Environmental Technology Verification Program

Demonstration Plan for Wellhead Monitoring Technologies

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Prepared by

Environmental Characterization and Monitoring Department
Sandia National Laboratories
and
Savannah River Technology Center

Sponsored by

Consortium for Site Characterization Technology
Environmental Sciences Division
National Exposure Research Laboratory
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Las Vegas, NV

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Sandia
National
Laboratories

Approval Signatures

This demonstration plan has been written to insure that all aspects of the demonstration are planned in advance of the demonstration, scientifically sound, and documented. The plan also insures that the technology demonstration process is conducted within prescribed quality specifications and health and safety regulations.

The signatures of the individuals below indicate concurrence with the specified plan and an agreement to operate in compliance with the procedures specified in this document.

U. S. Environmental Protection Agency

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Gary Robertson Date

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Demonstration Sites

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Timothy Jarosch Date

McClellan AFB: ______________________ ________
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Technology Developers

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Signature/Date

Inficon:

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Innova AirTech Instruments:

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Signature/Date

ORS Environmental Systems:

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Signature/Date

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Signature/Date

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Section 1 Executive Summary

This document outlines a strategy for a technology demonstration focused on field-portable, wellhead monitoring techniques for the analysis of chlorinated hydrocarbons in water. The demonstration is a component of the Site Characterization and Monitoring Pilot Project which in turn is a part of the EPA-sponsored Environmental Technology Verification Program (ETV). The Site Characterization and Monitoring pilot project of ETV program is intended to promote the use of innovative environmental site characterization and monitoring technologies in the environmental market through the systematic demonstration of those technologies in field demonstrations. These demonstrations are designed to illustrate and document the capabilities of relevant technologies by field tests at multiple sites. Technology performance is summarized in a verification letter which is accompanied by a comprehensive data analysis and documented in an Environmental Technology Verification Report.

The planning and execution of the demonstration is a collaborative effort between the Department of Energy's Sandia National Laboratories and personnel at the two sites selected for use in this demonstration: Savannah River Site, near Aiken South Carolina and McClellan Air Force Base, near Sacramento California. Both sites have significant subsurface contamination with various chlorinated solvents and offer contaminated groundwater monitoring challenges for the participating technologies.

The primary objectives of this demonstration are (1) to demonstrate technology performance characteristics for such operational parameters as detection levels, accuracy, precision, and instrument working range; (2) to compare technology performance to conventional field sampling protocols and laboratory analytical methods; (3) to document the logistical resources and degree of operator training needed to operate each instrument; and, (4) to produce a verified data set for use in considering the technology for future hazardous waste site investigations, for assessing the performance of remediation technologies, and for post-clean up monitoring.

Following a series of informal discussions with technology developers, a Developers' Forum was held in which the overall goals of the demonstration were discussed and the features of a variety of technologies applicable to wellhead monitoring were presented by each developer in attendance. Subsequent to this meeting, the scope of the demonstration was refined to wellhead monitoring techniques, and those technologies best suited for a wellhead monitoring demonstration were selected and invited to participate in the demonstration. The following vendors have verbally committed to participate and are presently involved in the demonstration design and review as reflected in this document:

Electronic Sensor Technology (Westlake Village, CA) EST-4100 -- A field portable gas chromatograph that incorporates a surface acoustic wave detector and headspace sampling methods for the determination of volatile organics in water.

Inficon Inc. (South Kent, CT) HAPSITE -- A field portable gas chromatograph-mass spectrometer with a headspace water sampling accessory

Innova AirTech Instruments A/S (Naerum, Denmark) Multi-gas Monitor Type 1302 -- A field-portable photoacoustic infrared spectrometer with a headspace water sampling accessory.

ORS Environmental Systems (Marion, MA) Accusensor -- A portable wellhead monitoring system for trichoroethylene in water based on a colorimetric reaction and a temperature correction algorithm.

Perkin Elmer-Photovac (Deer Park, NY) Voyager -- A three-column, multi-detector, field portable GC with headspace water sampling accessory and down-well sniffer tube.

Sentex Systems Inc. (Richfield, NJ) Aquascan -- A field-portable, purge-and-trap gas chromatograph with an argon-ion and electron capture detectors.

The experimental plan incorporates an approximately equal split in the number of performance evaluation and monitoring well samples, with a total sample number of about 75 samples to be submitted to each technology at each demonstration site. Additional blanks will also be included in the sample set at each site. The performance evaluation samples, mixed on-site during the field demonstration and derived from purchased quality control samples with accompanying certification, will be used to establish such technology performance parameters such as accuracy, instrument working range, and detection levels. Both performance evaluation and ground water samples will be submitted to each technology as blind replicates such that estimates of analytical precision can also be obtained across the working range of each instrument. Ground water samples will be taken from approximately 10 wells at each site, and are to be pre-selected based on historical analytical data, to provide trichloroethylene and perchloroethylene concentrations at five concentration levels or groupings in the range of 5 ppb to 5 ppm.

Splits of all performance evaluation and ground water samples are also submitted for analysis at a reference laboratory using EPA protocol SW8260 (Purge-and-trap GC-MS), such that a comparison of technology results and laboratory results can be made. DataChem Laboratories in Salt Lake City will be the reference laboratory. An audit of DataChem quality control programs and facilities and laboratory results on a set of check samples prepared by Sandia indicates that analytical procedures, equipment and personnel at this laboratory are of acceptable quality to insure that analytical results would be typical of other commercial laboratories conducting analysis by EPA method SW8260.

The demonstration plan also incorporates the use of pre-demonstration samples to be supplied to the participating technologies and the reference laboratory so that some experience with the sample matrix can be gained and possible problems with analytical methodologies can be worked out prior to the actual field demonstration.

This demonstration plan includes the following elements:

- Introduction (Section 2) -- An outline of the ETV program, its goals, and a description of the Site Characterization and Monitoring Pilot
- Roles and Responsibilities (Section 3) -- A presentation of the principal participants in the demonstration and their roles
- Technology Description (Section 4) -- A description each participating technology which includes general performance characteristics and a discussion of the technology's unique features.
- Site Description (Section 5) -- A brief description of the two sites at which the demonstration will be conducted. Also included are site geological descriptions and some representative groundwater monitoring results for both sites.
- Experimental Design (Section 6) -- A presentation of the experimental approach and accompanying rationale for the proposed design.
- Sampling Plan (Section 7) -- A detailed description of the well sampling and sample distribution procedures to be used in the demonstration.
- Data Management and Analysis Plan (Section 8) -- A written plan for data handling and analysis procedures during and following the field portion of the demonstration.
- Quality Assurance Plan (Section 9) -- A written plan for conducting the demonstration and for assessing the quality of the data generated.

- Health and Safety Plan (Section 10) -- An outline of the health and safety requirements that are anticipated at each site during the sampling and analysis activities.
- Deliverables (Section 11) -- A brief discussion of the reports and other documentation expected at the completion of this demonstration

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Section 2 Introduction

This chapter discusses the purpose of this demonstration plan and provides an overview of the Environmental Technology Verification's Site Characterization Pilot Project. Information is also presented on the selection of demonstration sites, key demonstration tasks, their associated schedule, and the selection of demonstration participants.

Demonstration Objectives

The overall purpose of this technology demonstration is to produce a set of field data which can be used to systematically document the performance characteristics of the participating technologies. This particular demonstration is targeted at demonstrating field-portable instrumentation for the measurement of chlorinated VOCs at groundwater sampling wells An industry-wide search for technologies suitable for this monitoring application resulted in the identification of seven technologies. Following a formal invitation to participate, all seven technologies have indicated an interest in further participation in this demonstration.

The technologies chosen for this demonstration were developed to provide real-time, relatively low-cost analyses of chlorinated VOC contamination in groundwater. Most have been designed to provide timely information at the site that will allow investigation and remediation decisions to be made more efficiently on site.

The primary objectives of this demonstration are:

(1) to verify instrument performance factors such as instrument accuracy and precision;
(2) to determine how well each developer's field instrument performs in comparison to conventional laboratory analytical methods and protocols;
(3) to produce a verified data set suitable for evaluating the applicability of the technology for extended use at hazardous waste sites;
(4) to demonstrate instrument attributes that may be of particular interest in the area of field analytical methods; and
(5) to record and evaluate the logistical and financial resources needed to operate each instrument.

Secondary objectives of this demonstration are to evaluate the wellhead monitoring technologies for their reliability, durability, cost, range of usefulness, and ease of operation. The demonstration is not intended to compare the various technologies with each other. Comparisons of technology performance will be made however, with analytical results from offsite laboratories using EPA analysis protocols. The conventional analytical methods will be referred to as reference methods throughout this demonstration plan and, accordingly, the laboratory data will be referred to as reference data.

Specifically, this document provides information on the following elements of the demonstration:

- Roles and responsibilities of demonstration participants;
- Technology Descriptions;
- Demonstration Site Descriptions;
- Experimental Design;
- Sample Collection Plan;
- Data Management and Analysis Plan;
- Quality assurance (QA) and quality control (QC) protocols; and,
- Health and safety requirements for performing work at hazardous waste sites

ETV Program - Site Characterization and Monitoring Pilot Background

Throughout its history, the US Environmental Protection Agency (EPA) has evaluated technologies to determine their effectiveness in monitoring, preventing, controlling, and cleaning up pollution. Since the early 1990s, however, numerous government and private groups have identified the lack of an organized and ongoing program to produce independent, credible performance data as a major impediment to the development and use of innovative environmental technology. Such data are needed by technology buyers and permitters both at home and abroad to make informed technology decisions. Because of this broad input, the President’s environmental technology strategy, Bridge to a Sustainable Future, and the Vice President’s National Performance Review, contain initiatives for an EPA program to accelerate the development of environmental technology through objective verification and reporting of technology performance. In 1994, EPA’s Office of Research and Development formed a work group to plan the implementation of the Environmental Technology Verification Program (ETV). The work group produced a Verification White Paper that guided the initial stages of the program. Following the efforts of this work group, a Verification Strategy was developed that updates the earlier paper based upon the evolution of the program over recent years. The Verification Strategy outlines the operating principles and implementation activities that are shaping the program, as well as the challenges that are emerging and the decisions that must be addressed in the future. The program will continue to be modified through input from all parties having a stake in environmental technology, through further operational experience, and through formal evaluation of the program.

The goal of ETV, which remains unchanged, is to verify the environmental performance characteristics of commercial-ready technology through the evaluation of objective and quality assured data, so that potential purchasers and permitters are provided with an independent and credible assessment of what they are buying and permitting.

Several important operating principles have defined the basic ETV program structure and remain fundamental to its operation. These are briefly outlined below.

Performance Evaluation Goal

Under ETV, environmental technologies are evaluated to ascertain and report their performance characteristics. EPA and its partners will not seek to determine regulatory compliance; will not rank technologies or compare their performance; will not label or list technologies as acceptable or unacceptable; and will not seek to determine “best available technology” in any form. In general, the Agency will avoid all potential pathways to picking “winners and losers”. The goal of the program is to make objective performance information available to all of the actors in the environmental marketplace for their consideration and decision making.

Commercial-Ready Technologies

The ETV program is a service of EPA to the domestic and international marketplace in order to encourage rapid acceptance and implementation of improved environmental technology. ETV, therefore, focuses its resources on technologies that are either in, or ready for, full-scale commercialization. The program does not evaluate technologies at the pilot or bench scale and does not conduct or support research. Participation in ETV is completely voluntary.

Third-Party Verification Organizations

ETV leverages the capacity, expertise, and existing facilities of others through third-party partnerships in order to achieve universal coverage for all technology types as rapidly as possible. Third-party verification organizations are chosen from the both the public and private sector, including states, universities, associations, business consortia, private testing firms, and federal laboratories. EPA designs and conducts auditing and oversight procedures of these organizations, as appropriate, to assure the credibility of the process and data. In order to determine if EPA participation is important to the commercialization process, ETV is testing the option of one totally unstructured and independent, private sector pilot in which EPA's role will be solely fiduciary. In addition, the Agency will continue to publish the results of commercial-ready technology evaluations that it conducts in the normal course of its business.

Pilot Phase

The program will begin with a three to five year pilot phase to test a wide range of partner and procedural alternatives, as well as the true market demand for and response to such a program. Throughout the pilot period, EPA and its partners will operate in a flexible and creative manner in order to identify new and efficient methods to verify environmental technologies, while maintaining the highest credibility standards. The operational objective will be to actively look for ways to optimize procedures without compromising quality. The ultimate objective of the pilot phase is to design and implement a permanent verification capacity and program within EPA by 2000, should the evaluation of the effectiveness of the program warrant it.

Pilot Technology Areas

ETV has begun with pilots in narrow technology areas in each of the major environmental media and will expand as appropriate, based on market forces, availability of resources, and the willingness of the marketplace to pay for third-party verification. For example, the drinking water technology pilot has started with a focus on microbial and particulate contaminants, and disinfection byproducts in small systems (less than 3300 users), an obvious and very large domestic and international market with pressing environmental problems. In fiscal year 1997 (FY97), the program will be expanded to the wider area of nitrates and synthetic organic chemicals and pesticides in all drinking water systems. Success in particular technology areas will allow the program to have a "pump-priming" effect to bring new technologies to the marketplace. Selection criteria for ETV pilot programs and other verification focus areas are discussed in a subsequent section of this paper.

Stakeholder Groups

ETV is guided and shaped by using the expertise of appropriate stakeholder groups in all aspects of the program. These groups consist of representatives of all verification customer groups: buyers and users of technology, developers and vendors, and, most importantly, technology "enablers", i.e., the consulting engineering community that recommends technology alternatives to purchasers, and the state permitters and regulators who allow it to be used. Stakeholder groups must be unique to each technology area in order to capture the important individual aspects of the different environmental media and to get buy-in from affected groups. For example, state drinking water permitters are necessary to participate in development of testing protocols for cryptosporidium; air pollution regulators are needed to evaluate innovative compliance monitoring devices; metal production parts manufacturers need to help design testing procedures for new coating compounds. In general, the role of stakeholders will be to assist in the development of procedures and protocols, prioritize types of technologies to be verified, review all important documents emerging from the pilot, assist in defining and conducting outreach activities appropriate to the particular area, and, finally, to serve as information conduits to the particular constituencies that they represent. As of June 1996, over 80 individuals are serving in the three stakeholder groups formed to date.

Private Sector Funding

Over the three to five year pilot phase of the program, the costs of verifying technologies in many pilots will move from a primarily government funded effort to a primarily private sector funded effort. At least two pilots will be vendor supported from the beginning. The original goal, as articulated in the 1994 strategy, called for complete private sector sponsorship within three years. A recent review (1995) of the program by a distinguished panel of outside experts convened by the EPA Science Advisory Board (SAB) concluded that such a goal was probably not achievable in so short a time-frame (they suggested five to eight years) and that some level of government support (10 to 20% of ongoing costs) would remain necessary to keep the activity viable. Conclusions on this issue will have to be reached as data emerge on the economic value-added of the program and the level of cost that the private sector is willing to bear in the various technology sectors.

Pilot Evaluation and Program Decisions

The Agency will collect data on operational parameters, e.g., number of participants; cost and time required to perform tests and report results, and on outcomes, e.g., use of data by the states and public; sales reported by vendors, in order to evaluate all aspects of the program. EPA will use this information to make long-term recommendations to the Congress on the future and shape of the program in December 1998. Among the choices at that time will be the formulation of a permanent, broad scale program; the narrowing of efforts to certain areas in which ETV appears to be effective; or the discontinuance of verification efforts. The latter conclusion could be reached either because state regulators/permit writers and the technology innovation industry are not assisted by ETV or because the cost of verification proves to be prohibitive.

Outreach and Information Diffusion

As was pointed out by the SAB in its 1995 review of ETV, verification alone will not move better, cheaper, faster technologies to success in the marketplace. Substantive and substantial interface with the permitters of environmental technology (primarily at the state level) will be necessary to have any chance of rapidly implementing innovative approaches. To date, the outreach activities of the program have been limited to assuring substantial state representation on the Stakeholder Groups that are designing the protocols and procedures for each pilot; developing informational fact sheets about the program; and placing a Web page on the Internet. In 1997, the Agency intends to develop an overarching outreach strategy with the help of a “corporate board” of major organizations in the technology area, e.g., National Governors Association, Western Governors Association, Environmental Council of the States, National Pollution Prevention Roundtable, appropriate corporations, and others. State permitter training, a national conference and other efforts will be included.

Market Gap Definition

Lastly, EPA will track applications and expressions of interest on the part of technology developers who come to all parts of the Agency that do not fit into the present suite of verification activities. This universe will be characterized during the initial stages of the pilot period and a strategy to address gaps will be developed.

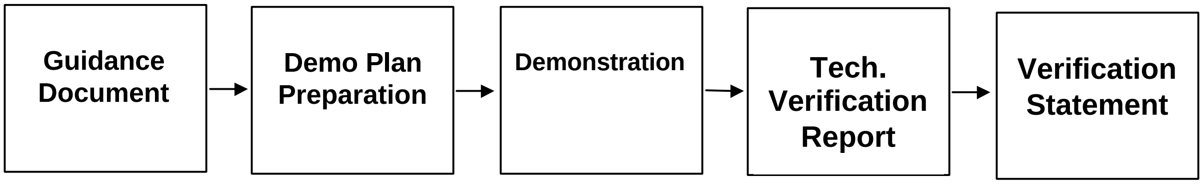
Consortium for Site Characterization Technology

The Consortium for Site Characterization Technology (CSCT) is a cooperative effort between the EPA, DOE and DoD groups that has been organized to carry out a significant portion of the ETV Site Characterization and Monitoring Pilot. The goal of the Consortium is to facilitate the acceptance and use of cost-effective technologies applicable to a wide range of environmental problems. The Consortium will meet its goal by working with technology developers and other agencies in planning and conducting demonstrations, evaluating data generated in demonstrations and managing and disseminating information. The Consortium is not intended to become another technology testing entity that must touch every technology, but rather it is designed to support existing demonstration efforts or developer-driven demonstrations. The Consortium does not offer direct financial support to those desiring to conduct a technology demonstration, however at least during its pilot phase, the Consortium does fund the activities of the Verification Organization. The developer is expected to secure the appropriate resources to support their part of the technology verification process.

The Consortium provides developers with a clearly defined technology verification pathway to follow, from demonstration planning to data evaluation and verification, as shown in Figure 2-1.

Environmental Technology Demonstration and Verification Process

Site Characterization and Monitoring Technologies



Responsible Party:

EPA with assistance: from Program Regions Other Agencies Developers Professional Societies	SNL and Sites with assistance from Developers (EPA review and approval)	Developer with Assistance from SNL (with EPA oversight)	SNL with assistance from sites (EPA oversight and approval)	Prepared by EPA and sent to Developer, EPA Program & Other Agencies State, Public

Figure 2-1 Environmental Technology Demonstration Verification Process

The technology verification process established by the Consortium is intended to serve as a template for conducting technology demonstrations that will generate high quality data that can be used to verify technology performance. This process will be applied to demonstrations conducted by both private and public (e.g., DoD and DOE) entities. The Consortium verification process is a model that can help in moving innovative site characterization and monitoring technologies into routine use more quickly.

The verification of a technology's performance involves five sequential steps :

(1) Development of a demonstration/test plan;
(2) Execution of the demonstration;
(3) Data analysis and reporting;
(4) Performance and cost verification; and,
(5) Information transfer.

Although the Agency is interested in any and all innovative site characterization and monitoring technologies, the Consortium staff and resources, and those of the verification entities, are limited. Therefore, a major role of the Consortium is to identify the technology and data gaps that impede cost-effective and efficient environmental problem-solving and to communicate them to the developer community. This assessment will allow prioritizing those technology demonstrations that meet the most pressing needs. The information that supports the assessment will be gathered from within EPA, other Federal agencies, states, tribes, and the user industries to ensure that the most pressing needs and gaps are addressed first.

The Consortium will provide technology cost and performance data to the intended technology user groups. An important product of the Consortium will be the preparation of reports that contain the data generated for each technology demonstration along with an assessment of the technology's performance. The dissemination of this performance information to the user community should help to alleviate much of the users' resistance to innovative technologies. Once a demonstration is completed and the data are evaluated, a report will be issued which will systematically evaluate technology performance characteristics. A verification letter[1] will be issued summarizing the technology’s performance and ability to meet the user communities’ site characterization and monitoring needs.

The credibility of the performance data will be assured because the Consortium will:

- utilize standard technology demonstration planning and execution guidelines;
- provide technical support to the technology developer during the preparation and execution of the demonstration;
- audit the demonstration while the technology is in field use;
- independently evaluate and verify the data set generated during the demonstration;
- report on the performance of the technology; and,
- widely disseminate performance information and educate users and regulators.

The Consortium is a partnership among the EPA, and the Departments of Energy and Defense (DOE and DoD). Both DoD and DOE have established programs and facilities (testing venues) for testing, demonstrating, and evaluating the performance of monitoring, measurement and site characterization technologies, among other technologies. As a partnership, the Consortium will offer valuable technical expertise to support the demonstration and verification of the performance of new and emerging technologies and will offer access to a wide array of testing venues.

It may be naive to expect that the Consortium, even when fully implemented, will be a panacea for developers and users of new and emerging monitoring, measurement, and site characterization technologies. However, the Consortium will *attempt* to fill many technical and institutional needs.

These include the following:

- Providing a sound scientific basis for demonstrating and evaluating technology performance
- Facilitating acceptance of innovative technologies by state, local and Federal regulators
- Supporting the implementation and use of "verified" technologies
- Identifying and, in working with the technology developer community, meeting changing user needs
- Increasing the number and commercial availability of innovative technologies
- Providing a mechanism to "pull" technologies being developed by DoD, DOE, and other public and private entities into routine use at a faster rate
- Providing incentive for developers to push the state of the technology beyond present capabilities.
- Leveraging resources and expertise among Federal agencies, the private sector, and academia.

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[1] The verification letter is prepared by EPA and provided to the developer. It is prepared in accordance with the performance characteristics achieved by each participating technology.

Technology Solicitation and Selection

Technologies are selected based on their potential use at hazardous waste sites as well as EPA regional interest in a technology. Each technology is evaluated for its ability to meet one or more of the following criteria:

- capable of being used in the field or in a mobile laboratory
- applicable to a variety of hazardous waste sites
- acceptable performance in comparison to conventional analytical methods
- acceptable logistical and economic resources to operate
- adequate maturity
- meets a recognized environmental characterization or monitoring need
- represents a special request priority
- addresses a unique problem

Technology solicitation and selection are carried out through the use of a Developers' Conference at which Developers, Verification Organization, and EPA personnel come together to discuss and review the applicability of various candidate technologies to an identified need in the environmental characterization and monitoring community. Following the conference, the Verification and EPA personnel review the candidate technologies and select those that best fit the anticipated demonstration area. In some cases, additional technology solicitation may be carried out following the conference in order to populate the demonstration with the most applicable technologies.

Technology Demonstration Process

After a technology has been judged appropriate for an ETV Demonstration, the developers are asked to submit a letter of intent to participate in the demonstration. This letter provides a description of the technology along with instrument performance characteristics such as instrument detection levels, accuracy, precision, linear range and others. These vendor-supplied instrument performance characteristics are particularly useful in the development of a comprehensive demonstration design by the verification organization. The activities listed below are carried out in the process of demonstration design

- Identifying demonstration sites that will provide the appropriate analytes in the desired environmental sample media or media (contaminants must be present in concentrations amenable to the technology being evaluated)
- Defining the roles of appropriate demonstration participants, observers, and reviewers
- Arranging analytical support for comparative testing (for example, reference analysis)
- Supplying standard operating procedures (SOPs), analysis methodologies, and other relevant protocols
- Addressing the experimental design, sampling design, QA/QC, health and safety considerations
- Scheduling field and laboratory operations, data analysis procedures, and data output format
- Determining logistical requirements and support (for example, field equipment, power and water sources, mobile laboratory, communications network)
- Anticipating possible corrective actions that may be required during the actual demonstration and providing this information to the demonstration participants
- Assuring the overall demonstration design will provide a data set adequate for the determination of instrument performance characteristics.

Technology Verification

Technologies are evaluated independently and, when possible, against commonly-used laboratory methods or technologies. Data resulting from this demonstration are used to establish instrument performance capabilities, limitations, and field applications of the technology. Following the demonstration, a detailed evaluation of the results are presented in a technology verification report. These reports, are prepared for each participating technology by Sandia National Laboratories (SNL), and are peer-reviewed by Sandia and EPA experts.

Demonstration Sites

Wellhead monitoring technology demonstrations will be conducted at two sites: Westinghouse Savannah River Site, near Aiken, SC and McClellan Air Force Base near Sacramento, CA. These particular sites were chosen for several reasons. The sites possess different climates, different modes of waste deposition, different soil types and soil textures. The sites are further differentiated by the chemical complexity of contaminated groundwater plumes. Savannah River Site has relatively simple groundwater plume that contain only several major components. McClellan, on the other hand, has groundwater plumes that contain a complex array of volatile organic compounds that poses an additional analytical challenge to many of the technologies scheduled to participate in the demonstration.

Demonstration Schedule

A summary demonstration timeline is shown in Table 2-1. The entire sequence from technology selection to issuance of verification report is estimated to span a 12-month interval. Demonstration activities, including sampling and analysis, are scheduled to occur at both sites in September 1997. Specific details of the planned demonstration activities are provided in the sampling plan in Section 6.

Table 2-1 Wellhead Monitoring Technology Demonstration Schedule

Task Description	Task Duration	Start Date	End Date
Technology ID & Select	105d	01/28/97	06/23/97
Developers' Conference	1d	01/28/97	01/28/97
Tech. Select and Review	45d	02/12/97	04/15/97
Issue Letter of Invit.	1d	04/22/97	04/22/97
Letters of Intent Received	1d	05/15/97	05/15/97
First Call Instr Perf Claims	29d	04/22/97	05/30/97
Instr Perf Parameters Rcvd	16d	06/02/97	06/23/97
Demonstration Planning	101d	03/17/97	08/04/97
Prepare Demo Plan	65d	03/17/97	06/13/97
Distrib. Demo Plan for Review	1d	06/16/97	06/16/97
Developer Review	20d	06/17/97	07/14/97
Dev Comment Rcvd	1d	07/15/97	07/15/97
Modify Demo Plan	5d	07/16/97	07/22/97
Demo Plan Complete	1d	07/23/97	07/23/97
Site Review/Visit	30d	04/21/97	05/30/97
Sites Selected	1d	06/02/97	06/02/97
Lab Review/Pre-Audit	22d	06/02/97	07/01/97
Lab Selected	1d	07/02/97	07/02/97
Pre-demo Sampling & Analyses	15d	07/14/97	08/01/97
Lab and Tech Reslt Rcvd	1d	08/04/97	08/04/97
Conduct Demonstrations	16d	09/08/97	09/29/97
Conduct Demo 1	5d	09/08/97	09/12/97
Conduct Demo 2	5d	09/22/97	09/26/97
Demo 1&2 Data Received	1d	09/29/97	09/29/97
Analysis and Reporting	166d	06/16/97	02/02/98
Prepare Tech Verific Rpt & Stmnt	95d	06/16/97	10/24/97
Distribute for Dev Rev	1d	10/27/97	10/27/97
Developer Rprt Review	14d	10/28/97	11/14/97
Developer Review Complete	1d	11/17/97	11/17/97
Incorporate Devel Comments	7d	11/18/97	11/26/97
EPA Peer Review	27d	11/27/97	01/02/98
Incorporate EPA Comments	7d	01/05/98	01/13/98
Publ Rprt and Verific Statmnt	14d	01/14/98	02/02/98
Project Complete	1d	02/03/98	02/03/98

Section 3 Roles and Responsibilities

This section identifies the organizations involved in the technology demonstration and describes the primary responsibilities of each organization. The methods and frequency of communication that will be used in coordinating the demonstration are also described.

Demonstration Participant Roles

The primary demonstration participants and roles are shown in Table 3-1. Roles for each participant are briefly discussed in the following paragraphs.

Table 3-1 Demonstration Participants and Roles

Agency/Company	Point of Contact	Role
US EPA -NERL (Las Vegas)	Stephen Billets Eric Koglin	EPA Project Co-Lead
Sandia National Laboratories	Wayne Einfeld	Verification Org. Project Lead
Westinghouse Savannah River Site	Timothy Jarosch Joe Rossabi	Demo Design and Site Support
McClellan Air Force Base	Phil Mook Timothy Chapman	Demo Design and Site Support
DOE EM-50 (Special Technologies Laboratory)	Paul Wang	DOE EM-50 Demo Design Support
Electronic Sensor Technology	George Pappas	Technology Developer
Inficon	Chuck Sadowski	Technology Developer
Innova Air Tech Instruments	Michael Vecht	Technology Developer
ORS Environmental Systems	Michael Gifford	Technology Developer
Perkin Elmer - Photovac	Mark Collins	Technology Developer
Sentex Systems Inc.	Amos Linenberg	Technology Developer

This demonstration is being conducted by SNL under the auspices of the US EPA National Exposure Research Laboratory - Characterization Research Division (Las Vegas). The EPA role is to administer the overall Site Characterization and Monitoring technology verification program. The EPA co-leaders are Stephen Billets and Eric Koglin.

Sandia National Laboratories' role as the Verification Organization is to provide technical and administrative leadership and support in demonstration planning, conduct, and data analysis and documentation. Sandia will take the lead in the process of technology solicitation and selection and demonstration planning. Prior to and at the field demonstration, Sandia will work closely with site personnel and technology developers to efficiently plan and carry out the demonstration. Sandia will provide auditors to conduct sample management and to review technology use during the field demonstration. Sandia will also take the lead in analysis of the data following the field demonstration and will summarize its findings in a Technology Verification Report for each participating technology.

The Savannah River Site (SRS) role is to provide management and oversight of the field sampling operations to be carried out at both sites. SRS personnel will also participate in development and peer-review of the formal demonstration plan as well as in post-demonstration data analysis and technical reporting. They will also provide historical information concerning SRS sampling wells to be used in the present demonstration, and a written well sampling methodology for use during the SRS portion of the demonstration. SRS personnel operate in cooperation with the EPA-NERL and Sandia National Laboratories under funding provided by DOE EM-50 and the US EPA through a contract with Sandia.

McClellan Air Force Base personnel will provide access to monitoring wells at the McClellan site and will also review the demonstration plan for adequacy at this particular site. McClellan personnel will have a limited 'hands-on' role in the actual conduct of the demonstration. Radian International, the

McClellan on-site contractor, will provide the well sampling team and equipment at the McClellan site and will operate under contract to Sandia National Laboratories.

The technology developers will be required to submit written technology descriptions for inclusion in the demonstration plan. They will also be required to review and comment on the draft demonstration plan. At the demonstration, the developers will operate the technology and be responsible for submitting their analytical data to the verification organization at the conclusion of the demonstration. The developers will also be required to review their respective Technology Verification reports prior to final publication.

The Department of Energy EM-50 through one of its contractor laboratories, Bechtel-Nevada, Special Technologies Laboratory, will take responsibility for planning and coordination of a special Visitors Day at the Savannah River Site demonstration.

Responsibilities

Specific responsibilities for each of the demonstration participants are outlined in detail below.

Project Lead: EPA CRD-LV

EPA will have overall project management responsibilities and described in more detail in the following elements.

- Final approval on technology selection and demonstration plan
- Management oversight during field demonstration
- Coordination of EPA peer-review of demonstration documents
- Final approval of Technology Verification Reports
- Preparation of Technology Verification Statements

Verification Organization: SNL Technical Lead

SNL, in consultation with EPA CRD-LV technical lead, is responsible for the following elements of the demonstrations at the Savannah River and McClellan sites:

- Design and prepare all elements of the demonstration plan with developer input.
- Develop a quality assurance project plan (QAPP) and a health and safety plan (HASP) for the demonstration activities in consultation with the site representatives.
- Field demonstration site selection
- Review and selection of reference laboratory support
- Providing detailed procedures for technology field use with developer input.
- Oversight of Performance Evaluation sample preparation and distribution
- Oversight of field sample collection, management and transport
- Coordinate site logistical and other support, as required
- Coordinate pre-demonstration and field demonstration activities
- Providing documentation of the experimental methodology and operation of the technology with developer input.
- Data reduction and technical reporting

Demonstration Site: Savannah River Site

- Assistance in preparation and review of demonstration plan
- Lead role in field sample collection, management and transport
- Lead role in pre-demonstration sample collection and distribution
- Assistance in data reduction, analysis, and technical reporting

- Vistor’s Day Coordination

Demonstration Site: McClellan Air Force Base, Environmental Managment Directorate

- Site access
- Sample collection (via onsite contractor -- Radian International)
- Site characterization information
- Health and safety information
- Other logistical information and support needed to coordinate access to the site for the field portion of the demonstration
- Vistor’s Day Coordination

Developers

- Provide input (technology description and performance specifications) for the demonstration plan
- Review and comment on draft demonstration plan
- Provide formal written procedures for technology field use
- Operation of the technology during the demonstration
- Provide data to verification organization in suitable format
- Review and comment on draft Technology Verification Report

Communication

Sandia National Laboratories will take the lead in the coordination of communication among all participants during all phases of the demonstration. Regular communication will be carried out through the principal point of contact of each organization. Communication will occur primarily via e-mail however conference calls will also be held periodically throughout the June through September 1997 time frame as well.

Section 4 Technology Descriptions

This section includes a description of each of the technologies who will be participating in this demonstration. At the present time, seven technologies have expressed an interest in participating in this demonstration. The technologies range from simple to complex and address a broad spectrum of characterization and monitoring needs encountered in regional or local groundwater monitoring programs. Each fulfills a specific characterization or monitoring role; and, in many cases, the technologies may be viewed as complementary to each other. Developers were also encouraged to submit instrument performance specifications since they are very helpful in the development of the experimental and sampling design. It is not the intent of this demonstration however to specifically evaluate developer claims concerning instrument performance. Alternatively, the demonstration is designed to provide a selection of samples for analysis by each technology such that a determination of key instrument performance characteristics such as accuracy, precision, working range can be objectively determined for each technology. These determinations will be carried out for all instruments without specific comparison to developer performance claims stated in this section. The various technologies are presented in alphabetical order in the following sections.

Electronic Sensor Technology: EST-Model 4100 - Field-portable, Fast GC with Surface Acoustic Wave Detector

Technology Description

The Model 4100, shown in Figure 4-1, is a very fast, handheld gas chromatograph which utilizes a detector based upon surface acoustic wave (SAW) sensor technology. The instrument can be operated from AC line power or battery, using a car inverter. The 4100 is designed to detect headspace vapors from the ppm to ppb range and speciate the analytes of interest via gas chromatography in 10 seconds. The 4100 has multiple applications in environmental measurement of analytes of interest in an air, water, or soil matrix. Air samples are injected into the instrument head via tedlar bags or from the headspace of enclosed containers using a septum and needle. A water trap is available as an option, to remove high levels of water from the sample under analysis.

The 4100 consists of a head unit, the chassis, and a laptop computer. The chassis contains the electronic circuitry; helium storage, for up to 5 days operation; while also serving as a carrying case for the 4100. The head contains the column, the trap, a six way valve, and the detector. The laptop computer contains the proprietary software that controls the 4100 thorough all operations. It also records all chromatograms and data for export and report generation into appropriate software. The 4100 is fully portable and takes approximately 15 minutes from set-up to full operation. Analytes of interest are calibrated using calibrated tanks or tedlar bags spiked to the concentration levels of interest. The unit weighs 35 lbs.

The 4100 is undergoing a California Environmental Protection Agency Certification for 10 volatile organic compounds. Subsequent compounds will be certified for regulatory reporting purposes based upon future market needs.

The 4100 has a base list price of approximately $30,000. Operational costs are less than $20.00 per day for 8 hours of operation. Sample throughput is one sample every one to two minutes, depending upon the analytes.

