FINAL REPORT

REVIEW OF CURRENT PRACTICE IN CHARACTERIZATION AND MONITORING

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Prepared for:

U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

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DISCLAIMER

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January 2001

Prepared for

U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

U.S. Department of Energy
Under Grant No.: DE-FG21-95EW55094

ACKNOWLEDGMENTS

This report is based on work supported by the U.S. Department of Energy, Office of Environmental Management, Office of Science and Technology's Deactivation and Decommissioning Focus Area, National Energy Technology Laboratory (NETL). The Principal Investigator, the Florida International University (FIU) Collaborators, and students at FIU would like to thank Dr. Paul Hart, Robert Bedick, and Steve Bossart for providing us with support and the opportunity to work on this project. In addition, FIU-HCET would like to thank Consumers Energy's personnel for collaborating in this demonstration and providing the Big Rock Point as the hosting demonstration site.

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ACRONYMS

CMST-CP	Characterization, Monitoring ,and Sensor Technology – Crosscutting Program
DDFA	Deactivation and Decommissioning Focus Area
DOE	Department of Energy
EM	Environmental Management
FIU	Florida International University
FY	Fiscal Year
HCET	Hemispheric Center for Environmental Technology
INEEL	Idaho National Engineering and Environmental Laboratory
MWFA	Mixed Waste Focus Area
NMFA	Nuclear Material Focus Area
ORR	Oak Ridge Reservation
SCFA	Subsurface Contamination Focus Area
SRS	Savannah River Site
STCG	Site Technology Coordination Group
TFA	Tanks Focus Area

EXECUTIVE SUMMARY

This two-year project had the goal of creating a database containing cost and performance data on baseline characterization and monitoring technology used at Department of Energy (DOE) sites. This database will facilitate the direct comparison of innovative technology to the current practice or baseline technology. The Site Technology Coordination Group (STCG) need statements were reviewed for characterization and monitoring needs for the DOE sites at Hanford, Oak Ridge Reservation, (ORR), Idaho National Engineering and Environmental Laboratory, (INEEL), and the Savannah River Site (SRS). The baseline technologies were identified from these need statements. Cost and performance data for each baseline technology was obtained, evaluated, and entered into the database. The Current Practice database is accessible to the Characterization, Monitoring Sensor, and Technology - Crosscutting Program (CMST-CP) and others at the Internet address <http://131.94.165.121/.> Access to this database from the CMST-CP webpage can be accomplished by the use of a link.

1.0 INTRODUCTION

Characterization and monitoring are important parts of environmental remediation of contaminated sites by the Department of Energy – Office of Environmental Management (DOE-EM). The actual remediation process often cannot begin or even be planned until characterization is complete. Monitoring is essential to verify the progress of remediation and of the waste stream. However, some contaminated sites are difficult, costly, or have a high exposure risk to personnel to characterize or monitor using the baseline technology or current practice. Therefore, development of new characterization and monitoring technologies is time-critical to remediate these sites.

The main task of the Characterization, Monitoring, and Sensor Technology Crosscutting Program (CMST-CP) is to develop and deploy innovative characterization and monitoring technologies that improve performance and reduce personnel exposure, cost, and detection limits. However, to evaluate different proposals for new technologies to decide which ones to develop or deploy, it is necessary to compare their cost and performance to the baseline technology. The goal of this project is to facilitate the direct comparison of new technologies to the baseline technology by documenting the current practices for site characterization and monitoring at DOE sites and by presenting the information in an easy-to-use, concise database. The database will assist the CMST-CP and others in evaluating or designing new technologies by identifying the baseline technologies and describing their performance and cost.

The characterization and monitoring need statements published by the Site Technology Coordination Groups (STCGs) of each site were used to identify the baseline technologies that are, in some manner, insufficient and need to be replaced with new technologies. Baseline technologies that perform satisfactorily and do not need replacement are not evaluated for the database. Cost and performance data of each baseline technology identified was obtained through documents, vendors, site personnel, and experts. The data was evaluated and tabulated into a database. The sites investigated were Hanford, Oak Ridge Reservation (ORR), Savannah River Site (SRS), and the Idaho National Engineering and Environmental Laboratory (INEEL). This database was placed on the Internet at <http://131.94.165.121/>, allowing the CMST-CP and others to access it. Access to this database from the CMST-CP webpage can be accomplished by the use of a link.

The database contains tables concerning the STCG needs and the identified baseline technologies. Continual discussions concerning the project and the database with CMST-CP personnel were held throughout FY99 and FY00. A prototype database was presented at the 1999 CMST-CP Mid-Year Review at Gaithersburg, Maryland, on March 9-10, 1999. The database was demonstrated to several representatives from the Decontamination and Decommissioning Focus Area and from CMST-CP who visited FIU-HCET throughout the duration of the project.

The purpose of this document is to report on the completion of this project and to describe the database. Section 2.0 describes the data assessment methodology. Section 3.0 presents the database and serves as a user manual. Section 4.0 lists the references used for each baseline technology in the database. The full references can be found in the Appendix.

2.0 DATA ASSESSMENT METHODOLOGY

The first step in this project was to identify the baseline technologies. The goal was to concentrate on the baseline technologies that had been identified as being inadequate in some aspect of site characterization or monitoring and required replacement with a new technology. Therefore, the STCG needs were reviewed for characterization and monitoring needs for four of the largest, more complex DOE-EM sites: Hanford, ORR, INEEL, and SRS. The STCG need statements list the baseline technologies used at the sites. Some need statements were ambiguous and required further investigation to identify the baseline technology. Sixty-three baseline technologies were identified.

