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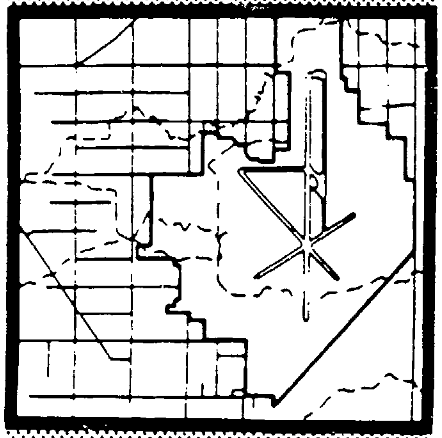
INSTALLATION RESTORATION PROGRAM
STAGE 3
McCLELLAN AIR FORCE BASE



PREPARED BY:
Radian Corporation
10395 Old Placerville Road
Sacramento, California 95827

MAY 1990

QUALITY ASSURANCE PROJECT PLAN

FINAL

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PREPARED FOR:
McCLELLAN AFB/EM
McCLELLAN AFB, CALIFORNIA 95652-5990

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McClellan AFB Quality Assurance Project Plan (QAPP) - Final Copy

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1. The above mentioned document is enclosed for your record (Atch 1). It supersedes the QAPP issued Aug 1989.

2. This document has been prepared for the United States Air Force for the purpose of aiding in the implementation of a final remedial action plan; and the ongoing nature of the Remedial Investigation/Feasibility Study, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this document, since subsequent facts may become known which may make this document premature or inaccurate. Acceptance of this document in performance of the contract under which it was prepared does not mean that the U.S. Air Force or the Department of Defense adopts the conclusions, recommendations, or other views expressed herein which are those of the contractor only and do not necessarily reflect the official position of either department. The attached Radian document has been reviewed as a matter involved in litigation and has been approved for release to the general public.

3. If you have any questions, contact Mr Bud Hoda, SM-ALC/EMR, (916) 643-1250.

Bud Hoda for
MARIO F IERARDI
Chief, Installation Restoration Division
Directorate of Environmental Management

1 Atch
QAPP Report

cc: SM-ALC/JA
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19 ABSTRACT *(Continue on reverse if necessary and identify by block number)*

This document is the McClellan AFB RI/FS Quality Assurance Project Plan (QAPP), and contains procedures for the collection, analysis and documentation for all anticipated sampling and analysis tasks. These include groundwater monitoring well installation, geophysical techniques, and sampling and analysis for groundwater, surface water, sediment, soil, soil vapor, and air.

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INSTALLATION RESTORATION PROGRAM (IRP)
STAGE 3

QUALITY ASSURANCE PROJECT PLAN
FINAL

FOR

McCLELLAN AFB/EM
McCLELLAN AFB, CALIFORNIA 95652-5990

May 1990

PREPARED BY:

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Contractor's Laboratory QA Officer David H. Gale
Contracting Officer's Technical Representative ____________
Contractor's Registered Geologist Thomas F. [illegible], R.G. #4473

NOTICE

This report has been prepared for the Air Force by Radian Corporation for the purpose of aiding in the implementation of a final remedial action plan under the Air Force Installation Restoration Program (IRP). As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the IRP, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it is prepared does not mean that the Air Force adopts the conclusions, recommendations, or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the Air Force.

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PREFACE

Radian Corporation is the contractor for the RI/FS program at McClellan AFB, California. This work was performed for the Installation Restoration Program Office (HSD/YAQI) under Air Force Contract No. F33615-87-D-4023, Delivery Order 0010.

This document is the Quality Assurance Project Plan, prepared according to Air Force and U.S. EPA Guidelines. This plan presents the quality assurance procedures, sampling procedures, and analytical procedures for all currently anticipated sampling and analysis tasks that will be conducted for the RI/FS.

Key Radian project personnel were:

Nelson H. Lund, P.E.--Contract Program Manager
Jack D. Gouge'--Delivery Order Manager
Bill Knight--Project Manager
Joy Rogalla--Task Leader

Radian would like to acknowledge the cooperation of the McClellan AFB Office of Environmental Management. In particular, Radian acknowledges the assistance of Mr. Bud Hoda and Mr. Mario Ierardi.

The work presented herein was accomplished between November 1987 and August 1988. Mr. Gary Woodrum, of the Installation Restoration Program Office (HSD/YAQI) was the Contracting Officer's Technical Representative.