Figure 4-1 The EST Model 4100

Principle Of Operation

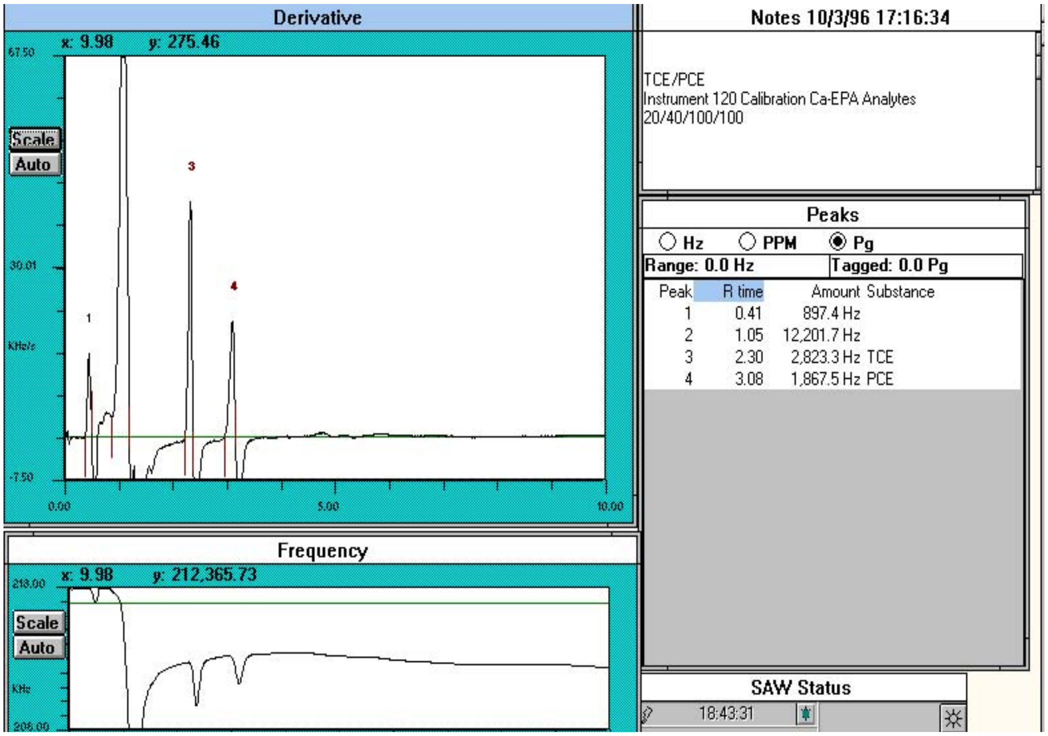
For the detection of VOC's, sampled air is pumped through a Tenax packed trap for a pre-selected time. The trap is then heated and the desorbed vapors are directed, via a temperature controlled rotary valve, to a short GC column. The GC column is thermally ramped and the effluent chromatographed vapors directed onto the surface of the SAW. The SAW, a 500Mhz resonator, is highly sensitive to any impinging vapors. The corresponding diminution in frequency caused by surface loading of the SAW oscillator is recorded and displayed in the form of an integram by a Windows based proprietary software adapted to run on an associated lap-top PC. The computer simultaneously displays an evolving chromatogram produced from the differential of the integram. The differential mimics the form of a traditional chromatogram but will usually display a typical negative inflection following each chromatographic peak which describes the physical effect of adsorption followed by desorption of each analyte from the SAW's surface. A typical chromatogram registered by the SAW detector is shown in Figure 4-2.

History Of The Technology

The 4100 was developed to meet the needs o the United States Department Of Energy through a research and development contract. As a fully temperature programmable instrument, it has the proven capability of analyzing semi-volatiles including PCBs, dioxins, and dibenzofurans. The 4100 is also used in the detection of narcotics, controlled substances, explosives, and nerve agents.

Technology Applications

The 4100 is designed to address the requirements of separating and quantifying the presence of volatile and semi-volatile compounds in water, soil and air. The technology meets the needs of site investigation, characterization, continuous monitoring, and post-closure, follow-up compliance. It is capable of screening incoming and processed waste in packaged form. Because of its dynamic range and 10 second response, the 4100 is used in laboratories to prescreen samples for applicable concentration before injection into laboratory GC/MC instruments. Site managers charged with the determination and clean-up of site contamination find the instrument as a valuable tool in receiving real time data at a fraction of the cost of laboratory analysis.



Notes 10/3/96 17:16:34

TCE/PCE
Instrument 120 Calibration Ca-EPA Analytes
20/40/100/100

○ Hz ○ PPM ● Pg

Range: 0.0 Hz
Tagged: 0.0 Pg

Peak	R time	Amount	Substance
1	0.41	897.4 Hz	
2	1.05	12,201.7 Hz	
3	2.30	2,823.3 Hz	TCE
4	3.08	1,867.5 Hz	PCE

Figure 4-2 Lab standard of TCE and PCE used for retention time calibration and quantitation:

Because of the sensitivity of the detector and the unit's design, the 4100 is able to separate a TO-14 mixture in 20 seconds to very low concentration levels.

Advantages Of The Technology

The 4100 offers on-site, real time speciation and quantification of analysis. Managers can make decisions based upon data that minimizes the efforts of drilling or moving expensive personnel and equipment.. The purchase of a 4100 is half of the cost of a laboratory GC/MS and provides a very high level of accuracy to meet regulatory requirements. It has been determined that the 4100 can save over 50% in laboratory analysis fees while providing real-time situational data.

Limits of the Technology

As a gas chromatograph, there are possible situations of co-eluting compounds.

Technology Performance Characteristics

The 4100 and its applicable standard operating procedures are applicable to a wide range of volatile and semi-volatile compounds. The following compounds are under CALEPA certification testing.

Minimum Detection Level and Practical Quantification Limit

The practical quantification limits for chemical analytes in a water matrix are shown in Table 4-1.

Table 4-1 Headspace Measurement Range of 4100

Analyte	Minimum (ppb)	Maximum (ppm)
Carbon Tetrachloride (CT)	70	100,195
cis-Dichloroethylene (DCE)	110	186,420
Chloroform (CF)	65	182,351
Trichloroethylene (TCE)	10	74,926
Tetrachloroethylene (PCE)	3	17,965
1,1,2,2 Tetrachloroethane (TCA)	1.3	6,256
Benzene (B)	45	106,711
Toluene (T)	4.5	29,276
Ethylbenzene (EB)	2.0	98,263
O-Xylene (o-X)	2.0	6,465

The practical quantification limit is the lower bound of the calibration range and represents a peak-to peak signal-to-noise ratio of 12:1. The signal level provides acceptable and reproducible signal integration with the 4100 Microsense software. The minimum detection level is estimated at 20% the PQL.

Precision and Accuracy

Precision and Accuracy for the EST-4100 instrument, as represented by the relative standard deviation on replicate measurements are shown in Table 4-2.

Table 4-2 Precision and Accuracy for the Model 4100

Analyte	Precision	Accuracy
Carbon Tetrachloride (CT)	7%	10%
cis-Dichloroethylene (DCE)	6%	8%
Chloroform (CF)	5%	5%
Trichloroethylene (TCE)	7%	7%
Tetrachloroethylene (PCE)	5%	3%
1,1,2,2 Tetrachloroethane (TCA)	5%	10%
Benzene (B)	4%	3%
Toluene (T)	4%	3%
Ethylbenzene (EB)	6%	10%
O-Xylene (o-X)	5%	5%

Instrument Working Range

The Model 4100 instrument is equipped with a number of controls which collectively constitute a GC measurement method and are user selected. The instantaneous measurement range is determined by the SAW detector and typically is greater than 20,000. The limit of detection (LOD) for a given analyte is determined by input sampling time and the retention volume of the inlet preconcentrator trap. The Limit of Detection is defined as the lowest level at which the detector response can be distinguished from noise.

The EST-4100 is capable of performing measurements up to the maximum vapor concentration as given by the saturation vapor concentration for each analyte. Saturated vapor measurements are made using methods with low sampling times and elevated detector temperatures. The specified instrument limits of detection (LOD) and maximum measurement levels for the 10 certification analytes in vapor phase are given in Table 4-3.

Table 4-3 Vapor Phase Measurement range for the Model 4100

Analyte	Limit of Detection (ppb)	Maximum (ppm)
Carbon Tetrachloride (CT)	70	100,000
cis-Dichloroethylene (DCE)	110	186,420
Chloroform (CF)	65	182,351
Trichloroethylene (TCE)	10	74,926
Tetrachloroethylene (PCE)	3	17,965
1,1,2,2 Tetrachloroethane (TCA)	1.3	6,256
Benzene (B)	45	106,711
Toluene (T)	4.5	29,276
Ethylbenzene (EB)	2.0	98,263
O-Xylene (o-X)	2.0	6,465

Method Detection Limits

Method Detection Limits for the analytes in the Cal EPA certification are given in Table 4-4.

Table 4-4 Method Vapor Phase Detection Limits for the 4100

Analyte	Method Detection Limit (ppb)
Carbon Tetrachloride (CT)	200
cis-Dichloroethylene (DCE)	350
Chloroform (CF)	200
Trichloroethylene (TCE)	30
Tetrachloroethylene (PCE)	10
1,1,2,2 Tetrachloroethane (TCA)	5
Benzene (B)	150
Toluene (T)	10
Ethylbenzene (EB)	5
O-Xylene (o-X)	5

Comparison With Reference Lab Analyses
The 4100 GC/SAW analytical results in a water matrix are within 5% or better of a reference laboratory instrument.

Specificity

The possibility of coeluting compounds provides the most common cause of interference. It is not generally possible to be certain that an unknown analyte is present as a coeluting compound based only on retention time data. Understanding the sampling environment and the potential target analytes is necessary to prevent the possibility of interference.

Other Field Performance Characteristics

Instrument Setup/Disassembly Time

The instrument setup/disassembly time is 20 minutes

Instrument Calibration Frequency During Use

Normally, a calibration mixture is run every 10 chromatographic runs. Based on typical sample throughput rates, this corresponds to about 3 calibration checks per hour

Ancillary Equipment Requirements

The instrument requires 110 AC which can be supplied via line connection, generator, or from a 12 volt car battery equipped with an invertor.

Sample Throughput Rate

Sample throughput rate is on the order of 2 minutes per sample or about 30 samples per hour.

Operator Training Requirements

A lab or field technician with some previous GC experience can become proficient after about one hour of training. The operator must be proficient in the operation of a laptop computer using a windows type interface. For an inexperienced person, the required training time to become proficient in instrument operation is one day.

Ease of Operation

The instrument can be operated by a single technician, however a second technician doing sample handling can expedite sample throughput.

Inficon: HAPSITE - Field-Portable Gas Chromatograph/Mass Spectrometer with Headspace Sampling Accessory

Technology Description

The HAPSITE is a field-portable gas chromatograph/mass spectrometer (GC/MS). The HAPSITE can be operated from battery or AC line power. The basic instrument is designed to sample gaseous samples in the ppb to ppm range, separate the sample components via gas chromatography, and detect components with a conventional quadrupole mass spectrometer. The primary application area of the HAPSITE is in direct air measurements. The HAPSITE also provides an MS only mode of operation in which an air sample can be directly sampled via a membrane interface into the mass spectrometer without separation via GC. The mass spectrometer is capable of scanning from 1 - 300 AMU and employs a continuous dynode electron multiplier. An equilibrium headspace sample accessory is used to concentrate volatile sample components from water, soil, or sludge in the gas phase above the sample. The headspace sample accessory introduces a portion of the gas phase above the sample into the GC/MS.

In the portable mode, the HAPSITE operates off of a proprietary pumping system which contains no moving parts, to maintain the vacuum of the mass spectrometer. The pumping system provides vacuum for 30 days, at 8 hours usage per day, and then must be replaced. In the portable mode, the system weight is 35 lbs. The unit is rugged and water tight and is designed to be operated in the typical environment found in a manufacturing/chemical plant or at a remediation site. It can withstand the normal shocks and bumps encountered during transport in such an environment. Battery life in the portable mode is 3 - 4 hours. The system uses a self-contained carrier gas and internal standard gas supply. The internal standard gases are used to tune and verify the mass spectrometer response. The internal standards can also be co-injected with air samples. The carrier gas supply provides for 8 hours of operation, and the internal standard gas supply will last 3 days at 8 hours per day of usage. The headspace sampling accessory can be operated via battery or AC line power, weighs 12.5 lbs., and will equilibrate up to 4 samples simultaneously. A separate carrier gas supply is required for the accessory.

The HAPSITE GC/MS can be operated in a portable or transportable mode. In the transportable mode, a suitable working environment such as a trailer or van equipped with 110 Volts AC line power, is required for operation. In the transportable mode, the HAPSITE GC/MS is mounted on a service module which contains a turbomolecular and backing pump. The combined weight of the system in the transportable mode is 75 lbs. An external carrier gas supply of nitrogen can be used in the transportable mode but is not required. An internal standard gas supply is required.

The HAPSITE consists of an *Inlet System (*heated transfer line, sample pump, gas sampling valve), *GC*, (isothermal oven and 30 meter ***.32mmid 1udf SP-1 capillary*** column which includes 5 meter pre-column for backflush), and *Mass Spectrometer System* (membrane interface, quadrupole mass spectrometer, internal computer, and hard disk). An external laptop PC is included with the system and can be used for system control as well as to display and analyze data in real time. The external PC is not required for operation once methods have been developed and stored on the HAPSITE internal PC.

The HAPSITE GC/MS with Headspace sampling accessory list price is approximately $95,000. Operational costs are less than $150/day, for 8 hours of operation. Water sample throughput is one sample every 15 minutes, following a headspace equilibration time of 30 minutes.

Principle of Operation

The headspace sampling accessory uses a temperature-controlled environment to equilibrate a water, soil, or sludge sample in a sealed vial. The volatile components in the sample matrix reach an equilibrium distribution between the water sample and the vapor headspace above the sample. The gas phase is then transferred to the gas sampling loop of the HAPSITE sample introduction system via a pump and carrier gas. The fixed volume of the loop is then injected onto the GC pre-column. The principle of sample equilibration and sampling is similar to US EPA Method 3810. The GC is operated isothermally at 60^{o}C and the analytes are separated during an 11-minute run. Compounds that would elute after 11 minutes are backflushed from the pre-column. Components elute from the GC column and enter the mass spectrometer ionizer assembly through a polydimethylsilicone membrane interface. The membrane is maintained at a constant temperature, 60^{o}C which excludes the majority of the N_2 carrier gas.

The separated compounds produce a characteristic 70 eV electron impact spectrum. When tuned to the manufacturer's specifications using the internal standard gas components, this will produce a consistent NIST library searchable spectrum for compounds in the low ppb to ppm range. The mass spectrometer can be operated in a full scan or selected ion mode (SIM). Target compounds are identified by their GC retention time and comparison of their mass spectra to a target compound library of spectra collected during calibration. Spectra of unknown compounds can be compared to spectra in the NIST (National Institute of Standards) Mass Spectral Library for tentative identification.

Quantification is accomplished by applying a relative response factor from a daily calibration standard. For the headspace method, internal standards and surrogates are used to identify and compensate for matrix effects.

History of the Technology

The HAPSITE GC/MS was originally designed to meet the requirements for source emission testing as specified in the 1990 Clean Air Act amendments. A method 301 validation has been completed and submitted to the EPA for the Determination of Gaseous Organic Compounds by Direct Interface GC/MS.

Technology Applications

The HAPSITE GC/MS with Headspace sampling accessory is designed to accurately determine the presence and concentration of volatile organic compounds in water, soil, and sludge. The technology is applicable for site investigation/characterization and for periodic monitoring to determine migration of volatiles at remediation sites. Site engineers charged with definition of site contamination and monitoring the effectiveness of remediation techniques are the largest group of potential users.

Advantages of the Technology

The primary advantage of the HAPSITE is the ability to provide GC/MS-quality results on-site. Decisions can be made in a cost-effective manner in regards to further drilling or the movement of expensive field equipment. The initial cost is comparable to a laboratory GC/MS equipped with purge and trap. Portable gas chromatographs with non-specific detectors are less costly, but lack the ability of GC/MS to identify and quantitate in complicated sample matrixes.

Limits of the Technology

The major limitation of the HAPSITE is the isothermal GC oven. Chromatographic run times are extended to 20 minutes in order to detect the dichlorobenzenes. The last five analytes from the 8260 list of compounds--1,2-Dibromo-3-chloropropane, 1,2,4-Trichlorobenzene, Naphthalene, Hexachlorobutadiene and 1,2,3-Trichlorobenzene--are not compatible with the instrument/method. The technique is limited to the determination of only those compounds with sufficient volatility to be removed from the sample in detectable concentrations with the equilibrium headspace technique.

Technology Performance Characteristics

The HAPSITE/Headspace GC/MS method is applicable to a wide range of organic compounds that have sufficiently high volatility to be effectively removed from water, soil, or sludge samples via equilibrium Headspace. The chemical compounds, shown in Table 4-5, have been evaluated and are suitable for analysis with the HAPSITE.

Minimum Detection Level and Practical Quantitation Limit

The practical quantitation limits for chemical analytes in water medium are listed in Table 4-5. The practical quantitation limit is the lower bound of the calibration range and represents a peak-to-peak signal-to-noise ratio of 10:1. This signal level provides acceptable and reproducible (± 20%.) signal integration with the HAPSITE software. The minimum detection level is estimated at ½ the PQL.

Accuracy

The HAPSITE GC/MS Headspace system will perform at an accuracy level of ±25% or better over the calibration range 95% of the time.

Precision

The precision, as represented by the relative standard deviation on replicate measurements, will be ±20% or better over the working range of the instrument.

Instrument Working Range

The HAPSITE can measure the volatile organics,listed in Table 4-5, over a dynamic range of 10^4. For tetrachloroethene this would represent a working range of 5 ppb to 50 ppm. The working range of the instrument can be adjusted from the lower limit upward by controlling the injection volume. If tetrachloroethene were to be measured in the 10 - 100 ppm range, the injection volume could be reduced by 50% to allow measurement within the linear dynamic range of the instrument.

Comparison with Reference Lab Analyses

The HAPSITE GC/MS analytical results for VOC's in water will differ from reference laboratory measurements, using Method 8260, by no more than ±35%, 95% of the time.

Data Completeness

Analysis and valid results will be reported for 90% or more of the samples presented for analysis during have no effect on the concentration of tetrachloroethene measured by the detector. Note: High levels of TPH may cause sample matrix effects which could change the partition coefficient for chlorinated organics. This is monitored by the use of internal standards and surrogates in the method.

Other Analytical Performance Characteristics

An MS tune check is to be performed every 12 hours to manufacturers specification using the tuning compounds 1,3,5 tris (trifluoromethyl) benzene and bromopentafluorobenzene. This tune check will verify the stability of the mass spectrometer. The system must pass this tune check prior to being used for sample analysis. In addition, the initial calibration curve for all target analytes must generate a relative standard deviation of 30% or less for each individual compound. A daily GC/MS calibration is to be performed at least once during every 12 hours of operation. Specific analytes from the calibration curve will be designated as Calibration Check Compounds (CCCs). All CCCs must generate a difference of 25% or less when compared to the initial calibration curve. A system blank will also be run prior to analyzing samples. The results from the blank will be below the detection limit for all analytes. Contamination of a high sample to a low sample will be less than .25% of the high sample. For example, a 5 ppm sample of tetrachloroethene would generate a result of less than 12.5 ppb in a blank immediately following the high level sample.the demonstration.

Table 4-5 Inficon - HAPSITE GC/MS Analyte List

Compound	CAS Number	PQL ug/L	Quant Mass
Benzene	71-43-2	5	78
Bromobenzene	108-86-1	10	77
Bromochloromethane	74-97-5	15	49
Bromodichloromethane	75-27-4	5	83
Bromoform	75-25-2	15	173
Bromomethane	74-83-9	5	94
Carbon Tetrachloride	56-23-5	5	117
Chlorobenzene	108-90-7	5	112
Chloroethane	75-00-3	10	64
Chloroform	67-66-3	5	83
Chloromethane	74-87-3	5	50
Dibromochloromethane	124-48-1	5	129
1,2-Dibromoethane	106-93-4	5	107
Dibromomethane	95-50-1	5	174
Dichlorodifluoromethane	75-71-8	10	85
1,1-Dichloroethane	75-35-3	5	63
1,2-Dichloroethane	107-06-2	5	62
1,1-Dichloroethene	75-35-4	5	61
cis-1,2-Dichloroethene	156-59-2	5	61
trans-1,2-Dichloroethene	156-60-5	5	61
1,2-Dichloropropane	78-87-5	10	63
2,2-Dichloropropane	594-20-7	10	77
1,1-Dichloropropene	563-58-6	10	75
cis-1,3-Dichloropropene	10061-01-5	10	75
trans-1,3-Dichloropropene	10061-02-6	10	75
Ethyl Benzene	100-41-4	5	91
Isopropylbenzene	98-82-8	10	105
Methylene Chloride	75-09-2	5	49
Styrene	100-42-5	5	104
1,1,1,2-Tetrachloroethane	630-20-6	20	131
1,1,2,2-Tetrachloroethane	79-34-5	20	83
Tetrachloroethene	127-18-4	5	166
Toluene	108-88-3	5	91
1,1,1-Trichloroethane	71-55-6	5	97
1,1,2-Trichloroethane	79-00-5	5	97
Trichloroethene	79-01-6	5	130
Trichlorofluoromethane	75-69-4	5	101
1,2,3-Trichloropropane	96-18-4	15	75
Vinyl Chloride	75-01-4	5	62
o-Xylene	95-47-6	5	91
m-Xylene	108-38-3	5	91
p-Xylene	106-42-3	5	91

Specificity

The HAPSITE GC/MS can measure and detect low levels of chlorinated organics in the presence of non-chlorinated hydrocarbons. A concentration of 100 ppm total petroleum hydrocarbons (TPH) in water will

Other Field Performance Characteristics

Instrument Setup/Disassembly Time

The HAPSITE GC/MS requires 30 minutes initial setup time. The HAPSITE and Headspace accessory can be shipped or carried as checked baggage. The carrier and internal standard gas canisters must be shipped as hazardous materials.

Instrument Calibration Frequency During Field Use

An MS tune check is required at startup and following every 12 hours of operation. A daily calibration check is also required at startup and following every 12 hours of operation.

Ancillary Equipment Requirements

A source of 110 volt 60HZ AC power is desired for initial startup of the instrument. Approximately 40% of the battery life is expended in startup. Normal operation would be to start the instrument on AC prior to taking it to the field. Then power the instrument via battery. Carrier gas and tuning gases are required. A 20ml luer lock syringe, 40ml VOA vials, 1ul syringes for internal standards and surrogates are also required.

Field Maintenance Requirements

Battery life is 3 hours; carrier gas replacement is required every 8 hours. Operation in the field requires a non-evaporative getter (NEG) pump. The usable life on the pump is 30 days at 8 hours of operation per day.

Sample Throughput Rate

Initial headspace analysis equilibration time for the first sample is 30 minutes. Analysis time is 15 minutes per sample. Up to four samples can be equilibrated simultaneously.

Operator Training Requirements and Ease of Operation

The HAPSITE GC/MS training is three days for someone familiar with the operation of GC/MS. This training includes the setup and maintenance of the instrument and methods. Training for field operation of the instrument requires 1 day.

Innova AirTech Instruments: Multi-gas Monitor, Model 1312 - Photoacoustic Spectroscopy Monitor

Technology Description

The Innova Multi-gas Photoacoustic Spectroscopy (PAS) Monitor is a field-portable monitor designed for monitoring volatile organic compounds in the vapor phase. A headspace sampling accessory extends the measurement capabilities of the instrument to a water matrix as well. The instrument's measurement technique is based on the photoacoustic effect. The photoacoustic effect is based upon the conversion of electromagnetic energy into sound energy by a gas, liquid or soil. It was discovered and investigated by Alexander Graham Bell in the late 1800´s, but was little more than a curiosity until 1970´s when there was a renewed interest due to the development of lasers and very sensitive detection techniques. Since that time, Photoacoustic based instruments have been used to monitor for a wide variety of chemicals in stack and vent emissions, ambient air, and in the troposphere.

The basic theory of the photoacoustic effect in gases using infrared radiation is straightforward. When a gas is irradiated with radiation of a frequency which corresponds to a resonant vibration frequency of the gas, some of the electromagnetic energy will be absorbed. This will cause some of the molecules of the gas to be excited to a higher vibration energy state. These molecules will subsequently relax back to the initial vibration state through a combination of radiative and non-radiative processes. For vibrational excitation, the primary relaxation process is non-radiative vibrational to translational energy transfer. This results in increased heat energy of the gas molecules, and therefore, a temperature and pressure increase in the gas. If the irradiating light is modulated, then the temperature and pressure will be modulated also. The modulated pressure will result in an acoustic wave, which can be detected with a sound measuring device, such as a microphone.

The amplitude of the acoustic wave will depend upon such factors as the geometry of the gas cell, incident light intensity, absorbing gas concentration, absorption coefficient, and the background gas. For a non-resonant spherical gas cell under steady state conditions, the amplitude of the acoustic wave can be found from the following equation:

$$P = K((Cp/Cv)-1)I_o\, c(1/f)$$

In the above, P is the sound pressure--the measured parameter, I_o is the incident light intensity, c is the absorbing gas concentration, f is the modulation frequency, Cp and Cv are heat capacities, and K is a cell and gas-dependent constant.

The monitor, shown in Figure 4-3, is known as the *INNOVA* Multigas-monitor, Type 1312. The instrument uses a heated nichrome wire as its infrared radiation source. The light from the source is focused by an ellipsoidal mirror, modulated with a mechanical chopper, and passed through an optical filter before entering the photoacoustic gas cell. The acoustic signal is detected with a pair of condenser microphones. The electrical signals from the microphones are amplified by preamplifiers mounted directly on the backside of the microphone and added together in a summation amplifier before being sent to an analog to digital converter for further processing. The digitized signal is then converted to a concentration reading using the proper calibration factor stored in the instrument.

The Type 1312 instrument measures 6.9 x 15.6 x 11.8 inches and weighs 19.8 lb. The power consumption is 100 *VA* and is supplied by either a 110 VAC or a 12 volt DC source. The cost of the system depends on the sample matrix but will fall in the range of $28K-35K

In this technology demonstration Innova will use it's new Photoacoustic Spectroscopy Monitor, Type 1312. The Type 1312 is a newer version of the type 1302 that has been previously tested at the Savannah River Site for CVOC compounds in air. The type 1312 has an improved signal to noise ratio of 3.3:1 affording lower detection limits. The 1312 can also work with lower sample volumes making it more suitable for head space monitoring applications.

During this demonstration, the Type 1312 instrument will be connected to a recirculation flask equipped with stirring and heating, as shown in Figure 4-3, for improved response time.

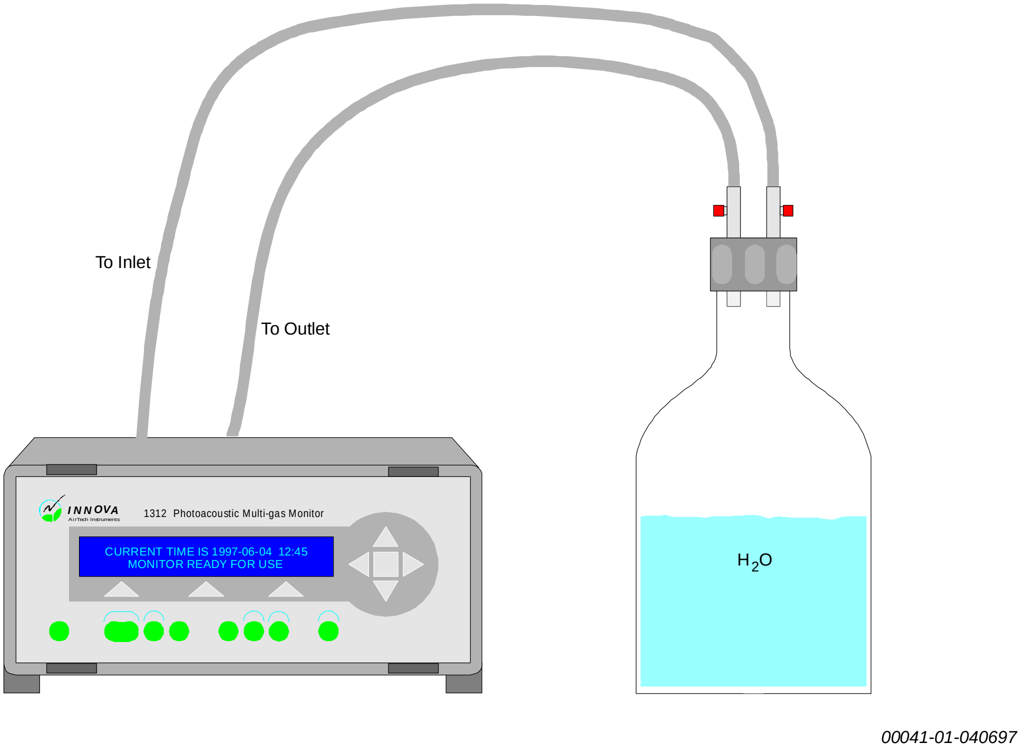


Figure 4-3 A diagram of the Innova PAS instrument configured for head space monitoring.

History of the Technology.

Optical filter and FT-IR type photoacoustic instruments have been used and evaluated in several cases for monitoring chlorinated volatile organic compounds (CVOC's) in the air at soil remediation sites and from gas wells and bore holes at CVOC contaminated sites. They have also been used to analyze CVOC's purged from soil and water samples.

One application of CVOC monitoring with the *Innova* Multi-gas monitor is the analysis of perchloroethylene (PCE) and trichlorethylene (TCE) mixtures. The ability of the instrument to monitor the compounds simultaneously has been evaluated in the laboratory at Bruel and Kjaer Instruments and in the field at the Savannah River Site in South Carolina. TCE and PCE are monitored using the 861 cm^{-1} and 900 cm^{-1} spectral regions respectively. The optical bandpass of the filters used for these regions is approximately 60 cm^{-1}. Since there is some absorbance from each compound in each of the regions above, a matrix method is used to determine each individual concentration. In this method, the matrix equation KC=S is solved for C, where S is a column vector containing the measured signals for each optical region, K is a N x N matrix containing the response factors for each gas in each of the different spectral regions, and C is a column vector containing the concentrations of each individual chemical.

Laboratory work has shown a linear photoacoustic sensor response for both PCE and TCE up to approximately 700 ppmv with a detection limit of approximately 0.07 ppmv for each. Above 700 ppmv the response becomes non-linear. Measurements on mixtures of the two chemicals indicate that accurate results can be obtained using the above matrix method.

The *Innova* Multi-gas monitor has previously been evaluated for field use in several different test scenarios at the Savannah River Site. In one scenario the instrument was used to monitor the concentration of PCE and TCE in the gas from a horizontal extraction well. Measurement results were compared with the results from a gas chromatograph (HP Model 5890). In general, the two instruments agreed to within 20% for both gases. The average relative percent difference for the PAS instrument when compared to the GC was 10.0 % (at concentrations less than 250 ppmv) and 11.4 % (at concentrations greater than 250 ppmv) for PCE with accuracies of 9.8% and 7.37% respectively for TCE. The precision (or stability) of the instrument was also evaluated over a 30-day interval by periodically measuring 100 ppmv standards. The relative standard deviation for 5 measurements over this time period was 0.85% for PCE and 1.16 % for TCE.

The instrument has also been used to monitor gas from vadose zone piezometer wells; on off-gas treatment monitoring; and to determine depth-discrete soil vapor concentrations of TCE and PCE with a cone penetrometer. A fourier transform infrared (FT-IR) based instrument from Innova (formerly Brüel & Kjaer) has also proven successful for laboratory-based purge and trap analysis of PCE, TCE, Carbon Tetrachloride and Chloroform in water at Ames Lab, Iowa State University, yielding detection limits for these compounds in the very low ppb range. Photoacoustic spectroscopy monitors from Innova have also been successfully used in indoor air quality measurements (several units have been sold to the US EPA), industrial hygiene applications, as well as fermentation emissions monitoring and many more applications.

Technology Advantages

Some of the advantages and characteristics of infrared photoacoustic spectroscopy as it pertains to trace gas monitoring are as follows.

1. High sensitivities can be obtained. Instruments using conventional infrared light sources such as heated nichrome wires have demonstrated detection limits in the low ppbv to ppmv range for single gases.
2. Photoacoustic based instruments are very stable, primarily due to the stability of the microphones. Microphones are some of the most stable transducers known, with output drifts of <10% over hundreds of years.
3. A dynamic range of up to 6 orders of magnitude relative to the detection limit for a particular gas can be achieved. Thus, very high concentrations can be measured with a single instrument.
4. Cell volume is very small (3 cm^3), reducing the amount of sample and calibration gas needed. The small cell volume also results in a very compact instrument.
5. Simple instrumental and optical setups can be used. In particular, multipass gas cells are not needed, thus eliminating the problems of maintaining optical alignment through this type of cell.
6. Photoacoustic based systems measure the absorbance directly instead of indirectly as in transmission based instruments. Consequently, a very good baseline stability results.

7. No consumables are needed, keeping the cost of operation very low.
8. The instrument will function in temperatures ranging from 5 to 40 deg C.

Technology Limitations

The main limitation of the technology is the fact that most organic gases absorb over a wide range of the IR spectrum making the measurement prone to interference. The Innova type 1312 has a unique cross compensation algorithm that allows it to compensate for known interference's. Possible interferences are all compounds that are active in the mid-infrared region. In a sample matrix with unknown interference's measurement results could be erroneous. The technology can therefor not replace laboratory testing but will drastically reduce the need for laboratory testing. The instrument is particularly well-suited for routine well-monitoring applications where the composition of the contaminants in the water are known.

Technology Improvements

Innova is investigating the use of various semi-permeable silicone based tubing that potentially allows measurements to be made directly in the liquid sample, thus eliminating the need to do head space monitoring.

Technology Applications

The photoacoustic spectroscopy technology has been very successful applied to the measurement of various organic compounds in air. By bringing the analyte of interest into the gas phase, the technology can also be used to monitor various organic compounds in water, soil and sludge.

Due to the high sensitivity combined with an extremely small sample cell we believe that our technology is the only IR based technology that can achieve the low detection limits needed for water and soil analysis applications. Since the technology is extremely easy to use, even unskilled operators can achieve good results.
The technology is particularly well suited for use at contaminated sites where the sample matrix is reasonably well known.

Technology Performance Parameters

Minimum Detection Level (MDL).

With PAS technology, almost any volatile chlorinated species which absorb in the infrared spectrum can be measured with a head space sampling technique. In general, chlorinated species have strong infrared absorption and thus give low detection limits.

We have performed laboratory measurements of chloroform and tetrachloroethylene in gas and aqueous phases. Detection limits for these substances in air and water samples are given in Table 4-6

Table 4-6 MDL and PQL in water samples

Analyte	MDL air	MDL water	PQL water
Tetrachloroethylene	70 ppb	2 ppb	7 ppb
Chloroform	70 ppb	3 ppb	10 ppb

MDL - Minimum Detection Level
PQL - Practical Quantitation Limit

Measured detection limits in air samples indicates that the detection limit (MDL) for chlorinated species in water to be in the range from 1 to 10 ppb with TCE being in the low ppb range. The detection limits in Table 4-6 have been determined with a type 1302 Monitor. Using our new type 1312 Monitor we expect to improve the MDL and PQL`s by a factor of 3 without affecting the upper limit of the working range.

Practical Quantitation Limits.

The practical quantitation limits (defined as 10 x MDL÷3) are also given in Table 4-7

Accuracy

Measurements are not yet performed to compare our "head-space" measurement result to certified standards; however as described previously in "History of Technology," a comparison of our measurement results on air samples to GC methods were within 20 %.

