.05    21.8   0.164   -0.14    0.17
1.10    14.7   0.049   -0.20    0.16
1.15     8.3  -0.004   -0.22    0.16
```

Caltrans developed their GVDC pilot project geotechnical data set in a Microsoft Access database, specifically for use in this project. Native CPT data files do not include all of the data reuired to complete a useful geotechnical XML file (for CPT tests), nor all of the data necessary to satisfy the GVDC front-end user website search requirments. The missing information includes critical parameters such as latitude and longitude, as well as CPT-test- specific details describing the cone tip used, contact information, etc.

Three tables of project-level and CPT-test-specific metadata were manually added to the Caltrans Access database in order for useful XML files to be generated, and for the data set to be searchable through the GVDC website:

- BAssoc: business associates table; information on the business contact for the CPT tests
- cptDataInfo: CPT data information; data pertaining specifically to the collection method and locality of CPT soundings, and information required by the OAIB for metadata harvesting
- cptParams: CPT parameters; detailed information pertaining to CPT cone tip used during the test

The Caltrans database structure is loosely based on the COSMOS/PEER-LL XML data format (Figure 11). The pilot project Caltrans Access database including example data is provided in the root:\Data Sets\Caltrans\-level directory of the report CD.

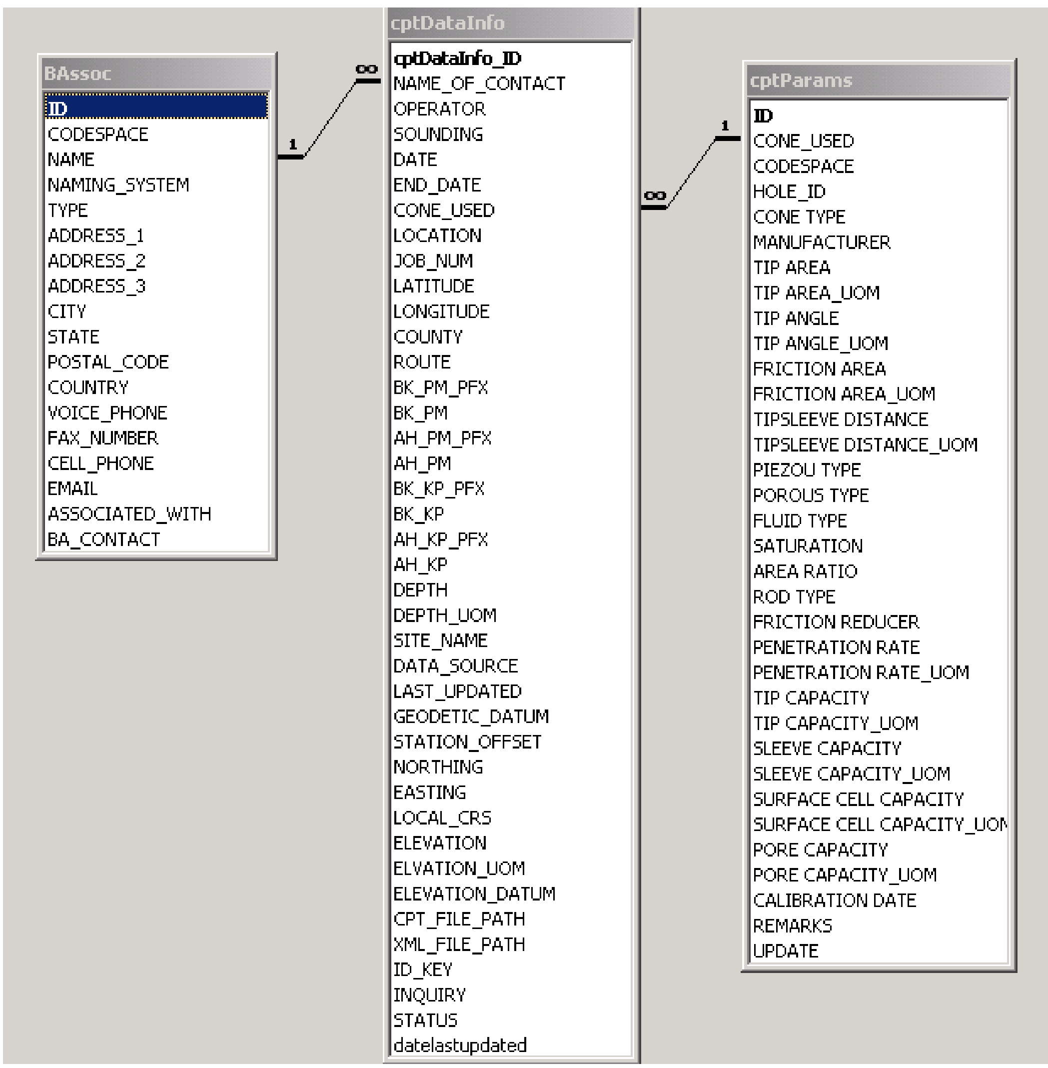


Figure 11. Relationship diagram of Caltrans database tables and keys (MS Access). See Tables 5, 6 and 7 for more information on tables.

The following tables were manually added to the Caltrans Access database, and include the parameters shown in Tables 5, 6 and 7:

Table 5. Caltrans Access database table BAssoc. This table is identical to the BAssoc table described in Chapter 3 (Benoit et al., this report).

Field Name	Data Type	Description
ID	Text	A code or simple name for the Business Associate. This value is intended to be a foreign key for referencing this data instance.
CODESPACE	Text	A value which describes the context for the development of the Id value. The Id is unique within this context.
NAME	Text	A common name for this business associate. This name does not need to be unique within the naming system.
NAMING_SYSTEM	Text	A list of names, or a method for developing a list of names, from which Name is developed.
TYPE	Text	The type of Business Associate. This should be one of the following: {company, person, consultant, work group, agency, other}
ADDRESS_1	Text	The street portion of the address. This may be multiple lines.
ADDRESS_2	Text	Alternate #2 street portion of the address. This may be multiple lines.
ADDRESS_3	Text	Alternate #3 street portion of the address. This may be multiple lines.
CITY	Text	The name of the city where the Business Associate address is located.
STATE	Text	The name of the state where the Business Associate address is located.
POSTAL_CODE	Text	The postal code, appropriate to the given country, where the Business Associate address is located.
COUNTRY	Text	The name of the country where the Business Associate Address is located.
VOICE_PHONE	Text	The phone number of the Business Associate. The phone number is qualified by the type of phone number (eg, fax, voice, voice mail, mobile) and the nature (business or personal)
FAX_NUMBER	Text	The fax number of the Business Associate. The phone number is qualified by the type of phone number (eg, fax, voice, voice mail, mobile) and

Field Name	Data Type	Description
		the nature (business or personal)
CELL_PHONE	Text	The cell phone number of the Business Associate. The phone number is qualified by the type of phone number (eg, fax, voice, voice mail, mobile) and the nature (business or personal)
EMAIL	Text	The email address of a Business Associate.
ASSOCIATED_WITH	Text	The company or group that this Business Associate is associated with. This is a foreign key to another instance of business associate. It is not required that the other instance be instantiated.
BA_CONTACT	Text	A foreign key to another Business Associate who serves as a contact for this Business Associate.

Table 6. . Caltrans Access database table cptDataInfo.

Field Name	Data Type	Description
cptDataInfo_ID	Text	A code or simple name for the CPT Data set. This value is intended to be a foreign key for referencing this data instance.
NAME_OF_CONTACT	Text	The business associate to which inquiries about this Hole Data may be addressed.
OPERATOR	Text	The business associate that executed the cone penetration test.
SOUNDING	Text	A site specific describing the location of the cone penetration test.
DATE	Text	The date that the cone penetration test was taken.
END_DATE	Text	
CONE_USED	Text	The type of cone penetrometer used for testing; a) mechanical cone, b) electric cone, c) piezocone, d) seismic piezocone, e) lateral stress cone, f) dynamic cone, g) acoustic cone, h) resistivity cone, i) vibratory cone, j) miniature cone, or k) other
LOCATION	Text	The job location.
JOB_NUM	Text	The job EA number.
LATITUDE	Number	Decimal latitude value.
LONGITUDE	Number	Decimal longitude value.
COUNTY	Text	The county in which the cone penetration test was taken.

Field Name	Data Type	Description
ROUTE	Number	The route or highway along which the cone penetration test was taken.
BK_PM_PFX	Text	Beginning post mile prefix.
BK_PM	Number	Beginning post mile.
AH_PM_PFX	Text	Ending post mile prefix.
AH_PM	Number	Ending post mile.
BK_KP_PFX	Text	Beginning kilopost prefix.
BK_KP	Number	Beginning kilopost.
AH_KP_PFX	Text	Ending kilopost prefix.
AH_KP	Number	Ending kilopost.
DEPTH	Number	The maximum hole depth for the cone penetration test.
DEPTH_UOM	Text	The Unit of Measure of the depth.
SITE_NAME	Text	A common name for the Site. This name does not need to be unique within the naming system.
DATA_SOURCE	Text	The name of the original source of data obtained for this Site. This could be the data provider itself, or another business associate that released the information to the data provider. This is intended to be a foreign key to a possible database entry.
LAST_UPDATED	Text	Date of data entry, or most recent update of exsting record.
GEODETIC_DATUM	Text	The geographic coordinate reference system (CRS) used to give the latitude and longitude of the location reference point.
STATION_OFFSET	Text	
NORTHING	Text	Distance northward from any point of departure or of reckoning, measured on a meridian.
EASTING	Text	The difference in longitude between two positions as a result of movement to the east.
LOCAL_CRS	Number	A description of the local coordinate system which applies to local x,y coordinates. This is expected to be a foreign key to an instance, however there is no requirement that the instance exist.
ELEVATION	Text	Elevation of the hole at the depth datum. Elevations are positive upward, measured from the elevation datum.
ELEVATION_UOM	Text	The Unit of Measure of the elevation.

Field Name	Data Type	Description
ELEVATION_DATUM	Text	The name of the elevation datum. Enter Mean Sea.
CPT_FILE_PATH	Memo	An absolute file path to a Hogentoggler generated .CPD file which, contains CPT data.
XML_FILE_PATH	Memo	An absolute file path to the xml file containing CPT data.
ID_KEY	Text	3 letter key for Test type (i.e. CPT)
INQUIRY	Memo	Whether or not Data is avalable. See R_Inquiry {One of the following: The the data was collected and is available; The data was collected but is not available for download, user should refer to contact information; Data not yet available through VDC.
STATUS	Text	***for deleted records
Datelastupdated	Text	***for harvester (temporary bug to be fixed) - extra format .e. 2002-03-14

Field Name	Data Type	Description
ID	Text	A code or simple name for Cone Penetration Test Parameters. This value is intended to be a foreign key for referencing this data instance.
CONE_USED	Text	A value describing which cone penetrometer was used for testing.
CODESPACE	Text	A value that describes the context for the development of the Id value. The Id is unique within this context.
HOLE_ID	Text	The hole, of which these CPT parameters are a part. The CPT parameters must be related to a hole. This value is a foreign key that should select an instance of Hole based on the Id value of the Hole.
CONE TYPE	Text	Type of cone penetrometer used for testing; a) mechanical cone, b) electric cone, c) piezocone, d) seismic piezocone, e) lateral stress cone, f) dynamic cone, g) acoustic cone, h) resistivity cone, i) vibratory cone, j) miniature cone, or k) other.

Field Name	Data Type	Description
MANUFACTURER	Text	The business name of the company manucturing the cone penetrometer. For example, Fugro, Hogentogler, Delft, etc.
TIP AREA	Number	The conical base area of the penetrometer tip. Typical values are 10 cm2 and 15 cm 2
TIP AREA_UOM	Text	Tip Area Unit of Measure
TIP ANGLE	Number	The apex angle of the conical point of the penetrometer tip. The standard value is 60 degrees.
TIP ANGLE_UOM	Text	Tip Angle Unit of Measure
FRICTION AREA	Number	The surface area of the friction sleeve located immediately behind the penetrometer tip. Typical values are 150 cm2 for the 10 cm2 and 200 cm2 for the 15 cm2.
FRICTION AREA_UOM	Text	Friction Area Unit of Measure
TIPSLEEVE DISTANCE	Number	The distance between the tip and the center of the friction sleeve.
TIPSLEEVE DISTANCE_UOM	Text	Tip Sleeve Distance Unit of Measure
PIEZOU TYPE	Text	The type of Piezocone is defined in part by the position of the filter element. The types in use: a) Type 1 (on the tip apex or at the midface on the tip), b) Type 2 (at the shoulder or behind the tip), c) Type 3 (above the friction sleeve), or d) other.
POROUS TYPE	Text	The type of material used as porous filter element. The following materials are typically used: a) plastic, b) sintered bronze, c) sintered steel, d) ceramic, or e) other.
FLUID TYPE	Text	The fluid used to saturate the porous filter element. The following deaired fluids are typically used: a) water, b) glycerin, c) silicon oil, or d) other.
SATURATION	Text	A description of the procedure used to saturate the porous filter element.
AREA RATIO	Number	Correction to adjust the penetration cone resistance due to penetration water pressures acting behind cone tip. Net area ratio correction, a, is applied to the cone resistance qc which becomes the corrected total cone resistance qt. a is dimensionless.

Field Name	Data Type	Description
ROD TYPE	Text	The type of pushing rods used for CPT penetration. Standard nomenclature can be used such as A-rod or N-rod.
FRICTION REDUCER	Text	A description of the type, size and location of the friction reducer behind the base of the cone should be reported if used.
PENETRATION RATE	Number	The rate of advance of the penetrometer. Rate should be between 20 +/- 5 mm/second.
PENETRATION RATE_UOM	Text	Penetration Rate Unit of Measure
TIP CAPACITY	Number	The capacity of the tip load cell.
TIP CAPACITY_UOM	Text	Tip Capacity Unit of Measure
SLEEVE CAPACITY	Number	The capacity of the sleeve load cell.
SLEEVE CAPACITY_UOM	Text	Sleeve Capacity Unit of Measure
SURFACE CELL CAPACITY	Number	The capacity of the surface load cell.
SURFACE CELL CAPACITY_UOM	Text	Suface Cell Capacity Unit of Measure
PORE CAPACITY	Number	The capacity of the pore pressure load cell.
PORE CAPACITY_UOM	Text	Pore Capacity Unit of Measure
CALIBRATION DATE	Date/Time	The date of the last calibration of the penetrometer. Specify which components were calibrated.
REMARKS	Text	A text descriptor providing additional information relevant to the CPT parameters and equipment especially if those differ from standard requirements.
UPDATE	Date/Time	The date of the last update to the data in this table.

Table 7. Caltrans Access database table cptParams.

A generalized illustration of how the Caltrans data set is integrated with the GVDC is provided in Figure 12.

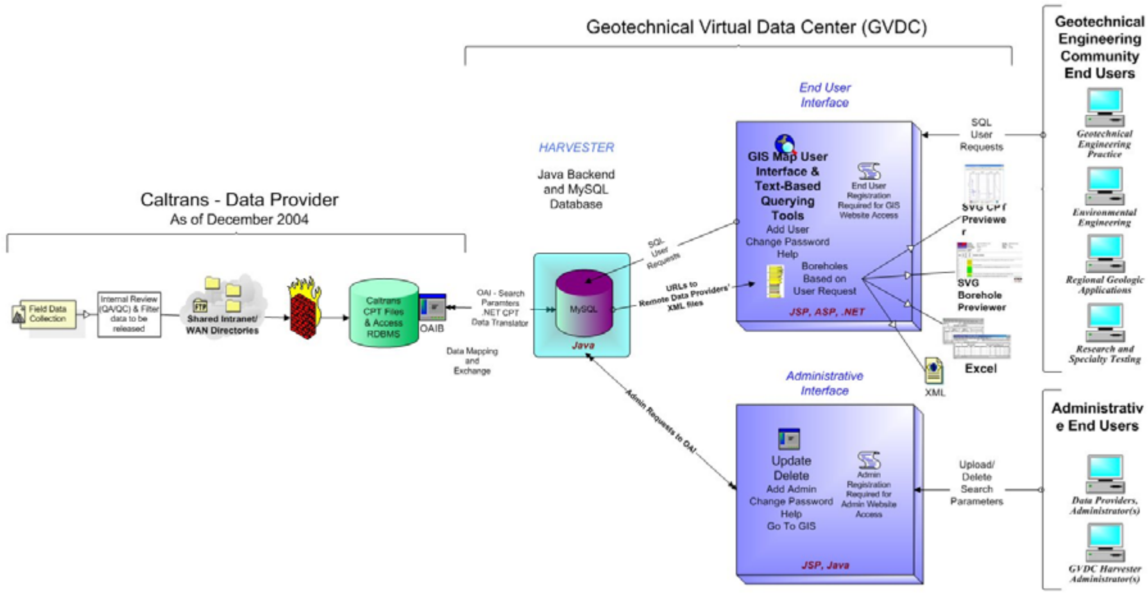


Figure 12. Schematic overview of Caltrans remote database and GVDC system architecture.

<u>Static VB.NET Translator for CPT data</u>

The Caltrans experience in complying with the GVDC requirments is provided as a rough guideline for converting geotechnical ACII text data files to XML (Grimes, 2004a). The process outlined herein is specific to Caltrans, where native CPT files (Hogentogler) are converted into COSMOS/PEER-LL geotechnical XML schema-complinat XML files. The 50 example XML files used in the GVDC pilot project are provided in the root:\Previewer_Applications\CPTLog\Caltrans\XML2SVG\LAData\-level directory of the report CD. The Caltrans VB.NET translator source code and example input files can be obtained by contacting Caltrans:

Loren Turner, Chief of Geotechnology Implementation Branch
Division of Research & Innovation, Caltrans
5900 Folsom Blvd.MS-5, Sacramento, CA 95819
Email: Loren_Turner@dot.ca.gov

An ASP.NET translator was developed at Caltrans using VB.NET, to convert native CPT data files into valid XML (Grimes, 2004a; see Contact Information: Paul Grimes). The ASP.NET application processes each CPT file individually,and each file in sequence within each CPT archive directory. The translator requires data from both the native CPT files and from the Caltrans Access database. The database is also updated during the process of generating the Caltrans CPT XML files.

At the beginning of the conversion process, the ASP.NET application retrives the parameter representing the physical file path of the plain text CPT file (cptDataInfo.cptFilePath). This is an absolute file path to the native Hogentoggler generated .CPD file. A dataset is generated containing data from the database related to the indicated CPT file path. The following ia a snippet of this VB.NET code:

```
Dim connString As String = + _ "Provider=Microsoft.Jet.OLEDB.4.0;data” + _
“source=G:\WebServer\cpthandler\database\cptDataInfo.mdb"
Dim cn As New OleDbConnection(connString)
Dim myWebClient As New System.Net.WebClient()
Dim strSQL As String = "SELECT * FROM cptDataInfo WHERE”
+_"CPT_FILE_PATH = = "" +-& cptFilePath & ""
Dim cmd As New OleDbCommand(strSQL, cn)
Dim da As New OleDbDataAdapter(cmd)
Dim ds As New DataSet()
da.Fill(ds)
```

The data is retrieved and stored in variables (cptDataInfo.cptLatitude, cptDataInfo.cptLongitude, etc.). The file obtained from variable cptDataInfo.cptFilePath is then opened using VB.NET’s “StreamReader” class. This VB.NET code is as follows:

```
Dim oStreamRead As StreamRead
oStreamRead = File.OpenText(cptFilePath)
```

Using the available VB.NET StreamReader functions, data from native CPT files is parsed and stored in fields (cptDataInfo.cptDate, cptDataInfo.cptJobNum, cptDataInfo.cptOperator, etc.) in the Caltrans Access database.