Approved: ______________________
Nelson H. Lund, P.E.
Contract Program Manager

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1.0 INTRODUCTION

The Quality Assurance Project Plan (QAPP) presents in specific terms, the policies, organization, functions, and specific quality assurance (QA) and quality control (QC) activities designed to achieve the data quality goals of a specific project. The U.S. Environmental Protection Agency (U.S. EPA) quality assurance policy requires a written and approved QAPP for every monitoring and measurement project, mandated or supported by the U.S. EPA through regulations, contracts, or other formalized means, not currently covered by regulation. Guidelines followed in the preparation of this plan are set out in U.S. EPA's Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (December 1980), and U.S. EPA Region IX QAPP: Supplemental Guidance to Interim Guidelines and Specifications for Preparing QAPPs (August 1986). Other documents that have been referenced for this plan include U.S. EPA's Guidance on Remedial Investigations Under CERCLA (June 1985), and the Guidance on Feasibility Studies Under CERCLA (June 1985), Compendium of Superfund Field Operation (September 1987), Data Quality Objectives for Remedial Response Activities (March 1987), Guidelines for Assessing and Reporting Data Quality for Environmental Measurements (January 1983) and the USAFOEHL/TS Handbook to Support the Installation Restoration Program Statements of Work. This QAPP will be modified as necessary when guidelines and regulatory documents are revised, or when additional sampling or analysis methods are required for the McClellan Air Force Base (AFB) Remedial Investigation/Feasibility Study (RI/FS).

This detailed QAPP has been prepared by Radian to ensure that the RI/FS at McClellan AFB produces data that are scientifically accurate and defensible. The establishment and documentation of these procedures will also ensure that the data are collected, reviewed, and analyzed in a consistent manner. This is especially important because there are 154 identified potential sites on the base, with a variety of environmental media to be sampled during discrete sampling and analysis tasks during the RI. Although specific sampling strategies and detailed work plans for many of the tasks have not been developed at this time, the QAPP includes all currently anticipated hydrogeologic studies, field sampling procedures, analytical methods, and QA documentation procedures related to sampling surface water, groundwater, soil, sediment, soil gas, and ambient air. As specific Work Plans are developed for various field activities, the QAPP will be referenced or excerpted as necessary. An applicability checklist

(Figure 1-1) developed from the comprehensive QAPP outline, and an applicability statement (Figure 1-2), will be completed, signed, and submitted along with each Work Plan to indicate that all appropriate sampling and QA procedures are included and will be followed. This procedure will be required for all Radian subcontractors as well. This format is necessary because much of the work has not been detailed, and work plans and subcontractors are not known at this time. In this manner, we will reduce redundancy and maintain better control over all aspects of the RI/FS.

The QAPP is required reading for all Radian staff participating in RI/FS work and will be in the possession of field sampling teams for all sampling efforts. Subcontractors will also be required to comply with procedures documented in this QAPP.

If revisions and/or new sections of the QAPP are required as part of a new field data collection task identified at a later date, they will be prepared as part of that task, and incorporated into the comprehensive RI/FS QAPP. This includes revisions to add information regarding subcontractor qualifications for sampling, well drilling, and analytical tasks.

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Figure 1-1. (Continued)

QUALITY ASSURANCE PROJECT PLAN
APPLICABILITY STATEMENT

The McClellan AFB Quality Assurance Project Plan (QAPP) prepared by Radian Corporation and dated ____________ (Revision Date) is sufficient for Project Quality Control during performance of the work specification in attached Work Plan, which is:

Titled: ______________________________

Dated: ______________________________

The attached QAPP Applicability Checklist designates the applicable sections of the QAPP.

____
Name of Task Leader/Contractor

____
Contractor Project Manager Signature

____
Date

Figure 1-2. Applicability Statement for McClellan AFB RI/FS Tasks.

2.0 PROJECT DESCRIPTION

The United States Air Force is conducting an Remedial Investigation/-Feasibility Study (RI/FS) at McClellan Air Force Base (AFB) to assess the extent and magnitude of contamination from past waste disposal and spill sites. This process includes the development of a remediation plan(s) for sites determined to pose a threat to human health or welfare, or the environment. The remedial investigation (RI) phase of the program includes multi-media sampling tasks to complete site characterization studies, and to assess potential exposure pathways.