After identifying the baseline technologies, research into the cost and performance data began. Information was obtained from many sources(listed in section 4.0), evaluated, and then tabulated. Information was obtained from DOE documents, vendors, site personnel, and experts. Unfortunately, many requests for information from site managers and end-users at the sites were unanswered. In such cases, data had to be obtained from documentation written by site managers and end-users about their work. A vast majority of these documents are available on the DOE website "DOE Information Bridge" at <http://www.osti.gov/bridge/> as an Adobe Acrobat file.

All the data was combined and compacted into several paragraphs. Concise descriptions were written for each technology, and the data was divided into two categories: performance and cost estimates. The performance capabilities were divided into the categories: ability to meet STCG need, time, waste, detection limit, and personnel exposure. The cost estimates included, when available, capital, maintenance, and operational costs.

The cost estimates for many of the baseline technologies were hard to generalize. Some technologies have a wide range of capital cost depending on the desired capabilities of the machine or instrument. Other technologies had a wide range of operational costs depending on the terrain, obstacles, required detection limit, and other factors. Costs obtained from different sources also had a variation in the dollar amount. Therefore, costs are often given as a range. Operational costs are given as dollars per foot, per square foot, per sample, per hour, or other unit. Subsite specific costs are not obtainable since each subsite has specific characteristics that change the cost, and each site contains numerous subsites.

3.0 DATABASE DESCRIPTION

3.1 USER INFORMATION

The Current Practice Database can be accessed at the Internet address <http://131.94.165.121/>, which is the login page. No domain name has been registered for the database. Users enter their login name and are sent to the database map; however, new users are required to enter some information (name, company name, and e-mail address) to obtain a login name (see Figure 1). The database map is a web page with several links that allow the user to access the information. The database map contains four divisions: the STCG Needs, Baseline Technology, Search, and Visitor Utility (see Figures 2a and 2b).

The STCG Needs are categorized (see Figure 2a) either by Focus Area -Decontamination and Deactivation (DDFA), Subsurface Contamination (SCFA), High Level Waste (HLW), Tanks (TFA), Mixed Waste (MWFA), and Nuclear Materials (NMFA)- or by DOE site (ORR, Hanford, INEEL, and SRS). The STCG Needs table has three columns: the need number, the title of the need number, and the baseline technology identified for that need (see Figure 3). The need number is a link that takes the user to the information on that specific need, which contains the STCG need name, STCG need number, description, requirements, regulation, baseline technology, site location, and focus area (see Figure 4). Moreover, the baseline technology name is a link that takes the user to the specific baseline technology table, which contains the baseline technology name, STCG need number, purpose, description, cost data, ability to meet STCG needs, time, waste generated, detection limit, personnel exposure area, and comment (see Figure 5).

The Baseline Technology section in the database map divides the technologies into focus areas and also has a "view all" option (see Figure 2b). The baseline technology table for each focus area has three columns: the baseline technology name, purpose, and the STCG need number(s) that identified this technology (see Figure 6). The baseline technology name takes the user to the same link as the baseline technology name in the STCG needs table. The purpose tells the user the use of this technology and does not serve as a link. The STCG need number takes the user to the information table for that specific STCG need number in the same manner as the STCG table. The View All option brings the user to a list of all the baseline technologies and allows the user to chooses the specific technology to view (see Figure 7).

In the search section of the database map, the user is presented with tools that search the database. The Selective Search has an option to choose either STCG Needs or the Baseline Technology and then sends the user to a page to choose the field area (such as "description," "cost," or "personnel exposure") and to write the search string in a blank box (see Figure 8). The other search option is the General Search, which allows the user to search for a word or phrase (the search string) among the entire text of the STCG Need or Baseline Technology text (see Figure 9).

The Visitor Utility has different links with a variety of options. It has the text of the database in Microsoft Word format (and can be downloaded), Member E-mail, Event Board, Post a Question, Member Chat, and Last 10 Visitors (see Figure 2b).

There is also a link that connects the user to the Home page or the login page. Other sidebar links are Description of the Database, Acronyms, About Us, Contact Us, Disclaimer, Links, and STCG Need Notes.

Figure 1. The login page is the main page of the database.