Precision

Instrument precision will be better than 20 % for concentrations ranging from the PQL to 0.5 ppm and better than 10% over the remaining working range of the instrument.

Instrument working range

For air samples, the working range for chloroform and tetrachloroethylene of the instrument with a one point calibration is from the PQL (0.2 ppm) to 10 times the MDL (0.07 ppm) giving a working range of 0.2 ppm to 700 ppm for air samples.

For water samples, a test of a 1-liter volume of water in a 2.5 L flask gave the following results: 1 ppm chloroform in water correlated to 35 ppm chloroform in the head-space, and 1 ppm tetrachloroethylene in water correlated to 50 ppm tetrachloroethylene in the head-space. These results yield a working range for chloroform and PCE as shown in Table 4-7 using a one-point calibration of the instrument. With a two-point calibration of the instrument, the range is extended as shown in Table 4-7.

Table 4-7 Working range of the Innova Photoacoustic Monitor in Water

Analyte	Single point calibration	Two point calibration
Chloroform	10 ppb-20 ppm	10 ppb - 200 ppm
Tetrachloroethylene	7 ppb-15 ppm	7 ppb-150 ppm

Comparison with reference lab analyses.

No comparison has been performed yet.

Data Completeness.

With 3 samples per hour it is possible to give measurement results for 20 samples per day. Analysis and valid results will be reported for 95% or more of the samples presented for analysis during the demonstration provided that no unknown interference's are present.

Specificity

The Innova instrument has a built-in cross compensation feature. The instrument can compensate for up to 4 known interfering species and water vapor. If the instrument is not calibrated to perform compensation for an interfering substance the signals are added and then the measurement result is dependent upon the sensitivity of the interfering substance at the wavelength range of the optical filter in use. For example:

> 10 ppm of chloroform and 100 ppm of xylene are present in the head-space.
> Without cross compensation, 100 ppm of xylene is equivalent to 3.5 ppm of chloroform.
> With cross compensation the interference is reduced to a positive interference of 0.07 ppm.

Other Field Performance Characteristics

Instrument Setup/Disassembly Time

The set-up time of the system is less than 15 minutes. The system can be air shipped in a cardboard box or alternatively, can be air transported as a carry-on item.

Instrument Calibration Frequency During Field Use

The recommended instrument calibration interval is 3 months.

Ancillary Equipment and Field Maintenance Requirements

The system requires 110V AC but can alternatively be operated on 12V DC and an AC/DC converter. No consumables are required for routine field use or maintenance (except for a fine particle air inlet filter that needs replacement once per month).

Sample Throughput Rate

The expected sample throughput rate is 3 samples per hour

Operator Training Requirements and Ease of Operation

Less than 1 hour of training is required to become proficient in instrument operation.

Summary Demonstration Performance Goals

Innova’s overall performance goal at this demonstration is to show that Photoacoustic Spectroscopy Monitors can provide a cost- effective, easy-to-operate solution to most of the monitoring needs at contaminated land sites where the sample composition is reasonably well known. The technology can be applied to air, soil, sludge and water samples and will be able to detect most volatile organic compounds with a PQL in the ppb range. The main benefits of this technology are its portability, ease of use, long calibration intervals and low detection limits.

The Innova PAS Monitor will detect any chlorinated compound, for which it is calibrated, at water concentration in excess of 25 ppb. The technology will produce results that are within 20% of the reference laboratory on 90% of the samples. The relative standard deviation over the working range of the instrument will be less than 20%.

ORS Environmental Systems: AccuSensor - Handheld TCE Monitor Using Colorimetric Methods

Technology Description

AccuSensor provides real time detection and measurement of TCE and/or tri-halomethanes in water to less than 10 parts per billion (ppb). The AccuSensor consists of a hand held, field portable meter and individually packaged, expendable reagent caps. The chemical reagent sealed in the caps enables the detection of TCE and/or tri-halomethanes (THMs) in aqueous samples. AccuSensor measures the visible light absorbance of products formed in the Fujiwara reaction in which pyridine and hydroxide ions react with TCE (and/or THMs). The reaction is specific for geminal dihalide compounds and ORS has optimized it for response to TCE (and/or THMs).

Principle of Operation

The optical system consists of an incandescent lamp, beam splitter, and two photodiodes in the meter, and the reagent cap. The measurement is made by optically interrogating the reagent reservoir with the lamp and monitoring the transmitted light with the two photodiodes. The measurement photodiode is filtered to pass a narrow bandwidth centered at the appropriate absorbance maximum while the second photodiode passes non-absorbing frequencies and acts as a reference. The absorbance is measured over a 5 minute period. The rate of formation of absorbing species is directly proportional to the aqueous concentration via Henry’s Law. The slope of the absorbance versus time plot is thus compared to a calibration curve in the meter and an aqueous concentration is calculated and displayed on the meter in ppb. The meter determines whether a TCE or THM measurement is being made based on the style of cap being used and automatically selects the appropriate analysis algorithm for the compound(s) of interest.

The AccuSensor system was designed for field portability and ease of use. The system, contained in a single shipping case, includes everything required for sample analysis and is easily transportable by the user. The total system weighs approximately 5 pounds. The hand-held meter unit weighs 1.5 pounds.

The acquisition cost of the AccuSensor system is $4,200. Expendable sensor caps are sold in packages of ten and cost $400 per package.

Sample and sensor cap handling are easily handled by a trained operator. An operator can become proficient in the use of the system in less than 30 minutes with minimal training. Once trained, the measurement procedure involves minimal sample handling or preparation. The sample is collected in a 40 ml VOA vial and a sensor cap attached for the measurement. *The sensor cap has been classified as an “empty” container at the conclusion of a measurement* and therefore may be discarded as non-hazardous, solid waste.

The AccuSensor system was designed to perform accurate measurements in the field. This instrument feature required the development of a complex temperature compensation algorithm, which is stored in the meter. The algorithm corrects for sample, sensor cap and ambient temperatures when different from room temperature. These temperature conditions may effect the system performance if not dealt with appropriately.

The AccuSensor system is most accurate in the low concentration range (1 - 1000 ppb) but is capable of measuring concentrations as high as 10 ppm.

History of the Technology

The basis for the AccuSensor measurement is in the Fujiwara reagent. This reagent was discovered in the early 1900s and has seen many uses since that time. The Fujiwara reaction is still used and investigated in many Universities and National Labs in efforts to better take advantage of the its sensitive colorimetric capability. The key AccuSensor feature is in the reagent packaging and interface with the meter. This patented feature simplifies the reagent handling and provides a reliable measurement environment.

Technology Applications

The problem addressed by the AccuSensor system is the expense in both time and laboratory analytical costs of TCE sample analysis. The AccuSensor provides real time, accurate measurement of TCE down to near-regulatory limits. This allows for the collection of more data, allows for faster decision making, avoids potential sample handling issues and greatly reduces the cost of sample analysis.

Advantages of the Technology

The AccuSensor technology offers several advantages. The reagent chemistry together with the optical configuration in the meter provides a high degree of specificity for TCE. The reagent also responds to the trihalomethanes (THMs) which are typically not found in ground water sources. No interferences have been identified, beyond the THMs, during the development testing of the AccuSensor.
The technology provides results in 5 minutes. The Fujiwara reaction, used for the sensing element, begins almost immediately upon introduction of the sample. The meter monitors the reaction for 5 minutes to allow for the collection of multiple sample points.

The colorimetric reaction is monitored using dual wavelengths. This feature accounts for ambient conditions and changes and eliminates the need to perform calibrations of the system. The meter calculates the rate of absorbance of the wavelength of interest referenced to a non-absorbing wavelength. For this reason the accuracy of a measurement is a function of the sensor cap and reagent rather than the meter and optics. The sensor caps are manufactured under high tolerance and strict quality control to insure that the sensors remain consistent. A simple calibration check of a known solution confirms that the system and caps are functioning correctly.

The operating range of the system is from 1 to 10,000 ppb. The response is not linear over this range and the non-linearity is programmed into the meter. The non-linear compensation causes less accurate results at the higher concentrations. The system is calibrated at 50 ppb to insure that the low range data is most accurate.

The use of the AccuSensor yields no hazardous material. Only the 40 ml VOA vial with sample and sensor cap must be discarded. The sensor cap is considered an “empty” container at the conclusion of a measurement.

The AccuSensor system will provide slightly more accurate results in a controlled/laboratory environment since the various temperature conditions are better controlled. However, the system provides compensation for these conditions such that field measurements are easily and accurately achieved.

The system provides near laboratory quality results for TCE concentrations in water at a cost of $40 versus a typical laboratory cost of $100. These less expensive, quality results are available in 5 minutes and can be obtained by a technician.

Limits of the Technology

The AccuSensor is limited in its operating temperature range. The sample temperature must remain above 5 C in order to insure that a headspace is developed. Best results are obtained at room temperature since at this temperature no temperature correction is required.

Other temperature errors can be obtained if the sample temperature, cap temperature and ambient temperature differ significantly and a measurement is not made according to the strict protocol. The temperature compensation algorithm requires rapid procession through the measurement steps. The potential temperature error is easily avoided if temperatures are allowed to equilibrate and stabilize.

The sensor caps respond to the trihalomethanes (THMs). To date these are the only known interferences. If present in the sample they will provide a 50 % response for similar concentrations.

The head space analysis is a major factor in the system's specificity performance. This fact also provides for a source of error in the event that the head space/water sample equilibrium (Henry's Law) is affected by other effects. These can be in the form of chemical factors which alter the equilibrium condition normally found in water. The other factor affecting head space is the temperature, but this has been treated separately and compensated for.

Technology Performance Characteristics

Minimum Detection Level

The AccuSensor system is designed to specifically respond to trichloroethylene (TCE). The MDL, established in the lab in accordance with Appendix B to part 136 of 40 CFR Ch. 1, for a 95 % confidence (2.447 * standard deviation) was measured as 6.0 ppb.

Practical Quantitation Limit

The PQL, defined as 10 times the standard deviation of the instrument noise, is 10 ppb for TCE in water.

Accuracy

The instrument will perform at an accuracy level of +-10 ppb or ±20 % or better over its working range, 95 % of the time.

Precision

Instrument precision, as represented by the relative standard deviation on replicate measurements will be 15 % or better over the working range of the instrument.

Instrument Working Range

The system will measure TCE in water at an accuracy level of ±10 ppb or ± 20 %, 95 % of the time over the standard concentration range of 6 ppb - 1000 ppb. The system will measure TCE in water at reduced accuracy, ±30 %, over the extended concentration range of 1000 ppb - 10,000 ppb.

Comparison with Reference Lab Analysis

The instrument analytical results for TCE in water sample splits will differ from reference laboratory measurements by no more than +- 12 ppb or +- 25 % in the standard working range, 95 % of the time.

Data Completeness

Based on normal operational procedures, the AccuSensor system is capable of performing analysis on all 70 - 80 samples provided during the demonstration. As a measure of safety it is assumed that 5 % of the sample analyses will not be successfully performed. Analysis and valid results will be reported for 95 % or more of the samples presented for analysis during the demonstration.

Specificity

The AccuSensor system is specifically tuned to measure TCE and the trihalomethanes (THMs). Given that the THMs are not present in the samples presented, since they result from the chlorination of surface water for disinfection, there is no interference expected for these compounds. No other compounds are expected to interfere with the TCE measurement.

Other Field Performance Characteristics

Instrument Setup/Disassembly Time

The time to set up the AccuSensor system to perform analysis is approximately 10 minutes. The disassembly time is approximately 2 minutes. The system can be hand carried to the test site. The sensor elements, which consist of an expendable reagent cap are shipped as hazardous material and must be handled accordingly during shipping to the site. The expended reagent caps are no longer considered hazardous and can be disposed of in standard solid waste containers.

Instrument Calibration Frequency During Field Use

As a result of the measurement method designed into the AccuSensor system no calibration is required in the field. A calibration reference measurement should be performed at the beginning and end of each day of testing to confirm that calibration is maintained in the system.

Ancillary Equipment Requirements

No ancillary equipment is required.

Field Maintenance Requirements

Standard alkaline, AA, batteries are used to power the system. A back-up set of batteries will be hand-carried to the test site along with the AccuSensor system.

Sample Throughput Rate

The AccuSensor system is capable of performing a measurement in 5 minutes. Allowing for sample preparation, analysis and disposal, the AccuSensor can perform an analysis every 7 - 8 minutes for a total of up to 60 samples per day.

Operator Training Requirements

Operator training can be achieved by reading the manual or by direct instruction. The entire training process takes approximately 10 minutes. Several measurements should be performed by a new user before proceeding through a test program.

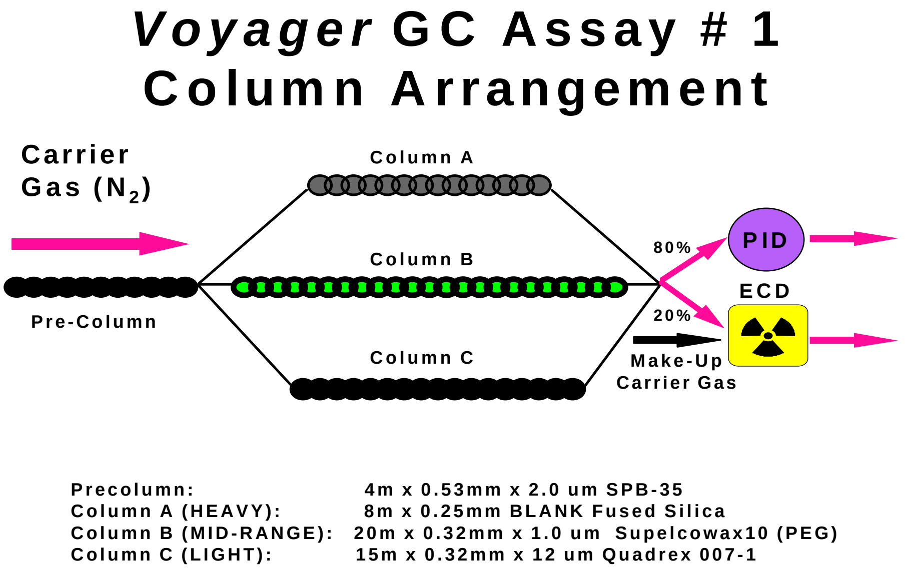
Ease of Operation

The AccuSensor system is extremely easy to use. Within 30 minutes of introduction and training, a user can meet the stated performance parameters. The AccuSensor system was designed as a field-portable instrument, with an emphasis on ease of use and rapid measurement.

Perkin-Elmer Photovac: Voyager - Field-Portable Gas Chromatograph

Technology Description

The Voyager is a field-portable, computer-controlled, gas chromatograph that incorporates three columns and dual detectors to broaden the analytical capabilities of the instrument. The photoionization (PID) electron capture (ECD) dual detector and triple column configuration is schematically shown in Figure 4-4. Each column has a pre-column/backflush flow of carrier gas to maximize baseline stability and significantly reduce carryover of unwanted analytes which would otherwise cause analysis delays.



Precolumn:	4m x 0.53mm x 2.0 um SPB-35
Column A (HEAVY):	8m x 0.25mm BLANK Fused Silica
Column B (MID-RANGE):	20m x 0.32mm x 1.0 um Supelcowax10 (PEG)
Column C (LIGHT):	15m x 0.32mm x 12 um Quadrex 007-1

Figure 4-4 A schematic representation of the Voyager GC

In the Total VOC analysis mode, the sample is drawn through the variable volume internal sample loop (which is also used in the GC mode) or injected by gas-tight syringe directly through the blank fused silica column (Column A) into the PID. The Total VOC concentration from headspace of water or soil gas is displayed 50 seconds after injection. This mode of operation is unsuitable for the ECD and is not utilized with this detector.

The Photovac Voyager GC can also be used to measure VOC contamination in water using a headspace sampling technique. A volume of the headspace above a water sample can be analyzed. This technique has been well documented in, for example, the EPA-ERT Document, “Compendium of ERT Field Analytical Procedures”.

The accuracy of aqueous standards is dependent upon the precautions taken in the transfer of liquids and the prevention of headspace loss. Cross contamination by using contaminated syringes must also be avoided. Both calibration and sample solutions should be maintained at the same ambient isothermal temperature condition to ensure similar vapor phase partition of VOCs into the headspace.

Commercially available methanolic solutions, normally used for calibration with purge-and-trap sampling in EPA Methods 601 and 602, can be used to prepare standards for aqueous headspace calibration of the Voyager. By storing the headspace concentration as the liquid concentration from the standards, the GC will display the results based on liquid samples. This approach will prevent confusion with air calibration data and negates the need for using Henry’s Law to calculate vapor concentrations with respect to liquid Typically, injection volumes of headspace range from 100 - 500uL.

Unique Technology Features

The Voyager field-portable gas chromatograph (GC) weighs just 15 lbs. and incorporates a high sensitivity Photoionization Detector (PID) together with a miniature Electron Capture Detector (ECD). Voyager’s dimensions are 15.4” long, 10.6” wide, and 5.4” high.

The instrument is the fourth generation in the evolutionary design of portable GCs from the Photovac division of the Perkin-Elmer Corporation. The Voyager was developed with due consideration of the ergonomic and analytical performance demands for in-field environments. Previous generations of PE Photovac portable GCs, such as the 10S50 and 10S70 GC, have been utilized by US EPA's Emergency Response Team (ERT) based in Edison, NJ. Standard Operating Procedures (SOPs) have been generated by the EPA-ERT on use of these instruments for water ,soil, ambient air, and soil gas analyses.

A unique internal analytical engine includes a specially designed miniature stainless steel valve array to provide fast sample delivery and minimize sample carryover (and contamination) due to high sample concentrations. The engine also incorporates a unique triple column arrangement with precolumn/ backflush and a syringe injection port for headspace sampling of aqueous and soil extract media. The entire internal sampling train, sample loop, GC columns, valving, and injection port is heated isothermally at a temperature from 55° C to 80° C.

Voyager is also unique in that it is the only GC of its kind in the world, which is classified Intrinsically Safe, Class 1, Division I, Groups A, B, C, and D rendering its usefulness and ruggedness in hazardous area locations.

The instrument is powered by field rechargeable and replaceable batteries which allow up to 9 hours of in-field use with a 5 hour charge time. Alternatively, the Voyager can be operated from an external 10-18V DC power supply such as a vehicle battery using a cigarette lighter receptacle. The instrument can also be operated on AC power.

Voyager can be effectively used to monitor Volatile Organic Compounds (VOCs) listed in EPA Method 8240 including chlorinated and aromatic hydrocarbons. Matrices of applicability of the technology include soil, soil gas, water, and ambient air.

Lower Detection Limits (LDLs) for VOC range from parts per trillion (sub- parts per billion) in water matrices to about 500 parts per million in ambient air, depending upon the type of compound. and using both PID as well as ECD.

Analytical results are displayed on the built-in liquid crystal display (LCD) and include both, a listing of compounds detected with concentrations as well as chromatograms. Built-in datalogging allows storage of up to 40 ten minute chromatograms or 400 total VOC analyses obtained from a total VOC screening mode of operation.

Analytical Methods

The Voyager GC can be configured with one analytical method (Assay) at a time. The Assay includes the compound library, column temperature, pressure (flow rate), and sampling method (internal variable volume loop or syringe injection). The preferred method of setting up a new analytical method is by using a PC interface and downloading files. A laptop will be required on site if various types of samples are to be analyzed so that different methods can be installed into the Voyager.

The PC does not have to be connected continuously to the instrument. However, for accurate quantitation of trace concentrations of target compounds it is recommended that the integration be verified by reviewing the file on the computer screen.

Advantages of the Voyager GC

The light weight (15 lb.) and small size, coupled with the triple column configuration and dual PID and ECD, means this instrument provides sensitivity and selectivity (through confirmational analysis) for a wide cross-section of VOCs on site. Furthermore, the ability to use the internal pump to draw samples from wellheads or to perform syringe injections of headspace of collected samples of soil and groundwater, adds further analytical flexibility for the different monitoring tasks.

Technology Limitations

The maximum isothermally controlled temperature of the analytical engine is 80^0 C. This permits introduction of gas or vapor phase samples only. Liquids cannot be injected into the GC. Hence, aqueous headspace analysis is carried out for groundwater and soil analysis.

With the exception of Naphthalene in groundwater and soils, higher molecular weight polyaromatic hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs) cannot be chromatographed at the maximum column temperature of 80^0 C.

The Photoionization Detector (PID) is not sensitive to inorganic gases such as nitrogen oxides, carbon oxides or sulfur oxides. Methane, which has a high ionization potential, is detectable at concentrations above about 10 ppmv.

The Voyager will be calibrated for site-specific target compounds at each of the two proposed sites for the demonstration plan. Once the environmental assay (Assay # 1) is uploaded from the PC into the Voyager, if “unknowns” match the retention times of any of the Assay listed compounds, these compounds will be *incorrectly identified and quantified as target compound*. However, since a calibration standard is not run for these “unknowns”, ratiometric calibration in Voyager’s software, will provide only a semi-quantitative measure of concentration.

If a down-well sampling probe is used, a number of factors are to be considered:

1. The integrity of the sample may not be maintained in traversing the sample line (especially with long line lengths), i.e. adsorption with concomitant sample loss may occur.
2. Although the measurement is more direct, the down-well water temperature may be less than the temperature and hence the overall method sensitivity may be somewhat less than that achieved by the headspace method for collected water samples.
3. Headspace calibrations and probe calibrations will not directly correspond. If both methods are being used on the same Voyager, a computer must be used to download the corresponding method or analytical results from one method must be processed later.

Technology Applications

The Voyager GC will detect chlorinated solvents such as Trichloroethylene (TCE) and Perchloroethylene (PCE) at parts per trillion (sub-part per billion) levels in aqueous media using the PID and ECD. Benzene, Toluene, Ethylbenzene, and Xylene isomers (BTEX) are also detected to these trace levels using the PID.

ECD Licensing Requirements

Information and a list of contacts, by state, is available from PE Photovac regarding licensing requirements for use of the ECD.

Operator Training

One full day of operator training is required which will cover instrument operation, calibration, automatic (pump) sampling, headspace syringe injection, data storage and retrieval, and method customization and development as well as routine maintenance and troubleshooting.

Technology Performance Goals

Minimum Detection Level (MDL)

Voyager, in its Assay #1 configuration equipped with a PID and ECD, and using a 500uL headspace injection, will meet the MDL with 95% confidence levels. The MDLs with 95% confidence are shown in Table 4-8 for the chlorinated hydrocarbons, (including TCE and PCE).

Practical Quantitation Limit (PQL)

Again, the Voyager with the Assay # 1 configuration and PID/ECD, will meet the PQL set at a level 5 - 10 times the standard deviation of the instrument noise signal. Table 4-8 shows the PQLs for the chlorinated hydrocarbons, (including TCE and PCE), with 95% confidence.

Accuracy

Voyager will provide an accuracy within ± 20% for each target compound over its working range, 95% of the time using a 3-point calibration.

Precision

The precision of the Voyager, as represented by the relative standard deviation on six replicate measurements, will be better than 20% over the working range of the instrument for each compound.

Comparison with Reference Lab Analysis

Comparison checks on the Voyager have not been carried out to date against reference analytical methods for chlorinated species in water which follow EPA protocols**.** However, it may be possible that this comparison can be performed prior to the field evaluation using Reference Methods from SW-846.

Data Completeness

A complete analysis for TCE, PCE, and BTEX, may take up to 20 minutes. Under these conditions, sample throughput will be approximately 20 samples and one calibration in an 8 hour day.
If there are only two analytes, e.g., TCE and PCE, analysis time will be greatly reduced and sample throughput will be significantly increased.

Table 4-8 Voyager Specifications for MDL, PQL, and Working Range for Selected Chlorinated Hydrocarbons

Compound	MDL [ug/liter]		PQL [ug/liter]		Upper Range [ug/liter]	
	PID	**ECD**	**PID**	**ECD**	**PID**	**ECD**
Column C					PQLx500	
Chloromethane						
Vinyl Chloride						
Bromomethane	0.12		0.36		180.00	
1,1-Dichloroethylene	0.08	0.06	0.24	0.18	120.00	90.00
Methylene Chloride	1.80		5.40		2700.00	
t-1,2-Dichloroethylene	0.04		0.12		60.00	
Vinyl Acetate	10.00		30.00		15000.00	
c-1,2-Dichloroethylene	0.60		1.80		900.00	
Chloroform		1.20		3.60		1800.00
1,2-Dichloroethane	40.00	80.00	120.00	240.00	60000.00	120000.00
1,1,1-Trichloroethane	12.00	0.18	36.00	0.54	18000.00	270.00
Carbon Tetrachloride		0.40		1.20		600.00
Column B						
Trichloroethylene	0.08		0.24		120.00	
1,2-Dichloropropane	6.00		18.00		9000.00	
Tetrachloroethylene	0.06	0.03	0.18	0.10	90.00	48.00
2-Chloroethyl Vinyl Ether	10.00		30.00		15000.00	
c-1,3-Dichloropropene	0.60		1.80		900.00	
Bromodichloromethane	32.00	0.10	96.00	0.30	48000.00	150.00
t-1,3-Dichloropropene	1.40	1200.00	4.20	3600.00	2100.00	#######
Chlorobenzene	0.12		0.36		180.00	
1,1,2-Trichloroethane	280.00		840.00		420000.00	
Dibromochloromethane	6.00		18.00		9000.00	
Column A						
Bromoform	20.00	10.00	60.00	30.00	30000.00	15000.00
1,1,2,2-Tetrachloroethane	180.00	30.00	540.00	90.00	270000.00	45000.00
1,3-Dichlorobenzene	0.80		2.40		1200.00	
1,4-Dichlorobenzene	0.60		1.80		900.00	
1,2-Dichlorobenzene	1.60		4.80		2400.00	

Specificity

Specificity is defined in this *performance statement* as the degree of separation in a mixture of analytes as measured by the chromatographic Resolution (R). Voyager's resolution is provided in Table 4-9 and is within 20% reproducible 95% of the time. Compounds with R<1 coelute.

Table 4-9 Chromatographic Resolution Factors [R]

Compound	Rt[sec]	R
Column A Compounds		
o-Xylene	472.8	**0.732554**
Styrene	506	2.554061
Bromoform	638.6	1.273147
1,1,2,2-tetraCE	715.3	5.864818
1,3-DCbenzene	1199.5	1.071834
1,4-DCbenzene	1313.5	2.555739
1,2-DCbenzene	1629	
Column B Compounds		
Benzene	267.5	1.380876
Unknown	287.2	2.806869
TCethylene	329.6	3.156698
MIBK	381.3	1.849868
1,2-DCpropane	413.7	2.9469
Toluene	468.8	**0.793757**
TetraCethylene	484.4	4.148373
2-Hexanone	571.7	2.617221
2-CEvinyl Ether	632	1.503103
c-1,3-DCpropene	668.6	1.579581
BDCmethane	708.7	4.532773
Ethylbenzene	833.9	1.303645
m-Xylene	872.8	0
p-Xylene	872.8	4.258226
t-1,3-DCpropene	1010	3.73403
o-Xylene	1144	**0.474421**
Chlorobenzene	1162	5.005429
1,1,2-TCethane	1367	6.393195
DBCmethane	1673	
Column C Compounds		
Chloromethane	105.7	1.022276
Vinyl Chloride	118.4	2.085997
Bromomethane	147.2	**0.623365**
Chloroethane	156.6	2.034817
Acetone	190.2	2.633388
1,1-DCethylene	241.1	**0.546346**
Dichloromethane	252.8	1.3532
CarbonDisulfide	283.7	1.306558
t1,2-DCethylene	316.3	**0.847202**
Vinyl Acetate	339	1.094645
MEK	370.3	1.491023
c1,2-DCethylene	416.8	3.632647
1,2-DCE	552.1	**0.499278**
1,1,1-TCE	573.3	1.577996
Benzene	645.2	**0.624743**
Carbon Tet	675.8	

Other Performance Criteria Relating to General Aspects of Field Operation

Voyager setup/disassembly time

The daily operational procedure should consist of the following steps:

1. Fill the built-in carrier gas cylinder with Nitrogen (assuming portable in-field operation).
2. Turn the instrument on.
3. Allow stabilization for 60 minutes.
4. Download desired Method (assuming a new Method is to be used from the previous day’s work).
5. Prepare standards and calibrate for the target compounds at a specified concentration.
6. Analyze samples.

If the carrier gas pressure drops below 200 psi as measured on the analogue gauge on the Voyager’s internal cylinder, the internal cylinder should be recharged from an external cylinder supply.
If the “battery voltage low” message is displayed on the instrument’s LCD, the Voyager should be switched off and the battery replaced with a fully charged battery (assuming in-field operation). After replacing the battery, the Voyager should be recalibrated in order to meet specifications.
If the Voyager was not connected to a computer before being switched off on the previous day, the instrument should be connected to a PC running the Windows-based SiteChart software so that any logged data files may be downloaded.
Shutdown time for the Voyager is less than 5 minutes.

Voyager calibration frequency during field use

Given target compounds for each of the two proposed demonstration sites well ahead of the test dates, multipoint calibration curves can be prepared and installed for each compound. Accuracy specifications assume such curves have been established for each compound under headspace conditions. This will increase sample throughput rather than utilizing a “generic environmental assay”. The Voyager will require daily calibration with the target analytes.

Ancillary equipment requirements

If the Voyager is used in a stationary (indoor) location, AC/DC power will be required for on-going analyses. Sample handling accessories will include such items as 40 ml VOA vials, gas-tight syringes for headspace sampling, and spare septa for the syringe injection port.
A cylinder of Zero grade Nitrogen should be available with a two stage regulator to run the Voyager in a stationary location or to refill Voyager’s internal carrier gas cylinder for in-field use of the instrument.

Field maintenance requirements

Refill of the internal carrier gas cylinder as required. Voyager’s on-board battery pack can be replaced in the field as required. Voyager’s 10.6 eV detector light source can also be cleaned or replaced in the field if necessary.

Sample throughput rate

Depending upon the number and molecular weights of the analytes to be monitored, a typical analysis time for TCE, PCE, and BTEX may take about 20 minutes in a complex sample background. Assuming an 8 hour workday, and a daily calibration (not including blanks), the number of samples would be about 20 per day. If only TCE and PCE are being monitored, the daily sample throughput will be significantly higher.

Ease of operation

Once the Method has been installed into the Voyager, the instrument can be disconnected from the PC for on-site (field) use and the Start/Stop key can be used simply to begin and end analyses as required. All data with chromatograms are logged on Voyager's internal datalogger and will automatically be downloaded on connection to a PC.

As an alternative field mode of operation, the instrument can be set in a "User" only mode where the field operator can only access the Method parameters by entering a "password" in the instrument previously set by the supervisor. The Voyager is used as a simple "point-and-press" instrument.

Sentex Systems Inc.: Aquascan - Field-portable Purge and Trap GC with Argon Ion and Electron Capture Detectors

Technology Description

The technology is based on purge and trap gas chromatography, using the SCENTOGRAPH "PLUS II" and a continuous purge and trap module.The SCENTOGRAPH "PLUS II" is a portable gas chromatograph system designed to provide a complete sample analysis, from calibration to results interpretation. The Computer controlled SCENTOGRAPH "PLUS II" automatically performs the following functions:

- Calibration
- Analysis
- Sample Collection and Injection
- Chromatographic Separation
- Compound Detection
- Peak Identification and Integration
- Data Display and Storage including chromatograms, Retention Times, Concentration levels and Operation Conditions
- Continuous Operation
- Recalibration at Predefined Frequencies
- Optional Remote Operation via Modem

The Scentograph "Plus II" consists of the following components:

Gas Chromatograph Module - This module includes the oven, columns, and detector(s). Packed columns of 1/8" diameter and up to 12 feet in length or capillary columns up to 105 meters in length and 0.53 mm ID are available (two columns can be installed in the oven at the same time). The column is heated in the oven whose temperature can be adjusted up to 179 °C. The detectors are mounted in a compartment in the oven and heated to operating temperature. The oven is well insulated and maintains the temperature of the column, the on-column injector, and the detector(s). For oprimum separation, a two stage temperature ramping is available.

Detector Module - The Scentograph "Plus II" can be equipped with one or two of the following choices of detectors. Both a Micro Argon Ionization Detector and Electron Capture Detector are included in one detector module. Changing from one detector to the other is accophlished by selecting electronic switches. This detector module is especially suitable for operation with capillary columns, and has the following sensitivity:
MAID Mode - sub parts per billion (µg/L) levels of volatile hydrocarbons (e.g. Benzene, Toluene)
ECD Mode - parts per trillion (ng/L) levels of chlorinated hydrocarbons (e.g. Ccl_4, TCE)

Principle of Operation

Volatile organic compounds (VOC) in water can be analyzed with the SCENTOGRAPH “PLUS II” by using the continuous Purge and Trap attachment. The SCENTOGRAPH “PLUS II” Purge and Trap system is a fully computerized sampling system that automates the necessary steps required for “purge and trap” analysis of water samples. The operator simply connects the teflon tubing and electrical cables, programs appropriate operating parameters and put calibration and analysis in 40cc vials. The results and operating conditions are stored in memory for later recall and review.

The “purge and trap” gas chromatograph (PTGC) method is used to detect low concentrations of VOC’s in water. In most cases concentrations will range from sub-ppb levels to hundreds of ppb’s. Higher concentrations, i.e. above 200 ppb, are normally detected using headspace analysis by syringe injection of the headspace or trapping headspace volumes directly.

The PTGC methodology efficiently removes the VOC’s from the solution by means of a purging process with inert (carrier) gas. The VOC’s are then carried to a sorbent material (usually Tenax or Carboxen). The adsorbed VOC’s are thermally desorbed onto the analytical column for separation. Detection is obtained with an Argon Ionization. The PTGC methodology identifies and measures extremely low levels of VOC’s, which are normally undetectable by other methods. Because low levels of VOC’s in water may not generally provide sufficient detectable concentrations of vapors when analyzed directly, the PTGC method provides a manifold concentration factor which brings the VOC’s into a detectable quantitative range. However, higher concentrations of VOC’s, in the ppm range, may be analyzed also, however, sample dilution to obtain a concentration for the instrument range may be necessary.

The Scentograph “Plus II” functions in two operational modes, calibration and sample analysis, as described in more detail in the following paragraphs:

Calibration Mode - In this mode, the Scentograph “Plus II” introduces a water sample with known VOC composition into the system and performs chromatographic analysis of that sample. It then displays this calibration chromatogram, including the name, concentration level, and retention time of each compound in the calibration mixture. The area under each peak is integrated and the concentration level of the standard is assigned to this peak area. Automatic multipoint calibration is also available.
Sample Analysis Mode -During this mode, the SCENTOGRAPH “PLUS II“ displays the analysis chromatogram above the calibration chromatogram and identifies each peak as it appears. The name, concentration level, and retention time of the compounds which match the compounds identified during calibration are listed. Compounds detected which do not match compounds identified during calibration are listed as “Unknown”. Their retention times and concentration levels, as compared to the first calibration peak, are also displayed. The “Unknown” compounds may be identified by computerized methods in which the sample analysis results compare with other calibration results stored in the SCENTOGRAPH “PLUS II” memory or by scanning various compound libraries in which hundreds of compounds may be listed. Since both modes are operated under the same conditions, and because calibration can be activated as frequently as required, analysis results obtained by the SCENTOGRAPH “PLUS II” are highly reliable and accurate.