2.1 Site History

McClellan AFB is located near Sacramento, California (Figure 2-1) and is an active aircraft maintenance facility associated with the Air Force Logistics Air Command. As part of past routine maintenance procedures at the base, a variety of hazardous materials were handled and disposed of, including: chlorinated solvents and caustic cleaners; waste from heavy electroplating metals; polychlorinated biphenyl (PCB) contaminated oils; contaminated jet fuels; low-level radioactive wastes; and a variety of oils and lubricants. These wastes were disposed of in several types of facilities, including burial pits, burn pits, and sludge/oil pits. At the time, these disposal methods were accepted industrial practices, and the base obtained permits from appropriate regulatory agencies as required. During the late 1970s, the potential for air pollution and groundwater contamination resulting from these practices was recognized, and land disposal methods were discontinued by 1981.

Initial investigations to identify and characterize contamination on and near the base identified 154 individual sites, most of which have been grouped into four general areas of contamination, designated Areas A, B, C, and D, which are shown in Figure 2-2, and are described as follows.

Area A

Area A encompasses approximately 200 acres located in the southeast portion of McClellan AFB in an area of heavy industrial activity involving trichloroethene (TCE) usage. Area A contains 54 sites that are potential sources of hazardous substances to the soils and groundwater; 5 Area A sites have been studied. Materials disposed of at the sites included refuse and refuse ash, 1,2-dichloroethane (1,2-