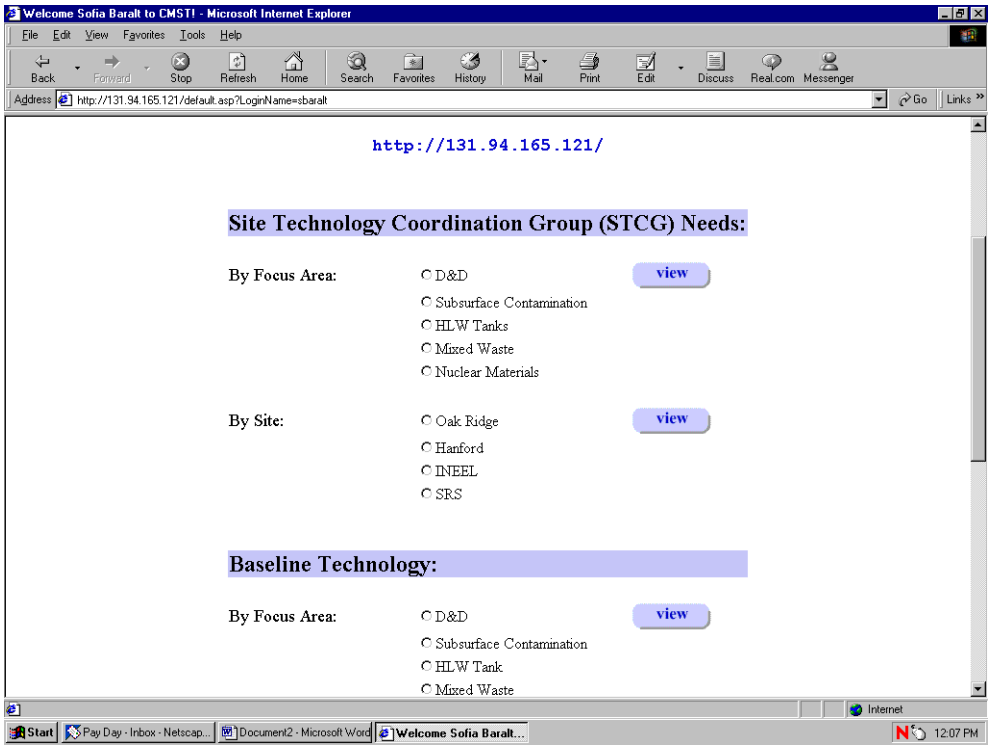


Figure 2a. The database map has different links that take the user to the Site Technology Group (STCG) Needs table or the Baseline Technology table.

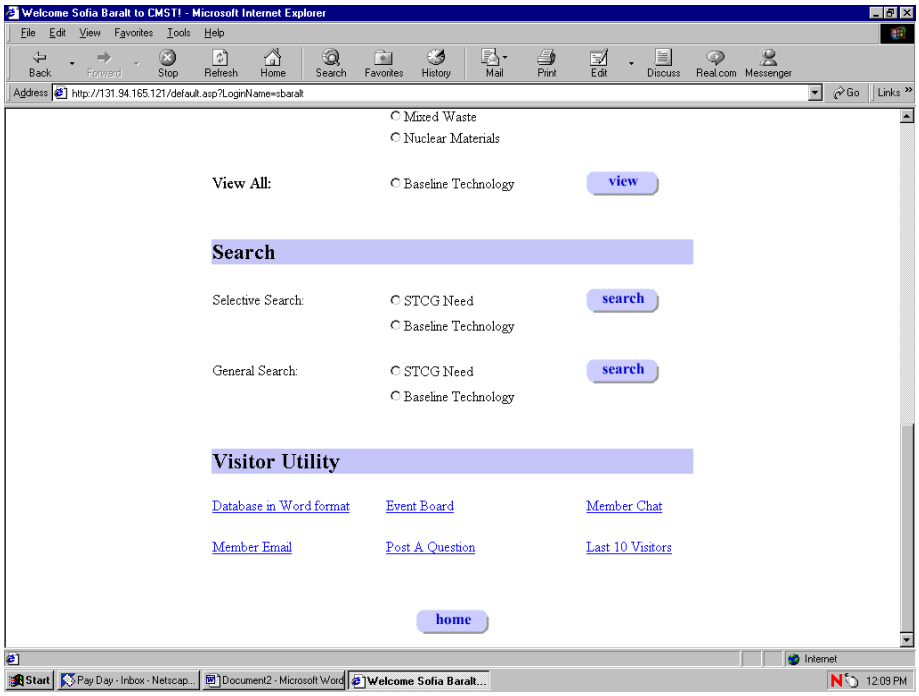
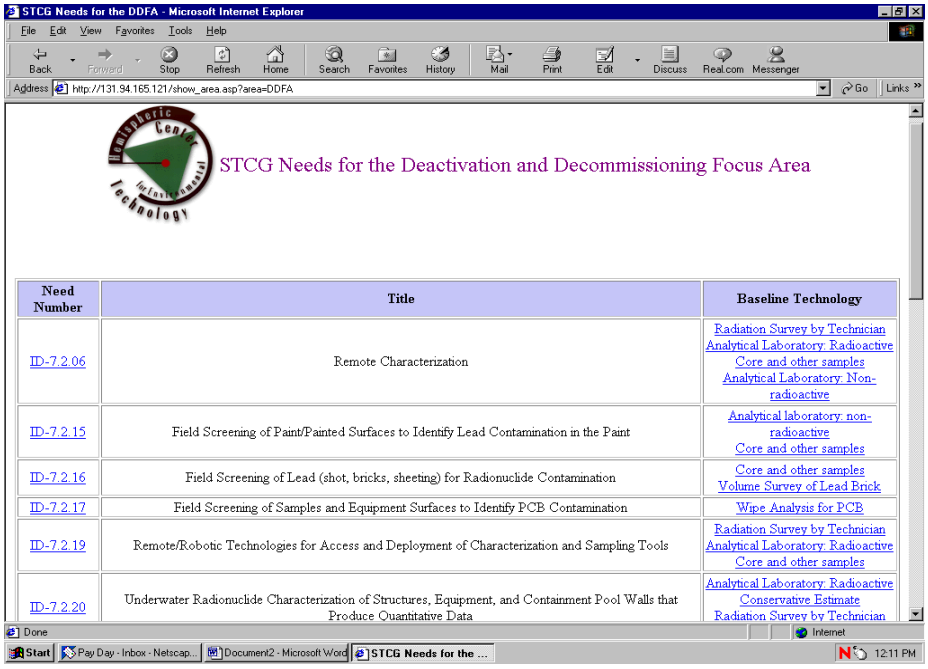


Figure 2b. This is the bottom part of the database map, showing the Search links and the Visitor Utility links of the database.