Once all required data has been retrieved from the native CPT file and the Caltrans Access database, the construction of an XML file is initiated. The translator application uses VB.NET’s StreamWrite class to generate XML files. In order to create the XML file, a URL or path is required. The application creates a subdirectory named “xml” in the same directory as that of the native CPT file being processed, and saves the XML file in that \xml\ directory. To summarize:

1) An XML file is generated in the desired location:

```
oStreamWrite = File.CreateText(cptFilePath & +_"\xml\" & cptSounding &
".xml")
```

2) The XML file contents are written to the newly created file one line at a time:

```
oStreamWrite.WriteLine("<?xml version=""1.0""?>")
oStreamWrite.WriteLine("")
oStreamWrite.WriteLine("<GeotechnicalData”+_
    “xmlns=""http://www.cosmos.org/v10"" +_
    “ xmlns:xsi=""http://www.w3.org/2001/XMLSchema-instance""")
oStreamWrite.WriteLine("xsi:schemaLocation=" +_
    " ../../x3sp/cosmos/SatelliteSchema.xsd"">")
```

```
''variable values are entered into the XML structure
oStreamWrite.WriteLine("<SiteID>Caltrans_" & cptJobNum & +_"_
    "_"   & cptLocation & "</SiteID>")
oStreamWrite.WriteLine("<Type>test/exploratory boring</Type>")
oStreamWrite.WriteLine("<Driller>" & cptOperator & "</Driller>")
oStreamWrite.WriteLine("<Logger>" & cptOperator & "</Logger>")
'End XML
oStreamWrite.WriteLine("</GeotechnicalData>")
```

3) The XML file is saved/closed:

```
oStreamWrite.Close()
oStreamWrite = Nothing
```

The ASP.NET translator application source code is available in the root:\Data Sets\CGS\-level directory on the report CD, and can be viewed by opening "cptToXML.aspx.vb" with Visual Studio .NET or with notepad.

Caltrans OAIB Customization

Since the Caltrans remote OAIB installation is integrated with an Access database, the Caltrans customization is nearly identical to the CGS implementation. Nevertheless, for the sake of completeness, the details specific to Caltrans OAIB integration are reported herein. To summarize, the following steps are required in order to install OAIB on the Caltrans production server:

1) Install Java 2 SDK version 1.4.1_02
2) Install Jakarta Tomcat release 4.1.18
3) Set environment variables for JAVA_HOME and CATALINA_HOME, such as C:\j2sdk1.4.1_02
4) Create a system DSN (ODBC Sytsem Data Source) to the customized Access database, residing on the same server; make sure to use the same name as in the OAIB data configuration file (discussed below)
5) Install OAIB verion 0.7, cocoa.jar file
6) Prepare Caltrans-data-specific configuration files:
    - OAIB data configuration file; should be placed in: ..\jakarta-tomcat-4.1.18\webapps\oaibdir\WEB-INF\
    - OAI configuration file; should be placed in: ..\jakarta-tomcat-4.1.18\webapps\oaibdir\WEB-INF\classes\

The OAIB-specific configuration files are required on the Caltrans production server, and should be maintained by the Caltrans database administrator. The pilot project Caltrans configuration files provided in the root:\OAIB_Configuration_Files\Caltrans\-level directory on the report CD are summarized as follows:

- test_oaib_caltrans.xml: Caltrans OAIB data configuration file. Provides data mapping between the JDBC-capable dataset (data providers' customized data sets) and the COSMOS/PEER-LL Geotechnical XML Schema. Make sure that <connection> points to the DSN, and <id-column name="sl_official_name" table="myquery"/> or the name of the OAIB query (discussed below).

- web.xml: OAI configuration file. Identifies the OAI-JDBC interface servlet, OAI server, OAIB data configuration file, and JDBC target class.

A simple Access query was designed to support the OAIB installtion on the Caltrans server. This query assimilates all of the data required for the GVDC search webpage. The OAIB Access query includes the parameters shown in Table 8:

Field Name	Data Type	Description
CPTDATAINFO_ID	Text	Table cptDataInfo – A code or simple name for the CPT Data set. This value is intended to be a foreign key for referencing this data instance.
LONGITUDE	Text	Table cptDataInfo – Decimal longitude value.
LATITUDE	Text	Table cptDataInfo - Decimal latitude value.
DATA_SOURCE	Text	Table cptDataInfo – The name of the original source of data obtained for this Site. This could be the data provider itself, or another business associate that released the information to the data provider. This is intended to be a foreign key to a possible database entry.
DATE	Date/Time	Table cptDataInfo - The date that the cone penetration test was taken. Format: Month/Day/Year.
END_DATE	Date/Time	Table cptDataInfo - Ending date of the collection activity for a given borehole. Format: Month/Day/Year.
LAST_UPDATED	Date/Time	Table cptDataInfo - Date of data entry, or most recent update of exsting record. Format: Month/Day/Year.
SITE_NAME	Text	Table cptDataInfo – A common name for the Site. This name does not need to be unique within the naming system.
DEPTH	Number	Table cptDataInfo - The maximum hole depth for the cone penetration test.
DEPTH_UOM	Text	Table cptDataInfo - The unit of measure of the measured depth.
XML_FILE_PATH	Text	Table hole_test_assoc – An absolute file path to the xml file containing CPT data.
ID	Text	Table BAssoc - A code or simple name for the Business Associate. This value is intended to be a foreign key for referencing this data instance.
NAME	Text	Table BAssoc - A common name for this

Field Name	Data Type	Description
		Business Associate. This name does not need to be unique within the naming system.
NAMING_SYSTEM	Text	Table BAssoc - A list of names or a method for developing a list of names.
TYPE	Text	Table BAssoc - The type of Business Associate. This should be one of the following: {company, person, consultant, work group, agency, other}
ADDRESS_1	Text	Table BAssoc - The street portion of the address. This may be multiple lines.
CITY	Text	Table BAssoc - The name of the city where the Business Associate address is located.
STATE	Text	Table BAssoc - The name of the state where the Business Associate address is located.
POSTAL_CODE	Text	Table BAssoc - The postal code, appropriate to the given country, where the Business Associate address is located.
COUNTRY	Text	Table BAssoc - The name of the country where the Business Associate Address is located.
VOICE_PHONE	Text	Table BAssoc - The voice phone number of the Business Associate.
EMAIL	Text	Table BAssoc - The email address of a Business Associate.
ASSOCIATED_WITH	Text	Table BAssoc - The company or group that this Business Associate is associated with. If the Business Associate is an employee, for example, the associate with would be the company which employs her.
BA_CONTACT	Text	Table BAssoc - A foreign key to another Business Associate who serves as a Business Associate for this Business Associate.
ID_KEY	Text	Table cptDataInfo – 3 letter key fro Test type (i.e. CPT).
INQUIRY	Text	Table cptDataInfo - Whether or not Data is avalable. See reference table R_Inquiry.name, should be one of the following: {Data Collected - refer to data provider for availability, Data Downloadable, or Data not yet available through VDC}.
STATUS	Text	Table cptDataInfo - Status of a record; should be one of the following: {Active (or other similar word indicating that the record is available), or "Deleted"; the latter is required to indicate a record to be deleted from the

Field Name	Data Type	Description
		GVDC}.
DATELASTUPDATED	Date/Time	Table hole_tests – Same value as date_last_updated. Format: Year-Month-Day. OAIB issue – to be debugged next OAIB release, early 2005.
LOCATION	Text	The job location.

Table 8. The Caltrans Access query attributes that satisfy the OAIB requirements for metadata harvesting.

Tabe A8 shows the correlation of Caltrans borehole data to OAIB-compliant metadata (the XML Schema), which satisfies the GVDC front-end website search page requirements. The portion of the OAIB data configuration file (test_oaib_caltrans.xml) that includes the data mapping is as follows:

<u>XML Instance Representation</u>

```
<result>
<md-format namespaceLocation="http://geodata.usc.edu/schema/" prefix="oai_dc"
schemaLocation="http://geodata.usc.edu/schema/
http://geodata.usc.edu/schema/harvester_geotech.xsd">
<geotechData>
<identifier><column name="cptDataInfo_ID"/></identifier>
<longitude><column name="latitude"/></longitude>
<latitude><column name="latitude"/></latitude>
<id_key><column name="id_key"/></id_key>
<data_source><column name="data_source"/></data_source>
<start_date><column name="date"/></start_date>
<end_date><column name=" end_date"/></end_date>
<last_updated><column name=" last_updated"/></last_updated>
<site_name><column name="site_name"/></site_name>
<depth><column name="depth"/></depth>
<depth_uom><column name=" depth_uom"/></depth_uom>
<xml_name><column name="xml_file_path"/>
</xml_name><id2><column name="id"/></id2>
<name><column name="name"/></name>
<naming_system><column name="naming_system"/></naming_system>
<type><column name="type"/></type>
<address_1><column name="address_1"/></address_1>
<city><column name="city"/></city>
<state><column name="state"/></state>
<postal_code><column name="postal_code"/></postal_code>
<country><column name="country"/></country>
 <voice_phone><column name="voice_phone"/></voice_phone>
 <email><column name="email"/></email>
<associated_with><column name="associated_with"/></associated_with>
```

```
<ba_contact><column name="ba_contact"/></ba_contact>
<date><column name="datelastupdated"/></date>
<inquiry><column name="inquiry"/></inquiry>
<site_id><column name="location"/> </site_id>
<source>delrec=<column name="delrec"/></source>
<sourcename>Caltrans</sourcename>
</geotechData>
</md-format>
</result>
```

At present, the OAIB application requires that all these fields be filled - none may return a null value. The value of <deleted-column name="delrec"/> should always be maintained, which corresponds to a MySQL data entry and is required by the Java Harvester application. Also it is not recommended to change any tag in the md-format XML. Notice that the last source name is the name of organization (such as CGS, USGS, etc.). If the attribute names are ever changed in the Caltrans database, only the database column names shown in this configuration file should be updated.

Whenever the Caltrans geotechnical database administrator initiates an update of the Caltrans data set into the GVDC (see section “Server Side Back End System Architechture”), the GVDC harvester communicates with the OAIB installation on the remote Caltrans production server. The Caltrans XML file URL’s are harvested concurrently with the other borehole metadata from the customized Caltrans database utilizing the OAIB query, accoding to the configuration file mapping shown above. The metadata are then stored on the GVDC server in the GVDC MySQL database. When an end user searches the GVDC website, the user only has access to metadata contained in the MySQL database. If the user decides to download specific borehole test data:

1) The user first must agree to Caltrans data usage and privacy policies, then
2) May download a dynamically zipped file containing the borehole data files they requested, in XML and/or Excel formats

Though the XML files on the remote Caltrans production server are streamed to the GVDC then zipped on-the-fly for the user, this action is invisible to the end user. The downloading process outlined above is presented in detail in section “Front End Website”.

4.1.3 United States Geological Survey (USGS)

The USGS became interested in participating in this project as a way to help support geologic and ground water modeling projects being conducted by USGS in the Los Angeles region (Ponti, 2004). The USGS currently maintains their own repository for detailed core and pore fluid chemical analyses conducted by USGS, using an in-house developed FileMaker-based core logging system. The project participants desired to support development of centralized access to a broad range of subsurface information from various sources.

The USGS participated as a data provider, first by implementing a new PostgreSQL database engine with geospatial extensions (PostGIS, Proj4 libraries) to collate and maintain their FOQUS LA project data. The USGS now maintains searchable geotechnical parameters in a PostgreSQL database (PostgreSQL, 2004).

The USGS PostgreSQL Database currently contains 8126 holes at 8089 sites. The Site Types include Water wells (6705), Oil wells (955), and Geotechnical (427) sites. This data has been released to the GVDC pilot project, and is now available online. This data set consists of 1478 holes, including USGS water wells, LACDPW barrier wells, and MetroRail geotechnical borings. The information in the database consists of hole metadata and geologic (Layer and Component) and moisture content data.

Some general issues that the USGS database developers faced in supporting GVDC access to their PostgreSQL database include the following:

- Data:
    - Dynamic content; At what point is data releasable?
    - Proprietary content
    - Release/review requirements
- Security
- Development and Maintenance Support
    - Little or no modifications were required to the existing database schema to enable GVDC access to the database
    - There are no specific maintenance requirements to support GVDC access

For the USGS and other agencies to participate in the GVDC, the GVDC system architechture needs to be able to adequately meet agency needs regarding minimal alteration of existing database schema, security and access requirements, and ease of maintenance. There is a fair amount of up-front labor costs to support the GVDC, though these are dominantly one-time expenditures. It is unknown what kind of a future effort will be required to maintain the XML translator (discussed below) as the XML schema and database both evolve.

Dynamic Java XML Translator for PostgreSQL

The USGS Translator consists of a Java application which must be installed as part of the GVDC system architecture (Devlin, 2004; Ponti, 2004). This Translator converts PostgreSQL borehole database records into valid XML on-the-fly, in a HTTP request/response environment (Figure 13). The XML Translator allows live generation of XML at the user's request to ensure delivery of "latest" data. The use of a "dynamic" translator eliminates need for manual update of xml files. The translator exists as a Java servlet that runs on the GVDC server, and allows for extraction of data without direct access by user's computers to the database.

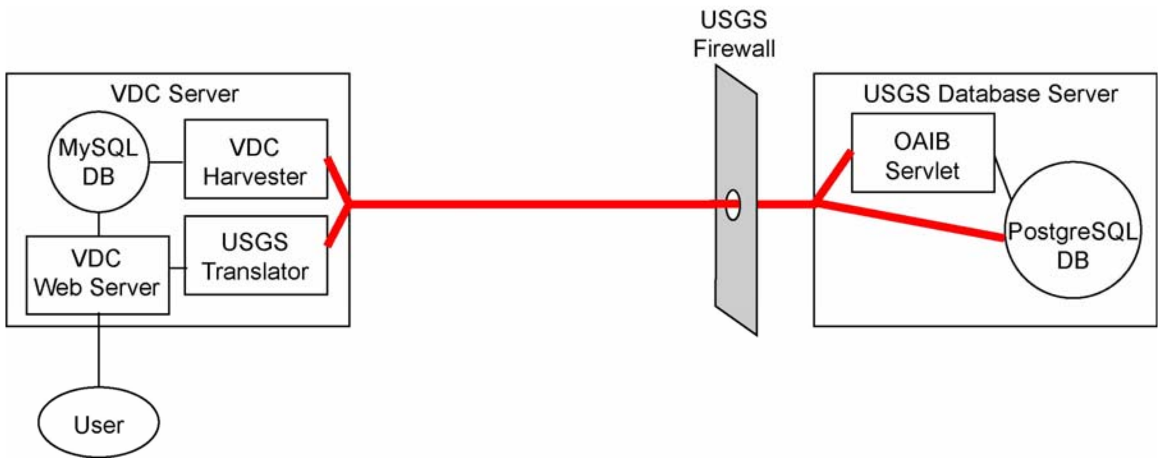


Figure 13. Schematic diagram of USGS PostgreSQL database, the USGS dynamic XML translator, and the GVDC system architecture (left).

Please see section "Dynamic XML Translation" under "Server Side Back End System Architecture" for further details.

OAIB Customization

OAIB was installed on the USGS server maintaining the PostgreSQL database. A summary of the GVDC access requirements are presented in Figure 14, 15 and 16.

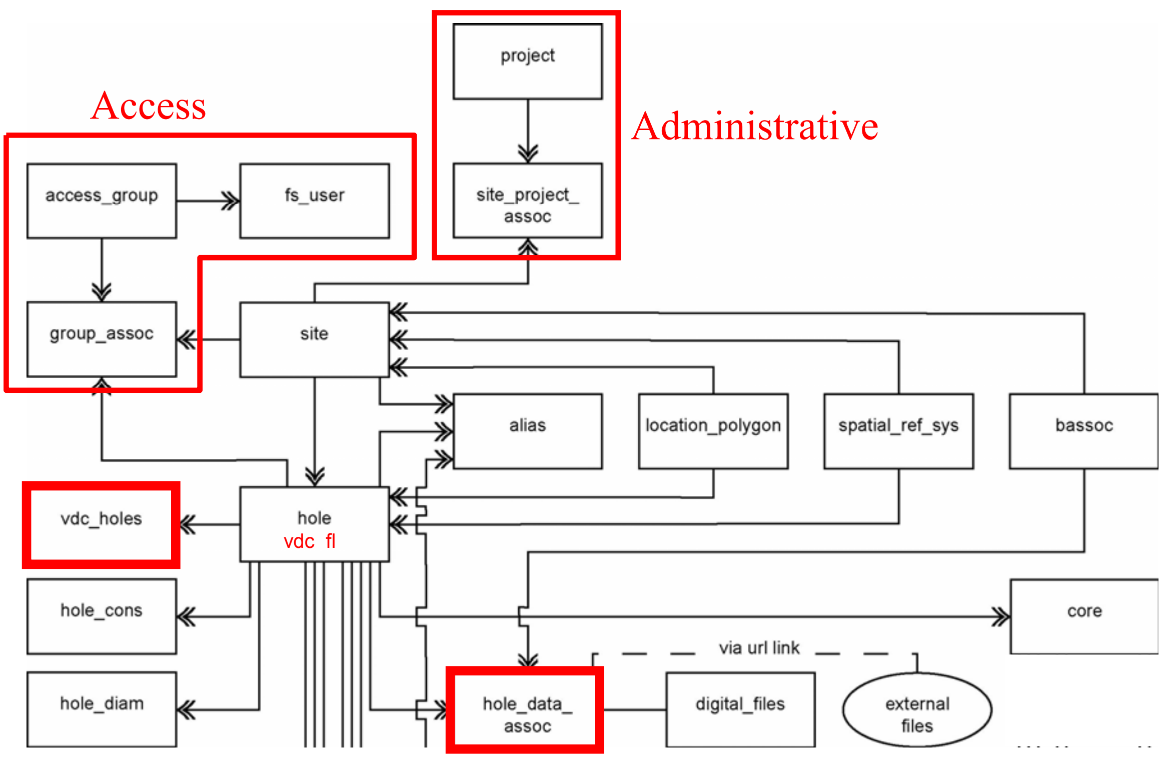


Figure 14. GVDC access requirements to the USGS PostgreSQL datasbase.