A number of detector systems are available with the Scentograph “Plus II” as described in more detail below:
Argon Ionization Detector - This detector is suitable for the detection of most organic compounds. Its simplicity and ruggedness makes it ideal for field use. The AID enables the SCENTOGRAPH “PLUS II” to detect sub parts per billion (ppb) levels of many compounds. It operates on the principle that organic compounds with ionization potentials equal or less than the excitaiton energy of argon (111.7 eV) will be

detected. When the carrier gas, argon, passes over a tritium (^3H) source, some argon atoms are energized to a metastable state and some are ionized. A steady stream of energized atoms (excitons) is produced in the detector cell. When organic molecules (R) enter the detector, they collide with the excitons. During this collision, energy from the excitons is released to the organic moleculs. Since the ionization potential of most of most organic compounds is less than 11.7 eV, they are ionized by the excitons. High voltage applied across the detector produces a current which is amplified, measured and generates the chromatogram. The high energy of the Argon Exitons can identify a large variety of compounds, include halomethanes and haloethanes, which can not be identified by other ionization detectors, (such as PID). The following reactions summarize how an AID works:

$$\mathbf{Ar \xrightarrow{^3H} Ar^* \text{ (Energized to the Excited State)}}$$

$$\mathbf{Ar^* \text{ (Exiton)} + R \text{ (Organic molecule)} \rightarrow Ar + R^+ + e^-}$$

Electron Capture Detector - The Electron Capture Detector is a highly sensitive detector, selective to compounds such as halogenated and nitrogenated hydrocarbons capable of capturing electrons. The ECD operates on the following principle: When Helium or Nitrogen is flowing through the detector and over Tritium (H^3), the following reaction develops:

$$\mathbf{He \rightarrow He^+ + e^-}$$

When low voltage is applied across the detector, a constant current is produced called the standing current. When a compound which has an affinity for electrons, such as an halogenated organic compound, enters the detector, the following reaction develops:

$$\mathbf{R\text{-}Cl \text{(halogenated compound)} + e^- \rightarrow R\text{-}Cl^-}$$

The compound "captures" the electron, and becomes a negative ion. The light, fast moving electrons in the detector turn to heavy slow moving ions. Since electrons are now captured by heavy molecules, the mobility of the negative charge is decreased, resulting in a decrease in the number of negative charges reaching the electrode. This reduction in current is amplified and measured. The ECD is specific to halogenated and nitrogenated compounds because they easily attract electrons. The ECD is very sensitive, particularly to compounds which are highly electro negative.

The Scentograph "Plus II" can also be equipped with Photoionization Detectors and Thermal Conductivity Detectors.

The Scentograph "Plus II" offers three methods to introduce sample to the GC column including a Preconcentrator, Sample Loop or Heated Injection Port.
Preconcentrator - The Scentograph "Plus II" is normally equipped with a preconcentrator packed with an adsorbent material. Different chemicals are used as the adsorbent material depending on the user's application. The preconcentrator is used when sample concentrations are expected to be 10 ppm or lower.
Sample Loop - A sample loop can be installed in place or parallel to the preconcentrator. The sample loop allows the automatic injection of fixed volume injections (usually 0.5 ot 1.0 cc sample size). If sample concentrations are expected to exceed 10 ppm, a sample loop should be utilized. The sample loop permits analysis of sample concentrations between 1 ppm and 1000 ppm of most compounds.
Heated Injection Port - The Scentograph "Plus II" can be equipped with an optional heated on-column injection port for syringe injection of gas or liquid. Direct injection of gas samples will attain sensitivities

similar to using a sample loop (ppm range for 1 cc injection). An accessory for an on-column injection to capillary columns is also available.

The Scentograph "Plus II" is equipped with an automatic sampling pump with intake of approximately 80 cc per minute. Sample is automatically pumped into the preconcentrator or sampling loop from the internal calibration system, the external calibration port or the analyze port.

The Scentograph "Plus II" is equipped with an internal calibration cylinder which supplies gas directly to the internal calibration system. Calibration gas from the internal cylinder flows thru an internal regulator directly to the sample loop or preconcentrator.

The calibration port, located on the right side of the Scentograph "Plus II" is used to calibrate from a sampling bag, headspace of an external container or other external source. (Note: External samples must be taken at ambient pressure. Pressure higher than amabient may cause internal valve malfunction or damage). With absence of pressure from the internal calibration system, the system will automatically introduce a sample from the external calibration port.

The analyze port, located on the right side of the Scentograph "Plus II", is used to sample air from the environment or from an enclosed source. When a sample bag is utilized for analysis, the bag may be attached to the analyze port with Teflon tubings.

The Scentograph "Plus II" utilizes an internal argon carrier gas (HP grade) for the AID/ECD configuration and helium carrier gas (HP grade) for the ECD, PID or TCD detection modes. The carrier gas cylinder will alow a minimum of eight hours of operation and is easily refilled.

History of the Technology

The Scentograph "Plus II" has been evaluated in three separate studies. In 1992, its performance was evaluated at a Supefund site under remediation. The results were presented in a peer reviewed article titled "Evaluation of Portable Gas Chromatographs" in the Proceedings of the 1993 U.S. EPA/Air and Waste Management Association International Symposium, VIP 33, Volume 2, 1993.

It was also evaluated in June of 1994 at a landfill adjacent to a residential area. Results from this study was presneted in a peer reviewed article: "On-Site Monitoring of Vinyl Chloride at Parts per Trillion Levels in Air" in the Proceedings of the 1995 U.S. EPA/Air and Waste Management Association International Symposium, VIP 47, Volume I, 1995.

Another study was done in August of 1995. In this study, downwind vapors from an artificial source generator were analyzed. Results of the study was presented in an article: "Performance Comparison of Field Deployable Gas Chromatographs with Canister TO-14 Analytes" in the Proceedings of the 1996 U.S. EPA/Air and Waste Management Association International Symposium, VIP-64, 1996.

Technology Applications

The Scentograph "Plus II" can be used in the continuous on-line monitoring of aqueous samples including drinking water, groundwater, surface water, leachate and waste water from hazardous waste sites.

Advantages of the Technology

Some of the advantages in utilizing the Scentograph "Plus II" are:

- Provides the highest sample integrity - There is no sample handling and storage involved. The Scentograph "Plus II" has its own pump that collects water sample into a 10 ml purge cell. Sample preservation and measurement prior to analysis are eliminated. A rinse cycle after each analysis is activated to purge the previous sample with high purity water to preven t carry over to the next sample.
- Timely and accurate results - The analysis is done in the field and often analytical runs are done within 15 minutes. The inherent error due to sample handling and transport is eliminated.
- Off-site laboratory quality results - The calibration standards used are also certified. The Scentograph "Plus II" can do multi-point calibration up to 5 different concentration levels. The response factors of the VOCs can be updated daily. In case a single point is used, calibration can be done as often as merited.
- Cost effective - The availability of results within minutes can guide sample collection for off-site lab analysis. The Scentograph "Plus II" can gather large volumes of replicate data that is too expensive to do using an off-site laboratory.

Limits of the Technology

The limiting factor of the Scentograph "Plus II" is its maximum operating temperature which is 179 °C. Although it offers two stage temperature ramping, the absence of a fan to cool the oven makes temperature programming cumbersome. It has been observed that co-elution of compounds is common.

Identification of VOCs is by retention time indices (RTI). If the RTI of the sample peak (s) match the RTI of the standard peak(s), they are assumed to be the same. If any non-target VOC has the same RTI, it can be misidentified as a target VOC.

Technology Performance Characteristics

Minimum Detection

The MDL concentrations listed in Table 4-10 were established in the lab in accordance with Appendix B, 40 CFR part 136.

Table 4-10 Chromatographic Conditions Method Detection Limits

ANALYTE	Retention Time, sec[1]	MDL, µg/L[2]
Chloroform	80	0.08
Benzene	103	0.06
Trichloroethylene	124	0.14
Tetrachloroethylene	256	0.09
Chlorobenzene	358	0.04

[1] Column condition: 30 m MXT-VOL (Restek) x 0.53mm ID x 3µ film thickness with argon carrier gas at 23ml/min flow rate. Column temperature held isothermal at 70 °C. Purge time is 50 seconds.

[2] Determined using seven (7) replicates of reagent water spiked with analytes at 1 ppb.

Practical Quantitation Limit

At 50 seconds purge time, it was determined that PQL for most compounds is 1 ppb. Increasing purge time to 200 seconds will lower the PQLof VOCs (e.g. benzene, trichloroethylene and tetrachloroethylene) to 0.1 ppb.

Accuracy

The Scentograph “Plus II” will perform at an accuracy level of ±20 % or better over its working range, 95% of the time.

Precision

The precision of the Scentograph “Plus II” , demonstrated by the relative standard deviation on replicate measurements, will be ±20% or better over its working range.

Instrument Working Range

At 50 seconds purge time, it was determined that the Scentograph’s linear range is from 1ppb to 500 ppb. Adjusting the purge time will also change the dynamic range of the Scentograph “Plus II”.

Comparison with Reference Lab Analyses

There has been no comparison studies done to date.

Data Completeness

At total of 20 samples will be completely analyzed daily. The analytical sequence will include at least one calibration, a blank, sample duplicate and sample spike. The estimate is conservative to accomodate sample dilutions and repeat analyses.

Specificity

The AID will detect analytes with ionization potentials of 11.7eV or less. Chlorinated compounds can be confirmed by switching the AID to the ECD mode.

Other Field Performance Characteristics

Instrument Setup / Disassembly Time

It takes an hour to initially assemble and condition the Scentograph “Plus II”. It takes less than 10 minutes to diassemble the unit.

Instrument Calibration Frequency

If a multipoint calibration is done initially, the response factor should be checked daily. If a single point is used, calibration should be done every ten samples.

Ancillary Equipment Requirements

Carrier Gas Cylinder and Regulator **-** This internal cylinder contains the carrier gas, as determined by the Scentograph “Plus II” user. The carrier cylinder is easily refillable and when filled, will provide a minimum of eight (8) hours supply of carrier gas**.**

Batteries **-** Lead acid, 6 volt, 6 amp hour rechargeable batteries are used. The batteries must be recharged after each portable operation (if applicable) or on a regular basis if the instrument is not in use. For fixed location operations, the system should be connected to an electrical source using the battery charger supplied with the unit. No damage is caused to the batteries if instrument is kept connected to the charger for a long period of time.

Computer **-** The Scentograph “Plus II” is equipped with detachable lap-top Personal Computer (PC). The computer includes a hard disk drive and a 3 1/2” floppy disk drive.

Software **-** The software program which operates the Scentograph “Plus II” is contained on the hard drive of the instrunebt’s PC. Data can be stored on either the removable diskette or the hard drive.

Field Maintenance Requirements

Internal carrier gas cylinder is refilled daily. The lead acid batteries is recharged daily after each portable operation. The Scentograph "Plus II" requires the same preventive maintenance as does a benchtop GC.

Sample Throughput Rate

A conservative estimate of sample throughput is at least 20 samples a day, assuming that there is no significant interferences encountered during the field demonstration.

Ease of Operation

The software that controls and operate the GC is user friendly. A few hours of training is sufficient for someone familiar with a GC.

Section 5 Site Descriptions

Two sites, namely the Savannah River Site near Aiken, SC and McClellan Air Force Base, near Sacramento, CA are selected for use in this Wellhead Monitoring Technology Demonstration. This section provides a brief history of each site, a discussion of salient geological features, and an outline of the nature and extent of contamination at each site.

Savannah River Site - Background and History

The Savannah River Site (SRS) is a Department of Energy (DOE) facility, focusing on national security work; economic development and technology transfer initiatives; and, environmental and waste management activities[2]. Owned by DOE and operated under contract by the Westinghouse Savannah River Company, the complex covers 310 square miles, bordering the Savannah River between western South Carolina and Georgia for 27 miles as shown in Figure 5-1.

Figure 5-1 The general location of the Savannah River Site in the Southeast United States.

Weapons material production at SRS has produced unusable byproducts such as intensely radioactive waste. In addition to these high-level wastes, other wastes at the site are include low-level solid and liquid radioactive wastes; transuranic waste; hazardous waste; mixed waste, which contains both hazardous and radioactive components; and sanitary waste, which is neither radioactive nor hazardous.

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[2] Much of this site descriptive material is adapted from information available at the Savannah River Site web page (http://www.srs.gov/general/srs-home.html).

Savannah River Site - Geological Characteristics

The Savannah River Site, shown in Figure 5-2, encompasses a 300-square-mile area near Aiken, South Carolina and is located on the upper Atlantic Coastal Plain. The site is underlain by a thick wedge (approximately 1000 feet thick) of unconsolidated Tertiary and Cretaceous sediments that overlay the basement which consists of Precambrian and Paleozoic metamorphic rocks and consolidated Triassic sediments (siltstone and sandstone). The younger sedimentary section consists predominantly of sand, clayey sand and sandy clay. The water table is found at a nominal depth of 130 feet.

Groundwater flow at the site is controlled by hydrologic boundaries. Flow at or immediately below the water table is predominately downward.; flow in the lower Tertiary aquifer is due to one of the Savannah River's tributaries; and flow in the Cretaceous aquifers is toward the Savannah River. Ground water flow in the shallow aquifers in the immediate vicinity of the Savannah River Demonstration Site is highly influenced by eleven pump-and-treat recovery network wells.

Savannah River Site - Ground Water and Monitoring Well Network Description

Past industrial waste disposal practices at the Savannah River Site, like those encountered at other DOE weapons production sites, often included the release of many chemicals into the local environment. These releases and early disposal practices have resulted in the contamination of the subsurface of many site areas by a number of industrial solvents used in, or resulting from the various weapons material production processes. The largest volume of contamination has been from chlorinated volatile organic compounds (VOCs). The primary VOCs encountered at Savannah River include: Tetrachloroethene (PCE), Trichloroethene (TCE), Trichloroethane (TCA), Freon-11, and Freon-113.

The area selected for the demonstration of wellhead monitoring technologies is designated the A/M area. The technology staging site is located near an abandoned process sewer line which carried waste water from M-Area processing facilities to a settling basin for 27 years, beginning in 1958. Site characterization data indicates that several leaks existed in the sewer line, located about 20 feet below the surface, producing localized sources of contamination. Although the use of the sewer line was discontinued in 1985, estimates are that over two million pounds of solvent were released into the subsurface during its use.

Figure 5-2 A map of the Savannah River Site. The site is approximately 20 miles wide in the east-west direction. The A/M area is located in the northwest corner of the site.

The A/M-Area, shown in detail in Figure 5-3, is located in the northwest section of the Savannah River Site (SRS) and consists of facilities that fabricated reactor fuel and target assemblies for the SRS reactors (M-Area), laboratory facilities, and administrative and support facilities (A-Area). Operations at these and other facilities within the A/M Area resulted in the release of chlorinated solvents, primarily trichloroethylene (TCE), tetrachloroethylene (PCE) and 1,1,1- trichloroethane (1,1,1-TCA) to the subsurface (Marine, 1984). These releases have resulted in the contamination of both soil and groundwater within the area. Since the discovery of dissolved solvents within the groundwater, SRS has pursued an aggressive path towards environmental remediation of the groundwater and subsurface contamination. To achieve this goal, SRS has installed an extensive groundwater recovery well network to treat contaminated groundwater; has supported the characterization of subsurface features to determine influences on groundwater flow; and, has supported a demonstration program for developing soil and groundwater remediation technologies.

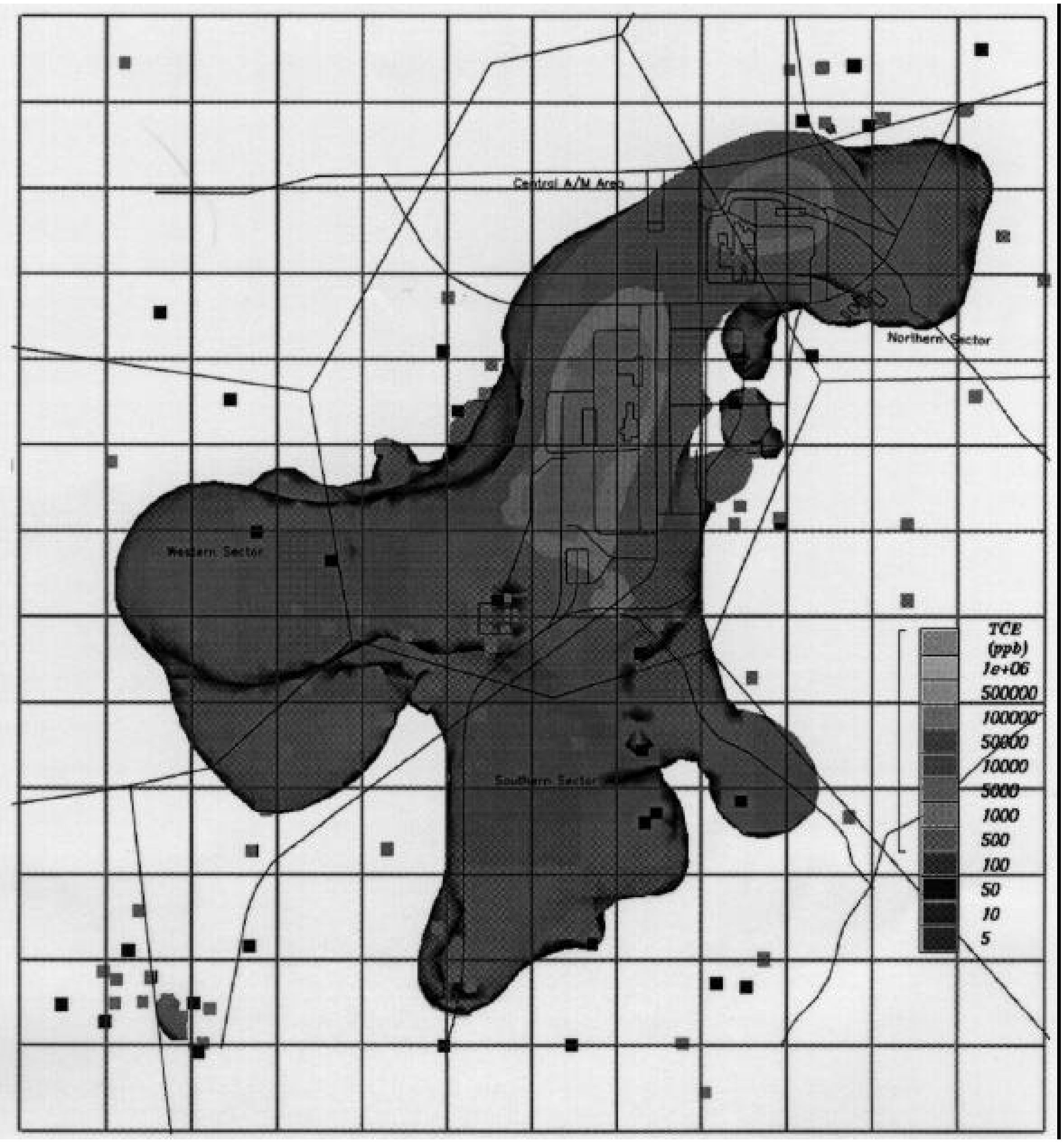

Figure 5-3 A map of the A/M area at the Savannah River Site showing the sub-surface TCE plume. The grid size is 1,000 feet. The dark squares mark soil borings and the light squares mark monitoring wells.

The monitoring well network in the A/M Area is extensive, as shown in Figure 5-3, consisting of approximately 400 wells. The largest group of wells, comprising approximately 70 percent of the total, is the MSB series which is associated with the plume originating from M-Area, the sewer lines and basin. The majority of these wells are constructed of 4-inch, PVC casing with wire wrapped screens varying in length from 5 to 30 feet. The wells are numbered sequentially based on the original installation date unless a new well is added to an existing cluster. Well clusters are further delineated with a letter (typically A through D) that indicates the relative depth and/or aquifer zone. The current convention has the A wells labeled as the deepest of a cluster while D wells indicate the shallowest, generally a water table well. The majority of the wells are screened either in the water table aquifer ("M-Area Aquifer", well depths ranging from 130 to 170 feet), the underlying tertiary aquifer ("Lost Lake Aquifer", well depths ranging from 170 feet to 205 feet), or a narrow permeable zone within the confining unit above the cretaceous aquifer ("Crouch Branch Middle Sand", well depths ranging from 215 to 260 feet). The wells are all completed with approximately 2-1/2 feet of stand pipe above ground and a protective housing. The wells are generally equipped with a dedicated single speed centrifugal pump (1/2 HP Grundfos Model 10S05-9) that can be operated with a control box and generator. The well connections for the pump also generally contain a flow meter/totalizer for monitoring pumped volumes.

The M-Area wells are measured quarterly for water elevations. All newly installed wells are monitored quarterly for one year measuring specific groundwater protection standards, inorganic constituents and field parameters. On a semi-annual basis, all point of compliance wells (41), plume definition wells (236), and background wells (6) are sampled for groundwater protection standards. All field parameters are measured in these wells as well. On an annual basis, inorganics and radionuclides are measured in all wells. The specific organic constituents measured in the quarterly surveys as listed in the site's RCRA permit are shown in Table 5-1. Organics are measured using EPA method 8260 (Purge-and-trap GC-MS) at an off-site contract laboratory. Concentrations are reported in the semi-annual ground water reports to South Carolina Department of Health and Environmental Control (SC-DHEC). Ground water concentration levels for TCE and PCE, the two principal organic contaminants in the subsurface plume range from low (<5 ppb) to very high (>10 ppm) levels. Typical quarterly water analysis results for selected monitoring wells are shown in Table 5-2.

Table 5-1 Savannah River Site M-Area Groundwater Monitoring Program Organic Analytes

Organic Analyte	Concentration Limit (ug/L)
Chlorobenzene	PQL
1. 1-Dichloroethane	PQL
1, 1, 1-Trichloroethane	200[a]
1, 1,2,2-Tetrachloroethane	PQL
1, 1-Dichloroethene	7
Trans-1,2-Dichloroethene	100
Trichloroethene	5
Tetrachloroethene	5
Polychlorinated Biphenols	0.5

PQL - Practical Quantitation Limit (PQL) as defined R.61-79.264 Appendix IX

[a] MCL - Maximum Contaminant Level as established in the U.S. EPA Drinking Water Regulations and Health Advisories (updated 5/94)

Table 5-2 Typical quarterly monitoring results for selected Savannah monitoring wells

Analyte	Analyte Concentration, ug/L				
	MSB 33	MSB 7C	MCB 14B	MSB 70C	MSB 4C
Trichloroethene	2.6	18.6	157	1,290	7,080
Tetrachloroethene	1.6	37.1	2.2	413	488
1,1-Dichloroethene		4.6.		60.9	
1,2-Dichloroethane			11.3		
1,1,1 TCA		1.4		16.6	
Carbon Tetrachloride			0.4		
Chloroform			4.1		

McClellan Air Force Base - Background and History

McClellan AFB is located 7 miles northeast of downtown Sacramento, California, as shown in 5-4. The installation comprises about 3,000 acres bounded by the City of Sacramento on the west and southwest, Antelope on the north, the unincorporated areas of Rio Linda on the northwest, and North Highlands on the east[3].

McClellan AFB has been an active industrial facility almost since its dedication in 1936, when it was called the Sacramento Air Depot. Operations have changed from maintenance of bombers during World War II and the Korean War, to maintenance of jet aircraft in the 1960s, and recently to include the maintenance and repair of communications equipment and electronics. McClellan AFB currently operates as an installation of the Air Force Materiel Command and employs approximately 13,400 military and civilian personnel.

The Sacramento Air Logistics Center, the industrial facility’s formal name, is located at McClellan Air Force Base, California, and is recognized as one of the high-technology industrial centers of the Department of Defense. The center has capabilities in advanced composites, microelectronics, electro-optics, software, hydraulics/pneudraulics, as well as system engineering, flexible manufacturing, and environmental technologies--products of a $400-million investment over the past 10 years.

The center also manages communications-electronics systems aircraft, and as the predominant US Air Force space logistics support facility, the ground control equipment that monitors space vehicles. McClellan currently is providing system sustainment support to all of the services, other US government agencies, and foreign nations.

McClellan is the largest industrial employer in Northern California and has been an active industrial facility since 1936. In 1995, the Base Realignment and Closure Committee decided to close McClellan Air Force Base by the year 2001.

McClellan repairs and maintains aircraft, space and communication equipment. Other responsibilities include high technology missions such as advanced electronics, fiber optics, advanced composites and neutron radiography. These missions require large volumes of hazardous materials, such as

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[3] Much of this site descriptive material is adapted from information available at the McClellan Air Force Base’s Environmental Directorate web page (http://www.mcclellan.af.mil/EM/BRAC/map.htm).

solvents, caustic cleaners, electroplating chemicals, heavy metals, low level radioactive wastes, and a variety of fuel oils and lubricants. Throughout its history, industrial processes at McClellan have included the following:

- parts cleaning
- painting and coating
- sealing and desealing
- equipment coolant replacement
- instrument repair
- chemical laboratory operations
- surface finishing (electroplating)
- paint stripping
- bonding and debonding (adhesive removal)
- draining and replenishing aircraft fuel
- metal fabrication and machining operations
- portable equipment maintenance

Currently, most of the industrial facilities are in the southeastern portion of the base. The southwestern portion has both industrial and storage areas. In the far western part are vernal pools and wetlands areas. Between these wetlands and the engine test cells along the taxiways is an open area that was used for disposal pits in past years. In the northeast were several aircraft washracks and parking areas; only one of these washracks is still used.

Approximately 990 acres beneath McClellan AFB are contaminated with volatile organic compounds. Normally, contamination is removed by pumping groundwater from wells to the surface for treatment. McClellan uses soil vapor extraction (SVE) systems to remove contamination from soils. SVE systems draw air through the spaces between soil particles literally stripping away VOCs and generating a contaminated off-gas. Currently, catalytic oxidation (cat-ox) or granular activated carbon (GAC) is used to remove VOCs from vapors.

McClellan has been designated as the Chlorinated Hydrocarbons Remedial Demonstration Site as part of the National Environmental Technology Test Site (NETTS) program. This is a joint Department of Defense and US Environmental Protection Agency program for the evaluation and testing of environmental remediation technologies. The Strategic Environmental Research and Development Program (SERDP) is the parent organization that provides support staff for the technologies undergoing test and development at McClellan.

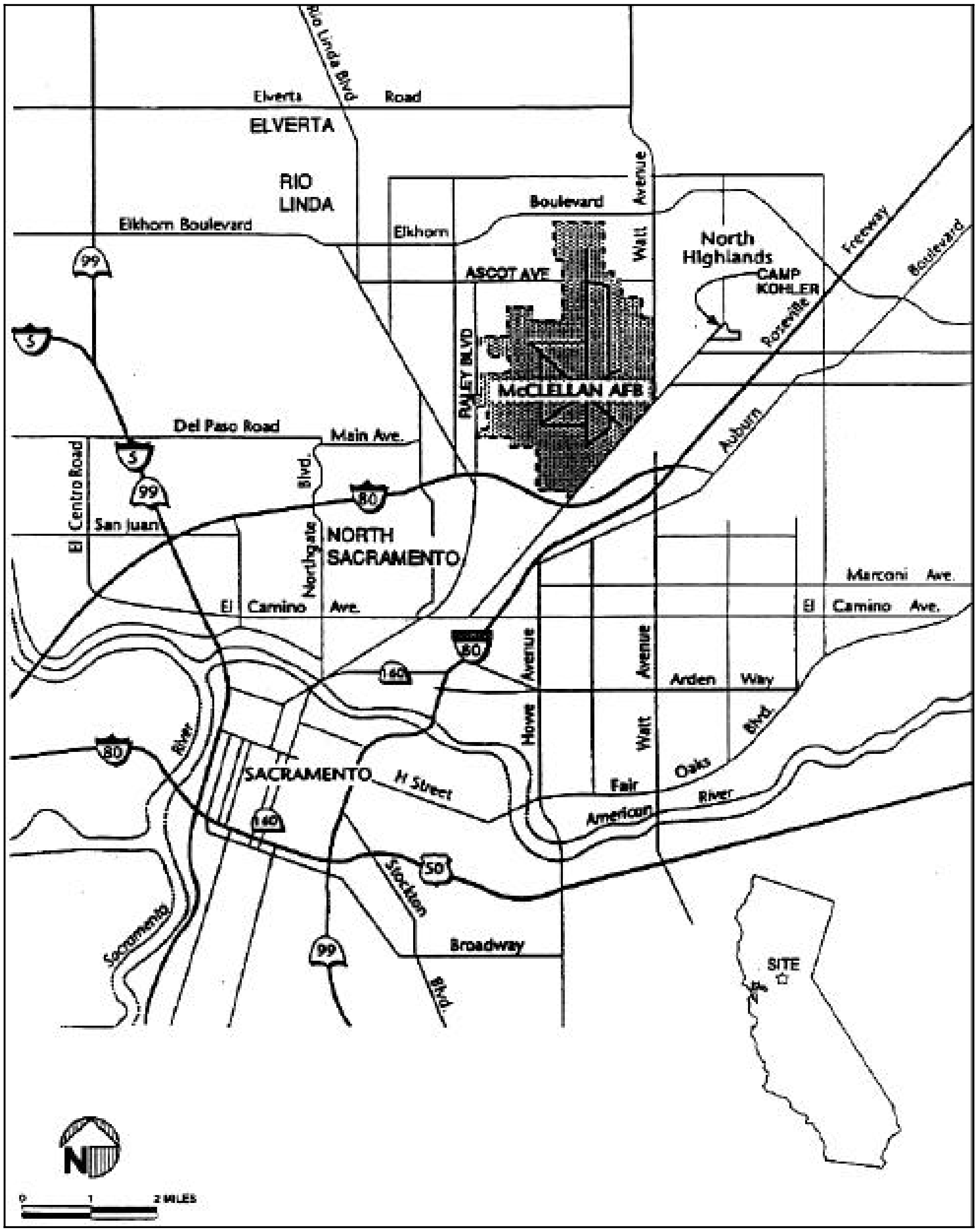

Figure 5-4 A map of Sacramento and vicinity showing the location of McClellan Air Force Base

McClellan Air Force Base is listed on the U. S. EPA's Superfund list of hazardous waste sites. The most important environmental problem at McClellan is that of ground water contamination caused by the disposal of hazardous wastes, such as waste solvents and oils, into unlined pits on base. This disposal method was standard procedure at the time (1940s through 1970s); since at that time the ability of these solvent wastes to fully penetrate sub-surface soil and ground water layers was not fully appreciated.

McClellan Air Force Base - Geological Characteristics

McClellan's environmental setting includes many features characteristic of the Central Valley of California. The Mediterranean climate in the Central Valley consists of mild, wet winters and hot, dry summers. Mean annual rainfall is 20.5 inches with about 80% of this precipitation falling between November and March.

Surface features at McClellan AFB include open grassland, creeks and drainages, and vernal pools, as well as industrial, residential, and runway areas. The land surface is a relatively flat plain that slopes gently to the west. Surface elevations range from about 75 feet above mean sea level (msl) on the eastern side of the base to about 50 feet msl on the western side. Two creeks receive most of the surface water runoff at McClellan AFB: Magpie Creek in the southern portion of the base and Don Julio Creek in the north-central portion. Secondary drainages include Robla Creek in the northern portion of the base, and an unnamed drainage canal traversing the central portion. The McClellan AFB stormwater drainage system directs stormwater runoff to these creeks and to Arcade Creek south of the base. These creeks also carry urban runoff from sources upstream of McClellan AFB.

Surface soils at McClellan AFB are variable, but generally are sediments that have formed from stream erosion of granite rocks in the Sierra Nevada. A hardpan layer, approximately 2 to 4 inches thick, has developed over large areas of the base at 3 to 10 feet below ground surface (bgs); this layer slows, but does not halt, infiltration of water; therefore, contamination occurring on the surface can migrate deeper and potentially to groundwater.

Natural resources at McClellan AFB include natural and artificial wetlands. The natural wetlands are ephemeral wetlands (vernal pools) on the western side of the base. Artificial wetlands include both the riparian areas of the Magpie Creek channel, the pond area built for flood retention, and the oxidation ponds (the "long ponds") next to Patrol Road, all on the western side of the base.

Land uses at McClellan AFB include industrial, military, and residential. Most of the land surrounding the base is zoned for low-density residential and agricultural use. Most residences are connected to municipal water supplies; however, some residences east of the base have private irrigation water wells. Land parcels designated for commercial office and industrial use are interspersed in this area, and include shopping centers, office complexes, and warehouses. Soil in the vadose zone, or the unsaturated zone between the surface and the groundwater table, is composed of interbedded layers of sands, silts, and clays. This zone is currently about 90 to 105 feet thick. Clays and hardpan layers slow, but do not halt, infiltration of liquids.

Groundwater is encountered at about 90 to 105 feet bgs, and flows generally south-southwest. At one time, the water table was much higher; however, water levels have declined continuously for about 50 years as a result of overdrafting by irrigation, supply, and extraction wells. In areas of groundwater contamination, changes in flow direction and the declining water table have produced a contaminant "smear zone." As groundwater levels decline, some of the groundwater contaminants remain in the newly-exposed portion of the vadose zone. These contaminants have remained as gases in soil pore spaces or as liquid films. Smear zones are generally encountered about 40 feet bgs.

The groundwater beneath McClellan AFB behaves as one hydrogeologic unit. That is, there is only one interconnected aquifer, or water-bearing zone. To help scientists analyze groundwater and contaminant movement, this one aquifer has been divided into five groundwater monitoring zones. The zones, shown in Figure 5-4 are named A, B, C, D, and E, from shallowest to deepest. Although the zones are connected, water within each zone moves horizontally more readily than it moves vertically. By measuring changes in groundwater flow and contaminant migration within each zone, scientists are better able to monitor the groundwater contamination beneath McClellan AFB.

McClellan Air Force Base - Ground Water and Monitoring Well Network Description

Groundwater at McClellan AFB is currently encountered at about 90 to 105 feet below ground surface (bgs). The groundwater itself is contaminated to a depth of about 400 feet bgs in some areas. Approximately 1,570 acres are underlain by groundwater plumes with contaminant concentrations exceeding background. Trichloroethene (TCE) is the most frequently detected contaminant. Some 93% of the contaminant mass is located in the shallowest portion of the aquifer. Some 14 billion gallons of contaminated water may underlie McClellan AFB.

Contaminants have been detected in the shallow (A), intermediate (B), and deep (C and D) zones of the aquifer beneath McClellan AFB. The extent of contamination is greatest in the A Zone, as shown in Figure 5-5. The contaminant that is most widespread and most frequently detected is TCE. A surface area of approximately 664 acres is underlain by a plume in the A Zone that exceeds maximum contaminant level (MCL) for TCE which is 5 µg/L.

The maximum contaminant level target volume is defined generally by TCE concentrations greater than 5 µg/L, because TCE is the most widespread contaminant. Areas where other VOCs were detected above MCLs generally fall within the 5 µg/L TCE isopleth. Eight “hot spots” (TCE concentrations in excess of 500 µg/L) also shown in Figure 5-5, have been identified in the A monitoring zone. Trichloroethene has not been detected above 500 µg/L in underlying zones B through E.

Eleven contaminants have been consistently detected in groundwater samples at concentrations greater than federal drinking water standards:

- Benzene;
- Carbon tetrachloride;
- Chloroform;
- 1,2-Dichlorobenzene;
- 1,2-Dichloroethane;
- 1,1-Dichloroethene;
- 1,2-Dichloroethene (cis and trans);
- Tetrachloroethene;
- 1,1,1-Trichloroethane;
- Trichloroethene; and
- Vinyl chloride.