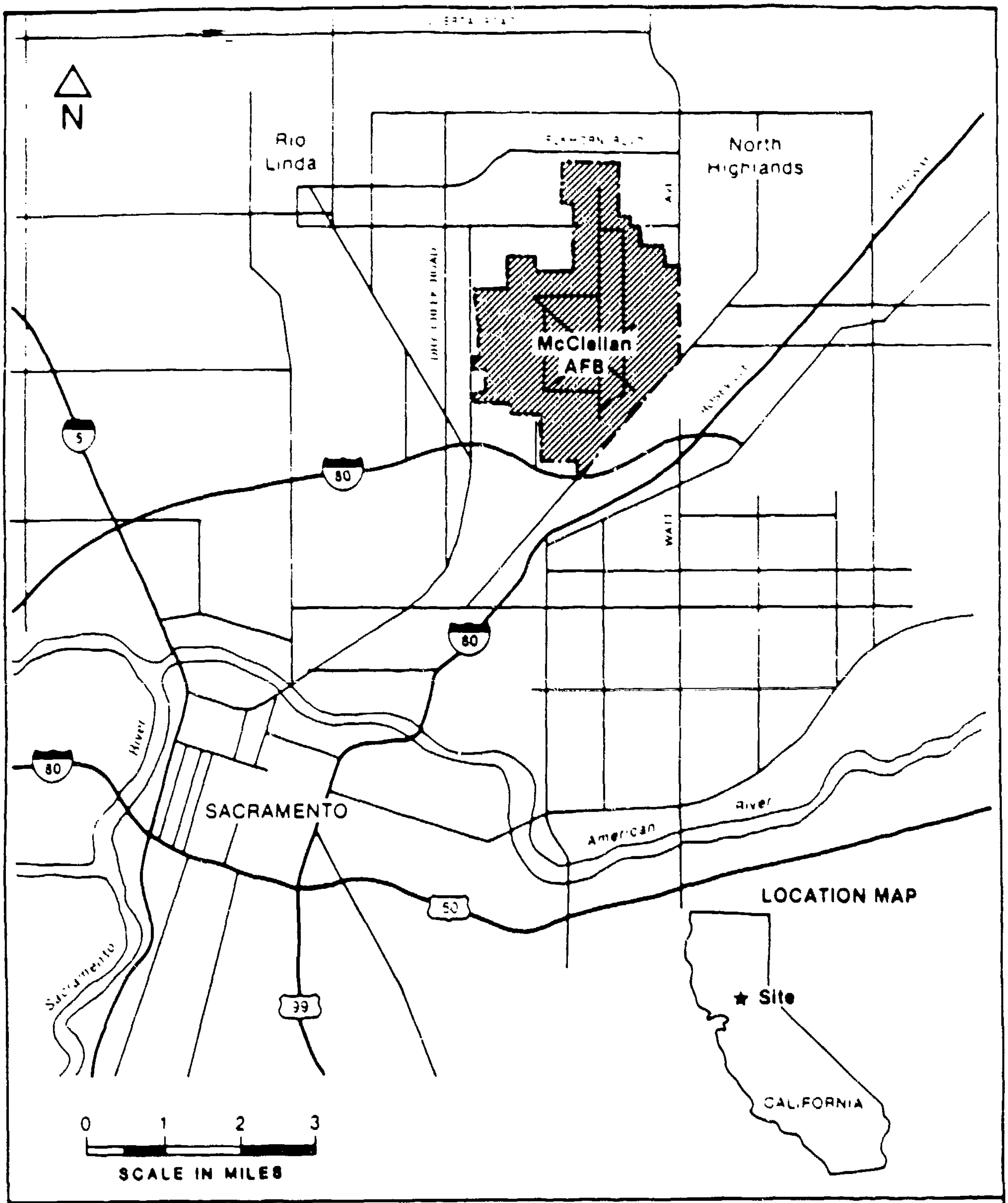

Figure 2-1. Location of McClellan AFB, near Sacramento, CA.

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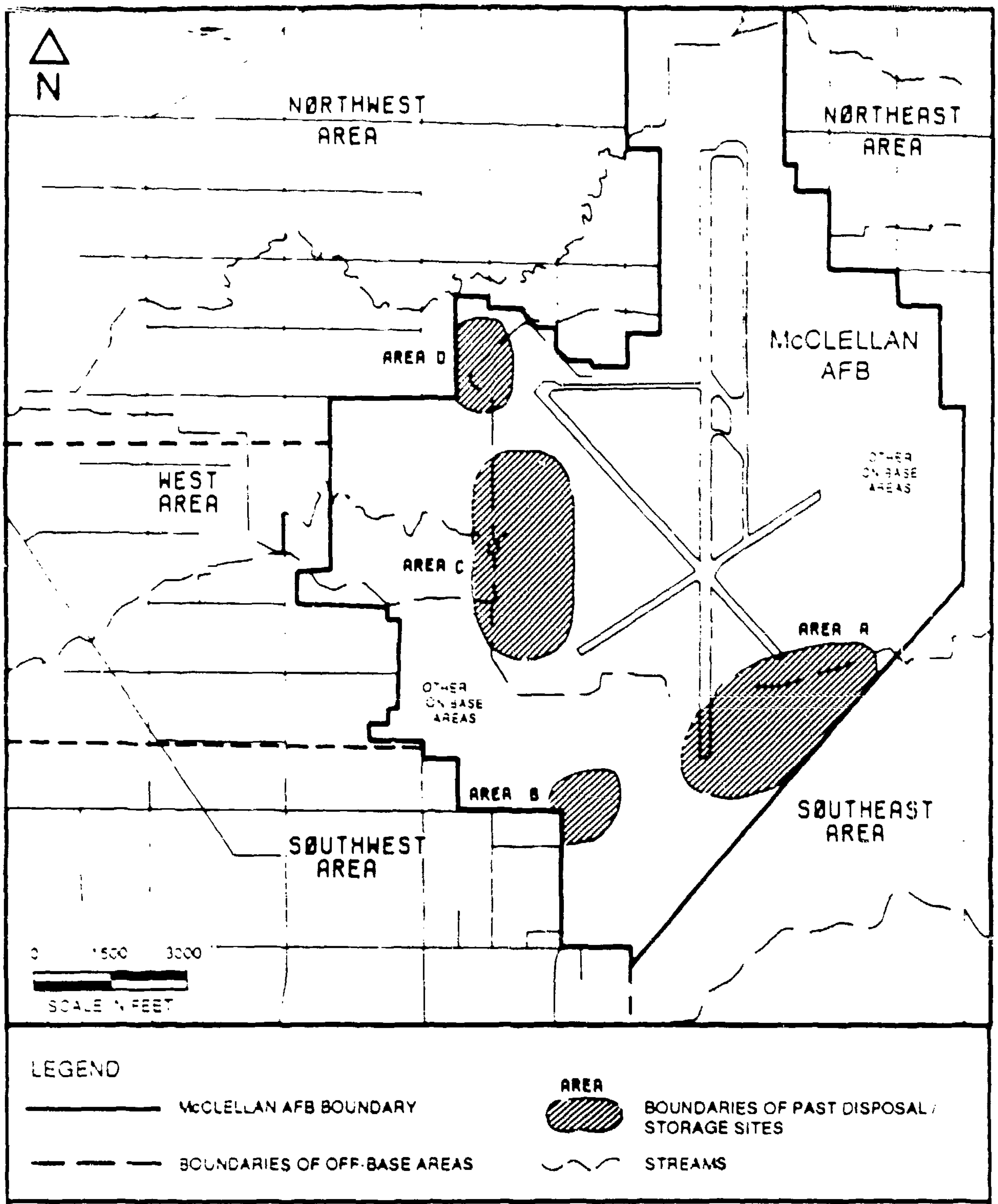


Figure 2-2. Areas Designated for Groundwater Investigations at McClellan AFB.