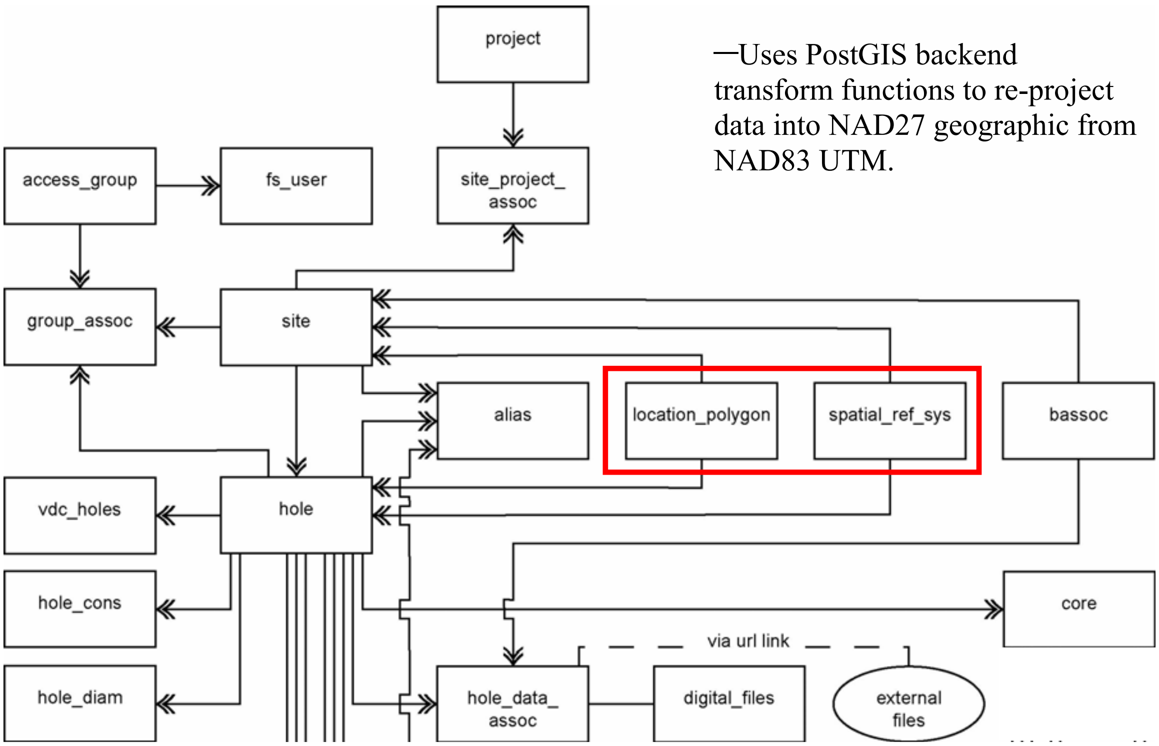


Figure 15. At present the GVDC only supports a standardized coordinate system.

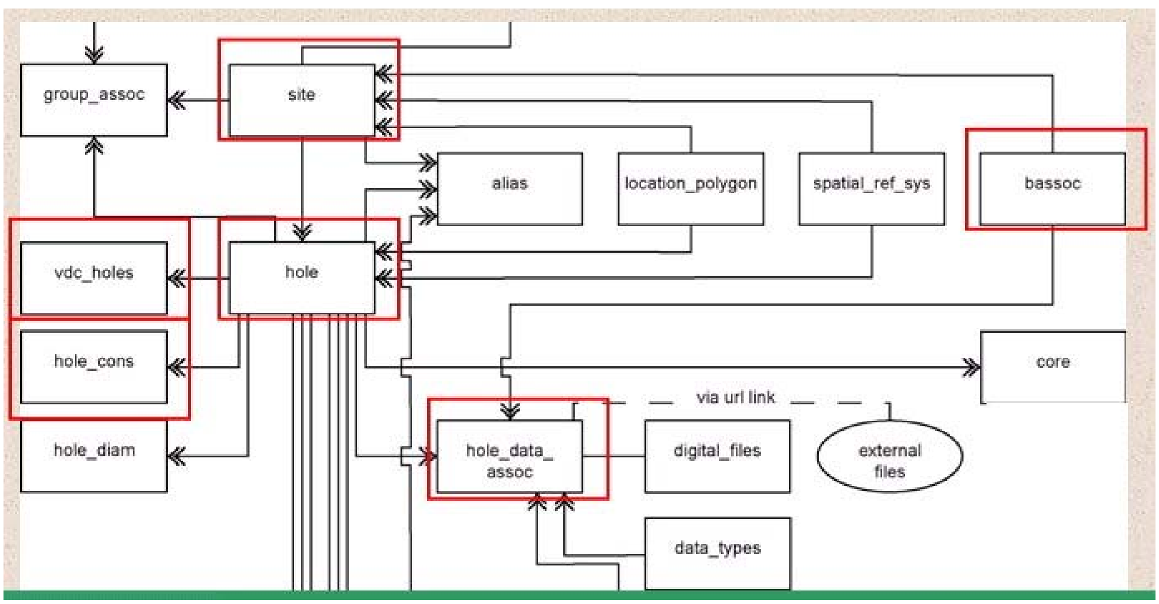


Figure 16. The GVDC harvester accesses a view that also uses backend stored procedures to set harvested values.

4.1.4 Pacific Gas & Electric

Simlar to the CGS applications, static VBAs are coded within the PG&E geotechnical Access database which trancptDataInfoates data directly from Access database tables into

XML files. The newly generated XML files are formatted according to the COSMOS Geotechnical Data XMLSchema (Chapter 3, Benoit et al., this report; see Contact Information: J. Hu). The VBA's perform the following functions:

1) Update native Access database tables to include information required by the GVDC
2) Convert geotechnical borehole test data and associated metadata into XML files
3) Save the XML files to a permanent directory on a hard drive.

The PG&E example database requires additional information in order for the data to be harvested utilizing OAIB. VBA's specific to the PG&E dataset are currently being updated that will generate the required parameters and save the information in PG&E database tabels. The PG&E dataset will be available online in early 2005.

4.2 OAIB – Open Archives in a Box

OAIB is an application specifically designed for exporting metadata stored in a relational database management system (RDBMS) over the OAI protocol for metadata harvesting (NCSA, 2004a). OAIB is based on the Components for Constructing Open Archives (COCOA) framework, which is included in the distribution installed on the GVDC data providers' servers. OAIB was used in this project to set up an the GVDC as an "Open Archives" server. Thus the GVDC can provide metadata based on the contents of RDBM's such as Access, PostgreSQL, or MySQL. This enables the data providers who have geotechnical data in RDBMS's to make their data accessible to the geotechnical engineering community.

The OAIB distribution used in this project also provided a configuration wizard enabling the application features to be controlled without requiring programming. The configuration wizard is described in detail by NCSA (-2004b). OAIB also provides an additional installation tool (NCSA, 2004c; 2004d). OAIB is written in Java, and has been tested on Linux, Windows, and Mac OS X. OAIB makes several critical assumptions about the structure of a data provider's database:

1) The remote database is accessible using JDBC. PostgreSQL is JDBC compliant, and MS Access is accessible by using an ODBC-JDBC bridge.
2) All the relevant data for a record can be retrieved with a single query. This is handled through the OAIB data query in each data provider's database.
3) There is a single column containing a unique ID for each record. This is analogous to a primary key in SQL.
4) There is a single column of SQL type DATE containing the date a record was most recently modified. OAI requires that such information be available about each record. This refers to the date each record was last updated by the data provider's database administrator

If the data providers' database does not meet these assumptions, there are steps that may be taken to make it compatible with OAIB. Please see the extensive documentation on OAIB in NCSA (2004a).

4.3 OAI – Open Archives Initiative

OAI Protocol version 1.1 was implemented in the pilot GVDC project. This section contains a brief overview of several components of OAI pertinent to the use of OAIB in the GVDC system architecture. It is beyond the scope of this document to present all the details, for instance on OAI protocols, requests and responses. For more information on OAI, please see OAI, 2004a.

According to the OAI (2004a) website:

"The goal of the Open Archives Initiative Protocol for Metadata Harvesting (OAI) is to supply and promote an application-independent interoperability framework that can be used by a variety of communities who are engaged in publishing content on the Web. The OAI protocol described in this document permits "metadata harvesting". The result is an interoperability framework with two classes of participants:

- Data Providers: administer systems that support the OAI protocol as a means of exposing metadata about the content in their systems
- Service Providers: issue OAI protocol requests to the systems of data providers and use the returned metadata as a basis for building value-added services"

In the world of OAI, a "harvester" is defined as a client application that issues OAI requests (OAI, 2004b). A harvester is operated by a service provider as a means of collecting metadata from repositories. A "repository" is defined as a network accessible server to which OAI protocol requests, embedded in HTTP, can be submitted (OAI, 2004a). Thus the OAI protocol provides access to GVDC borehole metadata stored in the MySQL database from OAI-compliant repositories, the data providers' remote geotechnical databases. A "record" is defined as an XML-encoded byte stream that is returned by a repository in response to an OAI protocol request for metadata from an item in that repository.

OAI version 1.1 supports the notion of a "deleted record", which may be used by the data providers' repositories. In OAI terminology, if a GVDC record is no longer available then it is to be considered "deleted". The GVDC maintains deleted records as "Persistent" in the GVDC MySQL database. In the case of the GVDC, "Persistent" means that the MySQL database maintains information about deletions with no time limit.

OAI requests are expressed as HTTP requests. A typical implementation uses a standard Web server that is configured to dispatch OAI requests to the software handling these requests. All responses to OAI requests must be well-formed XML instance documents. Encoding of the XML must use the UTF-8 representation of Unicode. Character references, rather than entity references, must be used. Character references allow XML responses to be treated as stand-alone documents that can be manipulated without dependency on entity declarations external to the document. COSMOS/PEER-LL Geotechnical XML Schema elements were selected as metadata to be harvested for the MySQL database, based on the requirements of the GVDC front end website search capabilities requested by the project developers.

5.0 SERVER SIDE BACK END SYSTEM ARCHITECTURE

The GVDC Demo harvester system architecture was built using Boreland JBuilder 6.0.438 Java software development tool. Generally accepted techniques were used throughout the development of the site.

5.1 Dynamic XML Translation

The USGS created an XML Translator that converts PostgreSQL borehole database records directly into valid XML, in a HTTP request/response environment (Devlin, 2004; Ponti, 2004). The XML is compliant with the COSMOS/PEER-LL Geotechnical XML Schema (see section "COSMOS/PEER-LL Geotechnical XML Schema"). This application must be installed on the GVDC server, rather than the USGS remote data server. The translator application is written entirely in Java, designed to run in any web container that adheres to the java servlet specification.

The translator application is divided into three packages:

- org.foqus.xml.generated
- org.foqus.xml.objectFactories
- org.foqus.xml.servlet

The 'generated' package contains many classes and interfaces for Object to XML binding. These classes are compiled directly from the schema using Castor, an open source java-XML binding tool (Castor, 2004).

This tool can analyze a schema and produce a java object model that maps to an XML data model, providing the functionality to consume and produce valid XML to and from the object model. This package handles all of the XML generation. The Castor tool is not fully schema compliant and has some limitations, one of which being it doesn't recognize abstract types and substitution groups. In these instances, the schema was customized and the validation code was rewritten. The application will not generate invalid XML. If an invalid data value is retrieved from the database, then the application will throw a validation exception at runtime and the request will not be processed.

The 'objectFactories' package contains factory classes that produce the various objects within the geotechnical data model. Each factory object takes a JDBC connection and a given VDC code relating to a hole that is released to the VDC and will produce the data component for the given hole, invoking any factories for nested types.

The 'servlet' package contains the gateway for the application to be invoked using http requests. A filter servlet intercepts all requests ending in ".xml" under the web application's domain and reroutes them to a Translator servlet. This servlet parses the VDC code from the request and invokes the Translator application for that hole, appending the XML data to the http output stream. Because the client requested a URL ending in ".xml", it will assume it has hit a static file on the web server and will download it just the same.

The three packages are compiled into one .jar file, "foqusXMLTrans.jar" (on report CD: \Translators_XML_examples\PostgreSQL_to_XML\Tomcat4\webapps\usgs\WEB-INF\lib\ foqusXMLTrans.jar). To use the application, install the jar file into the WEB-INF\lib directory of any Apache Tomcat web application directory and restart Tomcat.

The following files should be placed in the \Tomcat\webapps\usgs\WEB-INF\lib\ on the GVDC server:

- castor-0.9.5.2.jar
- foqusXMLTrans.jar
- pg73jdbc2ee.jar
- xerces-1.4.4-xmlc.jar

The service is invoked by a URL request to the full path of the host and application concatenated with the VDC code for the desired borehole and ".xml".

Example: http://localhost:8080/usgs/VDC_2227.XML

6.0 FRONT END WEBSITE

The final release of the GVDC Demo front end website, https://geodata.cosmos-data.org, was built using Macromedia Dreamweaver and Homesite software developments tools. Generally accepted techniques were used throughout the development of the site.

6.1 Main Website Design

The overall GVDC website "look and feel" was created by Interseller (2004) and Internovations (2004; see Contact Information: M. Jarvis and J. Castro, respectively). The front end and administrative webpages are coded in ASP (VBScript), HTML and JavaScript. These blocks consist of 607 files in 22 folders and can be obtained by contacting COSMOS (see root:\ Main_Website\readme.txt on the report CD):

J. Carl Stepp, Execustive Director
COSMOS Office
Pacific Earthquake Engineering Research Center
University of California, Berkeley

1301 South 46th Street
Richmond CA 94804-4698
Phone: (510) 231-9436
FAX: (510) 231-9471
e-mail: cosmos@eerc.berkeley.edu

The website background design displays geotechnical engineering related activities in illustrations collected from the project participants. Apart from the GIS map interface, the website conists of dynamic webpages with the following fucntionalities:

- End user registration and Login functionalities, behind SSL (Secure Socket Layer)
- Subscriber data search capabilities, including test-based search functionalities
- Subscriber data download functionalities, including:
    - Download geotechnical test data in XML format
    - Download geotechnical test data in MS Excel format, Excel files are streamed on-the-fly from XML files (Softartisans, 2004)
    - Multiple files in one or both formats are zipped (ZBit, 2004) on-the-fly and offered to the subscriber, to save on a permanent media
- Subscriber account maintenance
- Administrative Login and data management functionalities, including:
    - Subscriber account management
    - Interface for entering and editing data providers' disclaimers, usage and privacy policys that a subscriber must agree to in order to download data
    - Data source information management
    - Reports – download statistic on subscriber downloads, on a yearly, monthly, weekly or daily basis
    - Data and GVDC administrators' account maintenance
    - Legacy Data management, at this time for the four data providers (CGS, Caltrans, PG&E and USGS) – this page is integrated with the Java Harvester (using JSP, Java Server Pages) functionalities for harvesting geotechnical metdata from remote data provider's servers. An admistrator can directly add, update or delete records from the GVDC MySQL database.
    - Administrator help

Administrative privileges can be assigned to any data provider's database administrator by the GVDC administrator. The data provider's administrator can then have full access to the Administrative website functionalities, freely over the internet.

There are also a number of static webspages on the main front end user website:

- Home page leads the user to the GIS Map interface
- About the project – general information
- Project information – more detail of the project tasks

- User survey – results of the Geotechnical Data User Survey (see Chapter 2, Turner et al., this report)
- User forum – online message forum for different project committees
- News and events – Information of Workshops, proceedings and future project goals
- Calendar of project-related events
- Contact information, including project sponsors, partners and participants
- Subscriber help

Information on projects, participants, data providers, original data sources, etc., is dynamically loaded from the GVDC MySQL database (same database used to harvest borehole metadata from data providers) into these webapges. A synopsis of the website functionalities is provided in Chapter 4 of this report, "Pilot Geotechnical Data System Architecture and Databases" (Swift et al.).

A web server certificate was issued to COSMOS from Starfield (Starfield, 2004) for the domain "geodata.cosmos-data.org". This means that the GVDC website has been authenticated by a trusted Certification Authority. Once a certificate has been issued, the issuer sends an e-mail message containing the signed certificate, along with an intermediate certificate and certificate-installation instructions for all supported Web servers. The specifics of the installation procedure are determined by the choice of Web server software. Following installation of the certificate on the GVDC:

- All transactions are now confidential and are secured with SSL (Secure Socket Layer) encryption
- End user and data provider inforation (registration, MySQL metadata, and other website information) are protected

The front end GIS map interface coding (Farallon, 2004; see Contact Information: A. Peters), data translators and previewers, and the Java harvester back end administrative web pages and functionalities are integrated into the main website pages summarized above. These principal website functionalities are described below.

The following techniques were used in the development of the overall front end and administrative websites, and the GIS interactive map web pages (Farallon, 2004):

- N-tier architecture design, where site data sources, business rules, and content presentation can be upgraded and maintained relatively independently
- Modular site design that facilitates upgrading individual parts of the site without significantly impacting the rest of the site
- Use of re-usable functions or modules that contain code optimized to process specific data and return a set of results
- Encapsulation of complex code into re-usable objects that support objects and methods used by the site
- Complete release of memory addressed by objects by explicitly destroying each object after it is no longer needed

6.2 GIS Map Application Code Structure

The front end interactive GIS map was completely custom coded with ESRI's ArcIMS, which is used to generate the map images in HTML. The code is structured logically into three different groups, to aid in the maintenance of the site. Changes to the code can be isolated to one of these three groups, so issues can be tracked faster and with less threat of affecting other parts of the code. These three groups include:

- Gateway/Flow control blocks
- Function/Processing Blocks
- HTML Blocks

The GIS map application code structure files are contained in the root:\GIS_Map_Application\-level directories of the report CD.

6.2.1 Gateway/Flow control blocks

These blocks are Active Server Pages (ASP) written in primarily VBScript. These blocks control how user actions are interpreted and the direction the code should flow. Input is gathered from the user via the GIS map GUI, interpreted by the block, then control is passed to a subsequent block for further processing and display of results. These applications are located at the top of the workflow and thus can define variables that are used globally throughout the site. These blocks are mostly contained in the root:\GIS_Map_Application\scripts\-level directory and include the following files:

- CustomerDataMap.asp
- popContent.asp
- popDataTypes.asp
- CustomerDocSearch.asp
- CustomerDocSearchResults.asp

6.2.2 Function/Processing Blocks

The function/processing blocks are written primarily in ASP and JavaScript (JS) and do most of the work of the site. They take "instructions" from the Gateway/Flow blocks, and or by other Function/Processing blocks and respond with the "answers" to the end-users' requests. These blocks can modify variables, make calls to other subroutines, and access data in databases. These blocks are mostly located in the root:\GIS_Map_Application\includes\ and \js\-level directories and include:

- General_Functions.asp
- Html_Functions.asp
- Map_Functions.asp
- FileConversion.inc
- CosmosUtils.js
- FGIJSUtilities.js
- FGIVicinityMap.js

- ZoomBox.js

6.2.3 HTML Blocks

These blocks contain HTML only. There is no ASP or JS included in these files. They contain easily recognizable elements of the displayed pages and are based on templates designed by Farallon (2004), Interseller (2004) and Internovations (2004; see Contact Information: A. Peters and M. Jarvis and J. Castro, respectively).