Need Number	Title	Baseline Technology
ID-7.2.06	Remote Characterization	Radiation Survey by Technician Analytical Laboratory: Radioactive Core and other samples Analytical Laboratory: Non-radioactive
ID-7.2.15	Field Screening of Paint/Painted Surfaces to Identify Lead Contamination in the Paint	Analytical laboratory: non-radioactive Core and other samples
ID-7.2.16	Field Screening of Lead (shot, bricks, sheeting) for Radionuclide Contamination	Core and other samples Volume Survey of Lead Brick
ID-7.2.17	Field Screening of Samples and Equipment Surfaces to Identify PCB Contamination	Wipe Analysis for PCB
ID-7.2.19	Remote/Robotic Technologies for Access and Deployment of Characterization and Sampling Tools	Radiation Survey by Technician Analytical Laboratory: Radioactive Core and other samples
ID-7.2.20	Underwater Radionuclide Characterization of Structures, Equipment, and Containment Pool Walls that Produce Quantitative Data	Analytical Laboratory: Radioactive Conservative Estimate Radiation Survey by Technician

Figure 3. Only one screen length of the STCG Need table for the DDFA is shown. The underlined text serves as a link to the respective record for either the description of the need number or of the baseline technology.

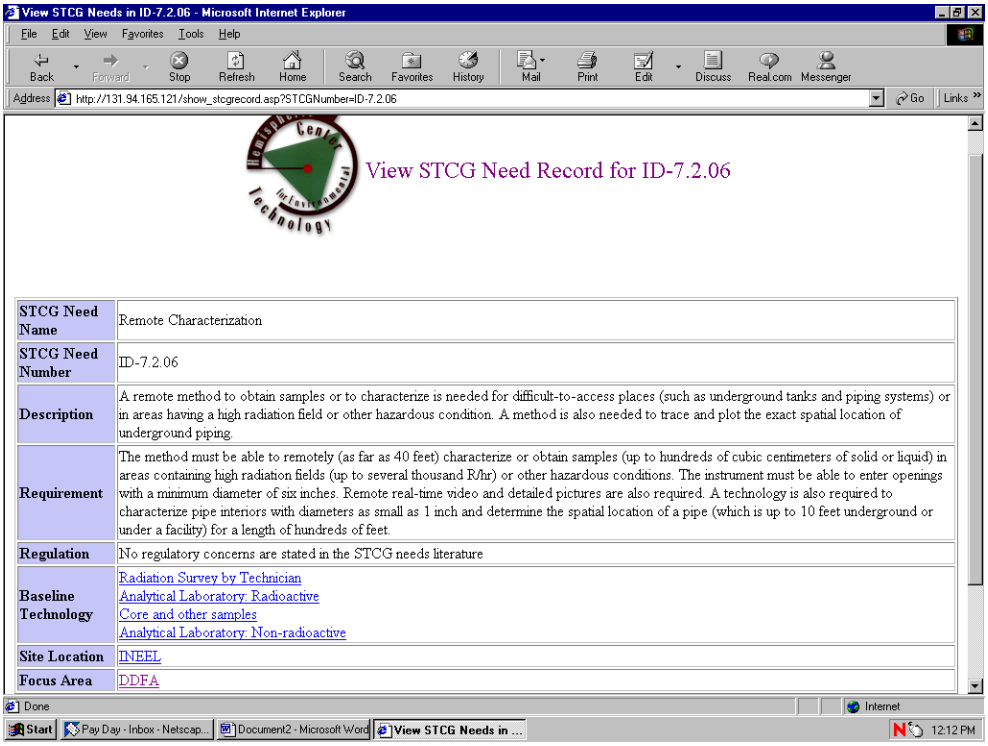


Figure 4. Only one screen length of this record for a specific STCG Need is shown.

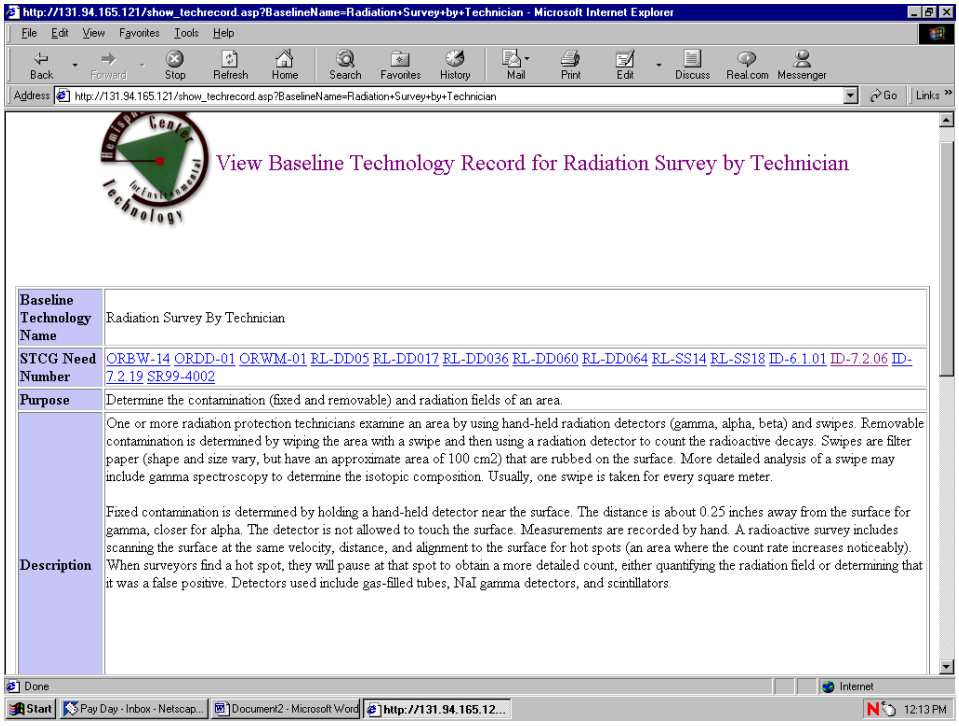


Figure 5. Only one screen length is shown of this record of a specific baseline technology with the description.