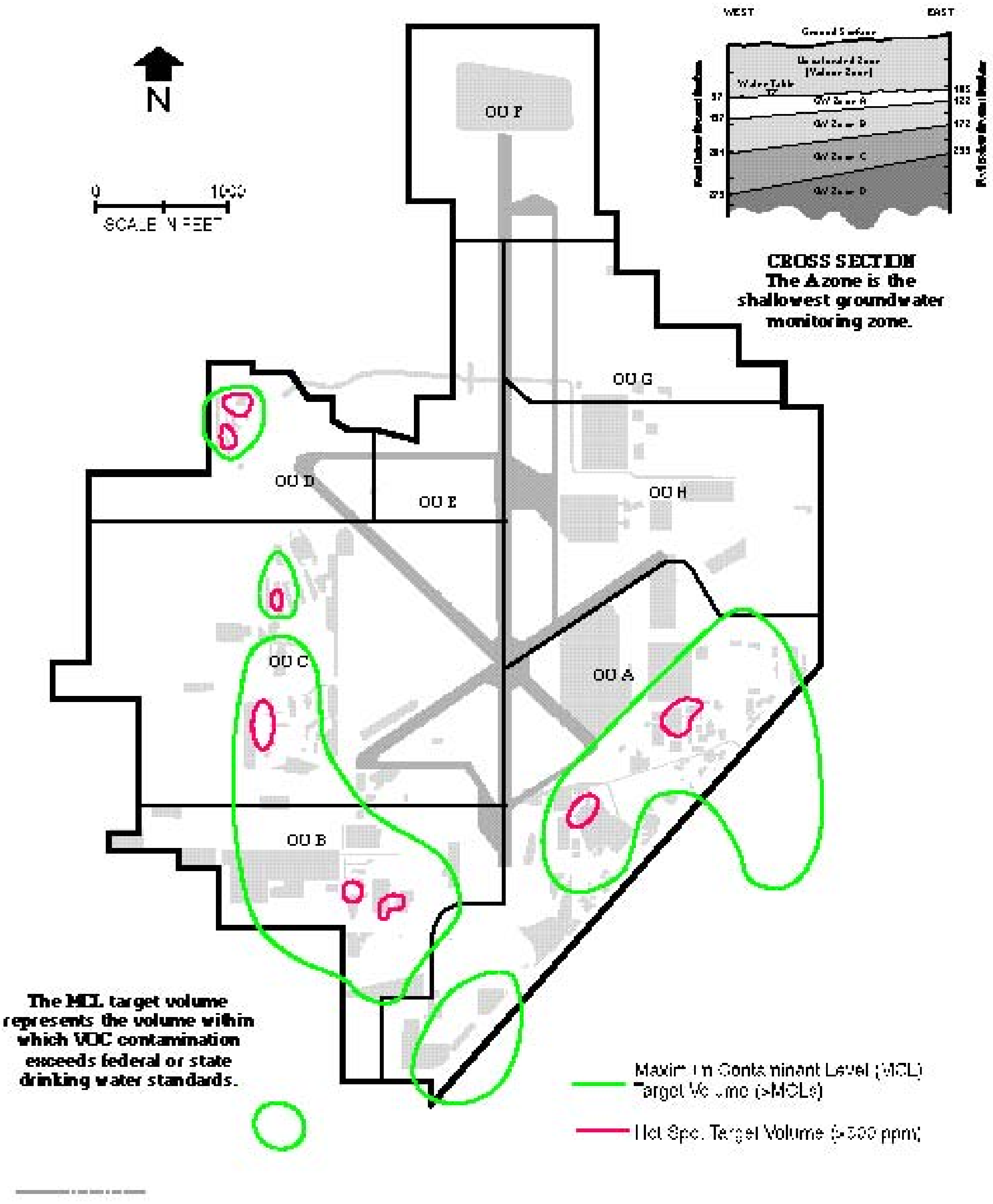

Figure 5-5 Operational Units and their corresponding sub-surface TCE plumes at McClellan Air Force Base in the shallowest (A) aquifer layer.

Five other contaminants, for which no federal drinking water standards exist, are regularly detected in groundwater samples:

- Acetone;
- 2-Butanone;
- 1,1-Dichloroethane;
- 4-Methyl-2-pentanone; and
- Toluene.

Two other contaminants are consistently detected, but in concentrations below the drinking water standards:

- Bromodichloromethane; and
- Trichlorofluoromethane (Freon® 11).

Monitoring wells at McClellan range from 2-inch to 8-inch diameter and are of typical construction. The well casing is Schedule 5 Stainless Steel 304 and the well screen Johnson Stainless Steel (304) with 0.01-or 0.02-inch screen slot size. The screen is surrounded by either 16 x 40 or 8 x 20 mesh gravel pack to a level about 3 feet above the screen. An approximate 3-foot sand bridge and 3-foot bentonite seal are placed above the gravel pack. A concrete sanitary seal of Type I and II Portland cement containing about 3 percent bentonite powder is used to seal the well casing between the bentonite seal and the ground surface. ***(include well construction figure?)***

Monitoring well locations and their sampling frequencies for the shallowest aquifer layer (Zone A) are shown in Figure 5-6 for all Operational Units. For this demonstration, monitoring wells that penetrate both A and B aquifer zones in Operational Units A, B, C, and D have been selected for sample collection. A total of 354 monitoring wells exist in these Operational Units at the A and B zone aquifer levels and of these, 20 that fall in the desired TCE concentration range have been selected as candidates for sampling. A number of high pump-rate extraction wells also exist at the site which feed into a network of water transfer lines leading to a ground water treatment plant for VOC removal that is located on the west end of the base. Contaminant concentrations are highest in these extraction wells since they are typically located nearest the subsurface contaminant source. These extraction well transfer lines may also be used for sample collection when high contaminant levels are desired in the samples. Additional details concerning the actual wells chosen for use in this demonstration are given Sections 6 and 7, Experimental and Sampling Plans.

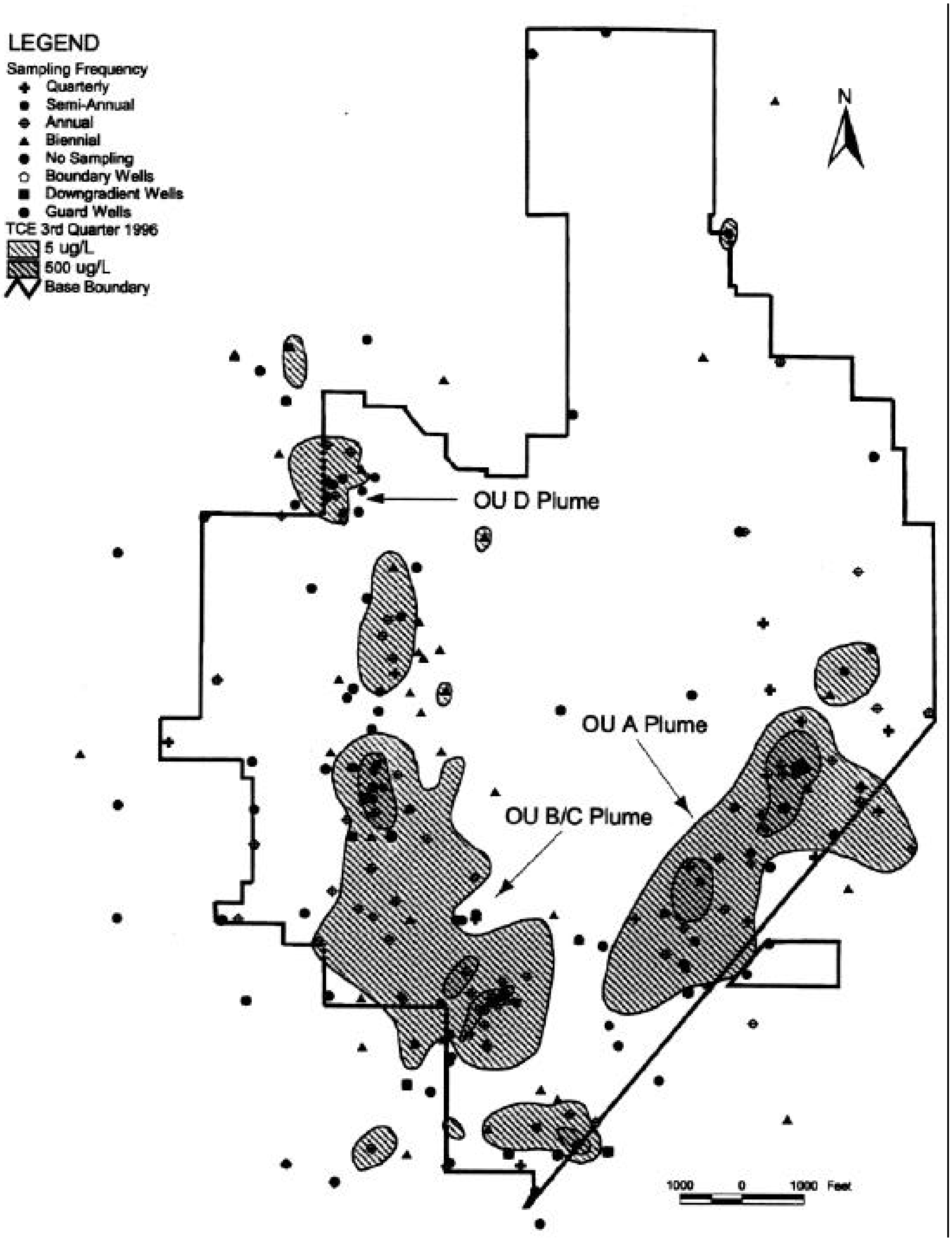

Figure 5-6 Map of McClellan AFB showing all Aquifer Zone A monitoring wells and their sampling frequency.

A routine groundwater monitoring program has been implemented at McClellan in which quarterly well sampling and analysis is carried out. Historical data from this monitoring program extends back as far as 1990 for many wells. Typical ground water analysis results for selected wells are shown in Table 5-3. As is evident from these data, TCE is the primary constituent in the samples, however PCE and other degradation products appear at lower concentrations. Non-chlorinated hydrocarbons such as BTEX (benzene, toluene, ethylbenzene, and xylenes) also appear in selected well samples.

Table 5-3 Typical quarterly monitoring results for selected McClellan monitoring wells

Analyte	Analyte Concentration, ug/L				
	MW 197	MW 327	MW 336	MW 330	MW 75
Trichloroethene	7.5	20.9	300	588	1930
Tetrachloroethene			1.4		0.2
1,1-Dichloroethene	0.2		3.8		0.9
1,2-Dichloroethane		0.3	144		0.8
Carbon Tetrachloride		17.2	10.6	6.5	
Chloroform		16.5	16.5	11.2	3.8
Methylene Chloride					0.6
Trichlorofluoromethane		0.9			
cis-1,2-DCE		0.5	6.8	44.4	42.1
trans-1,2-DCE				6.2	2.8
Benzene			5.4		
Chlorobenzene					0.2
Vinyl Chloride					10.9

Section 6 Experimental Plan

This section includes a description of the overall experimental objectives and the types of samples and sample numbers required to meet those objectives. A companion sampling plan, separately included in Section 7, incorporates detailed procedures for field sampling and sample handling at each of the demonstration sites. Additional supporting activities such as field audit procedures and post-demonstration data analysis procedures are included in Sections 8, Quality Assurance Project Plan and Section 9, Data Management and Analysis.

Demonstration Objectives

The primary objective of this demonstration is to evaluate and verify the performance of monitoring technologies for chlorinated volatile organic compounds (VOC) in ground water. Specific demonstration objectives are listed below:

- Verify instrument performance characteristics that can be directly quantified. Such factors include instrument detection levels, measurement accuracy and precision, sample throughput, and others.
- Verify instrument characteristics and performance in various qualitative categories such as instrument ease of operation, required logistical support, operator training requirements, instrument transportability, versatility, and other such categories.
- Compare instrument performance to standard laboratory analytical techniques currently employed for ground water analysis for chlorinated VOCs.

Technology Performance Factors

The experimental design encompasses both qualitative and quantitative performance factors associated with each instrument system incorporated into the demonstration. The overall approach in the experiment design is to collect an adequate volume of data such that instrument performance characteristics, that would be of interest to a potential instrument buyer, can be determined during the course of the demonstration.

Qualitative Factors

Some instrument performance factors or features, while important, are difficult or impossible to quantify. Important qualitative instrument performance factors are instrument portability, its logistical support requirements, degree of required operator training, ease of operation and others. Logistical requirements include a description of the technology’s power requirements, setup time, routine maintenance requirements, and the need for other equipment or supplies, such as a computer, reagent solutions, or gas mixtures. The qualitative factors are assessed during the demonstration in the following manner. Vendors will provide information concerning qualitative performance factors during preparation of the demonstration plan. These specifications are included in Section 4, Technology Description. During the field portion of the demonstration, auditors from the verification organization will observe instrument operation and document the degree of compliance of field operations with the methodology submitted in the demonstration plan.

Quantitative Factors

Many instrument performance factors in this demonstration will be quantitatively verified and reported. Quantitative factors include such instrument operational parameters as: measurement accuracy and precision, variation of accuracy and precision over a working range or over a range of environmental conditions, analyte detection level, linear range, measurement specificity, measurement comparability with reference techniques, and others. A overview of the rationale and procedures in each of these quantitative evaluation categories is given below. Specific details on source materials, sample composition, count etc are given in following sections.

Precision

The measurement uncertainty of a particular instrument will be assessed over its working range by the use of replicate analyses of a series of performance evaluation samples. At least four blind replicate analyses of PE samples at five concentration levels (e.g. very low, low, medium, high and very high--typically, VOC concentrations ranging from 5 ppb to 5 ppm) will be used at each site in this demonstration. The PE samples will be prepared from certified standard mixes and accompanied by written documentation from the supplier concerning their content, and purity. Results from these five sets of replicate analyses will be used to compute a standard deviation at each concentration level. The standard deviation will be used as a direct indicator of the overall measurement uncertainty obtained with a particular instrument. In the case of multicomponent mixtures, a standard deviation will be computed for each species measured by those instruments with multiple species detection capabilities. Additional details concerning this computation are presented in Section 10 - Data Management and Analysis.

Accuracy

A determination of measurement accuracy will be made in the working range of the instrument by using the results from the same set of PE samples described above for precision analysis. Two sets of four replicate PE samples in each of five concentration ranges that cover the working or linear range of the instrument will be given to each developer. Measurement accuracy will be computed for each concentration range by comparing the average reported value of the instrument, from replicate analyses, to the known composition of the sample. Additional details concerning this computation are presented in Section 10 - Data Management and Analysis.

Blank Sample Performance

At least two blank groundwater samples will be provided for analysis by each instrument system per day during the demonstration. These samples will be submitted as blind samples as a part of the daily sample set provided to each instrument operator. The results from these samples will be used to assess the degree to which instrument contamination and sample-to-sample carry over are observed during instrument operation.

Detection Levels

The scope of this demonstration does not permit an exhaustive determination of instrument detection levels. Alternatively, a number of samples at or near the expected detection level of each instrument will be provided to validate the instrument detection level for a number of analytes specified by each developer prior to the field portion of the demonstration. At least ten samples will be provided to each instrument operator in the concentration range of 1x to 2x of specified compound detection level for that particular instrument. The results from these analyses will be used score how well the instrument performs relative to detection levels specified in the Technology Description. Additional details concerning this computation are presented in Section 10 - Data Management and Analysis.

Instrument Linear Range

An assessment will be made as to the variation of the measurement accuracy and precision over the specified working range of the instrument. The assessment will be carried out using the same set of PE samples used for determination of measurement uncertainty and accuracy.

Measurement Specificity

To the extent possible, given limited demonstration resources, selected PE and ground water samples provided to each instrument operator will be prepared or collected in such a way as to allow a determination of the specificity of the instrument for a particular species in the presence of other possible interferent species. For example, TCE measurements will be carried out in the presence of PCE to determine the extent to which PCE interferes with the TCE determination.

Comparability with Reference Methods

In addition to a determination of instrument accuracy and precision using PE samples as an absolute reference, as described previously, an additional comparison of instrument results will be done with off-site reference laboratory results from sample splits of both PE and groundwater samples. The comparison results will be expressed in terms of percent deviation relative to the reference laboratory results and will be limited to the working range of the instrument. Additional details concerning this method of comparison are presented in Section 9 - Data Management and Analysis.

Instrument Cost

To a limited extent, instrument cost data will be compiled prior to and during the field activities and will be included in the verification report. In addition to actual instrument cost, other costs may include those associated with expendable supplies such as purge gases, glassware, carrier gases. No attempt will be made to determine labor costs associated with instrument operation, however the number of instrument operators and their degree of training required to operate the instrument will be included in the instrument evaluation.

Sample Throughput

For the purposes of this demonstration, sample throughput is defined as the number of PE or well samples that can be analyzed per day. The sample throughput determination does not include internal blanks, calibration or calibration check samples that may be required as a part of normal instrument operational procedures.

PE and Groundwater Sample Matrix

The field sample mix will be an approximate 55-45% split between PE and groundwater samples with a total of 75-80 samples to be submitted to each developer per demonstration site. Additionally at least two blanks will be provided to each participant on each day of operation. The preparation and use of internal blanks, internal or calibration samples, calibration check samples, and other such samples is the responsibility of each participant.

PE Source Material

Commercially available standard mixtures of chlorinated VOCs in methanol will be used to prepare PE samples (Supelco Catalog No. 4-8804 or equivalent). The standard mixtures are supplied with QC documentation giving the purity and weight of the analytes included in the mix. The content and concentration uncertainties of a typical certified standard mixture is shown in Table 6-2. The uncertainty about the mean “true” concentration values for the mixture components, as determined by triplicate GC analysis, is typically less than 2% relative standard deviation. These mixtures will be used as the starting material in the preparation of standard dilutions that will cover the desired range of chlorinated VOC concentration levels.

Table 6-1 Certificate of Analysis Data for a Typical PE Source Material

Analyte	Compound Purity	Concentration by Weight ug/L	Concentration by Analysis ug/L
Carbon Tetrachloride	99	120.0	119.9 ± 1.9
Chlorobenzene	99	599.9	576.6 ± 14.4
cis-1,3-Dichloropropene	99	120.0	116.8 ± 1.5
Methylene Chloride	99	600.0	575.7 ± 5.3
Tetrachloroethene	99	199.8	115.0 ± 0.5
trans-1,3-Dichloropropene	99	119.8	115.5 ± 0.5
trans-1,2-Dichloroethylene	99	120.0	115.6 ± 0.6
Trichloroethylene	98.7	119.9	116.2 ± 2.2
1,1-Dichloroethane	99	120.0	118.2 ± 1.3
1,1-Dichloroethylene	99	119.6	109.9 ± 1.6
1,1,1-Trichloroethane	99	120.0	117.8 ± 1.0
1,1,2-Trichloroethane	99	119.8	116.7 ± 0.3
1,1,2,2-Tetrachloroethane	98.8	120.0	115.7 ± 1.6
1,2-Dichlorobenzene	99	599.8	574.0 ± 16.6
1,2-Dichloroethane	99	119.8	120.0 ± 2.0
1,2-Dichloropropane	99	120.1	119.1 ± 2.2
1,3-Dichlorobenzene	99	599.8	578.1 ± 8.1
1,4-Dichlorobenzene	99	600.0	578.9 ± 8.6

Notes:

Concentration by weight (Column 3) is by the actual weight of material recorded during preparation of the mixture.
Concentration by analysis (Column 4) is the result of triplicate GC analysis of the stock solution (mean value ± standard deviation).

PE Sample Count

The PE sample count at each site categorized by primary analyte concentration level is given in the Table 6-2.

Table 6-2 PE Sample Count for Both Demonstration Sites

Sample Concentration Level	**No. of Samples**
Very Low Level (5-10 ppb)	
VOC Mix A	10
Low Level (10-50 ppb)	
VOC Mix A	4
VOC Mix B	4
Mid Level (200-400 ppb)	
VOC Mix A	4
VOC Mix B	4
High Level (600-800 ppb)	
VOC Mix A	4
VOC Mix B	4
Very High Level (1,000-5,000 ppb)	
VOC Mix A	4
VOC Mix B	4
Total Number of Samples	**42**

Ten PE samples are included at “very low”, 5-10 ppb concentration levels, near detection levels for many of the instruments. Results from these analyses will be reported as (1) a combined percent correct detects and no detects, based on the specified detection level of the instrument; and (2) percent false negatives (sample not detected at a level equal to or above specified detection level). In addition, four replicates are included at four higher PE concentration ranges for two different VOC mixes. These data will be used for accuracy, precision, linearity in working range, and other determinations. These samples will submitted as blind samples to the participants.   Two blank samples (deionized water) will also be provided as blind samles to each technology each day.

PE Preparation Techniques

PE samples will be mixed onsite, using the method outlined in Section 7, Sampling Plan, the evening before the day or on the day that they are dispensed and distributed to the participants. Samples will be kept under refrigeration until distributed to participants. Deionized, ultra-filtered water (Fisher Scientific Cat No. W2-20 or equivalent) will be used as the diluent in PE samples unless a suitable clean water source is available onsite. Unless special requests are made, the samples will normally not be preserved with chemical additives since their analysis is expected to be completed within 24 hours of preparation. Reference laboratory samples will be preserved by acidification as specified in Method 8260. The reference laboratory will provide pre-preserved sample vials, blue ice and coolers for their samples.

PE Sample Composition Information

Some of the participating technologies may require information concerning the content of the samples prior to carrying out an analysis. For example, the spectroscopic methods utilize a matrix-based calibration technique that requires all constituents of the sample to be known for optimal analytical results. Gas chromatograph techniques may require knowledge about the concentration of the sample to minimize the likelihood of column overload and unwanted instrument down time. In order to accommodate these requirements, the following information will be recorded for each PE sample and will be made available to the technology operator following written request. The degree of information requested by developers for each sample will be documented on the chain of custrody form and subsequently reported in the Technology Verification Report.

- Number of contaminants in the sample
- List of contaminants in the sample
- Boiling point range of sample constituents
- Approximate concentration range of contaminants in sample (Very Low, Low, Mid, High, Very High)

Groundwater Sample Count

Approximately 30 well samples will be provided to each participant at each site. Samples will be prepared in replicate groups of 3 or 4 such that measures of instrument precision can be obtained from the results. Sample count, categorized by primary analyte (TCE and/or PCE) concentration level is given in Table 6-3. Either three or four blind replicates will be prepared from each well sample and distributed as blind samples to each developer.

Table 6-3 Monitoring Well Sample Count for Both Demonstration Sites

Sample Concentration Level	No. of Samples
Very Low Level (5-10 ppb)	
Well 1	3
Well 2	3
Low Level (10-50 ppb)	
Well 3	4
Well 4	3
Mid Level (200-400 ppb)	
Well 5	4
Well 6	3
High Level (600-800 ppb)	
Well 7	4
Well 8	3
Very High Level (3,000 - 5,000 ppb)	
Well 9	3
Well 10	3
Total Number of Samples	33

Candidate Monitoring Wells

Although the sampling plan calls for sampling from two wells at each of the five concentration levels, at least four candidate wells that fulfill the sample requirements at each of the designated concentration ranges have been identified at both sites. This information is not included in the demonstration plan however, in order to insure the ability to provide truly blind samples to the developers. See comments on monitoring well sample composition in a following paragraph.

Sample Complexity

The selection of monitoring wells is driven by a requirement to have the samples span a desired TCE concentration range in order to evaluate the working range of the instruments. Savannah River groundwater samples will be relatively simple in composition and, in general, will have only two principal contaminants, namely TCE and PCE. Monitoring well selection at McClellan, on the other hand, was influenced by a desire to provide more complex samples to the developers. Samples at this site will contain other chlorinated VOC in addition to TCE and PCE. In some cases the samples will contain low levels of non-chlorinated VOCs as well.

Groundwater Sample Composition Information

As noted above for PE samples, some of the developers may require information concerning the content of the groundwater samples prior to carrying out an analysis. In order to accommodate these requirements, the following information will be recorded for each monitoring well sample and will be made available to the technology operator on request. The degree of information requested by developers for each sample will be documented and reported in the Technology Verification Report. Information on the composition of ground water samples will be based on historical data available from Savannah River's and McClellan's quarterly sampling programs. In selected cases, it may be possible that the composition of the well water has changed to a significant extent since the last time the well was sampled. The following information will be archived for each sample and made available to the developer following a written request for some or all of the information. As specified for the PE samples, information shared on sample composition will be documented on the sample chain of custody form as well as in the final Technology Verification Report. The information to be available on the groundwater samples is given below:

- Number of contaminants in the sample
- Boiling point range of sample constituents
- List of contaminants in sample
- Approximate concentration range of contaminants in sample (Very Low, Low, Mid, High, Very High)
- Historical analytical data from quarterly analysis reports

Groundwater Sample Collection Methods

Specific procedures for groundwater sampling that include well purge methods and times, sample collection, homogenization, and distribution techniques are outlined in Section 7, Sampling Plan.

Field Data Collection and Submittal

Technology Field Analysis Data

Vendor analytical data will be submitted by each developer to a designated auditor at the end of each day. The data must be submitted in digital format in a specified Excel spreadsheet format. In certain cases where results for a only a single analyte are generated, paper copy is acceptable. All analytical results must be referenced to the field sample number provided to the developer when the sample changed hands during initial distribution.

Non-detects should be reported for each analyte as less than the detection level. For example, an analysis for TCE that produced a no detect for an instrument with a TCE detection level of 20 ppb would be reported as <20 ppb.

No raw data (chromatograms, mass spectrums, absorption spectra etc.) should be submitted by developers. Raw data should be archived by the developer and must be available for inspection or additional investigation by the technology auditor during or following the field demonstration.

A logbook must be kept by each instrument operator. At a minimum, entries must include all samples (blank, calibration, calibration check, test, etc.) processed with the instrument along with a time entry for when each sample was processed. This notebook must be accessible to the field auditor for review during the field demonstration.

Normally, changes in data will not be permitted following its submittal to the technology auditor at the end of each day. Exceptions to this policy may be made and will be determined on a case-by-case basis. Revised data submittals that fall outside the stated policy will be documented in the Technology Verification Report. Developers should plan on finalizing and submitting all data prior to packing up and leaving each demonstration site.

Technology QC Data

Calibration data, calibration check data and other quality control data may be generated by technology operators during the field demonstration. There is no specific requirement to submit these data to the auditor during the field demonstration. At the discretion of the developer however, they may be submitted along with the analytical results. These data may subsequently prove useful to the verification organization during the data analysis phase of the project.

Other Field Demonstration Data

Other data of interest during the field demonstration such as site or area meteorological data, newly available well monitoring results from the ongoing quarterly monitoring program at both sites, and technology auditor data forms and notes will be identified and collected by the verification organization and may be used in the data analysis and reporting phase of the project.

Field Audit

One of the objectives of the field demonstration is to formally audit the operation of each technology during its use at one or both demonstration sites. The following paragraphs provide additional details on the field audit activities.

Three principal objectives are outlined for the field audit activities as shown below:

- Document Demonstration Plan deviations;
- Observe and record actual field practices of participants and their technologies; and
- Verify correct sampling procedures, e.g. sample handling, integrity, custody, distribution.

Sample Team Audit Procedures

The sampling team will consist of three members. Two members will conduct the sampling activities and a third will serve as a sample auditor. The sample auditor will verify that sample collection procedures are being followed. These activities will include verification of correct sample preparation, labeling, storage and distribution. The sample auditor will keep a log book and will also prepare all chain of custody documentation.

Technology Audit Procedures

The technology auditors will spend a minimum of 4 hours per demonstration site observing the operation of each technology, reviewing consistency of procedures, checking sample throughput rates, verifying operator requirements, reviewing logbooks, as well as providing clarification on demonstration procedures. The technology auditors will be knowledgeable in their assigned technologies and in the course of their duties will complete field technology audit forms.

Field Sampling Roles and Responsibilities

The following field personnel have been identified for sampling and technology auditing activity at the two field demonstrations.

SRS Demonstration

Demonstration Oversight: Wayne Einfeld (SNL), Steve Billets (EPA), and Tim Jarosch (SRS)

Field Sampling Team: SRS contract sampling technicians; Bob Helgeson, SNL sampling team auditor, Tim Jarosch, SRS sample collection oversight

Technology Audit Team: Gary Brown (SNL), Wayne Einfeld (SNL) and Tim Jarosch (SRS)

MCL Demonstration

Demonstration Oversight: Wayne Einfeld (SNL), Steve Billets (EPA), and Tim Jarosch (SRS)

Field Sampling Team: Radian sampling technicians; Bob Helgeson, SNL sampling team auditor, Tim Jarosch, SRS sample collection oversight

Technology Audit Team: Gary Brown (SNL), Wayne Einfeld (SNL) and Tim Jarosch (SRS)

Pre-Demonstration Sampling and Analysis

A set of pre-demonstration samples will be sent to each developer and the reference laboratory approximately 6 weeks prior to the first field demonstration at the Savannah River Site. Additional details concerning the pre-demonstration samples are given below.

Objectives

The use of pre-demonstration samples offers benefits to both the verification organization and the developers as outlined below:

- Provide PE and field samples, similar to those encountered during the field demonstration, to each developer in order to obtain information on sample matrix effects, calibration requirements, etc.
- Verify instrument maturity and readiness for field demonstration
- Test critical elements of sampling and distribution plan
- Check validity of reference laboratory results and analysis turnaround times
- Demonstration plan revision if necessary based on pre-demonstration sample collection and analysis outcome

Makeup Field Sample: PE Sample Split

Three PE samples and three SRS Well samples will be sent in an express mail overnight cool-pack to each participant and the reference laboratory.

The pre-demonstration sample set breakdown will be as follows:

PE Sample: 3 Low- to Mid-Level Concentration of 9-12 chlorinated VOC compounds

Groundwater Sample: 3 Low- to Mid-Level concentration of principal contaminant

Reference Laboratory

The reference laboratory will be DataChem Laboratories in Salt Lake City, UT. The laboratory is in the EPA CLP program and has an acceptable QA plan for all aspects of its operation. A number of blind PE samples were been shipped to the laboratory and were analyzed using method 8260. Laboratory results on these PE samples revealed acceptable peformance with average sample recovery for a 15 chlorinated VOC compounds in excess of 80%. Precision was also acceptable with the average relative percent deviation from replicate sample analysis at 3%. An onsite visit and review of laboratory facilities and procedures was conducted the week of June 22. A audit report of that and subsequent visits to the laboratory will be included in each Technology Verification Report.

Performance evaluation and groundwater sample splits will be prepared as zero headspace samples in 40 ml VOA vials and shipped via overnight airmail to the laboratory in insulated containers containing "blue ice". All analysis will be done using EPA Method 8260 (VOC by purge-and-trap followed by GC-MS analysis). The laboratory will also include a suite of internal quality control samples with each field sample batch run. These data will also be used in the data analysis portion of the project to further verify the laboratory analytical data. Analysis results will be available within 21 days of receipt of the sample at the laboratory. All analytical laboratory communications will carried out through Wayne Einfeld, the Verification Organization project lead. Laboratory analytical data results will be sent directly to the verification organization for use in the data analysis phase of the project.

Demonstration Schedule

The monitoring demonstration schedule itemized by task is included in Table 6-4.

Table 6-4 Monitoring Demonstration Schedule

Task Description	Task Duration	Start Date	End Date
Technology ID & Select	**105d**	**01/28/97**	**06/23/97**
Developers' Conference	1d	01/28/97	01/28/97
Tech. Select and Review	45d	02/12/97	04/15/97
Issue Letter of Invit.	1d	04/22/97	04/22/97
Letters of Intent Received	1d	05/15/97	05/15/97
First Call Instr Perf Claims	29d	04/22/97	05/30/97
Instr Perf Parameters Rcvd	16d	06/02/97	06/23/97
Demonstration Planning	101d	03/17/97	08/04/97
Prepare Demo Plan	**65d**	**03/17/97**	**06/13/97**
Distrib. Demo Plan for Review	1d	06/16/97	06/16/97
Developer Review	20d	06/17/97	07/14/97
Dev Comment Rcvd	1d	07/15/97	07/15/97
Modify Demo Plan	5d	07/16/97	07/22/97
Demo Plan Complete	1d	07/23/97	07/23/97
Site Review/Visit	30d	04/21/97	05/30/97
Sites Selected	1d	06/02/97	06/02/97
Lab Review/Pre-Audit	22d	06/02/97	07/01/97
Lab Selected	1d	07/02/97	07/02/97
Pre-demo Sampling & Analyses	15d	07/14/97	08/01/97
Lab and Tech Reslt Rcvd	1d	08/04/97	08/04/97
Conduct Demonstrations	16d	09/08/97	09/29/97
Conduct Demo 1	5d	09/08/97	09/12/97
Conduct Demo 2	5d	09/22/97	09/26/97
Demo 1&2 Data Received	1d	09/29/97	09/29/97
Analysis and Reporting	**166d**	**06/16/97**	**02/02/98**
Prepare Tech Verific Rpt & Stmnt	95d	06/16/97	10/24/97
Distribute for Dev Rev	1d	10/27/97	10/27/97
Developer Rprt Review	14d	10/28/97	11/14/97
Developer Review Complete	1d	11/17/97	11/17/97
Incorporate Devel Comments	7d	11/18/97	11/26/97
EPA Peer Review	27d	11/27/97	01/02/98
Incorporate EPA Comments	7d	01/05/98	01/13/98
Publ Rprt and Verific Statmnt	14d	01/14/98	02/02/98
Project Complete	1d	02/03/98	02/03/98

Section 7 Sampling Plan

The sampling plan for the Monitoring Technology Demonstration, outlined in this section, specifies field sample collection and handling procedures that will be used at both the Savannah River and the McClellan sites to collect water samples in such a manner that the experimental objectives of providing a homogeneous sample split to each technology and the reference laboratory are met. Careful adherence to the procedures contained in this section will ensure that a comparison between technology results and reference laboratory results is warranted and will not be biased by the collection and distribution of inhomogeneous groundwater or performance evaluation samples.

Overview of Savannah River Sampling Operations

Forty-two samples will be prepared from reference materials and distributed to each participant. Another 33 groundwater (GW) samples will be collected from selected monitoring wells at the Savannah River site and distributed to each participant. Performance evaluation and groundwater samples will be provided to participant technologies over a TCE concentration range from 5 ppb to 5 ppm, one of the primary contaminants at the site. Three or four blind replicate samples will mixed (PE) or collected (GW) at each of the following TCE concentration levels:

- Very Low (near instrument detection level): 5-10 ppb
- Low: 10-100 ppb
- Mid: 200-500 ppb
- High: 500-800 ppb
- Very High: 1,000 - 5,000 ppb

The planned sample count at each concentration level for PE and groundwater samples are specified in Tables 6-1 and 6-2 respectively. Samples will be delivered to each participant in batches of ten--one batch in early morning and the other in the early afternoon--on each of the four sampling days. To the extent possible, the maximum sample count will be provided as early as possible in the demonstration to those vendors with instruments that have high sample throughput. Samples will be delivered in coolers containing “blue ice.” An additional day is scheduled for public demonstration and visitor information and may also be used for sample analysis as time permits. For a complete description of the site and typical groundwater contaminant levels see Section 5, Site Descriptions.

Performance evaluation samples will be prepared and distributed to the demonstration participants during the first two days of the demonstration and groundwater samples will be collected and distributed the last two days. Sampling at the site will be carried out by an onsite sampling team who routinely collect samples as a part of the SRS’s quarterly groundwater monitoring program. Established well purge and sampling procedures as specified in the procedures manual for routine groundwater monitoring activities (Westinghouse Savannah River Site Manual 3Q5, Chapter 15, attached as Appendix A) will be followed. Much of the material collected into this sampling plan is derived from this written procedure.

Performance Evaluation Sample Preparation and Distribution

Performance evaluation samples will be mixed onsite the latter part of the week prior to the demonstration. All PE samples will be kept under refrigeration until distributed to participants. Deionized water will be used as the diluent in PE samples. Vendor samples will not be preserved through the addition of chemical additives with the exception of those going to the reference laboratory. The reference laboratory will provide their own pre-preserved sampling vials, “blue ice” packs, and shipping containers.

A PE sample preparation and distribution checklist follows:

1. PE standards are kept in fridge until ready for use.

2. Standards certificates cross-checked with ampoules; original certificates filed with sample management clerk--reasonable precautions taken to keep PE sample composition information confidential (no access to vendors).