Header.htm
Help.htm
LatLon.htm

6.2.4 Global Variables

Global.inc
Set up server parameters:

- Application("MapService") = "Cosmos2"
- Application("MySQLADOConnectString") = "uid=;pwd=;dsn=1097_01_Cosmos"

Setup Map Display Parameters:

- Application("MapWidth") = 623
- Application("MapHeight") = 424
- Application("pointMarkerType") = 0
- Application("pointWidth") = 5
- Application("pointColor") = 3329330
- Application("pointOutline") = 0
- Application("pointTransparency") = 1

CustomerDataMap.asp
Request Variables:

- gMainHiddenForm
- gMainLegendForm
- gMainFilterForm

Page Layout Variables:

- frameName
- frameName2
- hiddenForm
- legendForm
- filterForm

Map_Functions.asp
ArcIMS HTML Viewer Specific Variables:

- mSimpleMarkerSymbol
- mPointObject
- mAcetateLayer
- objmMap

- latLongText
- mTextMarkerSymbol
- objmConnector
- objmLayers

General_Functions.asp
- projectsConnString
- objConn
- objRS
- objCmd

ArcIMS HTML Viewer Specific Variables:
- CreateAIMSConnector
- CreateAIMSMap

FGIJSUtilities.js
- gDisplayMapAsp
- gDisplayListAsp
- gPopReportAsp
- gXYzoomLimitMin
- gXYzoomLimitMax
- gXLimitMin
- gXLimitMax
- gYLimitMin
- gYLimitMax

ZoomBox.js
- zoomBoxColor
- iWidth
- iHeight
- hspc
- vspc
- ovBoxSize

6.3 Data Previewers

Two data previewers are currently available that allow on-the-fly visualization of geotechnical data through the GVDC front end website. A dynamic SVG (Scalable Vector Graphics) (SVG; W3C, 2004c) previewer coded in VB.NET and C/C++ by Savage Software (Savage, 2004) displays geologic and geotechnical information in a typical Borehole format, for borehole records containing sufficient detailed lithologic information (ROSRINE, 2001). The second dynamic previewer is a VB.NET application that dynamically displays Caltrans CPT data as charts using SVG.

6.3.1 SVG Previewer for Boreholes

The borehole previewer application was written in VB.NET and C/C++ by Savage Software (2004; see Contact Information: I. Nincic). The borehole previewer is accessed on the GVDC front-end website by clicking the "BLG" (Basic Lithology) link under "Data Types" in a search results webpage (see section "Main Website Design").When the "BLG" link is clicked, a borelog is generated on-the-fly using SVG, displayed in a new browser window (Figure 17).

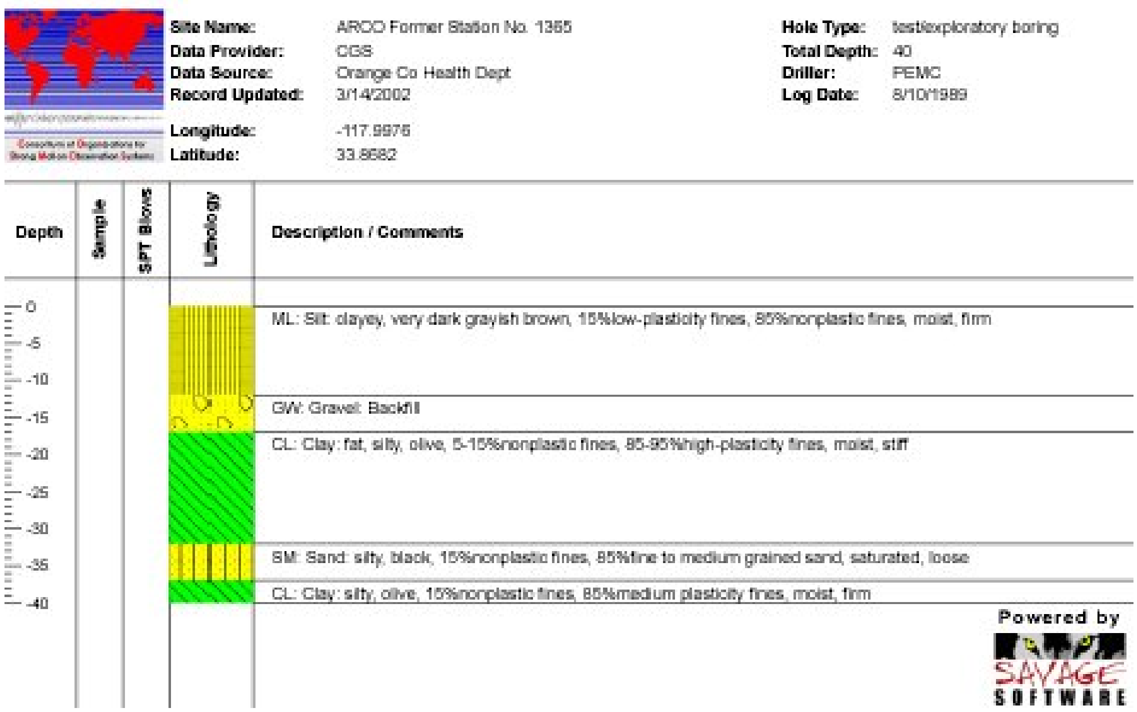


Figure 17. A borelog dynamically generated by the borehole previewer.

The source code is the best source of detailed documentation. Nevertheless to summarize, the command line application is straightforward:

```
ConvCmd input.xml output.svg [max_sample_hieght]
```

There is a single function call that converts borehole XML data to SVG:

```
ConvXML.Converter.Convert(infile, outfile, [max_sample_hieght])
```

Example: ConvXML.Converter.Convert("in.xml", "out.svg", 60)

The borehole previewer application is currently installed under IIS in the same root directory as the main website pages. After installation, these blocks consist of 24 files in 5 folders. There is a sample application in a \TestApp\ directory. A copy of the compiled application and/or a copy of the source code can be obtained by contacting COSMOS (see root:\Previewer_Applications\BoreLog\readme.txt on the report CD):

J. Carl Stepp, Execustive Director
COSMOS Office
Pacific Earthquake Engineering Research Center
University of California, Berkeley
1301 South 46th Street
Richmond CA 94804-4698
Phone: (510) 231-9436
FAX: (510) 231-9471
e-mail: cosmos@eerc.berkeley.edu

6.3.2 VB.NET SVG Previewer for CPT Logs

The GVDC CPT previewer was coded in VB.NET by Caltrans, to allow end users to view graphical charts of CPT data (Grimes, 2004b). The CPT previewer is accessed on the GVDC front-end website by clicking the "CPT" link under "Data Types" in a search results webpage (see section "Main Website Design").When the "CPT" link is clicked, CPT charts are generated on-the-fly and are displayed in a new browser window.

The CPT previewer application is first passed a URL corresponding to the location or path of an XML file containing Caltrans CPT data. The XML files must be compliant with the COSMOS/PEER-LL Geotechnical XML Schema (see section "Static VB.NET Translator for CPT data"). The previewer application downloads the requested XML file as a temporary file on the GVDC server (tmp.xml). The temporary XML file is parsed and the required CPT data is processed to dynamically generate multiple SVG images (charts) per CPT. The CPT charts and related metadata are displayed using HTML within a new browser window on the end user's computer (Figure 18). The SVG images provide the user with a graphical representation of the CPT data. The temporary XML and SVG are recreated and overwritten each time the browser window is refreshed or a user accesses the same "CPT" link on a GVDC search results page.

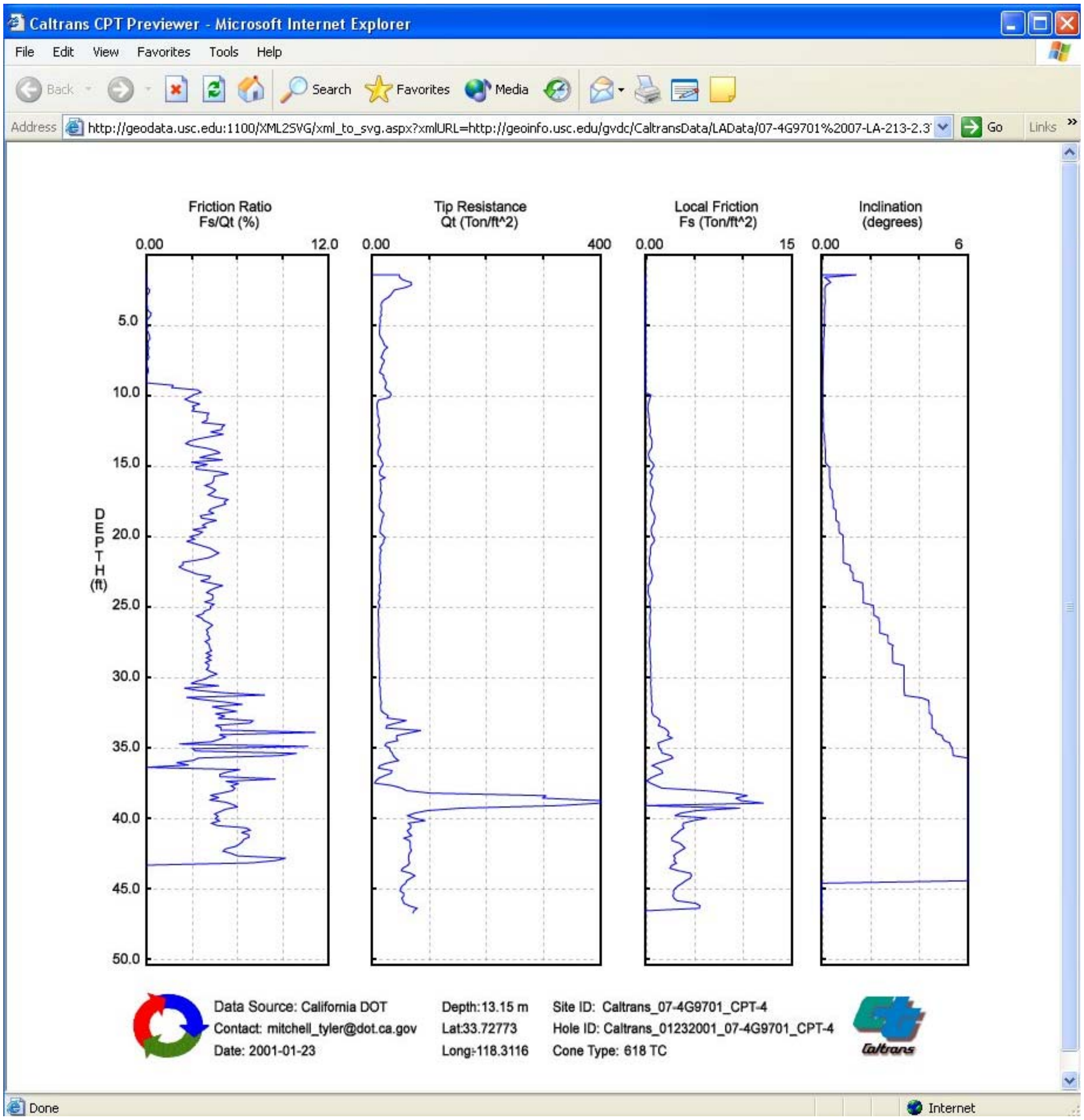


Figure 18. Charts and related metadata output for one CPT, generated by the CPT previewer.

The GVDC pilot project Caltrans CPT previewer source code is provided in the root:\Previewer_Applications\CPTLog\Caltrans\-level directory of the report CD. The following descriptions cover only those files which provide the main functionality to the previewer application.

- <u>xml_to_svg.aspx:</u> Specifies that the language of the aspx is "VB" and is using "code-behind". When loaded in a browser, it implements and inherits all of the code contained in xml_to_svg.aspx.vb. It is specified that the page will not be cached. This insures that the SVG images will be freshly loaded from the GVDC server each time the application is accessed.

- xml_to_svg.aspx.vb: Code required to download and read the CPT XML files, parse and process the XML data, create the SVG charts and SVG image containing CPT related metadata, and populate an HTML table contained in xml_to_svg.aspx with layout and image reference information required for the final output.
    - Private Sub Page_Load: This function is invoked when the application is loaded. Reads the value of the QueryString variable titled "xmlURL" which contains the URL to the desired XML file. This string will be stored in a local variable of the same name (xmlURL). In the event that a QueryString variable is not provided, the application is designed to process a sample file located on USC's geoinfo.usc.edu server, assigned to application testing and debugging. Once a valid URL is obtained, the XML file is downloaded to a temporary file (tmp.xml) within the applications' root directory. After downloading is complete, the physical path of the downloaded XML file is assigned to the variable xmlDownloadDestination. The function createSVGcharts is then invoked and passed the value of xml DownloadDestination.
    - Private Sub createSVGcharts: The XML file is accessed and read using VB.NET XmlTextReader. Relevant information is extracted and assigned to local variables. Numerical CPT data is read and assigned to arrays. Once the depth range of the CPT is aquired (for scaling the charts), VB.NET StreamWriter is used to generate the SVG images. An HTML table located in xml_to_svg.aspx is then populated, and the user is presented a new browser window containing the SVG images. The application has thus completed the required tasks and all objects are disposed of.

In order for the GVDC to accommodate the CPT previewer application, two of the exisiting Map Application files had to be modified as well:

- CustomerDocSearchResults.asp: The search results ASP was originally written by Farallon Geographics (Farallon, 2004) and was modified in order to accommodate the text-based Document Search option and the CPT previewer application (see the root:\GIS_Map_Application\scripts\-level directory on the report CD). These modifications are necessary to insure that the CPT previewer option is only available when corresponding to boring logs that actually contain CPT data and that the URL and QueryString contain the necessary information when the CPT Pre-viewer is actually loaded.
- CosmosUtils.js: To accommodate the modifications made in SearchResults.asp, one function was also added to CosmosUtils.js. This function retrieves the URL (including the appropriate QueryString values) for xml_to_svg.aspx (described above). When invoked, this URL is opened in a new browser window.

CPT Previewer Installation

The installation of the CPT previewer requires the use of Microsoft Visual Studio .NET. To install the VB.NET CPT previewer application on a server (MS Windows Operating System 2000 or XP):

1. Obtain a copy of "XML2SVG.zip" (see the report CD)
2. Extract the ZIP file to a folder named "XML2SVG"
3. Copy the folder onto your web server or, make the "XML2SVG" folder a virtual directory (see below: "creating a virtual directory", particularly step 9.)
4. Open Microsoft Visual Studio .NET
5. Click "File", highlight "Open" then, click "Project"
6. Browse to the "XML2SVG" directory and open the XML2SVG project file
7. after the project opens successfully, in "Solution Explorer" located on the right side of the screen, open "xml_to_svg.aspx"
8. Double click on the main window (it will appear as a grid of dots), this will automatically open the code section (xml_to_svg.aspx.vb)
9. In the code section, click "Debug" then click "Start". This will compile and execute the application. A set of sample charts should be produced once the application has ran.

Once these installation steps have been completed, the CPT previewer application is ready to run on this server. If no new parameters are available to the application, the previwer reproduce the same sample sets. In order to generate new charts, provide a URL (pointing to a COSMOS/PEER-LL Geotechnical XML Schema-compliant XML file containing CPT data) in the QueryString.

Example: http://www.mywebserver.com/XML2SVG/xml_to_svg.aspx?xmlURL=
httttp://www.aWebserver.com/XMLwithCPT.xml

Creating a Virtual Directory

To create a Virtual Directory (MS Windows 2000/XP) on the same server that the VB.NET CPT previewer application is installed on:

1. Go to the "Control Panel"
2. Open the "Administrative Tools" directory
3. Open "Computer Management"
4. Expand "Services and Applications" (to expand; click the plus sign on the right)
5. Expand "Internet Information Services"
6. Navigate to your web server
7. Right-click on the desired web site, highlight "New" then, click "Virtual Directory"
8. Click "Next"
9. For an alias name, type "XML2SVG", click "Next"
10. Browse to the "XML2SVG" directory, click "Ok", click "Next"

11. For permissions, put check marks next to “Read”, “Run Scripts”, “Execute” and “Write”
12. Click “Finish”

6.4 GVDC Server Side Code Structure

The GIS interactive map web pages are designed to flow from request to response in a circular fashion (Farallon, 2004). All application level variables can be instantiated in the global.inc file. Initially an end user enters the map page via the CustomerDataMap.asp page, which passes control to the Map_Functions.asp, General_Functions.asp, and HTML_functions.asp. CustomerDataMap.asp defines global variables used, which functions will be called and what actions will be performed. Map_Functions.asp, CosmosFunctions.asp, General_Functions.asp and HTML_Functions.asp are the main pages creating the map features. General_Functions.asp sets up the connection to the GVDC MySQL database (see MySQL Database Structure). Map_Functions.asp and CosmosFunctions.asp create the map and associated features, and render an acetate layer to dynamically display the borehole data contained in the GVDC MySQL database as points on the map. HTML_Functions.asp creates the navigation tools, vicinity map, latitude and longitude entry boxes, legend, and data type, date and depth filters. The main JavaScript blocks, ZoomBox.js, CosmosUtils.js and FGIVJSUtilities.js, handle most client side requests.

The borehole records requested by the end user through the GIS interactive map are passed to CustomerDocSearchResults.asp. The geotechnical data download and previewer blocks are outside of the GIS map code structure (see Data Translators, Dynamic Java XML Translator for PostgreSQL, and Data Previewers). The results can be downloaded by an end user via CustomerDocSearchResults.asp (see section Search Results – Data Download). Borehole and CPT previewers are also activated through the CustomerDocSearchResults.asp.

6.5 Search Results – Data Download

Each borehole record passed to the CustomerDocSearchResults.asp via the GIS interactive map or the text-based Documents Search can be downloaded, and “CPT” and “BLG” data types can be previewed (Figure 19). The end user may choose the XML (ASCII text file) and/or MS Excel check boxes to directly download the files. The user may also use the “CPT” or “BLG” previewer links under “Data Types” to view graphical representations of the data (Figures 17, 18 and 20).

The geotechnical borehole records chosen by the uder by clicking in the check boxes to the right of each record, are dynamically streamed to the user in a zip file (ZBit, 2004). The program ZBit is a zip-unzip component installed on the GVDC server. This component is invoked from the CustomerDocSearchResults.asp and zips the selected records on-the-fly for the user. The zip is delivered to the user through a typical windows download dialog box. The data can then be can be saved to a permanent media as desired by the end user.