Figure 6. Only one screen length is shown of the Baseline Technology table for the baseline technologies for the DDFA. The underlined text serves as a link to the respective record for either a description of the STCG need number or the baseline technology.

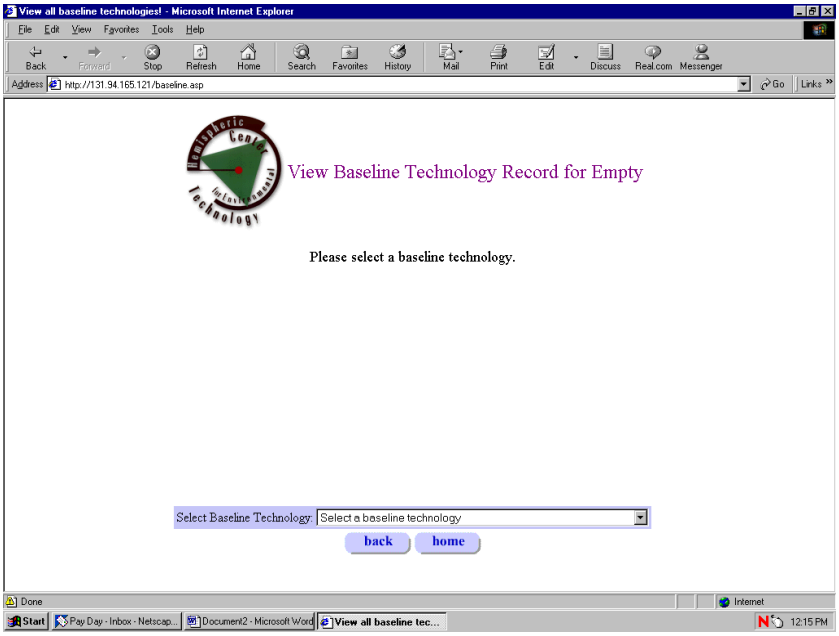


Figure 7. The user is allowed to choose the Baseline Technology of interest from the list that can be viewed by clicking on the down arrow to the right of "Select a baseline technology."

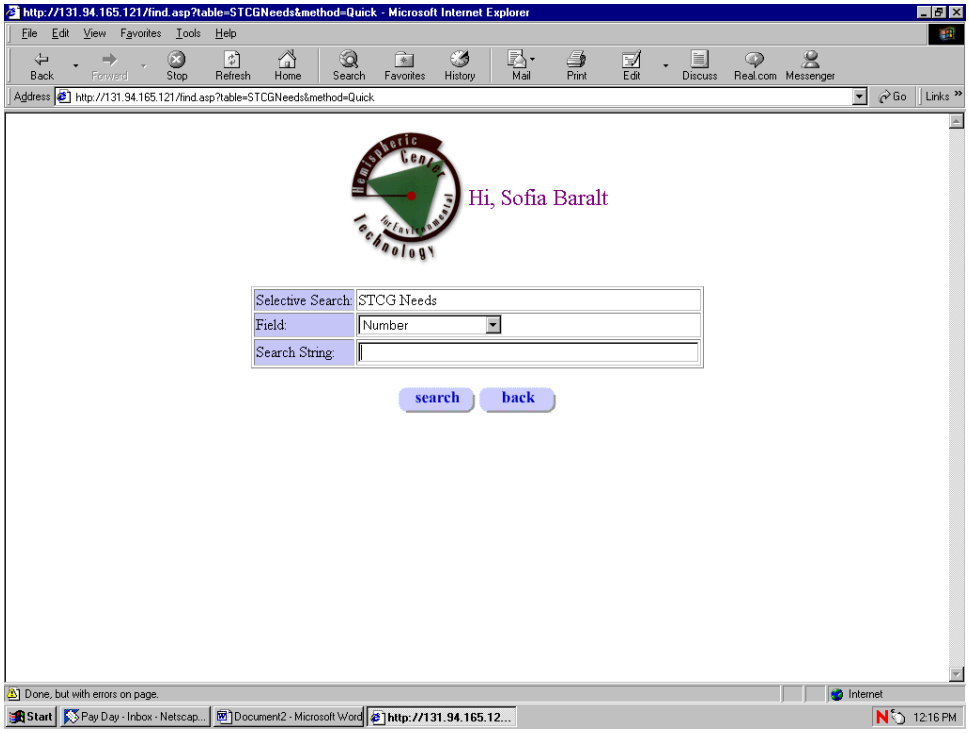


Figure 8. This screen allows the user to make a selective search for STCG Needs or Baseline Technology. The database asks for the field and the search string.