If no dilution is required:

3. Fill 10 or 20-L carboy to desired volume with DI water.
4. Carefully break PE solution ampoule where it is scored.
5. Withdraw 1 ml or other appropriate volume with pre-cleaned 1-ml volume Hamilton gas tight syringe.
6. Inject PE mix directly into carboy containing DI water.
7. Mix for 1 minute using teflon stir bar, then go to Step 16 or 17.

If intial dilution is required:

8. Partially fill 10 ml (or other suitable volume) volumetric flask with DI water
9. Carefully break PE solution ampoule where it is scored.
10. Withdraw 1 ml sample (or other suitable volume) with pre-cleaned 1-ml volume Hamilton gas tight syringe.
11. Inject PE standard into volumetric, keeping needle tip immersed in solution.
12. Dilute to volume and mix.
13. Carry out additional dilutions as required
14. Make final injection into 10 or 20-L carboy filled with appropriate volume of DI water.
15. Mix for 1 minute using teflon stir bar, then go to Step X
16. Optional Step: Transfer final solutions to teflon bag with zero headspace volume and equipped with a bottom spigot.
17. Dispense from carboy or bag into 40 ml VOA vials, 250 ml bottles and 1-L bottles and cap (zero headspace).
18. Record sample information on COC forms.
19. Keep samples inverted in cooler until distribution to participants.
20. Ship reference lab samples via express mail to laboratory in cool-pack every second day of the demonstration.

Groundwater Sample Collection and Distribution

Water samples will be collected from a selection of the candidate wells as described in Section 6, Experimental Plan. Measurements of conductivity, temperature or pH will not be made during well purge. Alternatively, the wells will be purged using historical analytical data by purging the same water volumes used during the quarterly groundwater monitoring program. In certain cases, purge time may be limited as a result of low water levels in the wells. The ground water samples will be brought to the surface using pre-installed stainless steel pumps through PVC pipe. Water samples will be collected into a 20-L glass carboy or a 10-L teflon bag with zero headspace. The samples will be allowed to equilibrate for 5 minutes prior to further handling. If a carboy is used a teflon stir bar will be used for one minute prior to dispensing of sample. The sample volume in the carboy must be at least two times the volume required for all samples to be prepared. The bulk sample will be dispensed by the sampling team into appropriate sample containers specified by each participant. The vials will have Teflon^{TM} lined septa tops (with butyl rubber backing) or screw tops, secured to the vials by either screw tops. All samples will be made up as zero headspace samples. Any further sample handling will be the responsbility of the vendor.

Table 7-1 Sample Configurations as Specified by Developers

Developer	Sample Configuration
Reference Lab	40 mL (zhs) VOA
EST	250 mL (zhs) bottle
Geotech/ORS	40 mL (zhs) VOA
Inficon	40 mL (zhs) VOA
Innova AirTech	1 Liter (zhs) bottle
PE-Photovac	40 mL (zhs) VOA
Sentex	250 mL (zhs) bottle

Blind replicate samples, as specified in Tables 6-1 and 6-2 will be provided for each field instrument. *For selected samples, an HP 5890 gas chromatograph deployed at the site will be used to carry out an onsite analysis using a modified headspace method. These data will be used to give semi-quantitative information about the composition and concentration levels of the samples.* Reference laboratory samples will be kept at a temperature of approximately 40 degrees F in an insulated sample shipping container and will be transported air express mailed to the analytical laboratory at the end of each second sampling day.

Decontamination of any sampling or support equipment will be performed by qualified SRS personnel using established SRS procedures. Decontamination of developer instruments will be performed by the instrument's owner or developer. SRS will provide de-ionized water as necessary. Any waste water will be collected by SRS personnel and disposed of according to established SRS protocol. Waste chemicals or solvents produced by the instrument owners or developers should be minimized, however.

Each well will be purged prior to sample collection. A minimum of two well volumes is required but four is typically used if possible. If the well goes dry while purging two volumes, the well is re-sampled after one day and an unpurged sample is taken. To the extent possible, wells likely to go dry during purge have not been included in the candidate well list. Site procedures normally require that specific conductivity, pH, and turbidity all be measured and recorded to confirm that stabilization has occurred (defined as successive parameter measurements taken a minimum of every three minutes which vary by no more than 10 percent). However, for the purposes of this demonstration, historical purge volumes from quarterly reports will be used to determine an adequate purge time.

Note: Two options are considered here. The first involves sequential sample collection directly at the . This is a speedy approach however the risk is run that the sample splits will not be homogeneous. The other alternative is the collection of a bulk sample followed by mixing in a zerohead space teflon bag followed by sequential dispensing into sample containers. The latter approach offers a better chance of getting homogeneous samples to the technologies and the reference lab and arguably the better choice.

Wellsampling Checklist

Bulk sample collection into 20-L carboy followed by mixing and dispensing.

1. At the , fill a 5-liter teflon bag with bottom spigot
2. Close all bag valves, label with preset identifier, log identifier in notebook and field checklist and transport to "staging" area.
3. Gently mix the contents of the bag for 5 minutes by slowing rotating the bag.
4. Clean 40 ml ZHS vial and caps (teflon lined) on hand.
5. Vendor-supplied containers on hand (Vendors have responsibility to provide clean sample containers, SRS personnel can provide DI water for rinsing)

6. Fill the ZHS vials in order listed above by gently filling them to overflowing, cap tightly, invert, and inspect for any air bubbles.
7. Fill and seal vendor containers per instructions from vendors in order listed above.
8. Label containers with preset demo sample number. This number should also be logged in a field notebook and on three copies of a COC (one for the vendor, one for the auditor, one on file).
9. Place all the samples in a cooler with blue ice.
10. Distribute samples and modified COC form to vendors.
11. At end of day, reference lab samples will be transferred to insulated shipping and shipped via express air.

Sequential Order for Sample Dispensing:

#1 SRS GC sample
#2 vendor A
#3 vendor B
#4 vendor C
#5 Reference lab
#6 vendor D
#7 vendor E
#8 vendor F
#9 SRS GC sample
[The vendor order can be rotated at the other wells.]

Sampling Schedule

Sampling preparation and collection will begin on Monday 09/08/97 and proceed as follows:
Day 1 (09/08/97) PE Sample Preparation and Distribution
Day 2 PE Sample Preparation and Distribution, Groundwater Sampling
Day 3 Groundwater Sampling and Distribution
Day 4 Visitors Day
Day 5 Final Sample Distribution (as required)

Sample Management Procedures

Formal chain of custody protocol will be maintained for all samples collected and distributed duringn the demonstration. A sample chain of custody form is included in Appendix B. Each participant is also required to keep a written logbook during the demonstration in which sample receipt is documented. All samples will be maintained by the sampling team in coolers or insulated shipping containers until delivery to participants. It is the responsibility of each participant to maintain samples at appropriate temperature and storage conditions following release of samples to their custody.

Deviations from the Sampling Plan

Deviations from the above sampling plan should be immediately noted by the field sampling team or the assigned sample management auditor. In the event of a plan deviation or anomaly, one of the onsite Principal Investigators (Tim Jarosch, SRS or Wayne Einfeld, SNL) should be immediately informed of the deviation such that corrective actions or modifications to the sample plan can be made and documented.

Overview of McClellan Sampling Operations

Sample collection and distribution at McClellan will be very similar to those carried out at Savannah River. Approximately 40 samples will be prepared from reference materials and distributed to each participant. Another 35 groundwater samples will be collected from selected monitoring wells at the Savannah River site and distributed to each participant. Performance evaluation and groundwater samples will be provided to participant technologies over a concentration range from 5 ppb to 5 ppm of TCE, one of the primary contaminants at the site. Either three or four blind replicate samples will either be mixed or collected at each of the following TCE concentration levels: (Sample count at each concentration level for PE and groundwater samples are specified in Tables 6-1 and 6-2 respectively.)

- Very Low (near instrument detection level): 5-10 ppb
- Low: 10-50 ppb
- Mid: 50-400 ppb
- High: 400-800 ppb
- Very High: 1,000 - 5,000 ppb

Samples will be delivered to each participant in batches of 10 at approximately 0800 hours and 1300 hours on each of the four sampling days. An additional day is scheduled for visitors information and public demonstration activities. For a complete description of the site and a discussion of typical groundwater contaminant levels see Section 4, Site Descriptions.

Performance evaluation samples will be prepared and distributed to the demonstration participants during the first two days of the demonstration and groundwater samples will be collected and distributed the last two days. Sampling at the site will be carried out Radian International, the onsite contractor that does out the groundwater sampling for the routine quarterly monitoring program. Established well purge and sampling procedures as specified in the Standard Operating Procedures McAFB-013 “Sampling Groundwater from Monitoring and Extraction Wells” and McAFB-024 “Field Instrument: Calibration and Operation of Water Sampling Field Instruments,” used by Radian during their quarterly sampling program. These two documents are included in Appendix C.

Performance Evaluation Sample Preparation and Distribution

Performance evaluation samples will be mixed onsite at a mobile laboratory provided by Sandia National Laboratories. Mixing and distribution will be carried out in a similarn identical manner to that performed at the Savannah River demonstration site.

Groundwater Sample Collection and Distribution

Groundwater sample collection from monitoring wells will be carried out over two days with five wells sampled each day. Sample collection, mixing and distribution procedures will be the virtually the same as specified for the SRS demonstration site. Detailed sampling procedures to be used by the Radian sampling team are included in Appendix B.

Sampling Schedule

Sample preparation and collection will begin on Monday 09/22/97 and proceed as follows:
Day 1 (09/22/97) PE Sample Preparation and Distribution
Day 2 PE Sample Preparation and Distribution, Groundwater Sampling
Day 3 Groundwater Sampling and Distribution
Day 4 Visitors Day
Day 5 Final Sample Distribution (as required)

Sample Management Procedures

Formal chain of custody protocol will be maintained for all samples collected and distributed duringn the demonstration. A sample chain of custody form is included in Appendix B. Each participant is also required to keep a written logbook during the demonstration in which sample receipt is documented. All samples will be maintained by the sampling team in coolers or insulated shipping containers until delivery to participants.

It is the responsibility of each participant to maintain samples at appropriate temperature and storage conditions following release of samples to their custody.

Deviations from the Sampling Plan

Deviations from the above sampling plan should be immediately noted by the field sampling team or the assigned sample management auditor. In the event of a plan deviation or anomaly, one of the onsite Principal Investigators (Tim Jarosch, SRS or Wayne Einfeld, SNL) should be immediately informed of the deviation such that corrective actions or modifications to the sample plan can be made and documented.

Communications, Documentation, Logistics, and Equipment

SNL will communicate regularly with the demonstration participants to coordinate all field activities associated with the demonstration and to resolve any logistical, technical, or QA issues that may arise as the each demonstration progresses. A short briefing and time for resolution of issues will be held at the start of each day during the demonstration. The successful implementation of the demonstration will require detailed coordination and constant communication between all demonstration participants.

All developer field activities will be documented by the verification organization. Field documentation will include field logbooks, photographs, field data sheets, and chain-of-custody forms. The SNL field team leader will be responsible for maintaining all field documentation. Field notes will be kept in a bound logbook. Each page will be sequentially numbered and labeled with the project name and number. Completed pages will be signed and dated by the individual responsible for the entries. Errors will have one line drawn through them and this line will be initialed and dated. All photographs will be logged in a field photo logbook. These entries will include the time, date, direction, subject of the photograph, and the identity of the photographer. Specific notes about each sample collected will be written on sample field sheets, and in the field logbook. Any deviations from the approved final demonstration plan will be thoroughly documented in the field logbook and communicated to the EPA technical lead and other parties that may be affected by the change.

Original field sheets and chain-of-custody forms will accompany all samples shipped to the reference laboratory. Copies of field sheets and chain-of-custody forms for all samples will be maintained in the project file, maintained by Sandia, the Verification Organization.

The Developers will provide all equipment necessary for the operation of their field instruments in analyzing samples. Field equipment that will be provided by the verification organization and site is listed in Table 7-2. Additional equipment that may be necessary for technology demonstrations is listed in Table 7-3. These articles are expected to be provided by each technology vendor.

Table 7-2 Equipment Supplied by Site and Verification Organizations

PE Sample Source Material
Deionized Water
Volumetric Flasks, Syringes
Sample Labeling Materials and Chain of Custody Forms
Data reporting forms (Excel Spreadsheet templates, forms, etc.)
Pre-cleaned 40 mL VOA vials
5-Liter Teflon Bags (for bulk sample collection, mixing and dispensing)
Data reporting forms
Submersible Pumps and tubing
Well Purge Monitoring Instruments (temp. pH, conduct. etc. MCL site only)
Decontamination hardware and solutions
Coolers and Blue Ice

Table 7-3 Developer-Supplied Field Equipment (as required by each technology)

Vehicle for transportation to the demonstration sites.
Power supply for equipment operation. (e.g. generator).
Computer data acquisition system, software manuals, and printer to provide hard copy.
MS Excel or other spreadsheet software
Internal standards for instrument calibration.
Appropriate sampling apparatus (syringes, head space vials, sorption tubes, etc.).
General laboratory supplies (solvents, tissues, etc.).
All necessary manifolding parts, fittings, and tubing.
Containers for transporting necessary fuel to generators.
All turbo pump and mechanical pump oil.
Appropriate clothing and equipment for inclement weather.
Safety glasses
Steel toed boots/shoes

Section 8 Quality Assurance Project Plan

The QAPP for this demonstration specifies procedures that will be used to ensure data quality and integrity. Careful adherence to these procedures will ensure that data generated from the demonstration will meet the desired performance objectives and will provide sound analytical results.

Purpose and Scope

The primary purpose of this QAPP is to outline steps that will be taken by the reference laboratory and by operators of the various wellhead monitoring technologies to ensure that data resulting from this demonstration is of known quality and that a sufficient number of critical measurements are taken. The QAPP also details the QA/QC criteria that will be used to validate the reference laboratory results. The EPA considers the demonstration to be classified as a Category II project. This section of the demonstration plan addresses the key elements that are required for Category II projects prepared according to guidelines in the EPA guidance documents Preparing Perfect Project Plans (1989), Preparation Aids for the Development of Category II Quality Assurance Project Plans (Simes 1991) and the Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (Stanley and Verner 1983).

The scope of the QAPP includes a comparison of wellhead monitoring technology results to those generated by a reference laboratory using EPA-approved methods. Each technology operator will use a formal written method or SOP specified by each individual developer in Section 4. The reference laboratory will use EPA SW-846 Method 8260 “Gas Chromatography/Mass Spectrometry for Volatile Organics Capillary Column Technique.”

Data generated by each technology will be evaluated to determine the level of data quality it is capable of generating. Each technology is expected to produce data quality that parallels the results from SW-846, Method 8260. An additional means of technology performance evaluation is afforded by the inclusion of many Performance Evaluation samples (of known content) in the experimental design. Adherence to the QA/QC requirements of this QAPP will ensure that definitive level data quality is generated by the reference laboratory.

Quality Assurance Responsibilities

SNL is responsible for preparing and coordinating with all developers, a QAPP for both demonstrations. For the purpose of this demonstration EPA document EPA QA/G-9 Guidance for Data Quality Assessment will be used as the QA/QC guideline until Protocol II is made available. This document is available upon request.

It is important that the project principals understand and agree on the experimental approach. For this reason, the Technology Demonstration Plan Approval Form must be signed by all key personnel. These signatures, which must be obtained before the final Demonstration Plan is submitted, indicate that the key personnel have read the appropriate sections of the Demonstration Plan and are committed to full cooperation and implementation of the study design elements.

All technology developers will review and approve the QAPP. The QA/QC oversight of all demonstration activities will be provided by Gary Brown, QA/QC officer SNL.
Samples will be collected and analyzed on site by the each technology and off site by the reference laboratory using EPA-approved methods. Many individuals will be responsible for sampling and analysis QA/QC throughout the demonstration. Primary responsibility for ensuring that sampling activities comply with the requirements of the sampling plan (Section 7) will rest with the SNL field team leader. QA/QC activities for the field demonstration will incorporate those activities recommended by the developers as well as those required by the EPA or SNL to assure that the demonstration will provide data of the necessary quality.

QA/QC activities for the reference laboratory analysis of samples will be the responsibility of the reference laboratory supervisor. If problems arise or any data appear unusual, they will be thoroughly documented and corrective actions will be implemented as specified in this QAPP. The QA/QC measurements made by the reference laboratory are dictated by the analytical methods being used. This QAPP includes additional QA/QC guidance which must be followed during the analysis of GC/MS demonstration samples. The QAPP for the DataChem Laboratories is available upon request.

Data Quality Parameters

The data obtained during the wellhead monitoring technology demonstration will be thoroughly documented and included in a Technology Verification Report along with conclusions drawn on individual technology performance parameters. For all measurement and monitoring activities conducted for EPA, the agency requires that data quality parameters be established based on the proposed end uses of the data. Data quality parameters include five indicators of data quality: representativeness, completeness, comparability, accuracy, and precision.

Representativeness

Representativeness refers to the degree to which the data accurately and precisely represents the conditions or characteristics of the parameter represented by the data. For the purposes of this demonstration, representativeness will be defined as presenting identical samples to each technology and the reference lab. In this demonstration, representativeness will be ensured by executing consistent sample collection and mixing procedures, including sample locations, sampling procedures, sample storage, sample packaging, sample shipping, and sample equipment decontamination as specified in Section 7, Sampling Plan.

Completeness

Completeness refers to the amount of data collected from a measurement process compared to the amount that was expected to be obtained. For this demonstration, completeness refers to the proportion of valid, acceptable data generated using each technology. More specifically, completeness in this demonstration refers to the number of samples analyzed expressed as a percentage of the number of samples provided to each developer. The completeness objective for data generated during this demonstration is 95 percent.

Comparability

Comparability refers to the confidence with which one data set can be compared to another. One of the important objectives of this demonstration is to evaluate how well the various monitoring technologies perform in comparison to conventional analytical methods used by a reference laboratory as described in the experimental design outlined in Section 6. The study design incorporates a high number of blind replicate PE samples of known composition to assist in this determination of data comparability. In other words, QC samples are built into the study design and are not left to the discretion of the technology operators.

Accuracy

Accuracy is a statement concerning systematic difference between sample results and the true value or reference laboratory value for the sample. Bias, a measure of the departure from accuracy, can be caused by such processes as errors in standard preparations, technology calibrations, loss of target analyte in the extraction process, interferences, and systematic or carryover contamination from one sample to the next. Accuracy and bias will be assessed for the monitoring technologies using sample data compared to reference lab results and measurements made on the PE samples. Accuracy will also be evaluated for the reference laboratory through the use of PE samples. PE samples used during this demonstration will provide the best estimate of accuracy because they are of known composition while the reference lab results are themselves estimates. Accuracy for the PE sample results will be evaluated through the comparison of percent recoveries for each target analyte. The study design calls for approximately 50% of all samples provided to the developers to be PE samples in order insure that reliable accuracy estimates can be obtained for each technology.

Precision

Precision refers to the degree of mutual agreement among individual measurements and provides an estimate of random error. Precision for this demonstration will be expressed in terms of the relative standard deviation (RSD) between replicate sample measurements.

Precision for each technology will be assessed with triple and quadruple replicates of both PE and groundwater samples. The replicate samples will provide an estimate of overall data precision and will included such influential factors as: sample collection, field preparation, handling, and transportation procedures, as well as analytical procedures.

The confidence interval of the mean is another measure of analytical precision and provides a range in which we would expect to find the true mean of a population with a given probability. For example, a 95% confidence interval implies that the repeated samplings and measurements of a particular sample or mixture will yield a value that lies within the given interval 95 times out of 100 trials.

Calibration Procedures, Quality Control Checks, and Corrective Action

Calibration procedures, method-specific QC requirements, and corrective action associated with non-conforming QC for the GC/MS technology and the reference method are described in the following subsections.

Initial Calibration Procedures

Initial calibration for each technology will be performed according to the developer's recommendation and as outlined in the written procedure. The types of standards used and the acceptance criteria for the initial calibration or calibration curve also will be those recommended by the developer. These recommendations will be thoroughly documented by each observer and included in the Technology Verification Report and the draft EMMC method prepared for each technology.

The initial calibration for SW-846, Method 8260 consists of the analysis of three concentration levels of each target analyte and a calibration blank. The low-level calibration standard will be at a concentration which defines the Lower Recovery Limits (LRLs) of the method. The remaining calibration standard levels will be used to define the linear range of the instrument. The initial laboratory method calibration is used to establish calibration curves for each target analyte.

Continuing Calibration Procedures

Continuing calibration checks for each technology will be performed according to the developer's recommendation. Normally, continuing calibration checks specify a maximum error tolerance for the repeated measurement of a stable calibration mixture over an extended (days or weeks) analysis interval. The standard levels used and the acceptance criteria for continuing calibrations also will be those recommended by the developer. These recommendations will be thoroughly documented by each observer and included in the Technology Verification Report, and the draft EMMC method prepared for each technology. The calibration procedure used for SW-846 Method 8260 is found in Appendix A Method 8260 (Gas Chromatography/Mass Spectrometry for Volatile Organics: Capillary Column Technique). Continuing calibration of the laboratory GC-MS instruments in Method 8260 is normally performed every 24 hours.

Method Blanks

The analysis of field blank samples by the various technologies will be performed as called out in the Experimental Design. The plan calls for the analysis of at least two blind blank samples each day of the demonstration. Field blanks will be analyzed by the reference laboratory using SW-846 Method 8260.

Laboratory PE Samples

A critical element of this demonstration's experimental design in the submittal of all field generated PE samples to the reference laboratory as well as to each technology. These samples are critical to the success of the demonstration since they provide the only absolute check of field technology and laboratory method accuracy during the demonstration. These samples will be analyzed using SW-846 Method 8260 by the reference laboratory.

Data Reduction, Validation, and Reporting

To maintain good data quality, specific procedures will be followed during data reduction, validation, and reporting. These procedures are detailed below.

Data Reduction

Data reduction will be performed by the operator performing the analysis. The various technologies will produce data in field logbooks, hard copy spectra, reports, hardcopy spreadsheet reports, and floppy disks containing field data. This data will be reduced to produce a report containing analytical results.

Data Validation

Each technology operator will verify the completeness of the appropriate data forms and the completeness and correctness of data acquisition and reduction. The reference laboratory or field team supervisor will review calculations and inspect laboratory logbooks and data sheets to verify accuracy, completeness, and adherence to the specific analytical method protocols. Calibration and QC data will be examined by the individual operators and the laboratory supervisor. Reference laboratory project managers and QA managers will verify that all instrument systems are in control and that QA objectives for accuracy, completeness, and method detection limits have been met.

Analytical outlier data are defined as those QC data lying outside a specific QC objective window for precision and accuracy for a given analytical method. Should QC data be outside of control limits, the reference laboratory or field team supervisor will investigate the cause of the problem. If the problem involves an analytical problem, the sample will be reanalyzed if possible. If the problem can be attributed to the sample matrix, the result will be flagged with a data qualifier. This data qualifier will be included and explained in the Technology Verification Report.

Data Reporting

SW-846 Method 8260 analytical data will be reported using the reference laboratory's standard data report form. At a minimum, the forms will list the results for each sample and include the detection limits, reporting units, sample numbers, results, and qualifiers.

Calculation of Data Quality Indicators

The following calculation will be used by all methods for determining precision for the reference laboratory. This calculation is used to determine the precision between sample results and duplicate sample results.

$$\text{RSD} = \text{SD} \div \text{MEAN} \times 100 \qquad (8.3)$$

where

RSD = relative standard deviation

SD = standard deviation
Mean = average concentration of analyte in replicate sample measurements
Standard deviation is determined through the following calculation.

$$SD = [\{\Sigma (x_i - mean)^2\} / (n-1)]^{1/2} \qquad (8.4)$$

where

SD = standard deviation
x_i = concentration of analyte in specific replicate sample
Mean = average concentration of analyte in all replicate samples
n = total number of replicate sample measurements

The following calculation is used to determine PE sample recovery, which can be used to assess the accuracy of the analytical method.

$$\% Rec = (Measured\ value \div True\ value) \times 100 \qquad (8.6)$$

where

% Rec = percent recovery
Measured value = Result from field instrument measurement
True value = The certified value as provided in the PE sample documentation

The following calculation is used to determine the 95% confidence interval for a population mean.

$$confidence = x \pm \{(t_n) \times [s / (n)^{1/2}]\} \qquad (8.7)$$

where

confidence = 95% confidence interval for a population mean
x = mean value
t_n = multiplicative constant for a standard t distribution that will yield a 95% confidence interval with n samples
s = standard deviation
n = sample size

Performance and System Audits

The following audits will be performed during this demonstration. These audits will determine if this demonstration plan is being implemented as intended.

Performance Audit

A performance audit will be carried out during this demonstration through the use of PE samples in the experimental design. PE samples will be ordered from a QC sample supplier and will be diluted to appropriate concentration levels onsite during the demonstration. They will be submitted to the reference laboratory and to the GC/MS technology developers for analysis. Percent recovery calculations for the PE samples will be used to evaluate both field technology and reference laboratory method performance.

PE samples come with statistics about each sample, which have been derived from the analysis of the sample by a number of laboratories using EPA-approved methods. These statistics include a value of the PE sample, a mean of the laboratory results obtained from the analysis of the PE sample, and an acceptance range for sample values. The reference laboratory is expected to provide results from the analysis of the PE sample that fall within acceptance limits specified in SW846 Method 8260.

On-Site System Audits

On-site system audits for sampling activities, field operations, and laboratories will be conducted. These audits will be scheduled and performed by a representative of SNL or SRS. Separate audit reports will be completed after the audits and provided to the participating parties in the Technology Verification Report.

Quality Assurance Reports to Management

QA reports provide management with the necessary information to monitor data quality effectively. It is anticipated that the following types of QA reports will be prepared as part of this demonstration project.

Status Reports

The SNL project manager will prepare periodic reports for the EPA project manager. These reports should discuss project progress, problems and associated corrective actions, and future scheduled activities associated with the demonstration. When problems occur, the SNL project manager will discuss them with the EPA project manager or EPA technical lead, estimate the type and degree of impact, and describe the corrective actions taken to mitigate the impact and to prevent a recurrence of the problems.

Audit Reports

Any QA audits or inspections that take place in the field or at the reference laboratory while the demonstration is being conducted will be formally reported by the auditors to the SNL analytical QC manager and the SNL project manager who will forward them to the EPA project manager.

Section 9 Data Management and Analysis

Introduction

The major portion of the activities outlined in this section will be performed by SNL. Each technology opererator will record and archive those data items identified in the Demonstration Plan as being the responsibility of the vendor. As part of this demostration, SNL will establish a data management system that will include computerized data files as well as hard copy data, such as field and laboratory sheets and hardbound logbooks. This data management system will be used to store analytical data obtained from each technology and the reference laboratory. The data management system will be used to conduct statistical analyses of the data and to verify that the data meet the quality parameters outlined in Section 8. The types of data collected during the demonstration are more fully desribed below.

Field Data Types

Site Environmental

Meteorological data that are pertinent to the demonstration periods. Other site data of interest in terms of technology performance (e.g. terrain where deployed, availability of power, water, etc)

Groundwater Sample Collection/Distribution

Field logbook data describing sampling procedures, deviations from SOP, well purge times, bulk sample mixing and dispensing operations. A complete record of sample numbers and chain of custody forms are included here.

PE Sample Preparation/Distribution

Field logbook data describing: PE sample preparations procedures, PE mix certificates of analysis, mixing and dispensing operations.

Technology Sample Analysis Results

Analytical results from each of the developers in hardcopy and optional electronic format. Data entries for each sample will include: sample no., time of analysis, analysis results by compound, anomalies encountered and other pertinent data items.

Technology Audit Results

A written narrative of the time spent by the auditors with each participating technology. The narrative will assess the various qualitative aspects of each technology and its performance as described in Section 6.

Experimental Plan Deviations

A written record of where deviations occurred in the actual demonstrations as compared to that called out in the demonstration plan.

Reference Laboratory Data Categories

Reference Laboratory Sample Analysis Results

Analytical data similar to that provided by each technology.

Laboratory QC Data

The accompanying QC data such as spike recovery, continuous calibration checks, lab precision checks, etc.

Reference Laboratory Audit Results

A written narrative of audit visits made to the laboratory during the lab selection process.

Field Technology Data Management

The operators will be responsible for obtaining, reducing, interpreting, validating, and reporting data associated with their technology’s performance. Each operator will be required to provide the SNL field team supervisor with copies of the results obtained from each sampling point, as well as any graphical data used for the delineation of site contamination. SNL will compare this data to the data generated by the reference analysis. The operators also will be responsible for providing information about the assigned technology. This information will include a general description of the technology and how it is used in the field. Technology auditors will take notes on specific aspects of the technology. These notes will be based on a checklist created for each technology before the demonstration activities begin. The checklist will provide information that will be used in the Technology Verification Report.

In general, the checklists will contain the following items:

- Description of equipment used
- Logistical considerations including size and weight of technologies, power requirements, and other accessories needed, but not provided by the developer
- Historical uses and applications of the technology
- Estimated cost of the equipment or the cost of using the equipment
- Number of people required to operate the equipment
- Qualifications of technology operator
- Training required for technology operator
- Description of data each technology can produce and a description of the operational mode required for producing this data
- Analytes which the technology can detect
- Approximate detection levels of each analyte
- Initial calibration criteria
- Calibration check criteria
- Corrective action used for unacceptable calibrations
- Specific QC procedures followed
- QC samples used
- Corrective action for QC samples
- Description of the number of samples that can be analyzed in one work day
- Description of the amount of time required for data interpretation
- Description of the reports and graphics that each technology will produce
- Specific problems or breakdowns occurring during the demonstration
- Matrix interferences found during the demonstration

The operators will be responsible for reading the approved demonstration plan, as well as any other information submitted to SNL by the developers. A copy of the completed checklists will be included in the Technology Verification Report.

Laboratory Data Management

All samples will be collected and documented as described in Section 6. Each sample will be labeled with a unique sample number assigned in the field. The sample number will include a three-digit, alpha-numeric code that will identify the sample number, as well as the site from which it was collected. Each sample will be submitted for analysis accompanied by a field sheet containing additional information about the sample. Once a sample has been submitted for analysis, data associated with the sample will be managed as described below.

Data Management

A logbook will be used to document sample receipt for each sample submitted for analysis. Laboratory tracking will be performed by the operator responsible for sample analysis. Samples will be analyzed and the data obtained will be reduced, validated, and reported as described in Section 6. Sample result tables will then be transferred from the report forms generated by the operators to the computerized data management system by computer file transfer or by data entry transcription. In either case, all data transferred to the data management system will be checked for transcription errors before the actual statistical evaluation is performed.

Qualitative and Quantitative Analyses and Evaluations

Samples submitted for chemical analysis will be analyzed by a reference laboratory. Each shipment of samples sent to the laboratory will be accompanied by a chain-of-custody form, which will be completed by the laboratory's sample custodian and returned to the SNL project manager. Samples will be entered into the laboratory's Laboratory Information Management System. This system tracks the progress of sample analysis within the laboratory and provides a reporting format for sample results. After samples are analyzed, the data will be reduced, validated, and reported as described in Section 6.

Validated sample results will be sent to SNL for entry into its data management system. In addition to sample results, SNL will request QA/QC summary forms for the reference analysis. These forms will enable SNL to verify the quality of data generated by these methods. SNL will then transfer this data into its data management system. All data transcribed will be double-checked for accuracy in SNL's data management system.

Section 10 Health and Safety Plan

This chapter describes specific health and safety procedures SNL and its contract personnel will use during the field work to be performed at the demonstration sites. The demonstration sites include the Savannah River Site and McClellan Air Force Base. The Health and Safety plan is intended to apply equally to demonstration activities at both sites. The purpose of the HASP is to define the requirements and designate the protocols to be followed during the field work specified under Occupational Health and Safety Administration (OSHA) 29 CFR 1910.120(b) Final Rule. All SNL personnel, subcontractors, and visitors on site must be informed of site emergency response procedures and any potential fire, explosion, health, or safety hazards related to demonstration activities. A copy of the HASP will be provided to all SNL personnel, subcontractors, and site visitors who may be exposed to dangerous conditions during the demonstration. This HASP must be reviewed and approved by the SNL health and safety director (HSD), the SNL project manager, and the EPA CRD. A HASP compliance agreement form must be signed by all field personnel before they enter the site. Any revisions to this plan must be approved by the EPA CRD-LV and SNL.

Westinghouse Savannah River Site (SRS)

The SNL project manager, field site supervisor, HSD, and site health and safety officer (SHSO) will be responsible for implementing and enforcing the health and safety provisions of this HASP. Their duties are described in the following subsections.

Project Manager and Field Site Supervisor

The SNL project manager will ultimately be responsible for ensuring that all demonstration participants abide by the requirements of this HASP. The SNL field site supervisor will oversee and direct field activities and is responsible for ensuring compliance with this HASP.

Health and Safety Director

Site Health and Safety Officer

Joe Rossabi, Senior Engineer
Westinghouse Savannah River

Visitors

Savannah River Site: Generally restricted to U.S. citizens, but the demonstration area is not classified.

Site Background

Type: Contaminated subsurface field site.

Location: The GC/MS demonstration project will be conducted at the Department of Energy (DOE) Savannah River Site (SRS) located near Aiken, South Carolina.

Physical Description: The demonstration site is located at the M-Area settling Basin. The area is vacant and unpaved.

History: M-Area Site of SRS is primarily contaminated by chlorinated volatile organic compounds (CVOC), such as perchloroethene (PCE), also known as tetrachloroethene, trichloroethene (TCE), and trichloroethane (TCA) used in past manufacturing operations. The primary source of CVOC contamination is a cracked process untreated waste water line in the M-Area. Waste water contaminated with CVOC occurred from the 1950's to the 1980's.

Surrounding Population: The immediate area is populated with personnel working within the SRS facility. Personnel working at or in the vicinity of the site are on site only periodically for technology demonstration and monitoring activities.

Topography: The site is relatively level.

Site-Specific Hazard Evaluation

The field activities to be conducted at the SRS present a variety of chemical and physical hazards. Actual personnel exposure to these hazards are dependent on the specific work tasks, weather conditions, levels of protection utilized, and personal work habits.

The identified potential hazards associated with the GC/MS demonstration project are listed below.

- Chemical
- Fire
- Heat Stress
- Mechanical
- Unstable/Uneven Terrain
- Insect and Animal Stings or Bites
- Noise
- Electrical
- Inclement Weather

Exposure Pathways

Inhalation

The risk of inhalation exposure from chemical contaminants is considered minimal because the concentrations of contaminants being characterized are low and sampling is performed using sealed containment. However, if a chemical release occurred, chlorinated volatile organic compounds such as perchloroethene (PCE), trichloroethene (TCE), and trichloroethane (TCA) may pose an inhalation hazard to field personnel. Periodic sampling with air monitoring equipment will be conducted to prevent inhalation exposure to PCE, TCE, or TCA and ensure the safety of personnel.

Direct reading instrumentation, such as a TSI Inc. RCL 5000, will be used for initial contaminant vapor survey and as necessary to determine atmospheric vapor concentrations of CVOCs. These instruments will be used in breathing zones and during maintenance, sampling, and demobilization activities, and at other site areas and perimeter locations, as deemed necessary by the SITE HEALTH & SAFETY OFFICER.

Dermal Contact

Personal exposure to CVOCs may occur by absorption through the skin or eye surfaces. On-site action levels in regards to the designation of personal protective equipment will be determined by the SITE HEALTH AND SAFETY OFFICER and are described in section 10.9.

Ingestion

Personal exposure to CVOCs may occur by absorption through the gut after ingestion. Ingestion will be avoided. On-site action levels in regards to ingestion protection protocol will be determined by the SITE HEALTH & SAFETY OFFICER.