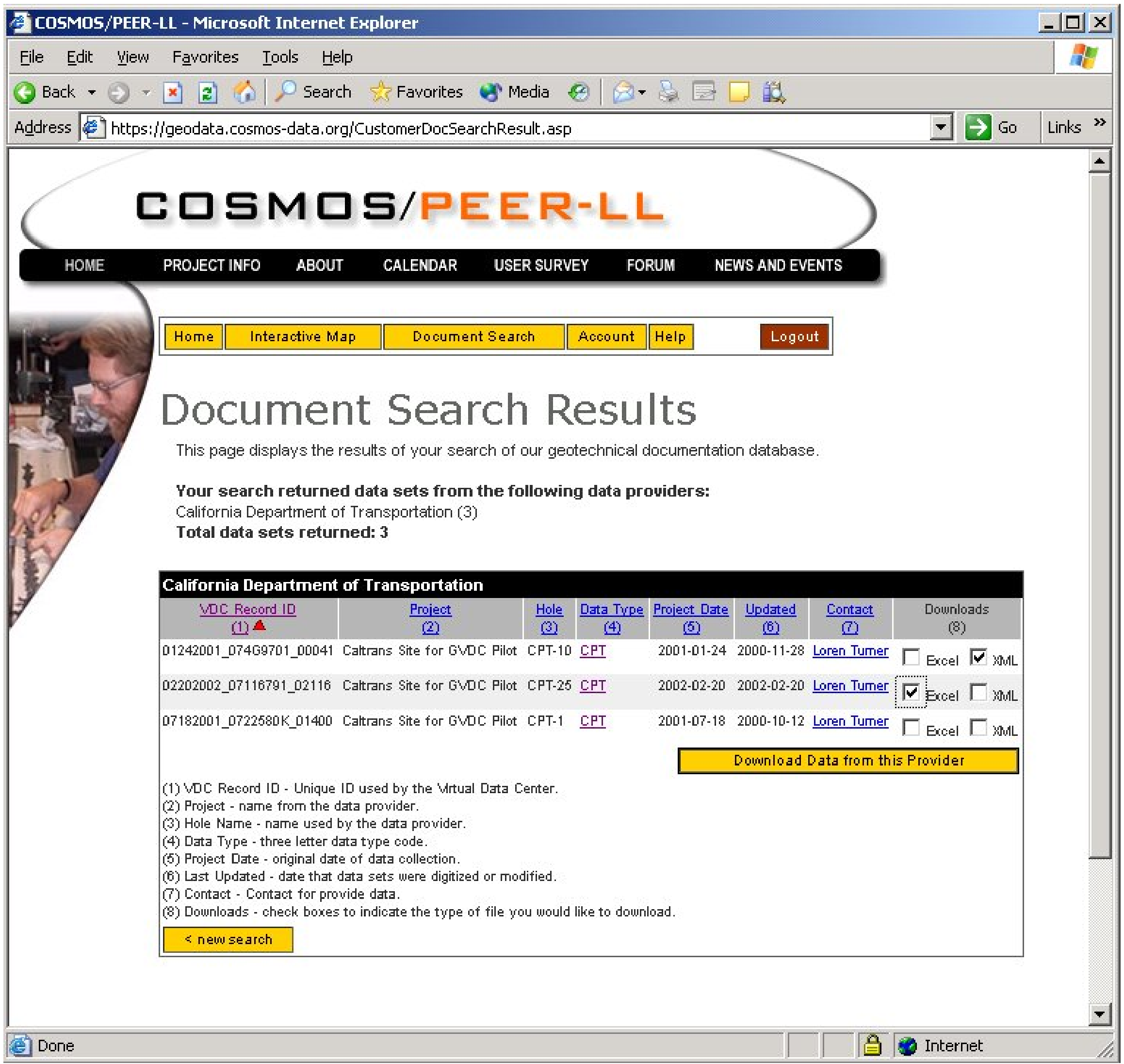


Figure 19. GVDC search results page. Borehole records are passed to CustomerDataSearchResults.asp and displayed as a list in the main website frame.

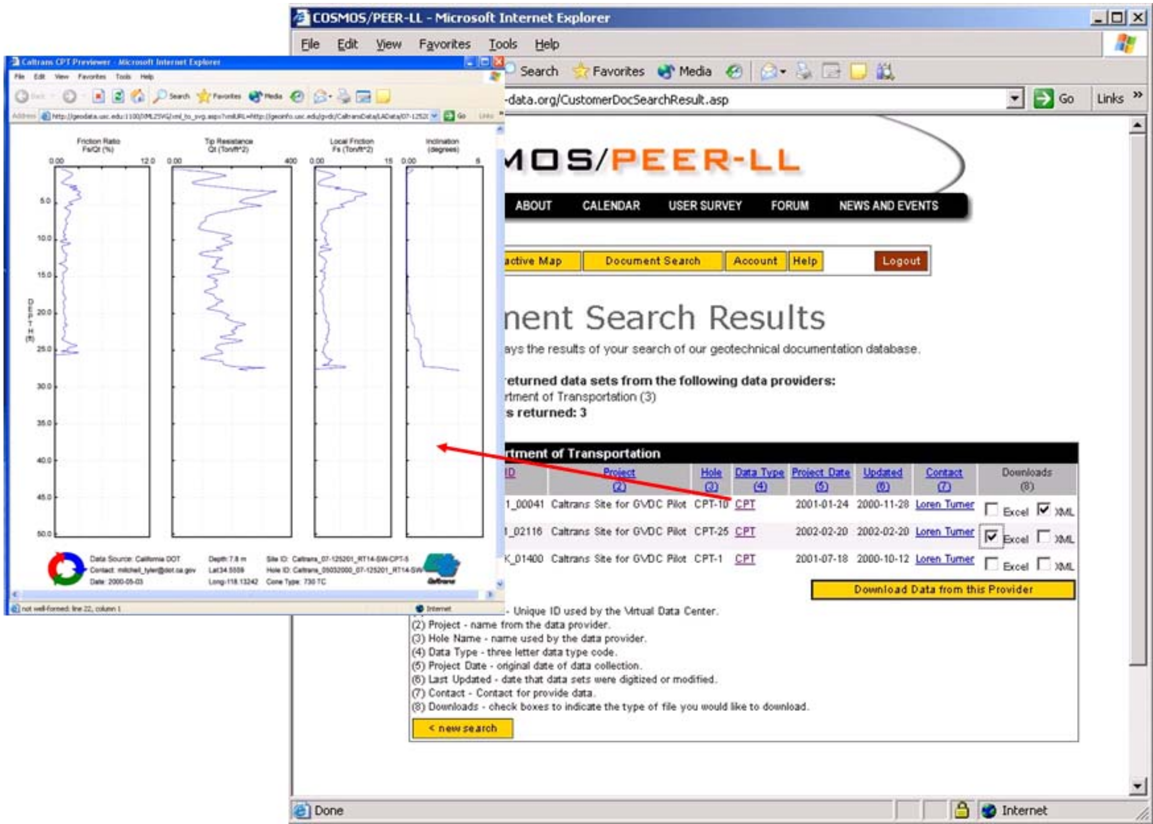
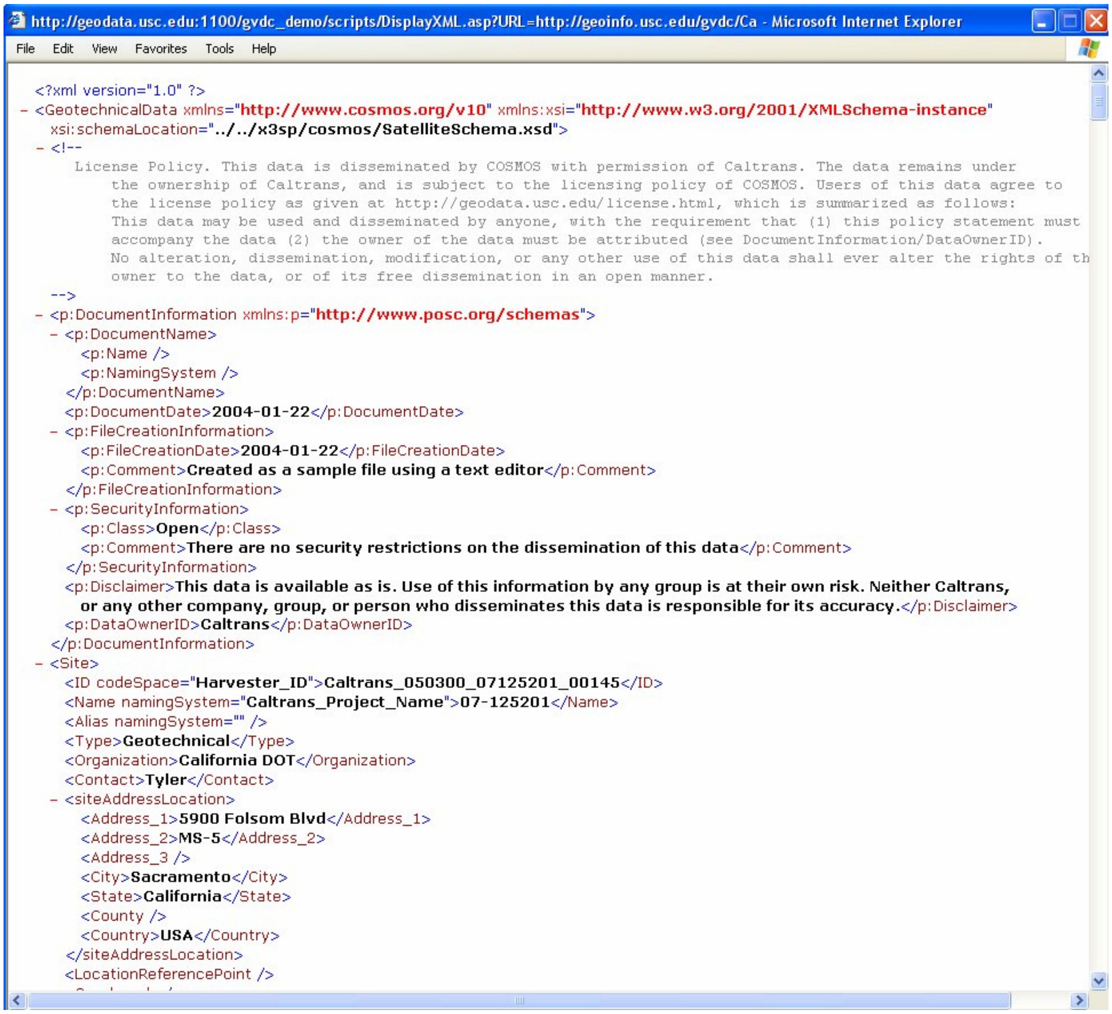


Figure 20. GVDC search results page. Charts and metadata for one CPT are displayed in a new browser window.

The CGS, Caltrans, and PG&E data XML files are small and queries usually only take a few seconds. The response for requests to the PostgreSQL database may take several minutes because it involves many queries into a complicated relation of tables in the USGS database. The resulting CGS, Caltrans and PG&E XML files are typically less than 100 KB, whereas the USGS XML files range in size from approximately 1.5-3.0 GB each.

6.5.1 Download in XML

Microsoft's XML DOM (Document Object Model) component, the XMLHTTP object, is used to provide client-side access to the XML documents in ASCI text format through the HTTP protocol. It exposes a simple API which is used to send requests and get the resultant XML. The results are provided on-the-fly as text (in XML) files, within the download zip files (Figure 21). The files can be saved to a permanent media as part of the zip file, along with any Excel documents within the zip that the user might have selected. The XML files can be edited using any of a number of free (usually trial versions) and commercially available programs, such as Cooktop (www.xmlcooktop.com), MS Notepad, Altova XMLSpy (www.xmlspy.com), or Macromedia Dreamweaver MX, to name only a few. Cascading stylesheets (W3C, 2004d) will be implemented in the future, which will format the raw XML text output into more easily readable HTML tables in similar pop-up windows.




```
http://geodata.usc.edu:1100/gvdc_demo/scripts/DisplayXML.asp?URL=http://geoinfo.usc.edu/gvdc/Ca - Microsoft Internet Explorer
File Edit View Favorites Tools Help

  <?xml version="1.0" ?>
- <GeotechnicalData xmlns="http://www.cosmos.org/v10" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="../../x3sp/cosmos/SatelliteSchema.xsd">
  - <!--
      License Policy. This data is disseminated by COSMOS with permission of Caltrans. The data remains under
          the ownership of Caltrans, and is subject to the licensing policy of COSMOS. Users of this data agree to
          the license policy as given at http://geodata.usc.edu/license.html, which is summarized as follows:
          This data may be used and disseminated by anyone, with the requirement that (1) this policy statement must
          accompany the data (2) the owner of the data must be attributed (see DocumentInformation/DataOwnerID).
          No alteration, dissemination, modification, or any other use of this data shall ever alter the rights of th
          owner to the data, or of its free dissemination in an open manner.
    -->
  - <p:DocumentInformation xmlns:p="http://www.posc.org/schemas">
    - <p:DocumentName>
        <p:Name />
        <p:NamingSystem />
      </p:DocumentName>
      <p:DocumentDate>2004-01-22</p:DocumentDate>
    - <p:FileCreationInformation>
        <p:FileCreationDate>2004-01-22</p:FileCreationDate>
        <p:Comment>Created as a sample file using a text editor</p:Comment>
      </p:FileCreationInformation>
    - <p:SecurityInformation>
        <p:Class>Open</p:Class>
        <p:Comment>There are no security restrictions on the dissemination of this data</p:Comment>
      </p:SecurityInformation>
      <p:Disclaimer>This data is available as is. Use of this information by any group is at their own risk. Neither Caltrans,
        or any other company, group, or person who disseminates this data is responsible for its accuracy.</p:Disclaimer>
      <p:DataOwnerID>Caltrans</p:DataOwnerID>
    </p:DocumentInformation>
  - <Site>
      <ID codeSpace="Harvester_ID">Caltrans_050300_07125201_00145</ID>
      <Name namingSystem="Caltrans_Project_Name">07-125201</Name>
      <Alias namingSystem="" />
      <Type>Geotechnical</Type>
      <Organization>California DOT</Organization>
      <Contact>Tyler</Contact>
    - <siteAddressLocation>
        <Address_1>5900 Folsom Blvd</Address_1>
        <Address_2>MS-5</Address_2>
        <Address_3 />
        <City>Sacramento</City>
        <State>California</State>
        <County />
        <Country>USA</Country>
      </siteAddressLocation>
      <LocationReferencePoint />
```


Figure 21. XML data file displayed in new browser window (ASCII text).

6.5.2 Download in Excel

A translator is also required to convert the geotechnical XML data into Microsoft (MS) Excel, a download format strongly desired by the geotechnical user community. The FileConversion.inc is coded in VBScript to translate XML data from the COSMOS Geotechnical Data XMLSchema version 1.0, into MS Excel workbooks (see Contact Information: J. Hu and J. Castro). Thus this include file converts both static and dynamically generated XML data from any data provider, as long as their XML data are valid. The FileConversion.inc utilizes Softartisan's ExcelWriter to deliver real Excel spreadsheets over the Web without the need for Microsoft Excel (SoftArtisans, 2004).

7.0 WORKFLOWS

7.1 Installation of ESRI ArcIMS

The purpose of this section is to aid in the installation process of the GVDC front and back ends. This section is divided into five parts: 1) installation of commercial GIS software, 2) installation of custom code used to serve the end user's GIS maps and interface with the Harvester backend, 3) loading of GVDC back end components including the harvester code, 4) how to connect the front end to backend data repositories other than the example Access database provided with the code, and 5) all of the steps involved in updating the COSMOS/PEER-LL Geotechnical XML Schema. It is highly recommended that the first part "ESRI ArcIMS Installation Notes" be reviewed, even if the front end application will be configured with a previously installed, functioning version of ArcIMS.

1) It is highly recommended to start with a "clean" computer, without any versions of Java (JDK), Apache Tomcat, or ArcIMS installed. Uninstall any existing version of ArcIMS using the un-installation instructions available on the new installation CD (i.e. see "Microsoft" section) and from the ESRI online support documents at "ESRI Knowledge Base" http://support.esri.com/index.cfm?fa=knowledgeBase.gateway
2) If the server will also contain the backend Harvester, then the server may contain only the versions of Tomcat and Java (JDK) required by the backend. These versions should also be compatible with the version of ArcIMS being installed.
3) The default port for IIS must be different from that reserved for Apache Tomcat; this is the port that will serve ArcIMS. In the example shown in Figure 22, the IIS default port is 1100.

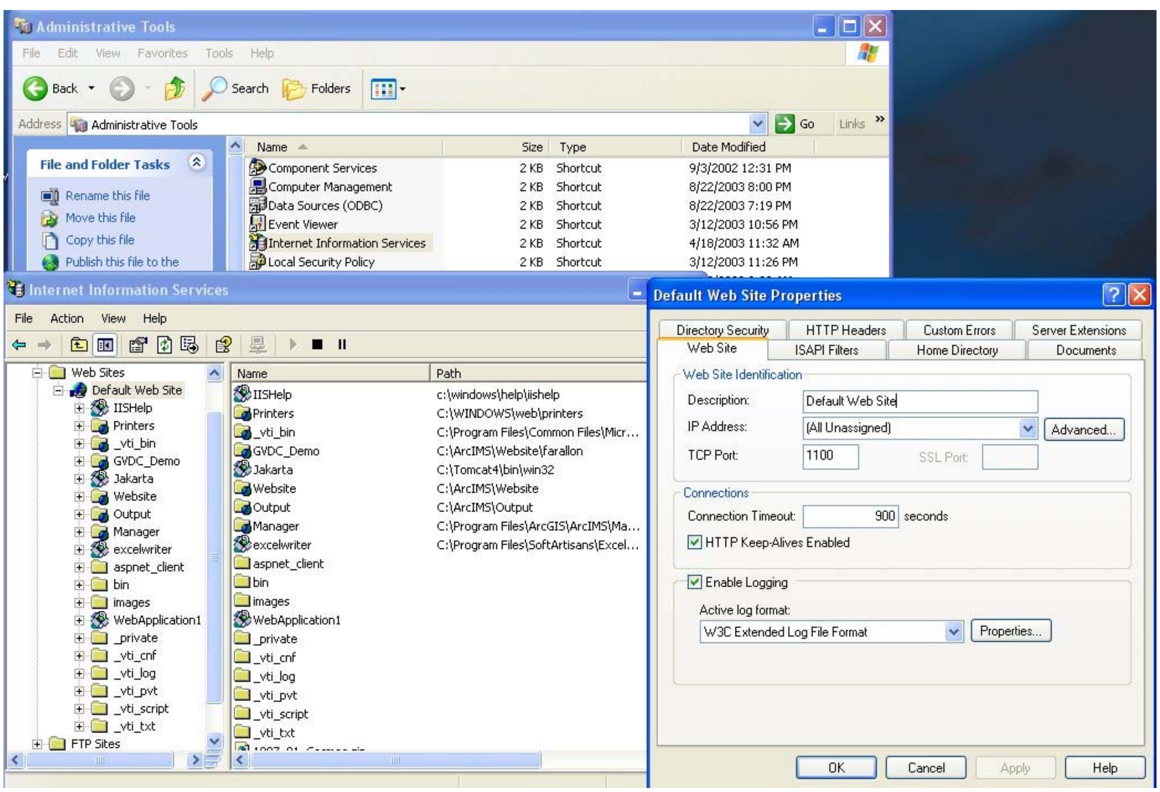


Figure 22. View IIS installation port number for Default Web Site.

4) For ArcIMS 4.0.1, Tomcat 4.0.5 should be installed, and in a directory called "C:\Tomcat4\", and port 8080 is recommended
5) ArcIMS 4.0.1 or higher is highly recommended; the front end application developed by Farrallon Geographics, Inc. for this project is known to be compatible with both versions 4.0 and 4.0.1.