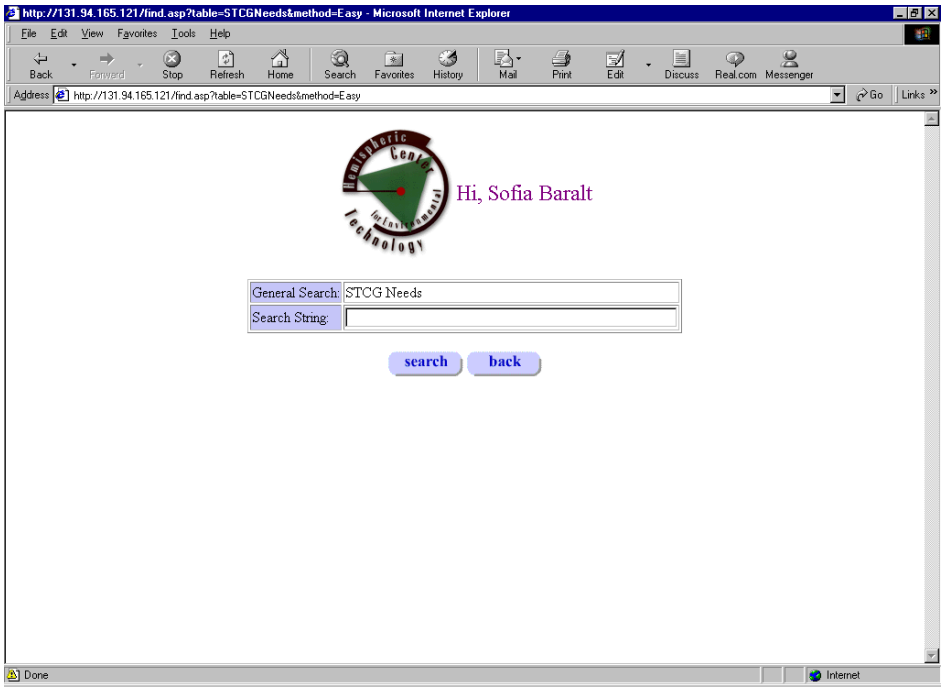


Figure 9. This is the screen for the General Search for either STCG Needs or Baseline Technology.

3.2 TECHNICAL INFORMATION

No domain name has been registered for this database; therefore, the user has to type the IP address to access the Current Practice Database. Access to this database from the CMST-CP web page can be accomplished by the use of a link. Microsoft SQL Server version 6.5 is used to manage the database and Microsoft Active Server Page (ASP version 2.0) is the main software to write all server side script files. One of the features ASP provides is that the third party, independent software companies, could offer specially designed software components to accomplish a specific task such as automated e-mail responder and file upload. These software components are written for the Windows NT system. ASPSMART®, a shareware program distributed by DIMAC AB, was incorporated into the server side scripts to provide a better web page functionality.

3.2.1 User functions

The web page is the online user interface that provides information to the users and web page administrator. The Current Practice database interface consists of two major parts, user interface and the administrator interface. Eleven user functions are implemented under the user interface and are described in section 3.1. The sign up function registers users with information they provide. Information such as user name, login name, and e-mail address are stored in the database table Users. User registration is requested to know who is using the database and to build a better relationship with them for the purpose of improving the database. Furthermore, other functions like Stats could help FIU-HCET gather useful information about web page traffic and design better web pages.

The retrieve function helps users who forgot their login name. This is a typical function implemented for the user's convenience. The login function verifies the registered user login name. More importantly, this function is combined with other functions to gather information about web traffic and to send greetings to individual users by personalizing the web pages the ASP server sends to users. The display function displays all STCG needs and baseline technologies in different focus areas or sites. Every individual STCG need or baseline technology is stored in the database tables. The database in word format function provides Microsoft Word files that contain all the individual STCG needs or baseline technologies. After the user clicks on the links, a free file in Microsoft Word format is downloaded to the user's machine.

The search function provides a means for users to search for specific STCG needs or baseline technologies. The user has two choices to search for an individual record, selective search or general search. Both search methods require the user to enter a phrase, word(s), or letter(s). When the database server finds the matches, the script highlights the matched phrase, word(s), or letter(s) with bold font and red color in the returned web pages. Selective search method requires the user to enter one more search criteria, one of the table fields. Thus, this method has a shorter search time. General search method requires minimum user input but has a longer searching time.

The event board function allows the registered users to post upcoming academic events online. This function is designed mainly for the user community. The member chat function gives the registered users a means to discuss the academic topic online. The member e-mail function is designed for the internal e-mail system. Only registered users may send documents or e-mails to

other registered users. The post a question function allows the registered users to post academic questions online so that other registered users might post the solution online. The last 10 visitors function records information on the last 10 visitors. This function shows visitor's browser type, IP address, visiting time, and other information. The main purpose of this function is to provide statistics for web page designers.

3.2.2 Administrator functions

Six functions are implemented under the administrator interface. The authentication function is the only invisible function implemented and verifies that only authorized people can have access to the functions that insert, modify, or delete records in the database. This function is called before the calls any other administrator function.

The view records in the tables function displays all the data fields in the tables. Fields hidden from the user interface will be displayed under this function. the web designer or the administrator may monitor all the data tables in the database. The add new records to tables function allows authorized people to add STCG needs or baseline technologies to the database. The change administrator password function allows the web designer and the web administrator to change their passwords for security reasons.

The update records in tables function has two sub-functions. One is written for a general update of individual records for an STCG need or baseline technology. With this function, authorized users can only update one record at a time. The other function is implemented to search the database and modify the focus area for all records that match the criteria set up by the authorized users. The delete records in tables function allows the authorized users to delete individual records in different tables.

3.2.3 Database tables

Seven database tables are established in the SQL server, namely Administrator, Baseline, Event, Question, Stats, STCGNeeds, and Users (see Table). Table Administrator is set up to store login name and password for authorized web page administrators. Table Baseline is set up to store individual records of baseline technologies. Table Event is set up to store information about upcoming academic events posted by the registered users. Table Question is set up to store questions posted by the registered users. Table Stats is set up to store visitor information. Table STCGNeeds is set up to store records of STCG needs. Table Users is set up to store information on registered users. Only registered users can have access to the user interface.