DCA), cresylic acid, skimming pond sludges, and industrial wastewater sludge. Groundwater samples collected from monitoring wells in the vicinity of Area A have contained a variety of volatile organic compounds (VOCs) including:

- TCE;
- 1,1-Dichloroethene (1,1-DCE);
- 1,2-DCA;
- Acetone;
- Toluene;
- Carbon tetrachloride;
- 1,1,1-Trichloroethane (1,1,1-TCA);
- Chloroform;
- Methylene chloride;
- Benzene;
- Ethyl benzene; and
- Trichlorofluoromethane (TCFM).

Contaminants reported in soil samples collected from sites in Area A include:

- Acetone,
- Benzene;
- Chloroform;
- Ethyl benzene;
- TCE;
- 1,1,1-TCA;
- Total xylenes,
- Bis(2-ethylhexyl)phthalate; and
- Di-n-butylphthalate.

Three base production wells located in Area A (BW-1, BW-2, and BW-12) have been closed because elevated concentrations of TCE have been reported.

Area B

Area B encompasses approximately 68 acres in the southwest portion of McClellan AFB, and includes 16 sites that are potential sources of hazardous substances to the soils and groundwater; 5 Area B sites have been studied. Area B has historically been an area of varied uses, including: storage buildings, a chemical laboratory, a woodshop and instrument repair facilities, a paint facility, and a plating shop. Materials handled at various locations within the area include: TCE, diethyl ether, low-level radioactive wastewater, and waste chemicals generated during plating activities. In Area B, TCE has been found in Base Production Well 18, which currently operates with a filtering system. City Well 150 located south of the area was closed because of TCE contamination. Volatile organic compounds reported in groundwater collected from Area B are:

- 1,1-DCE;
- TCE;
- Trans-1,2-dichloroethene (trans-1,2-DCE);
- Methyl ethyl ketone (MEK);
- Carbon disulfide;
- Dichlorobenzene;
- Chloroform; and
- Methylene chloride.

Contaminants reported in soil samples collected from sites in Area B Include:

- Chlorinated VOCs;
- Ketones;
- Phthalates; and
- Heavy metals (barium, chromium, arsenic, lead and copper).

Area C

Area C encompasses approximately 260 acres in the west-central portion of McClellan AFB. Forty sites inArea C are potential sources of hazardous substances to the soils and groundwater; all of these sites have been studied. Currently, Area C includes a Civil Engineering materials storage yard, the Industrial Waste Treatment Plant (IWTP), the Groundwater Treatment Plant (GWTP), an aircraft maintenance hangar, and a fire training area. These sites include refuse sludge pits, chemical waste pits, burn pits, waste oil and solvent storage ponds (used from the 1940s to 1971), surface storage areas, settling ponds, waste water ponds, and unlined drainage ditches. The area was used from the 1940s to 1972 for waste disposal into excavated trenches, which were sometimes burned, and were subsequently covered with fill material. These wastes were from a variety of sources, and included ash, burned debris, and general refuse. A wide variety of VOCs have been detected in groundwater samples collected from this area. The VOCs that have occurred in Area C wells at concentrations above Department of Health Services (DHS) action levels include:

- TCE;
- 1,2-DCA;
- 1,1-DCE;
- Tetrachloroethylene (PCE);
- Trans-1,2-DCE;
- Toluene; and
- Benzene.

A variety of VOCs, base neutral and acid extractable (BNA) compounds, and metals have been detected in soil samples collected from this area including:

- Chlorinated VOCs;

- Ketones;

- Benzene, toluene, xylenes;

- Phthalates; and

- Heavy metals (zinc, barium, arsenic, copper, antimony, lead, and vanadium).

A remediation measure consisting of expansion of the groundwater extraction and treatment system in Area C, began operation in August 1988.