6) Obtain ESRI technical support to assist in the installation. If support is unavailable, the following documents should be reviewed beforehand in order to install ArcIMS successfully:
    a. ESRI online support documents at "ESRI Knowledge Base", http://support.esri.com/index.cfm?fa=knowledgeBase.gateway
        i. ESRI Knowledge Base documents offer step-by-step instructions for installing ArcIMS on a given platform, with specified versions of Java (JDK) and web application servers. It is highly recommended to install the versions of JDK and web servers suggested in these articles, as the recommended releases were used to develop each specific ver of ArcIMS, thus will yield the most stable installation.
        ii. The installation notes used for the GVDC demo, "Install IIS 4.0/5.0 with Tomcat 4.1.12 using J2SDK 1.4.0 for ArcIMS 4.0.1 on Windows" are available (09/2003) at: http://support.esri.com/index.cfm?fa=knowledgebase.techarticles.articleShow&d=24280. Technical support via telephone was also provided by ESRI through the USC Site License for ESRI products (see notes below).
    b. Installation instructions on ArcIMS installation CD
    c. ArcIMS Help, see "Installation" for latest release notes, on ArcIMS installation CD
7) Perform a custom ArcIMS Installation, including installing the **ArcIMS Active X connector**, which is (critical!) required by the front end application. Also install the ArcIMS Tutorial Data, for testing the installation.
8) If installing ArcIMS ver. 4.0 on Windows XP (there is no specific documentation for this), the isapi_redirector.dll for Win XP must be used - download (link is available through article sited above) and copy to the directory indicated in the documentation for installing ArcIMS ver. 4.0 (see ESRI Knowledge Base for notes applicable to a given installation)
9) Following installation, confirm the settings of the System Environment variables (in Win XP, see Control Panel> System>Advanced>Environment Variables), i.e.:
    a. JAVA_HOME C:\j2sdk1.4.1_02
    b. CATALINA_HOME C:\Tomcat4

    These should point to the Java (JDK) and Tomcat directories, respectively (i.e. Figure 23).

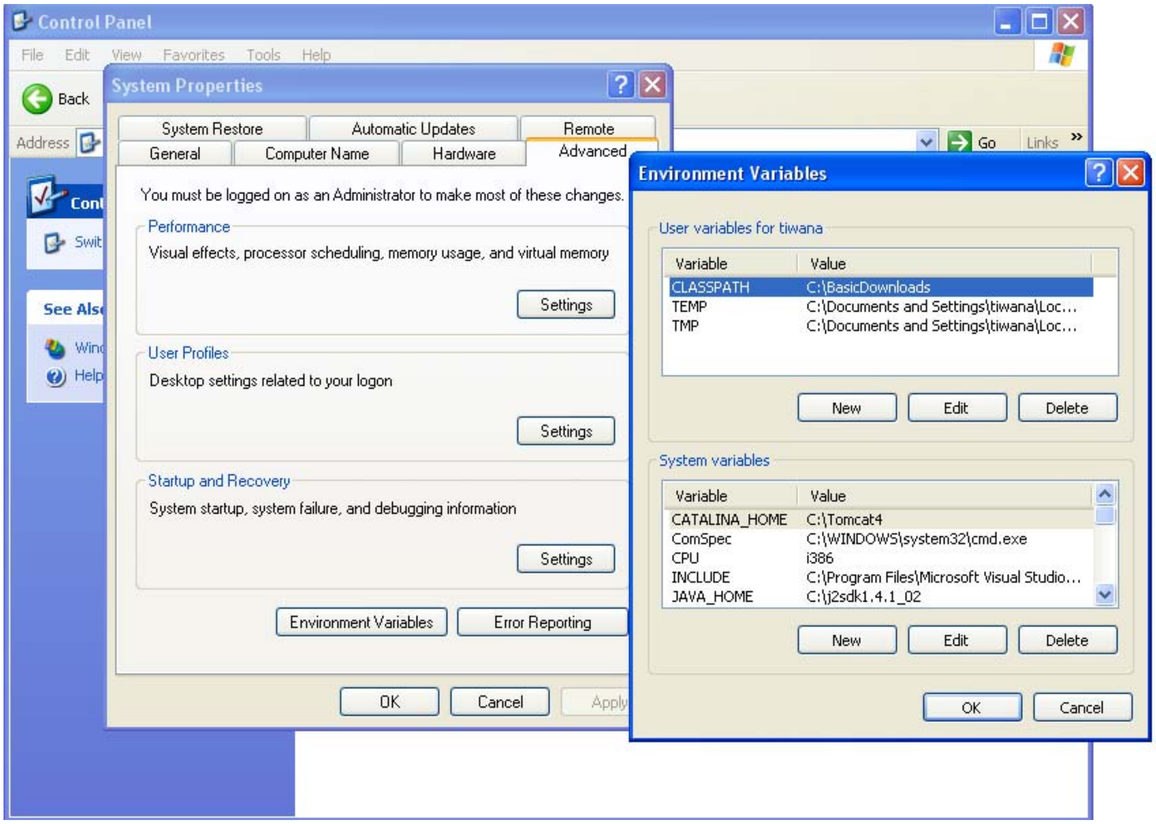


Figure 23. System Environment Variables, example settings for GVDC.

10) Confirm the setup of the following Virtual directories (Win XP: Control Panel>Administrative Tools>Internet Information Service, see new Default Web Sites (Figure 24), for example :
    a. Jakarta – C:\Tomcat4\bin\win 32 – contains isapi_redirector.dll
    b. Website – C:\ArcIMS\Website – directories such as ArcIMS tutorial, htmlviewer, and application directories
    c. Output – C:\ArcIMS\Output - empty

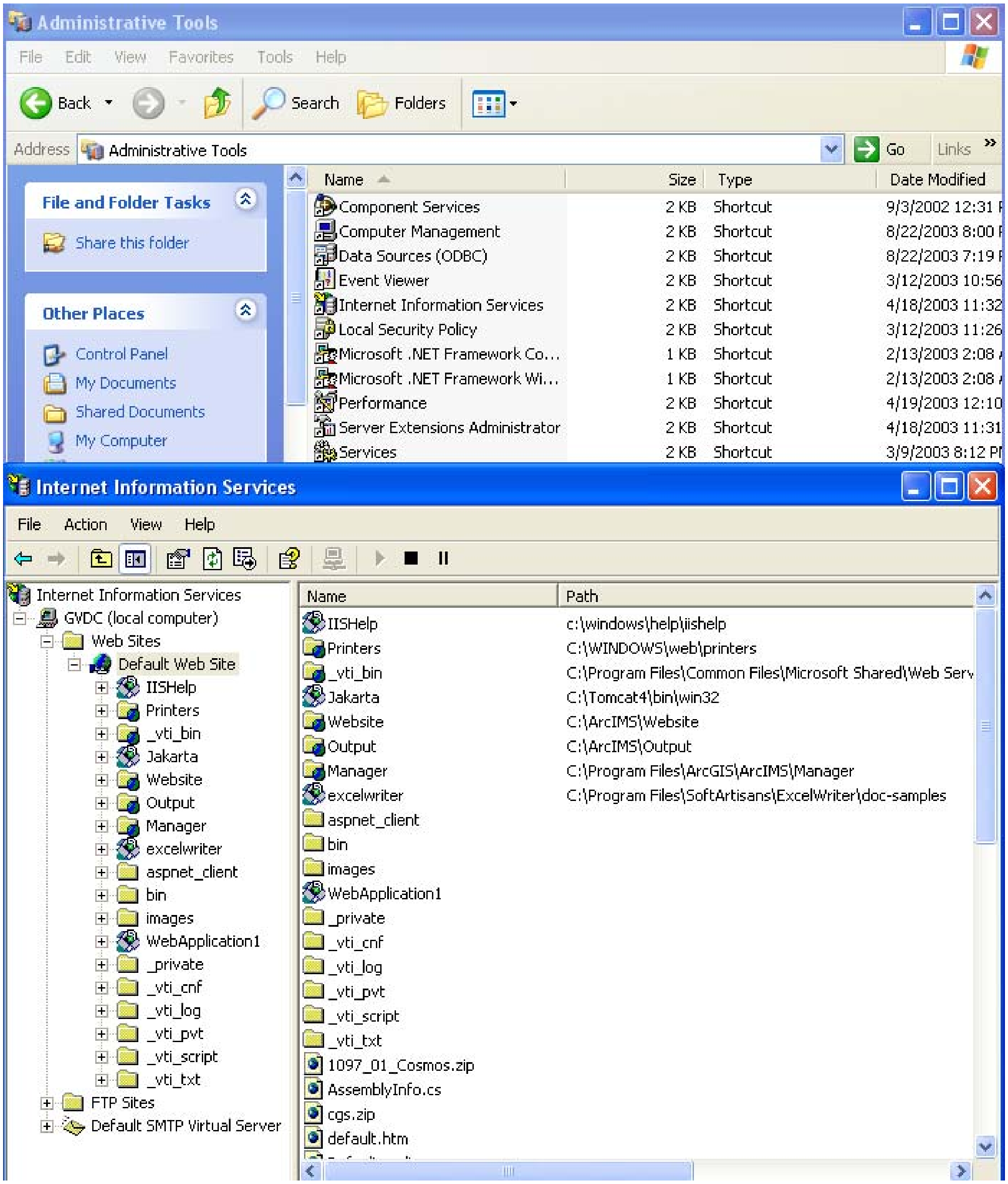


Figure 24. IIS Virtual Directories for GVDC.

11) Test the Tomcat installation by entering the root default URL in a browser i.e. http://geodata.usc.edu:8080/. An index.html page with information on Tomcat should display (i.e. Figure 25).

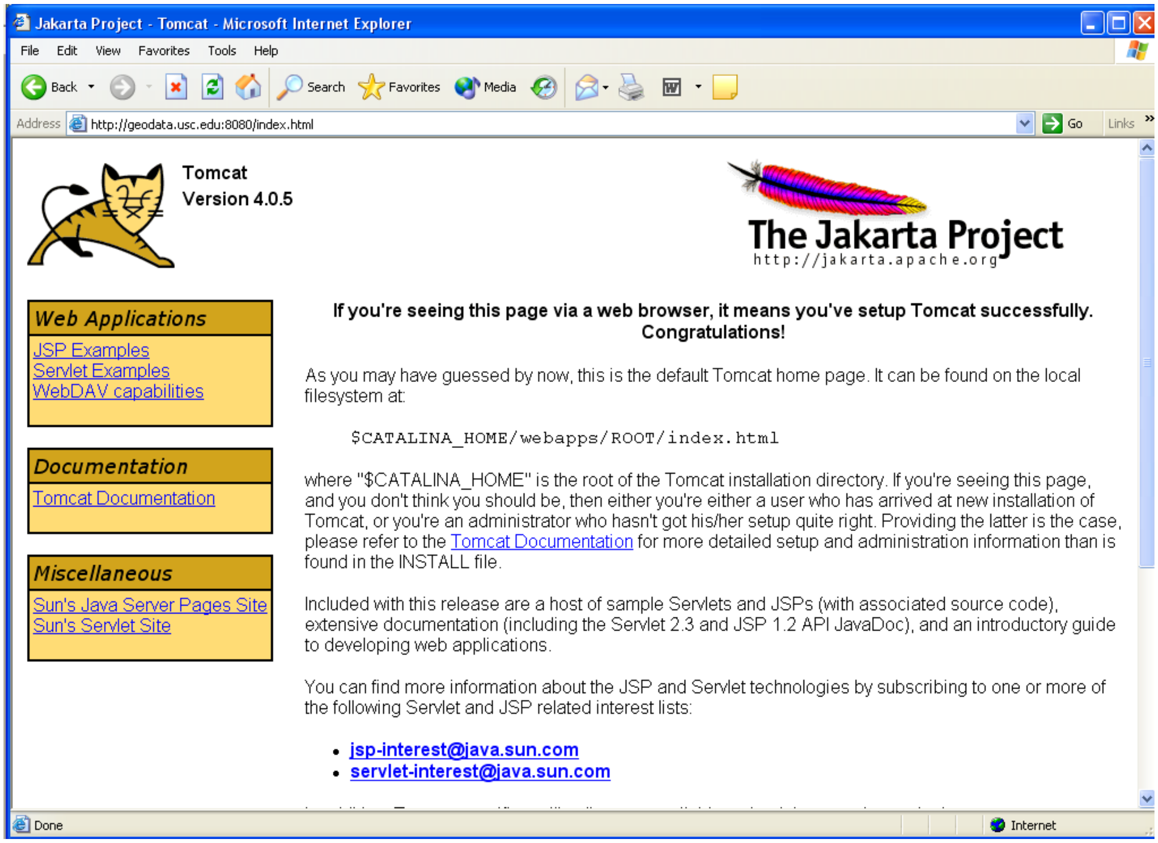


Figure 25. Example Tomcat installation default home page.

12) Upon installation, the default HTTP URL in ArcIMS Administrator includes the hostname, but not a specific port, even if the IIS default is other than 80**. In order to view a map being served from computers other than the server deploying ArcIMS,** the port number must be added manually to the ArcIMS Administrator HTTP URL (see View>Site Properties, "ArcIMS Site" and "Server Output" tags), such as http://gvdc:1100 (Figures 26 and 27). In this example, though the domain is geodata.usc.edu, the server hostname (required) is gvdc, and the IIS default port :1100 must be appended to the URL.

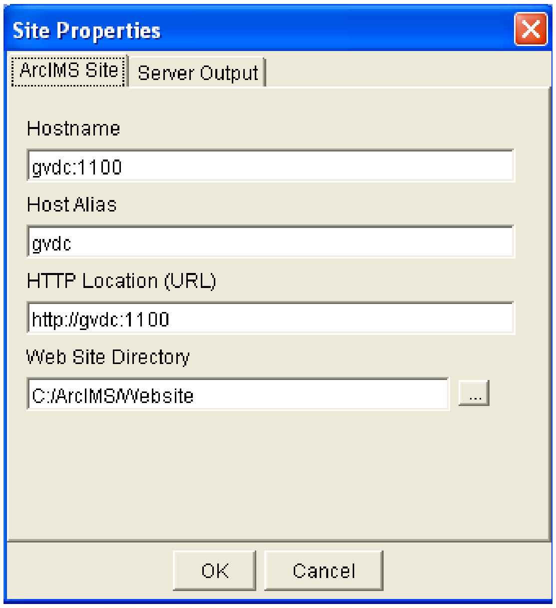


Figure 26. Administrator "ArcIMS Site", HTTP and port setup.

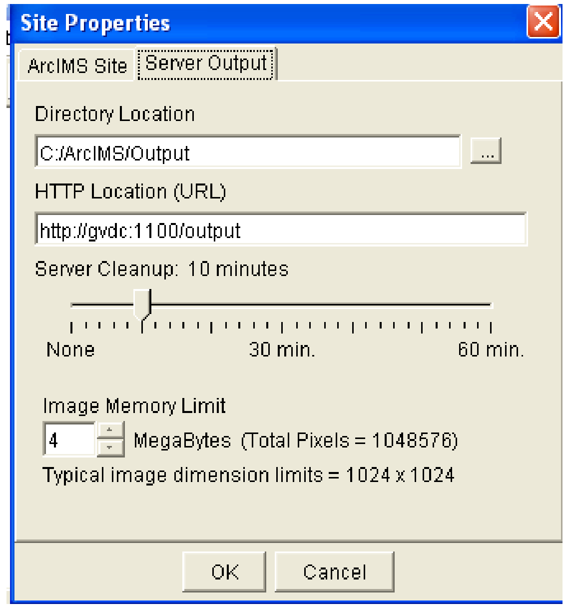


Figure 27. Administrator "Server Output", HTTP and port setup.

13) Test the installation by using the ArcGIS>ArcIMS>Diagnostic tool; enter the hostname such as 'gvdc' (not http://domainname), and the IIS port (Figure 28).

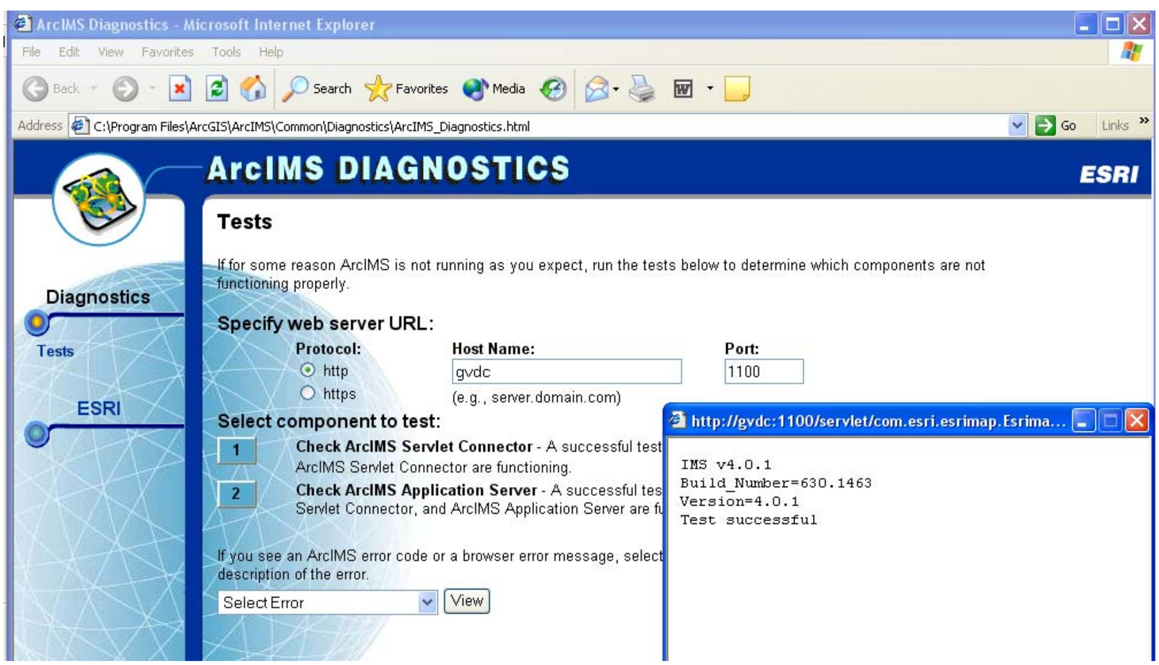


Figure 28.ArcIMS diagnostics tool for testing the servlet connector, example output (lower right) created by successfully selecting Component 1.

14) Launch ArcIMS Administrator. The user name and password will be the same as the Windows login under which ArcIMS was installed.

a. Highlight Services. Create a new “Test” Map Service. Service>New, enter in the following fields:
    i. Name – “Test”
    ii. Map File - an AXL file from the ArcIMS Tutorial data, such as C:\Program Files\ArcGIS\ArcIMS\Samples\TutorialData\AXL\SanFrancisco.axl
    iii. Vitual Server – Imageserver1
    iv. Under Server Output:
        1. Image Type should be JPEG
        2. Directory Location should point to the virtual output directory such as C:/ArcIMS/output
        3. HTTP Location should include the localhost name, such as http://gvdc:1100/output
b. Close ArcIMS Administrator.
c. Open a browser and enter the address of the Virtual directory “Website” created during the ArcIMS installation, i.e. http://geodata.usc.edu:1100/website (Figure 29).
d. Click on “htmlviewer” directory, the “Generic Map Setup” (Figure 30) on the “Sample HTML Viewers” page (Figure 29).
e. Under “Load Map Service” choose “Main Map” and “ “Overview Map” to be the services previously setup in ArcIMS Administrator, such as “Cosmos2” (i.e. Figures 31 and 32); select “Load”.
f. Seeing this test map or a similar example (from the axl files listed in the directory: \Program Files\ArcGIS\ArcIMS\Samples\ TutorialData\AXL\) is confirmation of a successful ArcIMS installation.