Health Effects

Chlorinated volatile organic compounds such as PCE, TCE, and TCA are classified by the National Institute for Occupational Safety and Health (NIOSH) as potential carcinogens. Symptoms of CVOC exposure include:

PCE: Perchloroethene (tetrachloroethene) - irritation of eyes, nose, and throat , dermatitis, and liver damage.

TCE: Trichloroethene - eye irritation, headache, vertigo, visual disturbance, tremors, nausea, vomiting, and dermatitis.

TCA: Trichloroethane - eye irritation, headache, lassitude, central nervous system depression, poor equilibrium, dermatitis, and cardiac arrhythmia.

Physical Hazards

Fire: A small potential for fire resulting from solvent vapor release and electrical equipment sparking associated with the CVOC extraction process exists. Neither TCE nor PCE is flammable. The potential for fire will be carefully considered during technology demonstration activities. The following specific actions will be taken to reduce the potential for fire during site activities:

- No smoking within 20 feet of the sampling sites.
- All electrical equipment will be grounded and maintained in accordance with Purus specifications and the current edition of the National Electric Code (NEC).
- Spark-proof tools will be used for all pumps and piping removal and reconnection.
- Hot work, including welding, will not be performed in potentially flammable atmospheres without prior monitoring by a combustible gas indicator.
- Fire extinguishers will be maintained on-site.
- All personnel will be trained on the location and use of portable fire extinguishers .

Heat Stress: Technology demonstrations are scheduled for mid-July. Heat stress may become a concern during the demonstration period because of elevated air temperature and relative humidity. Personnel will be provided adequate shelter, water, and work/rest regimens as required by environmental conditions. Additionally, sun screen may be used to reduce the risk of sunburn and skin damage caused by UVB solar radiation. Participants should bring their own PPE, lawn chairs, etc.

Mechanical: Machinery or equipment capable of movement will be stopped and the power source de-energized or disengaged, and if necessary, the movable parts mechanically locked or blocked to prevent inadvertent movement during cleaning, servicing, or adjusting operations. Controls will be locked in the off position and marked with accident prevention signs and/or tags. If machinery must be able to move during servicing, extension tools must be used to protect personnel from movement.

All other mechanical hazards, such as sharp edges, tripping hazards, bumping hazards, etc., will be identified and guarded or highlighted to ensure visibility and minimize the potential for personal injury.

Unstable/Uneven Terrain: Electrical cables represent a potential tripping hazard. When practical cables will be placed in areas of low pedestrian travel. If necessary, in high pedestrian travel areas, covers or bridges will be installed over cables. Site personnel shall attempt to minimize the potential for slips, trips, and falls by providing clean footing. Site personnel shall be aware of uneven terrain and existing ground level piping and conduit, and they shall maintain good housekeeping in the area. Permanent roadways, walkways, and material storage areas will be maintained free of dangerous depressions, obstructions, and debris.

Insect and Other Animal Stings and Bites: A potential for insect or other animal stings or bites exists during the technology demonstration period. Insect repellent may be used to minimize insect bite hazards. In the event of snake or other large animal bite, the injury will be immobilized and immediately reported to qualified medical personnel. All demonstration personnel will be notified of animal hazards at the initial safety meeting. Appropriate clothes should be worn.

Noise: Noise is not expected to be a hazard for the GC/MS technology demonstration and hearing protection is not required. However, hearing protection will be available on-site.

Electrical: All electrical connections and grounding will be in accordance with the current edition of the Nation Electric Code (NEC).

Inclement Weather: Severe weather conditions may generate lightning or flooding hazards. All site personnel will be responsible for monitoring weather conditions. If a potential for significant thunderstorm activity exists during demonstration activities, personnel will not be allowed in the field during the threat period. Personnel will take refuge in support shelters. Vehicles will not be driven in potential flood areas.

Training Requirements

All field personnel will complete a basic training course before assignment to any field activity. A minimum of 24 hours of OSHA training is required for unsupervised sites. Training will include:

- Medical surveillance, including recognition of signs and symptoms which indicate exposure to hazards.
- Recognition, evaluation, and control of chemical and physical hazards.
- Personal protective clothing and equipment.
- Safe use of engineering controls and equipment.
- Environmental monitoring equipment.
- Respiratory protection and respirator fit testing.
- Practical exercise in the use of personal protective equipment and monitoring instruments.
- Standard operating procedures and safe work practices.
- Site safety plan development.
- Emergency response plan development.
- Chemical decontamination procedures.

Prior to mobilization at the demonstration site all technology demonstration personnel will submit evidence of completion of a 24 hour OSHA training course and a letter from a physician stating that they have received a physical examination within one year and are physically capable of working at hazardous sites and wearing respiratory protection devices.

Prior to involvement in any field activity, all personnel will attend a safety briefing. The briefing will include the nature of the contamination, normal operating procedures, and emergency operating procedures.

Included in the initial briefing will be a review of:

- Visual emergency signals.
- Equipment capabilities and limitations.
- Nature of hazards and consequences of failure to use personal protective equipment.
- Emergency procedures.
- Contents of the Site Safety Plan and the individual’s responsibilities and duties in an emergency.

Review of MSDS or equivalent for the toxic materials present on site.

Personal Protection Requirements

Levels of Protection

Personal Protective Equipment (PPE) shall be appropriate to protect against known and potential health hazards encountered during routine sampling, operation, maintenance, and demobilization of the technology systems.

Protective Equipment and Clothing

Protective equipment and clothing will be selected based on known contaminant types, atmospheric concentrations, aqueous concentrations, and known routes of entry into the human body. In situations where the contaminant type, concentration, and exposure potentials are unknown, a subjective decision regarding the assignment of PPE will be made by the SITE HEALTH AND SAFETY OFFICER. The SITE HEALTH AND SAFETY OFFICER may choose to upgrade or downgrade the required PPE depending on work area conditions, atmospheric contaminant concentration, air temperature, or other environmental factors. All personnel will wear a modified D level ensemble.

Level of Protection: D modified

Respiratory Protection : None

Protective Clothing:

Suit Type:	Coverall (optional)
Boot Type:	Steel Toed
Glove Type:	Neoprene
Head Protection:	Hard Hat (as appropriate)
Eye Protection:	Glasses/Goggles
Hearing Protection:	Muff Type/Foam Inserts (optional)

Limitations of Protective Clothing

In the event of significant contaminant release, the site will be evacuated.

Duration of Work Tasks

Not applicable.

Respirator Selection, Use, and Maintenance

Not applicable.

Medical Surveillance

Health Monitoring Requirements

All personnel will successfully complete a physical examination. The examination will comply with OSHA 1910.120 requirements for hazardous waste site operations and will include:

- Occupational and general physical history.
- Complete physical examination which incorporates the head, torso, abdomen, limbs, and muscoloskelatal system.
- Chest x-ray, which may be waived in the judgment of the physician.
- Pulmonary function test.

- Audiometric test.
- Standard laboratory testing of blood and urine.
- Vision test.
- Electrocardiogram.

The following will be provided to the examining physician:

- Description of examinees duties.
- Anticipated exposure levels.
- Description of personal protection equipment requirements.
- Information from previous medical examinations.

The examinee will be informed of any medical conditions that would result in work restrictions that would preclude work at a hazardous waste site.

Documentation and Recordkeeping Requirements

Medical and personnel exposure monitoring records will be maintained in accordance with the requirements of 29 CFR 1910.120 and 8 CCR 5192.

Medical Support and Follow-up Requirements

In the event of a chemical exposure injury or illness, the SITE HEALTH AND SAFETY OFFICER and/or the PROJECT MANAGER will promptly initiate the steps necessary to identify the chemical(s). Chemical identification will be accomplished through the use of monitoring equipment and any available prior sampling data. The chemical agent(s) information will be made available to the treating physician and the PROJECT MANAGER.

Any injury or illness not limited to a first-aid response will require the SITE HEALTH AND SAFETY OFFICER to immediately notify the PROJECT MANAGER. Notification allows the coordination of resources to assist emergency response personnel and the treating physician in rendering appropriate care.

Any person suspected of having an overexposure to chemicals found on-site will be given another complete physical examination.

Environmental Surveillance

Initial Air Monitoring

Prior to arrival of technology demonstration personnel, air monitoring will be conducted around the perimeter and in the personnel breathing zones at the demonstration site. In the absence of representative personal exposure data, personnel breathing zones, varying site areas, and perimeter locations will be air monitored at the discretion of the FIELD SAFETY OFFICER. The air monitoring will determine atmospheric concentrations of CVOCs which may be present during sampling, maintenance, and demobilization activities.

Periodic Air Monitoring

Personnel exposure determination for each field activity will be made as frequently as deemed necessary by the FIELD SAFETY OFFICER.

Monitoring Parameters

Volatile organic vapors, as detected by the PID or FID, < 10.0 ppm above background require Level D protection with monitoring as necessary. Volatile organic vapors in the breathing space > 10.0 ppm above background requires the evacuation of all personnel not equipped at Level C.

Use and Maintenance of Survey Equipment

A Photovac Microtip photoionization detector and a flame ionization detector will be used to monitor CVOCs, within the environmental limitations of the instrumentation.

Heat Stress Monitoring

Air temperature and relative humidity will be monitored by appropriate instrumentation.

Site Control

The SITE HEALTH AND SAFETY OFFICER will enforce all site control requirements. Communications from the work site to other facilities will be by phone.

Site Control Zones

A warning barricade will surround the work area and warning signs stating hard-hats and safety glasses with side shields are required for entry will be posted as necessary and appropriate.

Safe Work Practices

Each company will provide the required training and equipment for their personnel on-site to meet safe operating practices and procedures and will be responsible for the safety of their workers. All general safety guidelines and procedures will conform to the following:

- 29 CFR 1910.120.
- Standard Operating Safety Guidelines (US EPA, November 1984).
- Westinghouse Corporate Health and Safety Requirements.

The following safe work practices will be implemented at the site for worker safety:

- Eating, drinking, chewing tobacco, and smoking will be permitted only in designated areas.
- Wash facilities will be utilized by all personnel before eating, drinking, or toilet facility use.
- All personnel will be required to wear hard-hats, protective glasses, and adequate hand protection on-site.

Health and Safety Plan Enforcement

A “three warning” system to enforce compliance with the Health and Safety Plan will be used.

- First infraction - violator receives a verbal warning.
- Second infraction - violator receives a written warning.
- Third infraction - violator will be requested to leave the site.

Complaints

Decontamination

Personnel Decontamination

As specified in CFR 1910.120.

Equipment Decontamination

Sampling equipment and tools affected by site contamination will be decontaminated using a water solution of Alconox, rinsed with tap water, and rinsed with distilled water. All contaminated site equipment will be decontaminated both before and after site activities. All uncontaminated equipment should be wiped with a wet towel at the close of site activities.

Decontamination materials will be containerized, labeled, and left on-site pending appropriate characterization of the material.

The following decontamination equipment and supplies will be used during the demonstration project:

- Alconox
- Distilled water
- Scrub brushes
- Towels
- Plastic buckets
- 55-Gallon DOT-17 drums

Emergency Contingency Planning

The objective of the Health and Safety Plan is to minimize chemical and physical hazards and operational accidents. The following directions are provided to ensure personnel respond to emergency situations in a calm and reasonable manner.

- Prior to commencement of field operations, an emergency medical assistance network will be established. Emergency phone numbers are listed in Section 10.16.5. A vehicle will be available on-site during all activities to transport injured personnel to the identified emergency medical facility. An ambulance or air-rescue will be on-call at the medical facility to transport seriously injured personnel to the nearest medical facility equipped to handle the specific emergency.
- Telephone numbers and locations of the nearest emergency room facilities will be posted at the site.
- At least two people will be present at the demonstration site during all activities.
- The SITE HEALTH AND SAFETY OFFICER will lead in all emergency situations.
- The SITE HEALTH AND SAFETY OFFICER will be certified to render first aid and cardio-pulmonary resuscitation (CPR) prior to initiation of field activities.
- A first aid kit will be available at the demonstration site.
- An emergency eye wash will be available at the demonstration site.
- An adequate supply of potable water will be available at the demonstration site.
- Demonstration personnel will be trained in emergency procedures during the personnel training sessions.
- Evacuation routes will be established by the SITE HEALTH AND SAFETY OFFICER and communicated to all personnel during the initial safety conference prior to field activity commencement.
- The SITE HEALTH AND SAFETY OFFICER will be responsible for ensuring that all personnel understand the specific emergency signals and procedures.

Injury in the Exclusion or Contamination Reduction Zones

Call for emergency medical assistance, notify the SITE HEALTH & SAFETY OFFICER, and render first aid. In an emergency, the primary concern is to prevent loss of life or severe injury to site personnel. In the event of protective equipment failure when immediate medical treatment is required to save a life, decontamination should be delayed until the victim is stabilized. If decontamination can be performed without interfering with essential life-saving techniques or first aid, or if a person has been contaminated with an extremely toxic or corrosive material that could cause severe injury or loss of life, decontamination must be performed immediately

Injury in the Support Zone

Call for emergency medical assistance, notify the SITE HEALTH & SAFETY OFFICER, and render first aid. The primary concern is to prevent loss of life or severe injury to site personnel.

Fire or Explosion

In the event of a fire or explosion, all site work will cease and the site will be evacuated. The SITE HEALTH AND SAFETY OFFICER will notify the PROJECT MANAGER and both will be expected to determine the appropriate action.

Protective Equipment Failure

In an emergency, the primary concern is to prevent loss of life or severe injury to site personnel. In the event of protective equipment failure when immediate medical treatment is required to save a life, decontamination should be delayed until the victim is stabilized. If decontamination can be performed without interfering with essential life-saving techniques or first aid, or if a person has been contaminated with an extremely toxic or corrosive material that could cause sever injury or loss of life, decontamination must be performed immediately.

Emergency Information Telephone Numbers

Person	Title	Phone Number
	Project Manager	
	Project Engineer	
	Medical Advisor	
	Center for Disease Control	(404)329-3311
		(404)329-2888
	National Response Center	(800)424-8802
	SRS Operations Center	@3-3911
(all emergencies)		

Hospital Route Directions

Directions to the nearest hospital, including a map, will be posted at the site.

Directions from SRS:

Turn left (north) on Road D
Turn left (west) on Road SRIA
Continue on SRIA to SRS Medical on right (north).

McClellan Air Force Base

Introduction

This section outlines Environmental Health and Safety measures to be adhered to during monitoring well sampling and analysis activities at McClellan Air Force Base. The majority of the document is taken directly from a health and safety plan developed by Radian Corp. and applies to well sampling activities to be carried out by Radian under special contract to Sandia National Laboratories. Radian is the on-site contractor responsible for routine well sampling associated with the base environmental program.

Field Activities and Key Personnel

Field activities during this demonstration can be summarized as follows. Approximately 40 water samples will be collected from 10 monitoring wells over a two-day interval. This activity will be conducted by Radian, the McClellan on-site contractor. These samples will be collected in bulk (approximately 2 L per sample) and transported to an SNL staging area at McClellan where they will be dispensed into appropriate sample containers and distributed to seven on-site developers. The samples will be analyzed by the developers during the course of the one-week demonstration at McClellan.

The following table lists the key personnel associated with the Monitoring Demonstration at the McClellan site.

Agency/Company	Point of Contact	Role
US EPA -NERL (Las Vegas)	Stephen Billets Eric Koglin	EPA Project Co-Lead
Sandia National Laboratories	Wayne Einfeld	Verification Org. Project Lead
Westinghouse Savannah River Site	Joe Rossabi Timothy Jarosch	Demo Design and Site Support Savannah River Well Sampling
McClellan Air Force Base	Phil Mook Timothy Chapman	Demo Design and Site Support
Radian International	Victor Auvinene	McClellan Well Sampling
DOE EM-50 (Special Technologies Laboratory)	Paul Wang	DOE EM-50 Demo Design Support
Axiom Analytical	Mike Doyle	Technology Developer
Electronic Sensor Technology	George Pappas	Technology Developer
GeoTech/ORS	Jim Butler	Technology Developer
Inficon	Chuck Sadowski	Technology Developer
Innova Air Tech Instruments	Michael Vecht	Technology Developer
Perkin Elmer - Photovac	Mark Collins	Technology Developer
Sentex Systems Inc.	Amos Linenberg	Technology Developer

Site Specific Hazard Analysis

This section presents a hazard assessment of conditions and contaminants known or suspected to be present during groundwater sampling activities at McClellan Air Force Base.

Chemical Hazards

A number of chemical contaminants have been detected in groundwater samples collected at or near McClellan Air Force Base (AFB) during the past few years. Compounds of particular interest include:

- Benzene;
- Carbon tetrachloride;

- 1,2-Dichloroethane;
- 1,1-Dichloroethene;
- Tetrachloroethene (PCE);
- Trichloroethene; and
- Vinyl chloride.

These compounds have been detected in relatively high concentrations in water samples, as revealed by a review of historical analytical results. Table 3-1 presents a list of these compounds and the approximate concentrations at which they were detected. It also identifies the wells where the samples were collected. Table 3-1 provides information which is useful for determining the potential for chemical exposure (i.e., the greater the concentration the greater the potential for volatile organic compound (VOC) emissions. Therefore, respirators equipped with organic vapor cartridges will be required when sampling all of the wells listed in Table 10-1, until real-time air monitoring provides documented data that VOC emissions do not present a hazard (as dictated by Table 10-?). Toxicological information and permissible exposure limits relating to these contaminants assist in defining the hazards associated with their contact. Table 10-2 presents the chemical hazards of these contaminants.

Due to their similarities in structure and composition, these substances produce similar health effects.
- Acute toxicity: Eye irritants; Central Nervous System (CNS) depressant (confusion, dizziness, nausea); and
- Chronic toxicity: Injury to liver, kidneys, and the adrenals.

In addition to the chemicals potentially present in the groundwater, strong acids, bases, and organic solvents (i.e., hexane, methanol) are used by field personnel to preserve specific compounds in groundwater samples or decontaminate sampling equipment. These chemicals may cause skin irritation and/or serious burns.

Table 10-1 Chemical Compounds in Monitoring Wells

Compound	Well Numbers	MCL (µg/L)	Amount Detected Above MCL
Trichloroethene	MW-128, 157, 158, 172	5.0	x 1000
Trichloroethene	MW-129, 41S, EC-1, EW-144	5.0	x 100
Trichloroethene	MW-26D, 27D, 65, 75 MW-132, 136, 139, 156, 159 MW-165, 166, 167, 173, 178 EW-137, 140, 141	5.0	x 10
Carbon Tetrachloride	EC-1, MW-172	0.5	x 100
Carbon Tetrachloride	MW-165, 173, 178	0.5	x 10
1,2-Dichloroethane	MW-128, 159	0.5	x 100
1,2-Dichloroethane	MW-172, EC-1	0.5	x 10
Tetrachloroethene	MW-157	5.0	x 100
Tetrachloroethene	MW-158	5.0	x 10
Benzene	MW-172	1.0	x 100
1,1,2,2-Tetrachloroethane	EC-1	1.0	x 10
Chromium	MW-160	0.05	x 10
1,1-Dichloroethene	MW-172	6.0	x 10
1,2-Dichloroethene	MW-172	16.0	x 10

MCL = Maximum concentration limit.
µg/L = Micrograms per liter of water.

Table 10-2 Chemical Hazards and Resulting Effects

Chemical Compound	PEL*	Symptoms and Effects
Volatile		
Carbon tetrachloride	2 ppm	These compounds produce similar health effects due to similarities in structure and composition. All are Central Nervous System (CNS) depressants. Exposures may result in headache, nausea, and an increase in reaction time; acute exposures may result in dizziness, narcoticlike effects, nausea, vomiting. Dermal exposures can cause dermatitis.
Dichloroethane	100 ppm	
Dichloroethene	200 ppm	
Tetrachloroethene (PCE)	25 ppm	
Trichloroethene	50 ppm	
Vinyl chloride	1 ppm	Vinyl chloride is a recognized human carcinogen. Acute exposure, produce CNS depression. Symptoms include dizziness, light-headedness, and nausea.
Benzene	1 ppm	Benzene is a suspect human carcinogen. Acute benzene exposure targets the CNS and is a proven hemotoxin. Studies have associated leukemia with chronic benzene exposure.

* PEL = The permissible exposure limit for 8 hours/day, 40 hours/week, for a working lifetime.

Physical Hazards

Several physical hazards are associated with field preparation and groundwater sampling activities. These hazards include:

- Trip and fall hazards associated with excess lengths of cable and discharge hose, blocking or congesting work areas;
- Overhead hazards resulting from hoisting pipe and equipment;
- Electrical hazards associated with the operation of generators;
- Pressurized gas cylinders (see Section 10.2.4);
- Fire hazards associated with the operation and refueling of motor vehicles and generators in remote, off-road locales;
- Working in areas of potential high vehicle activity;
- Increased braking distance for vehicles trailering water tanks;
- Burn hazard due to pressurized hot water when using steam cleaning equipment; and
- Heat stress.

Workers performing strenuous activities during the summer months may encounter heat stress conditions. Heat stress prevention procedures will be implemented when ambient temperatures exceed 90°F.

Radiological Hazards

Radioactive waste may have been discarded of in disposal pits and landfills found in OU C, and possibly in disposal pits or landfills found in other OUs at McClellan AFB. The most likely place to encounter the waste is in subsurface soils. There is the potential that some of the radioactive waste may have reached groundwater; however, at this time there is no evidence to support this possibility. These wastes include, but are not limited to low-level concentrations of: Cesium-137 (^{137}Cs), Strontium-90 (^{90}Sr), Radium-226 (^{226}Ra), uranium, contaminated waste water, and transuranic materials which may have been discharged or disposed of in the landfill areas (primarily OU C).

The radiological hazards associated with GSAP activities down gradient of known disposal pits and landfills, (in particular IC 19 in OU C) include the potential for direct exposure to, or ingestion, inhalation, and adsorption (through breaks in the skin) of ionizing radiation. Although the risk associated with this hazard is minimal, the safe work practices identified in Section 4.2.7 and the radiation monitoring procedures identified in Section 10.2.6.5 will address any potential radiological hazards. Cesium emits primarily beta radiation with secondary emissions of gamma radiation. Strontium emits only beta radiation and Radium emits alpha, beta and gamma radiation. Following "As Low As Reasonably Achievable" (ALARA) principles requires that strict radiological controls be maintained, and real-time radiological monitoring be conducted while work is proceeding in areas known to contain radiological hazards, and in uncharacterized areas suspected of containing radiological hazards. Hence, the radiation exposures are expected to be limited so as to be comparable to normal background radiation.

Internal radiation presents the greatest hazard to field personnel. External radiation also presents a hazard, but the measurements collected to date indicate that the hazards due to external radiation are low. Exposure to radiation will be controlled by performing radiation screening (as described in Section 6.5), using personal protective equipment and following strict decontamination and personal hygiene practices. Half face air purifying respirators with HEPA cartridges will be worn in areas suspected of having elevated radioactivity.

Table 10-3 (Monitoring Wells Down Gradient of Disposal Areas) identifies those monitoring wells which are located downgradient of known disposal pits and landfills. This table identifies the potential source and provides an approximate distance and direction of the monitoring well from the potential source.

Table 10-3 Monitoring Wells Down Gradient of Disposal Areas

Operable Unit	Site	WIMS-ES	MWs	Zone	Selection Rationale	Description
A	PRL 39	LF039	27D	B	<600' W	Landfill
A	PRL B-4	WP072	27D	B	<500' SW	Sludge drying bed
A	SA 60	WP217	68	A	<500' SW	Industrial wastewater drain
A	SA 96	WP247	68	A	<250' W	UST
A	CS 40	WP040	71	B	<200' SW	Industrial wastewater sludge
A	CS B-5	LF073	160	A	<100' SW	Empty lot
A	SA 69	WP224	172	A	<500' SW	Stream facility/UST
A	PRL P-8	WP084	175	A	<600' S	Acid and cyanide pit
A	SA 53	WP211	178	A	<500' S	Washrack
A	CS 38	LF038	186	A	<600' S to SW	Engine repair shop
A	SA 86	WP238	186	A	<1200' SW	Engine test/UST
A	CS S-7	WP092	203	B	<750' W	IWTP #3
A	SA 85	WP237	203	A	<650' SW	Oil/Water Separator
A	SA 73	WP227	222	A	100' Upgradient	Sump
A	PRL P-3	WP079	224	A	<100' SW	Steam Facility/UST
A	SA 101	WP252	228	A	<500' S	Sump
A	CS 24	LF024	243	A	<250' SW	Landfill
A	PRL B-2	DP070				
B	PRL B-1	LF069	145	A	<750' SW	Landfill
B	PRL B-9	LF076	149	A	<500' SW	Landfill

Operable Unit	Site	WIMS-ES	MWs	Zone	Selection Rationale	Description
B	SA 1	WP179	150	A	<500' SW	Surface disposal area
B	CS 48	WPO46	157	A	<500' SW	Abandoned IWTP
B	PRL 35	DPO35	217	A	<500' SW	Scrap metal burial pit
B	PRL S-5	WP090	217	A	<600' SW	Abandoned IWTP
B	CS 23	LF023	281	A	<100' SW	Landfill
B	CS 30	DP030	282	A	<500' SW	Surface spill area
C	CS 10	LF010	20D	A	<600' S to SW	Landfill
C	CS 43	LF043	20D	A	<500' SW	Burnpit
C	CS 52	DP050	20D	A	<100' SW	Burnpit
C	CS 11	LF011	44S	A	<600' S TO SW	Landfill
C	PRL 15	DP015	44S	A	<800' SW	Sodium valve trench
C	PRL 66C	WP062	44S	A	<500' W	Ditches and ponds
C	PRL 66D	WP062	44S	A	<1000' SW	Ditches and ponds
C	PRL 9	LF009	44S	A	<800' SW	Landfill
C	CS 13	LF013	62	A	<500' S TO SW	Landfill
C	CS 14	LF014	62	A	<600' S TO SW	Landfill
C	CS 67	WP063	62	A	At Well	Landfill
C	PRL 16	DP016	62	A	At Well	Sodium valve trench
C	PRL 50	WP048	62	A	<150' E	Settling pond
C	PRL 53	WP051	75	A	<600' SW	Settling pond
C	CS 42	LF042	128	A	<100' SW	Oil storage/landfill
C	CS 22	LF022	128	A	<500' SW	Burnpit/landfill

Operable Unit	Site	WIMS-ES	MWs	Zone	Selection Rationale	Description
C	CS 69	DP065	138	B	<700' SW	Burnpit
C	PRL 19	LF019	138	B	<500' SW	Landfill
C	PRL 21	DP021	138	B	<500' SW	Sludge/oil pit
C	PRL 66A	WP062	138	C	<750' SW	Ditches and ponds
C	PRL 57	LF055	139	A	<200' SW	Landfill
C	PRL 17	LF017	143	A	<1000' SW	Landfill
C	PRL 18	LF018	143	B	<500' SW	Landfill
C	PRL 20	DP020	143	A	<500' SW	Sludge/oil pit
C	PRL 41	LF041	143	A	<500' SW	Landfill
C	PRL 61	WP057	143	A	<1000' SW	Chemical waste pit
C	PRL 62	WP058	143	A	<1000' SW	Chemical waste pit
C	PRL 66B	WP062	143	A	<1000' SW	Ditches and pond
C	PRL 8	LF008	188	A	<500' SW	Sludge refuse/landfill
C	PRL 60	WP056	206	A	<50' SW	Holding ponds
C	PRL 65	LF061	286	A	<500'	Landfill
C	PRL 28	DP028	999	A	<100' SW	Skimming basin
C	PRL 68	WP064	999	A	<250' SW	Sludge ponds
D	CS 26	LF026	53	A	<100' W	Sludge/oil burn pit
D	CS 2	LF002	57	B	<50' SW	Sludge/oil pit
D	CS 3	DP003	57	A	<50' S	Sludge/oil pit
D	CS 6	DP006	57	B	<300' SW	Oil burn pit
D	CS A	DP151	57	A	<250' SW	Sludge disposal pit

Operable Unit	Site	WIMS-ES	MWs	Zone	Selection Rationale	Description
D	CS S	DP152	57	A	<250' SW	Fuel/solvent/oil burn pit
D	CS T	DP153	57	A	<250' SW	Fuel/solvent sludge pit
D	CS 1	LF001	91	A	<100' SW	Landfill
E	PRL 45	LF044	18D	B	<150' W	Paint waste landfill
F	PRL B-6	LF074	18D	B	5000'+ S	Waste area
G	None					No Waste/Disposal Pits or Landfills
H	PRL B-7	LF075	202		+2000' S	Spoil area

Safe Work Practices and Personnel Protection Methods

Work activities associated with this groundwater sampling program will involve some potential physical and/or chemical risks to field personnel. The following sections address the potential risks, the current work procedures, and personal protective equipment required to safely perform the various work activities.

Field Preparation

Several work activities, such as the addition of acids and bases to sample containers and the preparation of field blank water, are performed in advance of field activities. The following sections present safe work practices for these activities.

Sample Container Preparation

Acids and bases are used to preserve the groundwater for three types of analyses—SW Method 8020 (purgeable aromatics), SW Method 6010 (priority pollutant metals), and SW Method 9010 (total amendable cyanide). Hydrochloric and nitric acids are used to preserve samples for analysis by SW Method 8020 and SW Method 6010, respectively. A base, sodium hydroxide, is used to preserve samples to be analyzed by SW Method 9010. Small amounts of these acids and bases are added to the appropriate sample containers prior to initiating field activities. Liquid and vapor phases of these chemicals may cause severe burns; therefore, extreme care will be used when handling these chemicals.

Personnel handling acids and/or bases are required to wear long pants, long-sleeved shirts, and closed-toe shoes (preferably leather). In addition, the following personal protective equipment must be worn: acid-resistant vinyl or nitrile butyl rubber (NBR) gloves and chemical goggles or a protective face shield. All transfers will take place in a properly-operational fume hood or well-ventilated area. In the event of a small spill, the spill area will be thoroughly flushed with water.

If the acid has splashed onto the clothes or skin of an employee, the employee will immediately take an emergency shower and strip off the clothes while in the shower. Exposed areas will be rinsed for at least 5 to 15 minutes to ensure that the chemical has been completely diluted.

Occasionally, it is necessary to dilute concentrated stock solutions of acid. On these occasions, a protective splash apron will be work in addition to the previously-mentioned protective equipment. The dilution of acid with water creates an exothermic reaction which may generate a large amount of heat. To avoid excessive heat generation, small amounts of the acid will be added to a large volume of cool water. Small spills of concentrated acid will be neutralized with soda ash or sodium bicarbonate prior to flushing the area with water.

If a large spill of concentrated acid occurs, the individual will leave the area after advising others in the immediate vicinity of the spill. The area must be ventilated. The spill will be cleaned up only after a qualified health and safety professional has determined that the proper personal protective gear has been donned and that an appropriate cleanup plan has been identified. These spills usually can be neutralized with soda ash or lime.

Field Blank Water Preparation

The preparation of field blank water involves boiling deionized water on a hot plate and subsequently bubbling an inert gas through the cooled solution. Potential hazards arise when boiling water in Pyrex® containers and using compressed gases such as helium and nitrogen.

Boiling water will be supervised at all times to ensure that the container does not boil to dryness. Safety glasses with side shields and thermal protective gloves will be worn when handling the hot flasks.

Compressed Gases

Occasionally, compressed gases may be required to calibrate or operate field or laboratory instruments. The following procedures are designed to protect against employee injuries due to the improper use of compressed gases. The OSHA standards applicable to compressed gas use and storage may be found in 29 CFR 1910.101 through .105, and .166 through .168. Each person receiving, storing, and/or using compressed gases is responsible for implementing the following procedures.

Cylinder Receipt and Content Identification

When a cylinder is delivered to the receiving area, it should have attached:

- An identification label and/or marking indicating contents;
- An I.C.C. label; and
- A valve protection cap.

Under no circumstances should the means of identification be removed from the cylinder. The valve protection cap should also remain in place until the user has secured the cylinder and is ready to release the contents.

Securing of Cylinders

All cylinders must be secured to a wall, I-beam, or other immovable object by a safety chain or strap. If being transported in a portable cart, they must be secured by safety chain.

Compressed gas cylinders will be securely chained at all times to prevent accidental damage to the regulator head. When gas cylinders are not in use, main valves will be closed and any excess pressure to the regulator will be released. IF the cylinder is not to be used for an extended period of time, the regulator will be removed from the cylinder and the protective cover will be placed over the main valve. When gas cylinders are not in use, main valves will be double-checked to insure they are off. When the cylinders are in use, adequate ventilation will be provided to ensure sufficient oxygen replacement in the event of a system leak.

General Precautions for Handling and Storing

Any worker handling compressed gas cylinders will observe to the following precautions:

- Cylinders should never be dropped or permitted to strike each other violently.
- Cylinders may be stored in the open but should be protected against extremes of weather and from the dampness of the ground. Cylinders stored in the open should be shaded against direct sunlight.
- Cylinders will not be dragged, rolled or slid, even for a short distance. They will be moved by securing them and using a suitable hand truck.
- Safety devices in valves or cylinders shall not be tampered with.
- All empty gas cylinders will be marked with a tag labeled "EMPTY".
- No part of a cylinder should be subjected to a temperature higher than 125° F. A flame should never be permitted to come in contact with any part of a compressed gas cylinder.
- Cylinders will not be placed where they may become part of an electric circuit. When arc welding, precautions must be taken to prevent striking an arc against a cylinder.
- Oil, grease, or lubricants must not be used on any compressed gas tubing or piping fitting or thread.
- Teflon® tape or pipe joint compound must not be used on any gas compression-type fitting.

Regulator Handling and Use

A regulator should be attached to a cylinder without forcing the threads. If the inlet of a regulator does not fit the cylinder outlet, no effort should be made to try to force the fitting. A poor fit may indicate that the regulator is not intended for use on the gas chosen.

The following procedures should be used to obtain the required delivery pressure:

- After the regulator has been attached to the cylinder valve outlet, turn the delivery pressure adjusting screw counter-clockwise until it turns freely;
- Open the cylinder valve slowly until the tank gauge on the regulator registers the cylinder pressure;
- Never drain a cylinder below a gauge reading of 25 pounds per square inch; and
- Never use a "valve wrench" to close valves (it can damage some diaphragms).

Handling of Empty Cylinders

When cylinders are considered empty, the valves must be closed. Valve protection caps, outlet dust caps and other accessories shipped with the cylinder should be attached to the cylinder as received. The cylinder should be marked or labeled "EMPTY" or "MT." Cylinders should then be placed in a proper storage area to await pick-up for return to the supplier.

Carelessness in the handling of an empty cylinder could result in someone mistaking it for a full cylinder. connecting an empty cylinder to a high-pressure system could cause foreign materials to back up into the cylinder, creating all the attendant hazards of "suck-back" and possibly a violent reaction within the cylinder.

Leak Detection and Control

Leaks can be detected by painting points suspected of leakage with soapy water. A leak will cause bubbling. Never use a flame of detect leaks. If a leak cannot be easily repaired, it should be returned to the supplier, and the supplier notified of the defect.

Field Activities

The following subsections present safe work practices for the various field activities associated with sample collection and the decontamination of sampling equipment with organic solvents.

Personal Protective Equipment (PPE)

All Radian field personnel will be required to have the following PPE available at all times:

- Steel-toe leather or rubber boots;
- Chemical resistant gloves (nitrile butyl rubber-NBR);
- High voltage gloves;
- Half-face or full-face air purifying respirator;
- Organic vapor cartridges;
- Safety glasses with side shields;
- Real-time organic vapor monitor;
- Hard hat;
- Tyvek® coveralls or apron; and
- Additional safety equipment to be carried in the sampling vehicle at all times including: the Health and Safety Plan, a first aid kit, fire extinguisher, portable emergency eye wash station, orange pylons, and an audit checklist.

All field personnel will wear steel-toe leather or rubber boots when performing monitor well sampling. Nitrile butyl rubber (NBR) gloves will be worn during the sampling process to protect personnel from contaminants and organic solvents, and to ensure sample integrity.