Table.
The Seven Database Tables

Table Name	Table Fields	
Administrator	LoginName	Password
Baseline	BaselineName NeedNumber Purpose Description1 Description2 Description3 Description4 Description5	CostData Needs Time Waste Limit Exposure Area Comment
Event	ID Poster Event	Location Time
Question	ID Post_By Question Post_Time	Reply_By Answer Reply_Time
Table Name	Table Fields	
Stats	First_Name Last_Name Browser	IP Time ID
STCGNeeds	STCGNumber Name Description Requirement	Regulation Baseline Location Area
Users	LoginName FirstName LastName	Email Company

4.0 REFERENCES

4.1 REFERENCES BY TECHNOLOGY

The references used to obtain the descriptions, performance data, and cost estimates for each baseline technology are presented below. The full references are available in the Appendix. Information for the STCG needs was obtained directly from the STCG need statements published on the DOE site's STCG website.

Access Tank Through Riser
Cruz, 1999; DOE/RL, 1999; Environmental Management, 1998c; Gephart and Lundgren, 1996; Khaleel, 1999; Tank Focus Area, 1998a,b.

Active Neutron
BNFL, 1998; Canberra, 1998; DOE/ORO, 1999; DOE/SRO, 1999; Department Standards Committee, 1999; Dua, 1999; Fortner, 1999; Gilpin, 1999; INEEL, 1999b; Kapaun, 1999.

Analytical Laboratory: Non-radioactive
Cortes, 1995; Environmental Management, 1998e,f; Environmental Protection Agency, 1998e,f,g,h,i,j,k; INEEL, 1999b; Klatt, 1996; Koegler, 1999; Loaiciga et al. 1997; Michael, 1999.

Analytical Laboratory: Radioactive
DOE/RL, 1999; DOE/SRO, 1999; Environmental Management, 1998f,m; Fernald Environmental Management Project-STCG, 1999; INEEL, 1999b; Loaiciga et al. 1997; Koegler, 1999.

Calorimetry Technology
Antech, 1999; Bracken et al. 1998; DOE 1995; DOE/SRO, 1999; Encyclopaedia Britannica, 1999; Hsue et al. 1997.

Cold Vapor Atomic Absorption (AA) for Hg
Cole Parmer, 1999; Dean, 1995; DOE/ORO, 1999; Federal Remediation Technology Roundtable, 1999; Loaiciga et al. 1997; Solomon, 1999a.

Cone Penetrometer
Bratton, 1999; Cruz, 1999; Environmental Management, 1999a,c,k; Environmental Protection Agency, 1997b, 1998e; Federal Remediation Technology Roundtable, 1999; Tanks Focus Area, 1997; Wyatt et al. 1997.

Conservative Estimate
DOE/SRO, 1999; INEEL, 1999b.

Core and Other samples
DOE/SRO, 1999; Environmental Management, 1998i,j,n; INEEL, 1999b.

Coupon Tests
Corrosion Testing Laboratories, 2000; DOE/SRO, 1999; FTI Anamet, 1999; Howell, 1997 and 1998; INEEL, 1999b.

Culture Methods
Agdia, 2000; California See & Plant, 1999; Encyclopaedia Britannica, 1999; Fisher, 2000; Howell, 1998; INEEL, 1999b.

Destructive Sampling
Bio-Imaging, 1999a; DOE/CAO, 1996b; DOE/OH, 1999; DOE/ORO, 1999; DOE/SRO, 1999; Department Standards Committee, 1996; INEEL, 1999b; Oak Ridge National Laboratory, 1999; Waste Policy Institute, 1999.

Discrete Sampling of Process Water in Pipes
Cruz, 1999; DOE/SRO, 1999.

Drilling: Cable Tool
Cruz, 1999; DOE, 1995; Environmental Management, 1999a, c; Federal Remediation Technology Roundtable, 1999; Loaiciga et al. 1997; Masten and Booth, 1996; Pacific Northwest National Laboratory, 1998 and 1999a; Smalley, 1999; Tanks Focus Area, 1997; Thornton, 1999.

Drilling: Hollow Auger
Carmichael, 1989; Environmental Management, 1999b,k; Enviromental Protection Agency, 1998a; Federal Remediation Technology Roundtable, 1999; Loaiciga et al. 1997; Mitchem, 1999; Pitkin et al. 1999; Smuin, 1995.

Drilling Methods for Tanks
CMST,1998; DOE/RL, 1999; Gephart and Lundgren, 1996; Pacific Northwest National Laboratory, 1998; Smalley, 1999; Stang, 1997; Tanks Focus Area, 1997.

Drilling: Rotary
DOE, 1995; Federal Remediation Technology Roundtable, 1999; Loaiciga et al. 1997; Masten and Booth, 1996.

Drilling: Sonic
Armstrong et al. 1998; DOE/RL, 1995; Environmental Management, 1995; GeoDrilling International, 1998; Loaiciga et al. 1997; Tyler et al. 1999.

Drive Point
Federal Remediation Technology Roundtable, 1999; Geoprobe, 1999; Loaiciga et al. 1997; Sherbert, 1999.

Drum Headspace Sampling
Barile, 1998; Collins et al. 1998; Defense Nuclear Facilities Safety Board, 1997; DOE/CAO, 1996a,b; INEEL, 1999b.

Ductile-Brittle Temperature Charts
INEEL, 1999b.