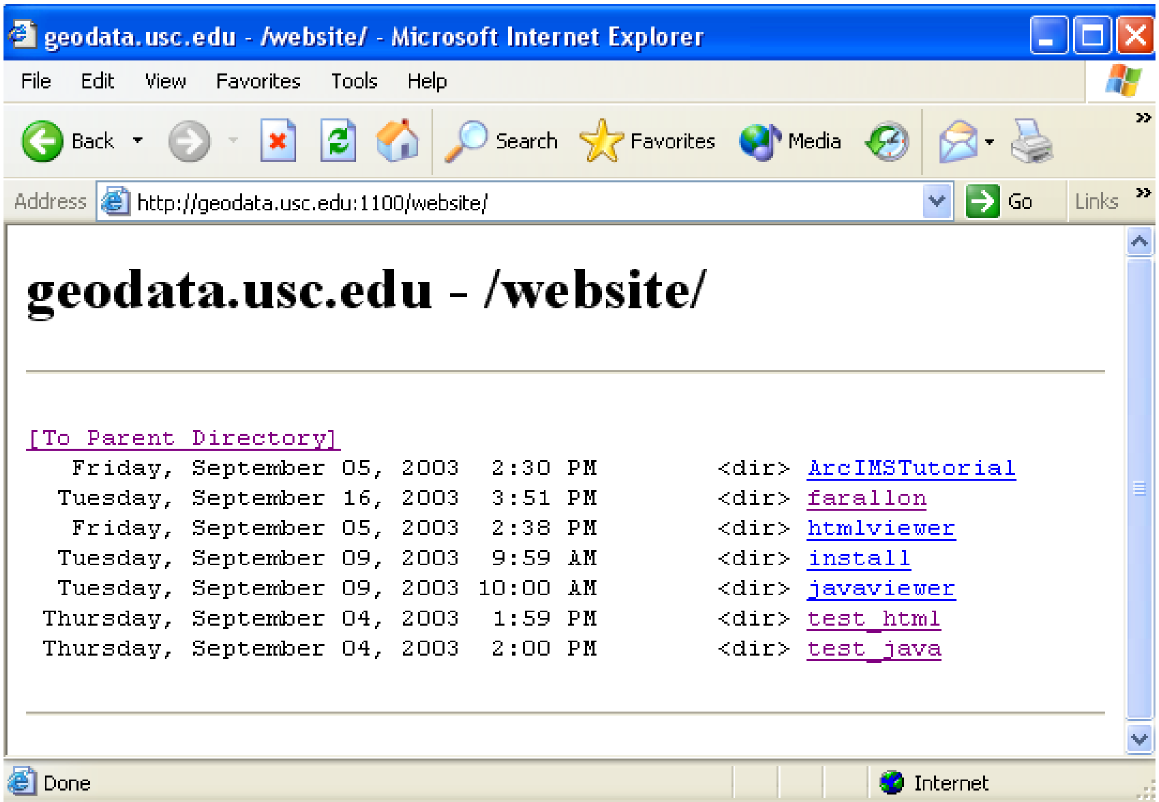


Figure 29. List of ArcIMS directories under virtual directory “Website”.

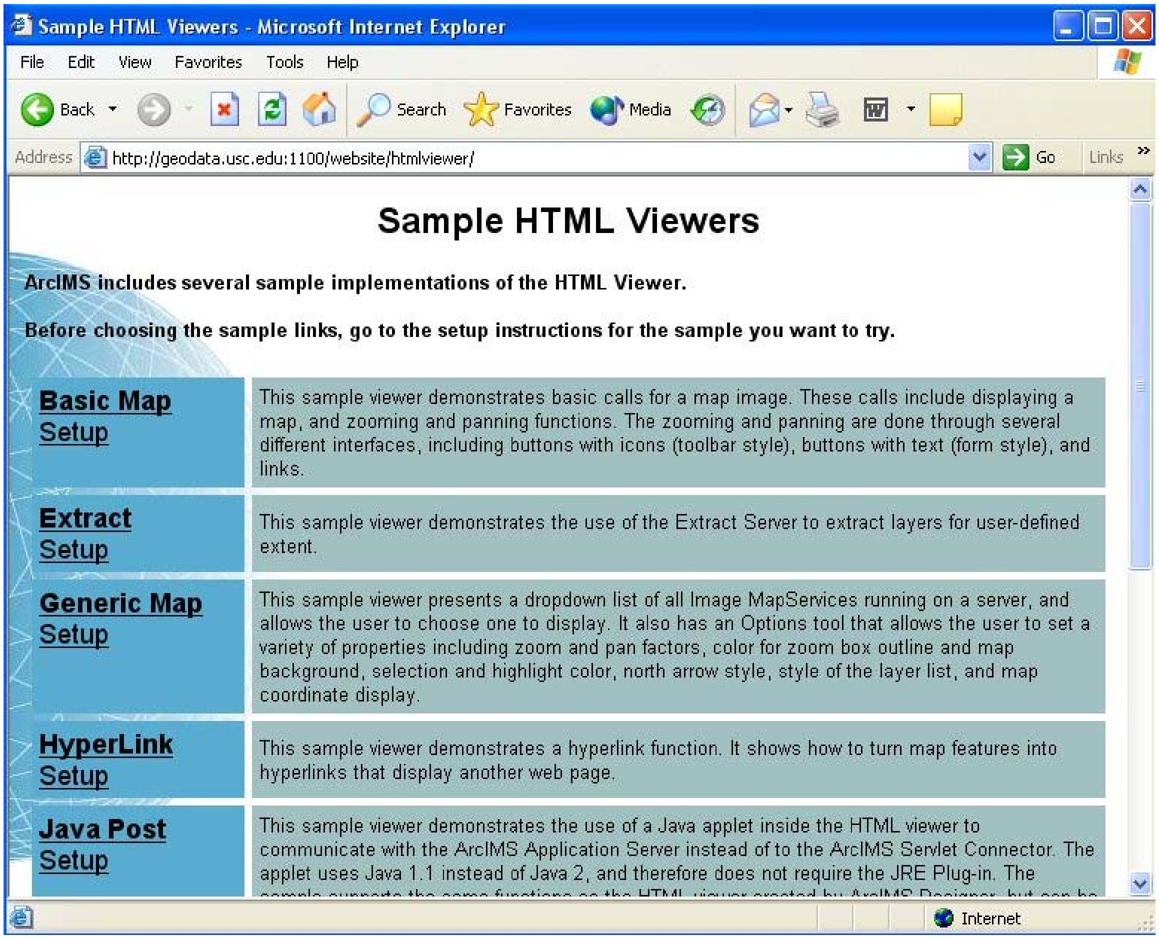


Figure 30. Sample HTML Viewers page, ArcIMS Tutorial examples.

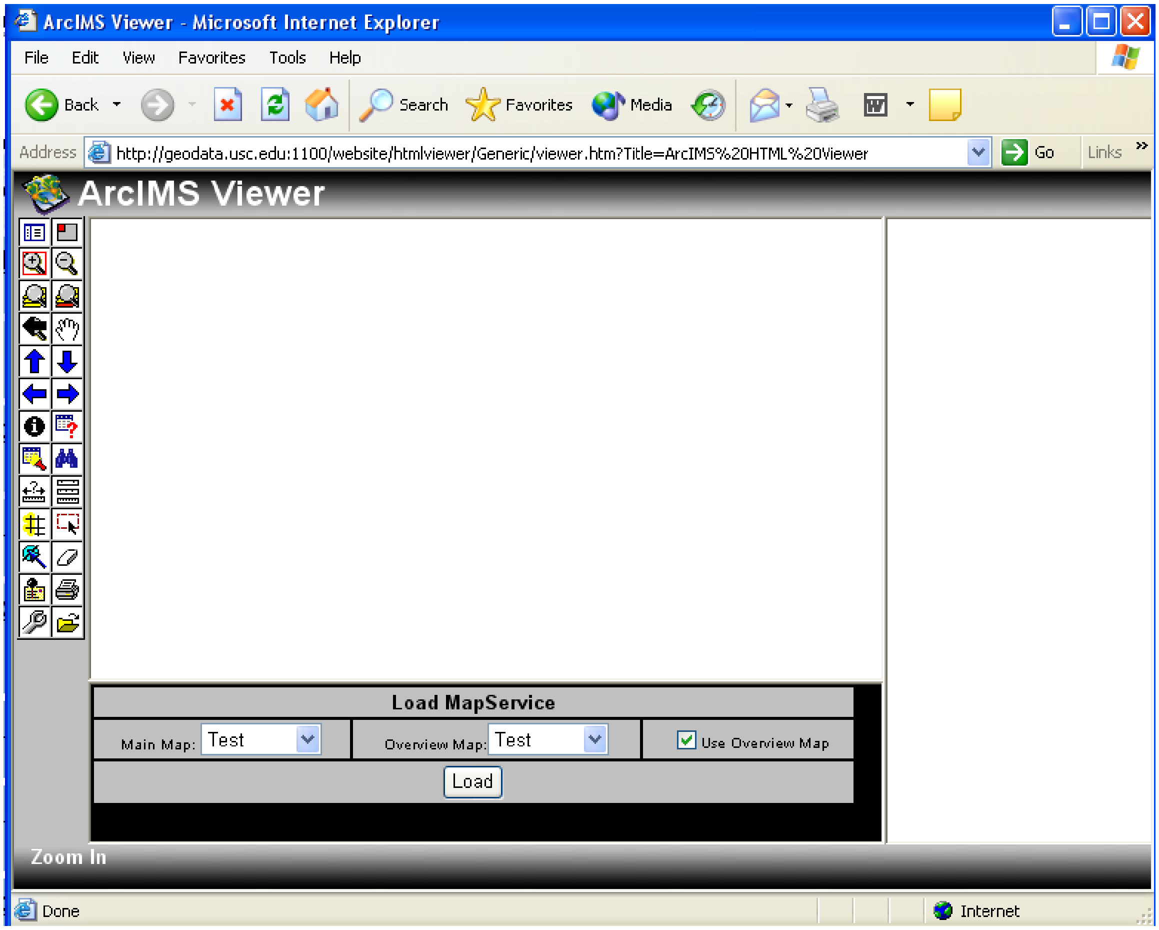


Figure 31. Generic Map Diaglogue Box, and HTML viewer example.

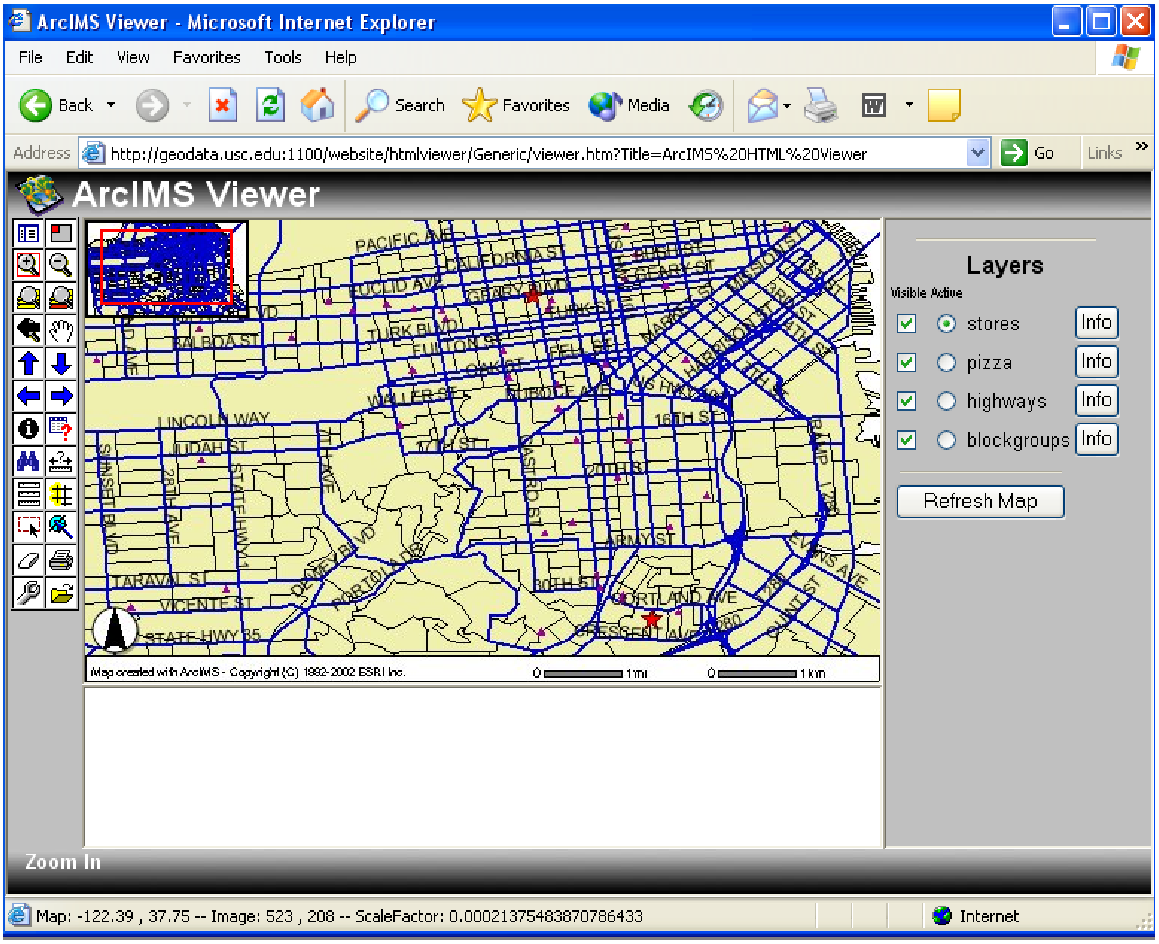


Figure 32. "Test" Map service, viewed with a Generic Map example viewer.

7.2 Update COSMOS/PEER-LL Geotechnical XML Schema and GVDC

A new phase of this project, "COSMOS/PEER-LL 2L03 - Modification of the COSMOS-PEER LL Pilot GVDC and Implementation", will be funded by PEER in 2005. Project 2L03 will include 1) expansion of the Pilot GVDC Data Dictionary to include data standards for shear wave velocity profiles, laboratory geotechnical testing, and insitu testing such as SASW, and 2) modification of the GVDC system architecture and tools for compatibility with the revised data exchange standard. A number of changes to the server-side and client-side COSMOS/PEER-LL Pilot GVDC system architecture were recommended to support new versions of the COSMOS/PEER-LL XML Schema to be developed in the project.

The following GVDC system components require modification:

- GVDC Database Structure
- Client Side Data Preparation and Exchange Protocol
- Server Side Back End System Architecture and Administrative Website
- Server Side Front End Website

- Documentation and Users Manual

The GVDC-related technical tasks to accomplish these developments are described in Task 1, Subtasks 1a through 1i.

The 2L03 work on the GVDC will be accomplished in three main tasks each of which have several subtasks, described below.

Task 1 - Modify the server-side and client-side COSMOS/PEER-LL Pilot GVDC system architecture, and upgrade the system server to support a larger user-base

The current version of the COSMOS-XML Schema will be modified. The modifications will involve the following COSMOS GVDC system components.

- GVDC Database Structure
- Client website interface and tools
- Client Side Data Preparation and Exchange Protocol
- Server Side Back End System Architecture and Administrative Website
- Server Side Front End Website

The modified system will be documented and a users manual will be prepared.

Work to accomplish Task 1 is divided into the following subtasks:

<u>Subtask 1a – Modify MySQL Database</u>
The required modifications to the GVDC database structure, MySQL, will consist of changes to tables, existing attribute names, attribute definitions, and relationships (keys), as well as any other modifications that may be identified during the development of the Task 1.

<u>Subtask 1b – Modify Client Side Exchange Protocol</u>
Modification of database structure, i.e. applicable stored procedures and OAIB configuration file will be made as required for the linked databases of the current data providers: California Geological Survey, Pacific Gas & Electric Company, Caltrans, and the US Geological Survey's PostrgreSQL.

<u>Subtask 1c – Modify Server Side Data Translators</u>
This subtask will make required modifications of:

- USGS Java XML Translator for PostgreSQL
- CGS and PG&E VBA XML Translators for Access
- Caltrans Translator for Legacy CPT Data Files

<u>Subtask 1d – Modify Server Side Data Previewers</u>
Work in this subtask will be done to modify:

- Convert existing SVG previewer for CPT and boreholes to a Java-bases application for cross-platform compatibility
- Convert existing Caltrans NET SVG previewer for CPT data to a Java-based application for cross-platform compatibility
- Develop and integrate into the GVDC a new Java-based previewer for down-hole seismic velocity logs and suspension velocity logs

Subtask 1e – Modify Server Side Front End Interactive Map
Work in this subtask will enhance the interactive GIS Map application and related code (i.e. SQL) as well as the Map Search Results code for compatibility with other modifications of the GVDC proposed here.

Subtask 1f - Modify Search Results and Data Download code
Work in this subtask will modify the ExcelWriter – download in Excel (from XML) and develop XSLT Stylesheet for easily viewing XML downloads for compatibility with other modifications of the GVDC proposed here.

Subtask 1g – Develop and integrate into the GVDC a new Java-based previewer for seismic velocity logs and suspension velocity logs
This task will develop a previewer software module for various seismic velocity, including PS-Logging, Downhole Logging, Crosshole velocity data, and velocity profiles derived using the surface wave profiling, SASW. This module will be similar to the previewer modules for CPT soundings and for borehole logs. The first action of this effort will be to evaluate whether the Petrochemical Open Software Consortium (POSC) module, WellLogML, can suitably be adopted. If it is determined that WellLogML can suitability be adopted for previewing geotechnical seismic velocity logs, the emphasis of this subtask will be on properly integrating the WellLogML package into the GVDC. The subtask will be accomplished by a small working group constituted of experts in the acquisition and geotechnical application of seismic velocity logs. The seismic velocity log previewer package will be integrated into the GVDC System as part of the modification of Server Side data previewers in Subtask 1d.

Subtask 1h – Hardware Upgrade and Redundancy
The GVDC will be duplicated on a second, high capacity server, which will become the production server. The existing server will be used to support system development and modification and for redundancy of the system.

Subtask 1i – Documentation, Users Manual and Final Report
The modifications to the GVDC System and changes to the architecture will be fully documented and will be included in the Final Report. This subtask also will include the preparation of a users manual, which will be made available to users at the GVDC website.