Safety glasses with side shields will be worn while working around the compressor and discharge line of the sampling apparatus during the purging of the wells. Hard hats will be work when working in areas where overhead hazards exist.

All field personnel will be fit-tested with a half-face and a full-face air purifying respirator prior to commencement of field activities. Organic vapor chemical cartridges will be used with the air purifying respirators. Respirators are not expected to be used routinely, but will be available for use if air monitoring results indicate the need.

Work practices which promote the safe and healthful use of air purifying respirators include:

- Respirators which are hot in use shall be kept in clean plastic bags and carried in a rigid container (to prevent facepiece disfiguration) in the sampling vehicle at all times;
- Respirators shall be cleaned with a sanitizing solution recommended by the respirator manufacturer, and rinsed with clean water at the end of each work day in which it was used; and
- Respirators equipped with organic vapor cartridges (OVCs) will follow a regular OVC replacement schedule. Each OVC shall have the respirator installation data clearly marked on the cartridge. An appropriate OVC replacement schedule would be:
    - Once each week with little to no use of the respirator;
    - Once every other day with consistent (daily) use of a respirator in organic vapor concentrations of 1 - 100 ppmv;
    - Once each 8 hours of use in organic vapor concentrations greater than 100 ppmv (> 100 ppmv);

- Once every hour of use in organic vapors in which there is any detectable vinyl chloride*****.

*****See Appendix B for further direction on the use of organic vapor cartridges for protection against vinyl chloride.

Approach to the Well

Many monitor wells are located in large remote fields. These fields are often overgrown with waist-high vegetation that may obscure drainage ditches known to be present throughout many of the fields. When approaching wells under these conditions, one person will walk, 30 to 50 feet ahead of the vehicle to check for drainage ditches and hidden debris.

During periods of moderate to heavy rain, the stability of the ground also will be checked to ensure adequate traction for the vehicles. If a vehicle should become stuck, the field crew will be careful in any attempts to free it. If, after a few attempts, the vehicle is still stuck, additional help will be sought rather than jeopardizing worker safety.

Vehicle Traffic

It will be necessary to perform sampling at wells where vehicle traffic may be present. High visibility cones or barrier tape should be used to warn approaching vehicles and to direct traffic safely around sampling activities. Once the sampling vehicle/water trailer is positioned at the well, cones and/or barrier tape should be erected. Adequate clearance should be left around the sampling location to allow the sampling activities to be completed safely. Special precaution should be used around blind corners and in areas potentially used as short-cut routes.

Sampling the Well

As a precautionary measure, a respirator shall be used when removing the well pipe cap on all non-dedicated wells, and wells with a known history of organic vapor emissions, and wells for which organic vapor emissions have not been characterized.

Real-time air monitoring will be conducted in the worker's breathing zone (BZ) with an organic vapor monitor (OVM) photoionization detector, and the method of collecting measurements in the BZ will be standardized. This will be done by providing a suitable support for the instrument so that the instruments air inlet can be positioned 12"-18" above the well casing in the vicinity of the workers BZ. This can be accomplished by using a bucket for the ground level completions, and a tripod for the above ground completions. All OVM measurements will be adjusted in respect to background measurements. For instance, if background OVM measurements indicate 2 ppmv organic vapor concentration (OVC), and BZ measurements indicate 7 ppmv (OVC, assume 5 ppmv OVC is present in the BZ because of emissions from the well.

Hazard Analysis—Equipment Operation

Field team use of numerous pieces of equipment creates some potential inherent physical hazards, as follows:
<u>Water Trailer</u>—The water trailer adds considerable weight and length to the sampling vehicle, making the turning radius greater and stopping distance longer. Drivers will be aware of these conditions and exercise added caution when towing the trailer.
When backing a trailer, care will be taken to avoid jack-knifing the trailer. Backing will be done slowly, with gradual direction corrections. Abrupt changes in direction at moderate speeds may cause the trailer to jack-knife.

Special care will be exercised when hitching and unhitching the water trailer. When backing the vehicle up to the water trailer, a second team member will stand off to the side to direct the driver. No sampling team member will stand between the trailer and the moving vehicle. The vehicle's transmission will be placed in "Park," and the parking brake firmly applied before hitching or unhitching the trailer.

Refueling Equipment—Refueling equipment (generators and compressors) will be necessary. Engines will be allowed to cool 3 to 5 minutes before adding fuel. Care will be taken not to overfill gas tanks. If a spill should occur, the excess fuel will be wiped up before restarting the engine. Chemical-resistant gloves will be used when handling fuel. Chemical-resistant gloves will then be properly disposed of and uncontaminated gloves will be donned before sampling.

Generators—Electric generators will be operated with caution, as they pose a hazard for potential electric shock. The generator will never be operated during wet conditions and worker's hands will be dry when using this piece of equipment. During an equipment emergency, high voltage gloves will be used to operate or shutdown the equipment.

Steam Cleaner Operation—During steam cleaner operation, extra caution will be exercised to avoid serious burns. Safety glasses and protective gloves will be worn by all personnel involved with steam cleaner operations. Control of the steam jet will always be maintained, and workers will avoid contact with the backspray. Workers also will avoid contact with the propane burner exhaust. The metal surfaces around the exhaust get extremely hot and can cause severe burns.

Submersible Pump—The submersible pump shall not have the electrical supply connected while being lowered or raised from the well. This will reduce the probability of electrical shock or arcing hazard.

Sample Handling and Collection

Skin contact with contaminated water or equipment shall be avoided at all times. Extra caution will be exercised when filling bottles containing acid or base preservatives. Following sample collection, sample container lids will be tightened to prevent any leaks, and the containers rinsed with clean water to ensure that the bottle surfaces are free of contaminated water. Containers will then be inserted into protective foam sleeves and placed in ice coolers to prevent breakage during transport. Employee procedures and work practices to be followed during groundwater sampling include the following:

- Field personnel shall position themselves upwind of chemical exposure sources when conducting well sampling, sample collection, and equipment decontamination procedures.
- PVC or NBR gloves and safety glasses with side shields shall be work when filling sample containers and when handling equipment or sample containers that have come in contact with groundwater.
- A smooth rubber or vinyl protective edge shall be secured to the rim of the well pipe above ground level when rising and lowering the submersible pump. This will prevent the abrasion and scraping of the electrical lines of the submersible pump on the well casing.
- The power switch for the winch control shall be inspected to ensure it is grounded and waterproof.
- The downhole electrical line shall be secured to each section of pipe going into the well to prevent abrasion against the well pipe.
- A tension gauge (i.e., spring) installed on the pulley assembly for the submersible pump shall provide a degree of cable play. It should also provide an indication of increased line tension if, for example, the submersible pump should get hung up in the well pipe.

- During removal of the sampling line (pipe) from the well, all pipe breaks will be kept at waist height to reduce the splash hazard of water in the line and facilitate handling of pipe.

Radiation Exposure Control

Radian strongly supports the Air Force's policy to maintain individual and collective dose equivalent exposures to radiological hazards ALARA. The overall objective of Radian's ALARA program is to control radiation exposure to members of its staff, its subcontractor's staff, and members of the public such that all exposures are well below applicable regulatory limits. It is the policy of Radian that individual and collective dose equivalents be maintained at ALARA levels. Natural background, therapeutic, and diagnostic medical exposures will not be included in exposures from occupational sources.

Occupational and non-occupational radiation exposure guidelines have been recommended by the Nuclear Regulatory Commission (NRC) and the National Council on Radiation Protection and Measurement (NCRPM). The recommended maximum whole-body radiation dose is currently 5 rem per year. In the past, an action level of 2 mR/hr was recommended for hazardous waste workers. This dose was derived from NRC annual permissible exposure limits. This 2 mR/hr level is still used by Department of Defense agencies. EPA has recommended an action level of 1 mR/hr. This is considered an extremely safe level. An individual would have to be continuously exposed to 1 mR/hr for 14 hours per work day for an entire year before the maximum recommended annual dose limit of 5 rem would be exceeded.

The primary means of controlling radiological exposures are by controlling access (minimize contact through isolation and containment of the material) and duration of stay in radiation areas. The methods used to control exposure include evaluating the radiological conditions, specifying proper precautions, providing experienced health physics planning and job coverage, providing extra controls for high radiation areas, posting areas, using appropriate protective clothing, monitoring personnel, and updating personnel records to determine where exposure reduction is warranted. Radian's policies and practices toward radiological protection are based on program requirements presented in 10 CFR 20, and in the Department of Energy's (DOE) Radiological Control Manual. In combination, these practices all play important roles in controlling exposures.

The Project Health and Safety Officer (PHSO) will determine the appropriate levels of protection when work activities are not covered by standard procedures.

Personal Hygiene

Personal hygiene is the most effective way to control potential chemical exposure from skin absorption or accidental ingestion of hazardous compounds. Some general rules to obey when working the field include:

- Wash your hands and forearms with soap and water before eating, drinking, or smoking;
- Immediately wash exposed areas of the body which contact contaminated liquid or equipment;
- Wash your hands before using the toilet;
- Take a thorough shower at the end of the day;
- Wear clean work clothes at the start of each workday, and change work clothes at the end of each workday;
- Immediately change clothing saturated with contaminated liquids; and
- Store food and personal gear separately from contaminated equipment and sample containers.

Adverse Weather

Sudden inclement weather can encroach on samplers in the field. Field crew members shall carry the appropriate clothing for changeable weather. In severe weather conditions (i.e., high winds or electrical storms), the sample crews will leave the area and find shelter until the weather permits continued sampling or a decision is made by the field task leader to halt the sampling activities.

Personnel Training and Medical Surveillance

Safety, Health, and Emergency Response Training

All authorized on-site personnel must have satisfactorily completed the required Occupational Safety and Health Administration (OSHA) 24 hour or 40-hour Hazardous Waste Training Course and the annual eight-hour refresher training (when necessary) as specified in 29 CFR 1910.120. In addition, field personnel with supervisory responsibilities will have completed the eight hour supervisors training class. All field personnel working independently of an immediate supervisor will be required to have three days of direct supervision. Before work begins, a site-specific safety orientation will be conducted by the field coordinator and/or project health and safety officer for all employees and subcontractor personnel engaged in field work. The orientation will include:

- Review of the employees rights and responsibilities under OSHA;
- Health effects and hazards of the chemicals identified or suspected to be on site;
- Protection against chemical and physical hazards, snakes, insects, animals, and human pathogens;
- Implementation of the "buddy system";
- Personal hygiene;
- Decontamination procedures;
- Standard safety procedures;
- Personal protective equipment (PPE);
- Work area/zone health and safety information including:
- Site layout,
- Procedures for entry and exit of areas and zones, and
- Standard safe work practices;
- Medical surveillance program; and Emergency procedures, including:
- Emergency contacts,
- Instructions for implementing the emergency response and contingency plan, and
- Location of emergency equipment.

The project director or field coordinator must record the participants' signatures on the Health and Safety Documentation Form (Appendix A) and must provide weekly safety meetings. The topics to be discussed and recorded during the weekly safety meeting include:

- The date\time of the meeting;
- Who conducted the meeting;
- Where the meeting was conducted;
- The topics discussed;
- Accidents reviewed;
- Suggestions/comments; and
- Participants' signatures.
- A record of the meetings, topics discussed, and meeting attendees must be maintained in the project field log.

Training Workers Potentially Exposed to Radiological Contamination

At least one team member who will be working in areas potentially contaminated with radiation will participate in a radiation safety training course. The training event will consist of modular video presentations supplemented with hands-on training with the radiation monitoring instruments. The training will last approximately 60 minutes and will cover the following subjects:

- Basic radiation physics;
- Biological effects;
- Radiation risks to workers;
- Background radiation; and
- Radiation regulations.

The hands-on portion of the training will familiarize the field personnel with the proper selection and use of portable radiation survey instruments, the proper scanning techniques for each instrument and material type (soil core, PPE or skin), how to interpret readings from the instrument, and how and where to record results of the screening. Field personnel who will be working in potentially contaminated areas will be required to attend the training. Attendance at the training will be documented by the PHSO.

Medical Surveillance

This section discusses what the medical surveillance program (as required by 29 CFR 1910.120) entails, how the results are reviewed by a physician, and how participation is certified.

Medical Surveillance Program

Radian and subcontractors provide their employees with a biannual in-depth medical examination, and a physician's interpretation of each employee's medical surveillance examination, including the ability of the employee to wear a respirator. These medical records are available to the employee. Before site operations begin, subcontractors must submit documentation of all site employees' participation in their medical surveillance program to the Radian project director.

A comprehensive medical examination shall be performed if an employee develops signs or symptoms indicating possible overexposure to hazardous substances and/or heat or cold stress.

Physician Review

All medical surveillance and examination results are reviewed by a licensed physician certified in Occupational Medicine by the American Board of Preventative Medicine. All field personnel will be approved to perform the necessary work.

Exposure Monitoring Program

Real-Time Photoionization Detector (PID)

At the beginning of well sampling activities at each location, a real-time instrument capable of detecting organic vapors (e.g., a photo-ionization detector (PID) will be used to sample the vapors at the well pipe immediately after removing the well pipe cap, and after purging 1 to 2 well volumes. When conducting real-time air monitoring in the worker's breathing zone (BZ) with the PID, the method of collecting measurements in the BZ will be standardized. This will be done by providing a suitable support for the instrument so that the air inlet can be positioned approximately 12 to 18 inches above the well casing in the vicinity of the workers BZ. This can be accomplished by using a bucket for the ground level completions, and a tripod for the aboveground completions. All PID measurements will be adjusted in respect to background measurements. For instance, if background PID measurements indicate 2 ppmv organic vapor concentration (OVC) and BZ measurements indicate 7 ppmv OVC, assume 5 ppmv OVC is the concentration in the BZ resulting from emissions from the well. Detectable concentrations of organic vapors will require the field crew to follow the appropriate responses listed in Appendix B, and developed specifically for the Groundwater Sampling

Personnel. Organic vapor concentrations at groundwater monitoring wells will be recorded on a data log.

Detector Tubes

If the real-time instrument detects contaminants at the well head, air samples will be collected using direct reading Draeger® colorimetric indicator tubes, as directed by other Radian documentation. These indicator tubes will determine the presence of likely contaminants in the atmosphere near the well. Contaminants to be monitored include 1,1,1-trichloroethane, 1,1,2-trichloroethene, 1,1-dichloroethene, 1,2-dichloroethane, and vinyl chloride. The air samples will be collected by drawing a known volume of air through a Draeger® tube and observing any colorimetric change indicating the presence of airborne contaminants. An estimate of contaminant concentration can be assumed by observing the portion of the detector tube with any detectable color change and matching that to the values marked on the side of the detector tube. Care should be exercised to use the correct number of compressions of the Draeger® pump for the detector tube being used. Directions for the proper number of compressions can be found in the instructions contained in each package of detector tubes.

Field team members should be aware that actual air contaminant concentrations can vary by 25% from the values displayed by the detector tubes. Detector tubes may also indicate false positives because more than one chemical compound may cause a reaction resulting in a similar reading. The field team has to assume that a compound indicated as a false positive is actually present in the air, and respond according to the Hydrocarbon Response Criteria (Appendix B), and the Detector Tube Response Table (Appendix C).

When using the hand pump, care should be exercised to:

- Completely compress the bellows;
- Allow sufficient time for the bellows to completely expand; and
- Use the correct number of compressions (as dictated in the instructions for the detector tubes).

Readings will be taken at the well head and in the field team members breathing zone.

Data Log

A log of the results of the real-time instrument and the detector tube observations will be made part of the permanent field project file. This log will contain historical data on each well, and will be available for reference in the field preceding well monitoring operations.

The following information will be recorded on a field data sheet:

- Time and date;
- Location;
- PID results, initially and after purging;
- Type of detector tubes (if required)
- Color change; and
- Individual performing tests.

Heat Stress

During the summer, the field activities at McClellan AFB involve working in warm to hot temperatures, often over 100°F. An appropriate work/rest regimen should be initiated under hot conditions. An example would be a 20 to 30 minute work period followed by a 10 minute rest period in a shaded location. The body's reaction to heat stress can be determined by monitoring the person's heart rate (HR). If the HR is higher than 110 beats per minute, the next work period should be shortened by 33%, while the length of the rest period stays the same. If the HR is 110 beats per minute at the beginning of the next rest period, the following work cycle should also be shortened by

33%. Resting HR should be determined prior to the start of on-site activities. For a healthy individual, the resting HR is usually 60 to 72 beats per minute. If symptoms of heat stroke are observed, workers will seek medical attention immediately and contact the Project Safety Officer.

When field teams are working in these high temperatures, precautions will be taken to avoid heat stress illnesses. These precautions include:

- A shaded work area;
- Provide adequate quantities of liquids, such as water or Gatorade™; and
- A clean towel which can be moistened and used to cool heat-stressed personnel.

Heat-related disorders can range from dizziness, nausea, and profuse sweating in the early stages, to unconsciousness, brain damage, or even death in the late stages (see Section 10.2.7.2).
Heat stress can be prevented by establishing work-rest regimens and avoiding overexertion. Liquids should be replenished frequently throughout the day. Workers also should rest in the shade, away from surfaces that radiate heat (metal or concrete) as often as possible so they may more efficiently cool down during rest periods.

Radiation Monitoring Procedures

(Note: This section applies only to the monitoring wells identified in Table 10-3.)

Before sampling the well, the well casing will be screened with the NaI detector/ratemeter. After confirmation that radiation does not exist above background levels, the well sampling procedures may continue. If elevated concentrations are detected (greater than 2X background), follow the instruction provided in Appendix D.

Downhole sampling equipment, samples, etc., will be scanned during retrieval from the well, and after retrieval from the well. All sampling and monitoring equipment will be screened for radiological contamination after use, but before being removed from the site. The filled sample containers and sampling equipment (bailer, downhole line, purge line, water level meter, pH test kit, etc.) will be placed on plastic sheeting (if possible). These materials will be scanned using a NaI detector/ratemeter combination (for beta gamma radiation) with the detector at a distance of 1 cm above the object being scanned. Scan equipment slowly (about 1 foot/min.) when the equipment is being removed from the hole and after being placed on the plastic sheeting. Hold the instrument steadily in one position when scanning the open portion and exterior of the filled sample container. Using the audible response of the survey meter, listen for changes in the rate of response. Record the instrument reading at the highest rate. If the instrument reading exceeds twice the background level, consider the sample or equipment to be potentially contaminated and follow the procedures indicated in Table 5-3. If measurements indicate greater than 2X background levels, continue to scan the exterior of equipment and sample containers with the G-M and alpha scintillation detector (using the same technique described above), stop work, and follow the procedures provided in Appendix D.

If contamination exceeds 2X background, all personnel will conduct a self-screen of hands, shoes, socks, lower portion of legs, lower portion of arms, head, and neck. Any detectable radioactivity shall be removed from personal clothing or body surfaces prior to exiting the area. Follow the decontamination procedures described in Section 7.0 of this Plan. If contamination cannot be removed, contact the Base RSO and await his/her instructions prior to exiting the area. During emergencies, requirements for prompt medical care or for emergency evacuation take precedent over monitoring requirements.

Personnel Exposure Investigations

If a situation occurs involving a suspected or known personnel exposure to ionizing radiation in excess of the limits presented in Table 10-4, the situation will be promptly investigated by the PHSO and may include special bioassays, radiation surveys, air sampling, or dosimeter analyses. Such an occurrence shall also be reported immediately to the EMR field representative and the appropriate regulatory agency. Management response and follow up should be effective, inclusive of stopping work, if necessary, to ensure that appropriate corrective actions are taken to preclude the recurrence of the accident or incident. The incident investigation report shall identify root cause(s) of radiation performance problems. A report of the incident will be provided to the contracting officer with the timeframe established in the McClellan Base Contract.

Site Control Measures and Decontamination Procedures

Contamination control procedures minimize the possibility of transferring hazardous substances from the site. These procedures consist of site control measures (the delineation of work zones, communications, and site security) and decontamination procedures (necessary for both personnel and equipment). Contaminants encountered during sampling operations must not be transferred outside the work zone unless properly containerized, and must be removed from clothing, personnel, and equipment prior to relocation from that zone.

Site Control Measures

Site control can be achieved through effective delineation of the work zone, by providing a means to communicate, and by establishing site security.

Work Zone Delineation

To minimize the transfer of hazardous substances from the site and to ensure proper protection of personnel during sampling operations, three work zones will be established. The site safety officer, a role filled by the field team leader, will establish the three contiguous work zones: 1) the exclusion zone (EZ); 2) the contamination reduction zone (CRZ); and 3) the support zone (SZ).
During field survey activities and other activities deemed appropriate by the field coordinator, no formal work zones will be delineated. However, if air monitoring by a photoionization detector (PID) indicates organic vapor concentrations at 0-5 ppm above background, or if radiological activity is detected at 2X background, Radian's site health and safety officer must divide the work area.

Exclusion Zone (EZ)
Contamination does or could exist in this zone. Only properly authorized and trained individuals wearing appropriate personal protection equipment (PPE) will be allowed to enter and work in this zone. All people entering the EZ must wear at a minimum Level D protection. If space allows, the outer boundary of the EZ will initially be established as a 20-foot radius circle surrounding the monitoring well. This outer boundary, or Hotline, will be defined in the field by printed hazard ribbon, cones, or flags. The EZ boundary may be adjusted as monitoring information becomes available.

Contamination Reduction Zone (CRZ)
The CRZ will be located upwind of the EZ, between the EZ and the SZ and will provide a transition area between the potentially contaminated EZ and the clean SZ. Exit from the EZ will occur through this CRZ. The CRZ will limit the transfer of contaminating substances on people, equipment, or in the air through a combination of decontamination and zone restrictions. Within this zone, personnel may perform limited personal decontamination (e.g., face and hand washing) and certain PPE and

small equipment decontamination. Buckets or wash basins for decontamination may be stationed on a sheet of plastic.

Support Zone (SZ)

The SZ will be located upwind of the EZ (where possible) and considered an uncontaminated area. Support facilities (mobile field office), equipment, vehicles, PPE, food storage, and a first aid station will be located in this zone. Potentially contaminated personal clothing, equipment, and samples are not permitted within this zone unless properly containerized.

Site Security

No special site security measures will be required except those required by McClellan AFB. Limited access to the base should eliminate specific site security requirements except those needed to maintain site integrity, such as secured (locked) well caps.

Decontamination Procedures

Decontamination of personnel and equipment leaving the EZ will be performed to minimize human exposure to hazardous substances and to minimize contamination of surrounding areas. The CRZ allows limited personnel decontamination and the decontamination of certain PPE and small equipment. If the decision is made not to establish an EZ or CRZ, decontamination will be performed on site in a manner deemed appropriate by the site safety officer. More extensive personnel decontamination may be performed at Radian's support facilities, and larger equipment will be decontaminated at the central decontamination area.

Radiological Contamination

The primary problem associated with the radionuclides anticipated is the spread of contamination to individuals, uncontaminated areas of the base, private autos, etc. Spread of contamination to individuals can involve possible uptakes of radionuclides into the body by inhalation or ingestion. Hence, emphasis will be placed on radiation monitoring of all samples and equipment exposed to monitoring wells with the potential for radiological contamination. Radiological contamination is defined in Table 7-1.

Table 10-4 Surface Radiological Contamination Limits

(Adapted from NRC Regulatory Guide 1.86)

Type of Radioactivity	Total Contamination[1]	Removable Contamination[2]
Alpha	300 dpm / 100 cm^2	20 dpm / 100 cm^2
Beta-gamma	5000 dpm / 100 cm^2	1000 dpm / 100 cm^2

dpm: disintegrations per minute

[1] Correction for probe size and efficiency shall be considered. For a G-M detector with a pancake probe, the correction factor will be approximately 60 (e.g., multiply the measured value by 60 for comparison with the table values); for an alpha scintillation probe of about 50 cm^2 area, the correction factor is approximately 6.

[2] Determined by taking a swipe with a soft, absorbent paper using moderate pressure. If area is less than 100 cm^2, wipe entire surface.

Personnel Decontamination

Persons leaving the EZ must first follow decontamination procedures in the CRZ. Hand tools and other sampling equipment used in the EZ and reusable PPE (boots, safety glasses, etc.), will be cleaned prior to removal from the site each day. The step-by-step sequence for personnel decontamination is as follows:

- Wash outer gloves and boots at the boot-washing station;
- Remove wrist tape and outer gloves, and place in a disposal container;
- Remove ankle tape and disposable coveralls and place in the disposal container;
- Remove respirators and place in designated locations in the CRZ;
- Remove inner gloves and place them in the disposal container; and
- Wash hands and face and proceed to the SZ.

Respirators must be fully decontaminated after each use. At the end of each work day, all project personnel will thoroughly wash their face, neck, hands, and forearms, and any other exposed skin with soap and water. If monitoring or a general exposure assessment indicates that an employee has become contaminated, notify Radian's project health and safety officer.

Equipment Decontamination

All equipment leaving the EZ must be decontaminated either within the CRZ or at the central decontamination area. Small equipment such as hand tools will be thoroughly decontaminated within the CRZ before being placed in the SZ.

Equipment decontamination is performed in the field using hexane and methanol. The procedure involves suspending the equipment over a bucket and rinsing it using a squirt bottle. Spent decontamination solutions are collected in a container for proper disposal. Field crew members should be careful to limit overspraying during decontamination. Decontamination should not be conducted near hot equipment (e.g., generators, pumps). Field crew will wear NBR gloves and safety glasses with sideshields when performing decontamination.

If any equipment becomes radiologically contaminated, the SSO will immediately notify the PHSO and the equipment will be secured in air-tight plastic wrapping and remain in the EZ until further direction is provided by the PHSO for transportation to a designated decontamination area for appropriate decontamination.

Decontamination of Radioactive Materials

Items of equipment, PPE, other material, and individuals might become contaminated with radioactivity during work in the drilling area. Information on the nature (alpha or beta) of the radioactivity and the extent will be determined through monitoring/screening procedures discussed in this plan. Radioactive contamination is to be removed using procedures discussed in previously in this section. Any waste material from this type activity shall be monitored as any other operation where radioactivity is encountered and containerized as waste.

If the decontamination procedures provided do not remove the contamination, the SSO will immediately notify the PHSO and the equipment will be secured in air-tight plastic wrapping and remain in the EZ until further direction is provided by the PHSO. Material which is found to be contaminated will be placed in a 0.006 in thick plastic bag and sealed with tape. On the outside of each such container, a label will be placed indicating the name or initials of the person handling the waste, date, time, location (site and on-site area), contents, and an estimate of the quantity of radioactivity in micro-curies (µCi). Estimates of the µCi content of the waste will be determined by measuring the alpha and/or beta activity with portable instruments and multiplying the activity per unit area (i.e., $\mu Ci/cm^2$) times the total contaminated area.

Waste Management

All spent wash water and all discarded PPE and other expendables will be sealed within approved container(s) and managed according to the Hazardous Waste Management and Transportation Plan.

Radioactive Waste Minimization

Work activity in a radiological area can result in the accumulation of significant quantities of suspect radioactive material. Specific measures will be taken to minimize the accumulation of any radioactive waste. These include monitoring all items used in a radiological area including PPE, rags or other material used to wipe or clean equipment, plastic used for laydown, and general trash. Nothing will be placed in a container and labelled as radioactive unless it has been surveyed and found to exceed release criteria in Table 7-1.
Waste containers will then be removed to a storage/processing area as directed by the Base RSO. Records of waste generated, including information on each bag label will be maintained in a bound logbook. Such records will be available for inspection/audit as directed by the Base RSO.

Emergency Response Plan and Phone List

Emergency procedures listed in this plan are designed to give the field team instruction in handling medical emergencies.

Injuries

Medical problems that may occur on-site need to be handled competently and quickly. Each field team member will be aware of the instructions and information given below.

- Each field team member must also know the location and contents of the first aid kit and first aid manual supplied to them.
- Become familiar with the hospital locations (Figure 8-1) and the emergency telephone numbers in Section 8.3 of this document of the Air Force Base, community ambulances, and medical facilities provided in the Emergency Phone List.
- Seek professional medical attention for personnel who are not breathing, bleeding severely, experiencing intense pain, or are unconscious. Each member of the site team will know how to call for an ambulance (on and off base).
- If you get chemicals or dust in your eyes, flush them with water for 15 minutes.
- Do not remove objects that are stuck in the eye. Always seek medical attention for eye injuries.
- All burns (chemical or thermal) will be treated by running cold water over the affected area.
- Report all injuries to the Project Safety Officer and/or your supervisor.
- In case of any emergency, the McClellan Air Force Base (AFB) Environmental Management will be notified.
- An American Red Cross Standard First Aid Book will be kept near the first aid kit at all times.
- The field Task Leader (TL) is responsible for ensuring documentation of all injuries. Documentation will include:
    - Who is injured;
    - Nature of injury;
    - Who was present at the injury site;

  - Time and location of injury;
  - Brief history of events preceding injury;
  - Medical services rendered; and
  - Hospital or authority treating injury.
- Stop bleeding with direct pressure. Place a bandage over the wound and press firmly. Use a tourniquet only in extreme cases when unable to stop severe bleeding.
- If an employee contacts contaminants, wash the affected area with soap and water as soon as possible. If large amounts of waste come in contact with the body, a full-body shower with soap will be required immediately. The employee will be taken or directed by the Field TL to the on-base support facilities for full-body showering established prior to operation with McClellan AFB's Safety Officer.

Emergency Equipment Needs

The following equipment must be available at each site:
Portable emergency eye wash with distilled water (to be changed once per quarter and recorded in field log);
Two 5-pound ABC-rated fire extinguishers; and
An adequately stocked first aid kit and first aid instruction manual.

Fire and Explosion Response Procedures

Fires on site can be started by natural occurrence, or by unsafe work practices. The field team will have two 5-pound multipurpose (A, B, C) fire extinguishers on hand at all times. The procedure for using a fire extinguisher is to pull the safety pin, point the extinguisher at the base of the flames and discharge the extinguisher by sweeping the flames from a distance of about 6 feet. The extinguisher operator should move in as the flames are being put out. Never use water on an electrical fire or a solvent fire. All extinguishers should be dry chemical and labeled "Class A, B, C." Keep decontamination solvents and engine fuels well away from any ignition sources.

The On-Site Safety Officer and/or TL will notify the fire department immediately of the location of any fires that occur (even if they have been extinguished) in order to minimize the fire risk to the surrounding neighborhoods. If welding is required, welding permits will be secured before starting. If a large fire should develop, all personnel will leave the area immediately and move to a secure position upwind of the fire. The base fire department will be notified immediately.

An explosion requires the immediate termination of site activities and evacuation from the site. The cause of the explosion shall be determined, and prevented from reoccurring, before activities will be permitted to resume. The Project Director (PD) and Project Health and Safety Officer (PHSO) will be informed immediately if an explosion occurs. McClellan AFB Environmental Management will also be notified.

Heat Stress

All project personnel should be familiar with the signs and symptoms of heat stress, as follows:

- Heat Exhaustion - dizziness, fatigue, copious perspiration, cool skin that is sometimes pale and clammy, and nausea; and
- Heat Stroke (life threatening) - hot, dry, flushed skin; delirium, and coma (in some cases).

Heat stress can be prevented by resting frequently in a shaded area and consuming large quantities of fresh, potable water. If symptoms of heat exhaustion are observed, the person will be required to rest in a shaded area and consume liquids. If symptoms are widespread or observed frequently, an appropriate work/rest regimen will be initiated. This may involve limiting the work period so that after 10 minutes of rest, a person's heart rate (HR) does not exceed 110 beats per minute.

Emergency Phone List

HOSPITALS

On-base (if life threatening): 115 (From Base Phone)

Out-patient Clinic: Building 541

Off-base: 537-5000
Mercy-San Juan Hospital - Emergency Room
6501 Coyle Avenue
Carmichael, CA

URGENT CARE

Immediate Care
Elkhorn Plaza
5339 Elkhorn Plaza
331-2800

FIRE

On-base: 117 or 643-6666
Off-base: 911

AMBULANCE

On-base: 115 (From Base Phone) or 646-8115

Off-base: 911

POLICE

On-base: 112 or 643-2111

Off-base: 911

RADIAN SAFETY OFFICER - To be contacted in this order:

Kim Worl	(916) 362-5332 (Office)	452-0573 (Home)	762-4849 (Pager)
Rick Moore	(916) 362-5332 (Office)	368-1611 (Home)	

BASE SAFETY OFFICER

Ron Gamber: (916) 643-6227

ENVIRONMENTAL MANAGEMENT

Elaine Anderson: (916) 643-0830 ext. 146

Jerry Robbins
Mario Ierardi
Bud Hoda
Paul Brunner
Kevin Wong (RPM) 643-0830 ext. 159

SURGEON GENERAL BRANCH

Beeper: (916) 328-2042

Attachments:
Appendices A, B, C, and D

Section 11 Deliverables

Several documents and reports will be produced by the SNL as part of this demonstration. Deliverables include a Demonstration Plan and a Environmental Technology Verification Report for each technology participating in the demonstration. Each of these reports is discussed below.

Demonstration Plan

This demonstration plan has been prepared to provide a detailed description of all activities that will take place as part of this demonstration. Key elements of the demonstration plan include the following:

- Test Plan - The test plan includes an overview of the demonstration process (Section 1), a description of the roles and responsibilities of involved parties (Section 3); technology descriptions (Section 4); site descriptions (Section 5); a discussion of the experimental design and sampling protocols (Sections 6 and 7) and an explanation of the methodology for evaluating the performances of the technologies (Sections 8 and 9).

- Quality Assurance Project Plan - This section was prepared according to EPA guidelines listed in the statement of work. The QAPP includes a project description, delineation of QA/QC responsibilities, QA objectives for critical measurements, sampling and analytical procedures, data reduction, validation, and reporting procedures, plans for system and performance audits, and descriptions of internal QC checks, calculation of data quality indicators, plans for corrective actions, and QC reports to management. The QAPP is provided in Section 8.

- Health and Safety Plan - The HASP identifies the key personnel who will be involved with demonstration activities and the minimum training requirements for field personnel, evaluates anticipated hazards associated with field work, and discusses site entry, personal protection equipment, communication, and decontamination procedures to be followed during field work. The HASP is provided in Section 10.

•Technology Verification Report

The main product of a completed demonstration under the CSCT Demonstration Program is a Technology Verfication Report. This report documents the results of the demonstration for each developer and reports on the performance of the technology. The TER will include descriptions of analytical and instrument procedures, data collection and management procedures, and associated QA/QC requirements.

The report for this demonstration project will include the following specific elements:

- A demonstration summary prepared according to directions from the EPA project manager
- A description of the technology that was demonstrated including diagrams, operating instructions, and a brief discussion of the theoretical concepts under which the technology operates
- A description of the experimental design for the demonstration including method protocols, sampling and analysis procedures and methods, QA/QC procedures and records, descriptions of the demonstration sites, and any other pertinent information about the demonstration
- An interpretation and assessment of the technology comparing their analytical results to those obtained using conventional analytical methods
- Analytical performance data and data interpretation for each technology including an evaluation of data quality parameters (precision, accuracy, comparability, completeness, representativeness), and a description of the methods used to assess this data
- Conclusions about the advantages and limitations of each technology on its own merit compared to conventional EPA sample analysis

- Recommendations for the potential use of the technologies for field screening, as well as recommendations for improvements or further testing, if appropriate

Technology Verification Statements

The technology briefs are one-page summaries of the gross findings presented in the ITER. A technology brief will be produced for each technology demonstrated. These documents are intended to be technology transfer fact sheets.

Other Reports

Other reports or documents may also be prepared as directed by the EPA. Examples of other reports which may be required include memorandum trip reports following field activities or visits to developer facilities. In addition, the EPA project manager may require development of technology transfer documents including technology mailers, bulletins, journal articles, or other publications.