Eddy Current Techniques
Anderson et al. 1995; Birring, 1999; DOE/RL, 1999; EPD, 2000; INEEL, 1999a; Thomas, 1995.

Electrical Resistivity
Bergstrom and Mitchell, 1996a; Child, 1997; DOE/ORO, 1999; Environmental Management, 1998k; Enviromental Protection Agency, 1995; EPA Reachit, 1999; Geometrics, 1999; Geosphere, 1997; Geoterrex, 1999; Jerimov, 1999; K.D. Jones, 1999; Loaiciga et al. 1997;

MGC, 1999; Mitcham, 1999; National Technology Transfer Center, 1999; Schwendeman and Wilcox, 1989; Sharma, 1997; Smith, 1999.

Electromagnetic Surveys
Bergstrom, 1996b; Environmental Management, 1998k; Environmental Protection Agency, 1997b; Gisco, 2000; Hopmans et al. 1999; Instrument Depot, 2000; Schonstedt, 2000; Sharma, 1997.

Excavation of Test Trenches or Pits
Bechtel, 1996; Boggs and Shaddoan, 1996; Environmental Management, 1998c,g and 1999e; Federal Remediation Technology Roundtable, 1999; Fernald Environmental Management Project-STCG, 1999; Loaiciga et al. 1997; Masten and Booth, 1996; Pacific Northwest National Laboratory, 1998; Tanks Focus Area, 1997; Thompson Machinery, 1999.

Gamma Spectroscopy
Biodex, 1999; Canberra, 1998; Department Standards Committee, 1999; DOE/CAO, 1996b; DOE/ORO, 1999; DOE/SRO, 1999; Dua, 1999; Environmental Management, 1998i and 1999f; Environmental Protection Agency, 1997b; Fortner, 1999; Gilpin, 1999; INEEL, 1999b; Kapaun, 1999; Lockheed, 1998; Oak Ridge National Laboratory, 1999; Pacific Northwest National Laboratory, 1999; Studiecentrum voor Kernenergie - Centre d'étude de l'Energie Nucléaire, 1999; Westinghouse Savannah River Corporation, 1999.

Geophysical Logging
Berwick et al, 1998; DOE/GJO, 1998; Keck, 1997; Loaiciga et al 1997; Mitcham, 1999; Mount Sopris, 1997; Pacific Northwest National Laboratory, 1998; Sharma, 1997.

Grab Sampling ("Bottle-on-a-String")
CMST-CP, 1999; Cruz, 1999; DOE, 1993; DOE/SRO, 1999; Environmental Management, 1999g; Fluor Daniel Hanford, 1998; Gephart and Lundgren, 1996; Maraj, 1997.

Gravity Survey
Edcon, 1999; LaCoste & Romberg, 1999; Microgeophysics Corporation, 1999; Scintrex, 1999a,b; Sharma, 1997; Shoppach, 1999; Technos, 1999.

Ground Penetrating Radar
Bergstrom and Mitchell, 1996a; Child, 1997; DOE/RL, 1999; DOE/SRO, 1999; EPA Reachit, 1999; Federal Remediation Technology Remediation, 1999; Geometrics, 1999; Gisco, 1998; Hunaidi and Giamou, 1998; K.D. Jones, 1999; Lee, 1999; Loaiciga et al, 1997; Lyle, 1998; Koppenjan et al. 1998; Microgeophysics Corporation, 1999; Mitcham, 1999; Pacific Northwest National Laboratory, 1998; SENSOFT, 1999a,b; Sharma, 1997; Smith, 1999; Wyatt et al. 1997.

Groundwater Monitoring/Cased Well
Carmichael, 1989; Cruz, 1999; DOE/RL, 1999; DOE/SRO, 1999; Environmental Management, 1998k,l; Environmental Protection Agency, 1995; Federal Remediation Technology Roundtable, 1999; Freeze and Cherry, 1979; Instrument Northwest, 1993; Loaiciga et al. 1997; Schwendeman and Wilcox, 1989; Smuin, 1995; Tanks Focus Area, 1997.

Inductively Coupled Plasma - Mass Spectroscopy (ICP/ICP-MS)
Federal Remediation Technology Roundtable, 1999; Loaiciga et al. 1997; Solomon, 1999a.

Inner Capsule Movement Test (ICMT)
DOE/RL, 1996 and 1999

Intrusively Enter Pipes
DOE/SRO, 1999

Liquid Penetrant Testing
Godfrey, 1999; INEEL, 1999b; Magnaflux, 1998; Non Destructive Testing Association, 1996.

Loss on Ignition (LOI)
DOE/SRO, 1999; Fisher, 2000; Haschke and Ricketts, 1995; Hsue et al. 1997; Inert Systems, 2000; Los Alamos National Laboratory, 1997; Martinez et al. 1998.

Magnetic Anomaly Detection
Environmental Management, 1998k; Enviromental Protection Agency, 1997b; Loaiciga et al. 1997; Schonstedt, 2000; Sharma, 1997; Surveyors Shop, 2000.

Material Balance Calculations/Measurements
CMST-CP, 1998; Gephart and Lundgren, 1996; Schwendeman and Wilcox, 1989; Westinghouse Hanford Corporation, 1995.

Noble Gas and Tracer Experimentation
DOE/ORO, 1999; Environmental Management, 1998k; LeCain, 1998; Oklahoma University, 1997; Pennsylvania Department of Environmental Protection, 1997; Quinlan, 1990; Webster, 1996; Technos, 1999.

Optical Sludge/Supernate Interface Detector
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