Task 2 – Expansion of the Data Dictionary Standard
AS part of 2L03, the current GVDC Data Dictionary (COSMOS XML v1.0) will be expanded to include data standards for various seismic velocity (i.e., PS-Logger,

Downhole Logging, Crosshole velocity data, and velocity profiles derived using surface wave profiling, SASW), laboratory geotechnical testing (i.e., triaxial, consolidation, and so on), and insitu testing (i.e., pressuremeter). A Data Dictionary Working Committee constituted of experts in the development of data dictionary standards and experts in the specific types of data to be captured by the revised dictionary will accomplish this task. Task 2 will be completed early in the Project and will become input to Task 1.

Task 3 – Development of an Operation and Maintenance Plan
This task will build on the discussions and recommendations developed in the June 21-23, 2004 COSMOS-PEER LL-FHWA Workshop. Discussion Groups identified policy and implementation issues that must be addressed and resolved as part of long-term M&O Plan for the GVDC and developed extensive recommendations. This task will use the workshop recommendations as a framework for developing a draft O&M plan.

8.0 DATA USAGE AND PRIVACY POLICIES

8.1 GVDC Data Usage and Privacy Policies

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Information Collected And How It Is Used

We do collect personal information directly from individuals who volunteer to use some of our services. Collection of this information is required to deliver the specific services, but use of these services is voluntary. COSMOS/PEER-LL does not sell any "electronically collected personal information." Any distribution of "electronically collected personal information" will be solely for the purposes for which it was provided to us.

What Happens To Information You Submit To Us?

If you choose to submit information to us, the information will be transmitted through secure methods to our COSMOS/PEER-LL GVDC (Geotechnical Virtual Data Center) database. Any private information will only be used for the purposes for which it was provided and will not be shared with another entity except as prescribed by law. Please see our Privacy Policy for additional information.

Surveys

If during your visit to the COSMOS/PEER-LL GVDC web site you participate in a survey or send an e-mail, the following additional information will be collected:

o The e-mail address and contents of the e-mail; and
o Information volunteered in response to the survey.
o The information collected is not limited to text characters and may include audio, video, and graphic information formats you send us.

If You Send Us E-Mail

You may choose to provide us with personal information, as in e-mail with a comment or question. We use the information to improve our service to you or to respond to your request. Sometimes we forward your e-mail to other COSMOS/PEER-LL employees who may be better able to help you, and this staff may be employed by a different university or agency. Except for authorized law enforcement investigations or, as required by law, we do not share our e-mail with any other organizations.

We use your e-mail to respond appropriately. This may be to respond to you, to address issues you identify, to further improve our web site, or to forward the e-mail to another agency for appropriate action.

Public Disclosure

In the State of California, laws exist to ensure that government is open and that the public has a right to access appropriate records and information possessed by State government. At the same time, there are exceptions to the public's right to access public records. These exceptions serve various needs including maintaining the privacy of individuals. Both State and federal laws provide exceptions. All information collected at this site becomes public record that may be subject to inspection and copying by the public, unless an exemption in law exists.

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(b) The purposes for which personally identifiable data are collected shall be specified at or prior to the time of collection, and any subsequent use of the data shall be limited to and consistent with the fulfillment of those purposes previoucptDataInfoy specified.
(c) Personal data may not be disclosed, made available, or otherwise used for a purpose other than those specified, except with the consent of the subject of the data, or as required by law or regulation.
(e) The general means by which personal data is protected against loss, unauthorized access, use, modification, or disclosure shall be posted, unless the disclosure of those general means would compromise legitimate agency objectives or law enforcement purposes.

8.2 Individual Data Provider Policies

Data usage and privacy policies obtained from data providers are displayed online through the GVDC as-is, without any modification of text by the GVDC administration. These policies are stored in the MySQL "gvdc" database table coreproviders.Disclaimers. Examples of policies provided for the GVDC pilot project by the data providers are presented below.

8.2.1 California Geological Survey

<u>Conditions of Use</u>
Please note that this Use Policy is subject to change without notice, and that it reflects California State's current business practices. This Use policy is dated December 7, 2000.

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"Electronically collected personal information" that we automatically collect includes your domain name or Internet Protocol address, and statistical information about which web pages you visit. If you voluntarily participate in an activity that asks for specific information (i.e., completing a request for assistance, personalizing the content of the web site, sending an e-mail, or participating in a survey) more detailed data will be collected. If you choose not to participate in these activities, your choice will in no way affect your ability to use any other feature of the web site.

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Children are not eligible to use services that require submission of personal information, and we require that minors (under the age of 18) do not submit any personal information to us. This includes submitting personal information to the State as part of a user profile or personalization profile. If you are a minor, you can use these services only if used together with your parents or guardians. If you are a minor, you should seek guidance from your parents.

If the State decides to begin collecting personal information from children, it will notify parents that it is being requested, disclose the reasons for collecting it, and disclose our intended use of it. The State will seek parental consent before collecting any personally identifiable information. If it does collect it, parents may request information on the type of data being collected, view their child's information, and, if they choose, prohibit the State from making further use of their child's information. The State will not provide personal information about children to third parties.

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The information we automatically collect or store is used to improve the content of our web services and to help us understand how people are using our services. This information does not identify you personally and is used for gathering web site statistics. The information we automatically collect and store in our logs about your visit helps us to analyze our web site to continually improve the value of the materials available. Our web site logs do not identify a visitor by personal information, and we make no attempt to link other web sites with the individuals that browse the State's web site.

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USE OF INTERNET REQUEST FOR ASSISTANCE FORM INFORMATION
Any information you provide to us will only be shared with entities involved in your case as necessary. Information you provide may be included with other consumers' information to be used for statistical reporting, trending data, and/or investigative actions. For example, we may need to retain information that becomes part of an enforcement action or consumer complaint case for a period of time after the closing date of the case.

If you provide us with information regarding an issue that does not fall within our regulatory jurisdiction, we may refer your information to the appropriate local, State, or federal agency on your behalf.

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We use your e-mail to respond appropriately. This may be to respond to you, to address issues you identify, to further improve our web site, or to forward the e-mail to another agency for appropriate action.

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LIMITATIONS SPECIFIC TO GEOTECHNICAL BORING LOG INFORMATION
It is important to understand what is (and is not) included with geotechnical boring log data. Users should review the descriptive metadata files before beginning to use the data. The following are some general characterizations of the data that one should be aware of when using these data, which may limit its use for specific purposes.

Geotechnical data have been compiled from existing repositories of cities, counties and other public agencies. We cannot vouch for the accuracy or precision of any of the data because we did not participate in the initial fieldwork involved in its generation. Nevertheless, we have strived to select for our files only those logs with adequate documentation and of sufficient quality that we judge are appropriate for use in our mapping efforts.

An attempt has been made to capture the data and compile it in our database in a way that represents, as closely as possible, what is shown on the boring logs and presented in the reports that accompany them. However, a range of individuals, from licensed, experienced geologists on our staff to relatively inexperienced student assistants has been involved in entering the data into our database. It is likely that all of these individuals did not follow exactly the same procedures (no matter how well defined) during data entry. Naturally, because not all drilling-rig operators and on-site geologists or engineers use industry standard descriptions or techniques, we have been forced, at times, to try to trancptDataInfoate nonstandard data and nomenclature to standard, or consistent, nomenclature and values.

Variations in our methods of locating borings and estimating the elevation of the ground surface where the boring was made depend upon several factors. These include: the type of maps presented in the report; the documentation in the report and on the log; the terrain information available in our GIS system; and the vintage of the map we use to locate the boring. In some cases, the best available topographic maps that we use to locate borings and estimate elevations predate changes due to local development and grading.

Difficulty in discerning from the log and associated report all of the parameters used in making the boring is very common. Occasionally, we have been required to make deductions and assumptions about how the borings were advanced.

A few parameters (for example, dry density) can be recorded exactly as presented on the log or on the associated laboratory data sheets. Alternatively, because not all labs and firms report parameters the same way, we may trancptDataInfoate the data to a different form for recording in our database.

Soil descriptions are taken verbatim from the logs/reports. However, in a very few cases we have had to supplement or correct apparent errors in descriptions or classifications that were omitted from the original log or incorrectly reported.

Because of these limitations, we ask that the data not be stored and widely redistributed from another data server. These data are under continuous updating, auditing, editing, and in some cases are completely removed from distribution because of serious uncorrectable errors. By restricting distribution to the DOC/CGS data server, propagation of erroneous information can be kept to a minimum. The Geotechnical Virtual Data Center uploads data directly from the DOC/CGS server, and is kept aware of its current contents and changes via regular metadata updates.

This Use Policy is subject to change without notice.

Privacy Policy
For details regarding the California Department of Conservation's Privacy Policy, please see our Conditions of Use. The text below reflects general requirements for State departments.

Pursuant to Government Code Section 11019.9, all departments and agencies of the State of California shall enact and maintain a permanent privacy policy, in adherence with the Information Practices Act of 1977 (Civil Code Section 1798 et seq.), that includes, but not necessarily limited to, the following principles:

(a) Personally identifiable information may only be obtained through lawful means.

(b) The purposes for which personally identifiable data are collected shall be specified at or prior to the time of collection, and any subsequent use of the data shall be limited to and consistent with the fulfillment of those purposes previoucptDataInfoy specified.

(c) Personal data may not be disclosed, made available, or otherwise used for a purpose other than those specified, except with the consent of the subject of the data, or as required by law or regulation.

(d) Personal data collected shall be relevant to the purpose for which it is needed.

(e) The general means by which personal data is protected against loss, unauthorized access, use, modification, or disclosure shall be posted, unless the disclosure of those general means would compromise legitimate agency objectives or law enforcement purposes.

Each department shall implement this privacy policy by:

Designating which position within the department or agency is responsible for the implementation of and adherence to this privacy policy; Prominently posting the policy physically in its offices and on its Internet website, if any; Distributing the policy to each of its employees and contractors who have access to personal data; Complying with the Information Practices Act (Civil Code Section 1798 et seq.), the Public Records Act (Government Code Section 6250 et seq.), Government Code Section 11015.5, and all other laws pertaining to information privacy, and Using appropriate means to successfully implement and adhere to this privacy policy.

8.2.2 California Department of Transportation (Caltrans)

The conditions of use and privacy policy information for the Caltrans data set will be provided by Caltrans and subsequently available throiugh the GVDC in early 2005.

8.2.3 United States Geological Survey (USGS)

The conditions of use and privacy policy information for the USGS data set will be provided by the USGS and subsequently available throiugh the GVDC in early 2005.

8.2.4 Pacific Gas & Electric (PG&E)

The conditions of use and privacy policy information for the PG&E data set will be provided by PG&E and subsequently available throiugh the GVDC in early 2005.

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10.0 CONTACT INFORMATION

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APPENDIX 4

CONCLUSIONS AND RECOMMENDATIONS FROM THE JUNE 21 – 23 WORKSHOP: ARCHIVING AND WEB DISSEMINATION OF GEOTECHNICAL DATA

Three Topical Discussion Groups convened in breakout sessions and developed the conclusions and recommendations of the workshop. The breakout discussion topics were:

- **Technical Issues**: John Bobbitt, Chair, Jennifer Swift, Recorder;
- **Policy Issues:** Charles Real, Chair, Clifford Roblee, Recorder; and
- **Implementation and Management Issues:** Carl Stepp, Chair, Loren Turner, Recorder.

Each Topical Discussion Group reported the results of its breakout discussions as conclusions and recommendations to the workshop attendees in plenary session. Discussions of the Topical Discussion Group reports developed the consensus conclusions and recommendations of workshop attendees that are summarized below.

<u>**Technology Issues:**</u>

1. **Short-term Implementation:** COSMOS should proceed with implementation of the GVDC using the Geotechnical Data XML Schema (GVDC-XML; W3C, 2004a) versioning (1.0, 2.0, …..). Implementation should include the establishment of a working group that will oversee the maintenance of the released version. Upon release of a version a new committee should be formed to oversee the development of the next version. All new versions must have backward compatibility with previously released versions. Subsequent versions of the schema would likely include:
   - ❑ Addition of new data types such as other lab and insitu geotechnical test data, and geophysical test data (i.e. shear wave velocity).
   - ❑ Incremental schema changes resulting from coordination efforts with other standards organizations.

2. **Development of a General Data Exchange Standard:** Workshop participants strongly recommended that actions be undertaken to develop a data exchange standard that has broad international consensus. The consensus standard could be developed by merging the GVDC-XML and the AGSML (Association of Geotechnical and Geoenvironmental Specialists; AGS, 2004) by implementing one or a combination of the following four options.
   - Option 1 – improve GVDC-XML geotechnical data model;
   - Option 2 – COSMOS works with AGS to develop a consensus standard.
   - Option 3 – Both COSMOS and AGS could drop their existing standards and put standard into Open GIS (Geographic Information System) framework.
   - Option 4 – COSMOS could adapt GVDC to Open GIS.

Migration to the Open GIS Consortium (Open GIS Consortium, Inc.) standard has the potential advantage that it would open access to geotechnical data to a significantly larger user community. Several issues would need to be addressed:

- Need champions to lead this development.
- An organization would need to learn GML (Geography Markup Language; W3C, 2004b) in order to implement it.
- Would require a geotechnical data working group within the OGC.
- Would likely require two years to implement.
- AGS likely would consider this as a long-term objective.
- Would require approximately $10k (1-2 weeks of work) to adapt GVDC to Open GIS.

  Other standards (besides AGS) and models must be considered:
  - Japan – they are currently using XML with OGC. They have developed GML 2.0 and are developing GML 3.0 to be ISO compatible.
  - Europe – France and Germany are using a “Eurocode” system.

- Other Data Modeling tools may could be, in addition to XML Schema could be adopted:
  - Ontology – has the capability to build knowledge/links in addition to words into GVDC-XML.
  - OWL – is a language for ontology on the web (W3C, 2004c). The XML Schema can be translated into OWL if desired, though the model would require some adaptation.

Consideration of these issues goes beyond the development of a consensus data dictionary standard, which can be viewed as a separate effort, although there is a dependency of data model development.

3. **The following steps are recommended/required to release GVDC-XML schema to version 1.0.**
   - Declare the schema to be normative.
   - Establish a working group to oversee version developments.
   - Develop “User Guidelines” for Data Providers.
   - Require compliance standards.
   - Provide for documentation of numerated lists.
   - Hire a full time person to operate the GVDC and interact with data providers and users.
   - Develop training materials and hold training classes for GVDC data providers and their user base.

4. **Other recommendations:**
   - Release example data and the standard now.
   - Initiate major changes (merging with AGS, OGC) now.
   - The GVDC should only have simple previewers.

- Farm out reliability and liability to another entity.
- Have software vendors test the schema.
- COSMOS should evaluate whether the GVDC has enough end user applications in place to go to implementation.
- COSMOS should establish sister sites linked through the GVDC.

Policy Issues:

1. **DOTs' interest level in advancing common standards:** States have a genuine interest in developing common standards for data exchange, but believe there are barriers that must be overcome.

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The high benefit of having the ability to exchange data in a common standard is recognized, however.

- A common standard would help achieve consistency/completeness in contracts.
- A common standard would add value with respect to intrastate sharing.

2. **Is the GVDC technology appropriate for general application by all states?** More time is needed to evaluate the GVDC and compare the Data Dictionary with agency needs. The GVDC is moreover, only one component of a geotechnical asset management system

3. **Would the GVDC system be a justifiable investment for a state DOT?** The consensus response to this question is yes. More readily available data would reduce project costs. Since a broad geotechnical assets management system has several componentsthe GVDC would need to be integrated with the larger system.

4. **How can the GVDC development and implementation be coordinated with the broader FHWA initiative to develop a general "geotechnical assets management" system?** The project for development of the FHWA geotechnical assets management system (GAMS) should proceed. As the GVDC is a component of the GAMS, the extent to which it will be adopted and the level of its use will occur over time as state DOTs fully define and justify their needs.

5. **Who should operate the GVDC?** Essential requirements are indemnity and sustainability. The consensus recommendation is that the GVDC could be operated by a non-profit organization.

6. **What policy barriers exist?** States must honor their policies and policies are too variable among states to be fully stated at this time. Each state will need to determine its policies and establish procedures for working within them.

7. **How should data quality be managed?** Data quality should be managed to avoid serious restrictions on data being entered into the system. Users can judge data quality by the available metadata: certified reports (i.e., signed by a licensed professional), AASHTO certified laboratories, purpose for which data were acquired. It also was noted that data quality impacts liability issues.

8. **How should liability be managed?** It is recommended that COSMOS research liability exposure posed by the GVDC. In geotechnical engineering practice liability rests with the registered professionals who use the data rather than with the data provider. If a user obtains data from the GVDC and then finds later that it is bad data, the liability is not clear. Disclaimers and user guidance documents should be developed. COSMOS should consider following the AGS and Kentucky examples and establish a legal working group to address liability matters

Implementation & Management Issues:

1. **What are the next steps to have the COSMOS GVDC adopted by practice?** A key next step is to establish a funding mechanism for implementation and operation of the GVDC. This means marketing the system through presentations at conferences such as FHWA regional geotechnical conferences, the management sessions of the Transportation Review Board (TRB) and to technical working groups, development of a brochure and circulating it widely among potential supporters, and development of an appealing Web site. Action should be taken to market the GVDC to states that have not yet recognized the benefit of a data management system. Contacts for agencies and organizations can be provided by the FHWA. Publications should be prepared for technical journals and workshop proceeding.

A second key need is to resolve the data standard issue by developing a standard that has broad consensus among standards groups such as POSC and AGS as well as by professional organizations that represent the practicing geotechnical profession. Action should be taken to form a working group that is broadly representative of the stakeholders to prepare a draft consensus standard under the oversight of a standards organization.

2. **What are viable mechanisms for sustained funding of ongoing COSMOS GVDC development and operations?** $250,000.00 is reasonable estimate of the annual cost of operation and continuing upgrading of the GVDC. The cost would be higher or lower depending on the level of effort devoted to upgrading the system. FHWA-state DOT pooled funding is a potential source of support for continuing development for two to there years. State DOTs need to understand the benefits that the GVDC brings to their businesses, the cost of integrating it into their businesses, and the benefits to their businesses in terms of operational and economic efficiencies. A proactive effort should be made to communicate these benefits to the state DOTs, most of which do not currently perceive data as an asset.

COSMOS working with data providers and users should develop a business plan that achieves self-sufficiency for long-term operation of the GVDC. Supplemental funding from public agencies that are major data providers or users should be considered as part of a business plan.

3. **What mechanism can/should be established for robust coordination of efforts related to the development of geotechnical site characterization and data management systems?** Action should be taken to form both policy and technical oversight for continued development and implementation and long-term operation of the GVDC. The technical oversight committee should oversee continuing technical developments and the policy oversight committee should provide policy guidance.

4. **What mechanisms are needed to bring dispersed and broader systems together?** An early action should be taken to develop a consensus geotechnical data exchange standard. This action could be initiated by the formation of a working group constituted of representatives of the COSMOS GVDC-XML schema and the AGSML schema. The working group should be charged with developing a consensus standard that can be adopted by all geotechnical data providers. The conduct of this effort should be broadly coordinated with other organizations that have geotechnical data exchange standards or may be in the process of developing data exchange standards.

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