Area D

Area D encompasses approximately 140 acres in the northwest corner of McClellan AFB. Twelve sites in this area are potential sources of hazardous substances to the soils and groundwater; all of these sites have been studied. These include waste burn and debris pits, fuel and sludge disposal pits, a wastewater sludge disposal and burn pit, a skimmed oil burn area, a sodium valve disposal pit, and an industrial wastewater sludge landfarm. Samples from a number of groundwater monitoring wells in this area have shown high concentrations of VOCs, primarily 1,1-DCE, 1,1,1-TCA, and TCE. The degree of contamination in soils in Area D varies from no contamination to high levels, primarily VOCs. Two remediation measures have been implemented in Area D: A clay cap was constructed over former sludge/oil disposal sites, and a groundwater extraction and treatment system was installed and has been in operation since early 1987.

Other Areas

In addition to the sites in Areas A, B, C, and D, historical record searches have identified another 32 sites located on base that may be potential sources of contamination; 26 of these sites have not been studied.

2.2 Sampling and Remediation Activities

Other sampling and remediation measures have been implemented. From 1979 through 1986, residential drinking water wells near the base were sampled and analyzed for organic compounds and priority pollutant metals. Volatile organic compounds were consistently detected in some of these wells above state action levels. As an immediate remediation measure, city water hookups were provided for homes near the base. A monitoring well network has been installed and includes on- and off-base wells that are located upgradient and downgradient of known disposal areas. Currently, 136 monitoring wells are sampled quarterly for organics and priority pollutant metals. The quarterly sample data are being analyzed to determine the magnitude and extent of contamination, and to monitor changes in groundwater quality that may be attributed to the extraction and treatment systems.

The analytical results for the residential and monitoring wells to date indicate the presence of shallow to deep groundwater contamination in and near known disposal areas on base, and contamination of the shallow ground-water zone in areas southwest, west, and northwest of the base. Contamination in some of these areas appears to be localized. The Area D extraction system appears to be decreasing contaminant concentrations in middle and deep groundwater zones in the immediate area, and is affecting groundwater flow directions in the area by creating a pumping depression.

2.3 Data-Collection and Use

During the RI, separate tasks will be implemented to characterize unstudied sites, expand the monitoring well network to allow more complete characterization of the extent of groundwater contamination, and to sample surface water, sediment, soil, soil gas, and air at designated sites. The samples will be analyzed for volatile and semivolatile organic compounds, priority pollutant metals, cyanide, pesticides (including dioxin), and total petroleum hydrocarbons; samples from one site will be analyzed for low-level radioactivity.

In addition to completing the site characterization, the data collected in the various sampling tasks will be used to:

- Identify potential human exposure pathways and environmental hazards;
- Provide input for risk assessment of the exposed human population; and
- Provide information in determining appropriate cleanup levels for hazardous sites.

Detailed Work Plans for these tasks are currently being developed and some tasks will be implemented during 1989. The initial tasks related to characterization of unstudied sites will aid in determining which of the remaining tasks are most important. It is not possible to set a detailed schedule for completion of the RI/FS because of the number of unstudied sites, and the amount of additional information needed before decisions about remedial measures can be made. However, an estimate of 10 years to complete sampling and analysis and other RI/FS activities is made, based on the rate of progress to date and comparison with other RI/FS programs.

3.0 PROJECT ORGANIZATION AND RESPONSIBILITY

The organization of the Remedial Investigation/Feasibility Study (RI/FS) project team is presented in Figure 3-1, and consists of administrative and technical personnel with experience in areas pertinent to the remedial investigation (RI). A brief description of the primary staff, and responsibilities for management, quality assurance, peer review, and task leadership on field tasks and support tasks is given below.

3.1 Project Management

- Mr. Jack Gouge' is the Delivery Order Manager in Sacramento, with responsibility for the contractual aspects of the project. He is the Radian's McClellan Air Force Base (AFB) primary contact person for the United States Air Force (USAF).

- Mr. Bill Knight, is the Project Manager with responsibility for the technical quality of all aspects of the RI/FS, and management of the daily project activities.

- Mr. Tyler Thompson is the Assistant Project Manager with responsibility to assist the Project Manager in daily project activities and assure technical quality of the RI/FS.

The Delivery Order Manager and Project Manager have overall responsibility to ensure that all activities are performed in accordance with United States Environmental Protection Agency (U.S. EPA), USAF, state, and local requirements, and according to Radian policy.

3.2 Quality Assurance

- Mr. David Lewis is Radian's Quality Assurance Officer (QAO), and is independently responsible for ensuring that the designated quality assurance (QA) procedures are followed, and that field and laboratory audits are conducted as necessary. This is accomplished by his involvement in planning and reviewing the Quality Assurance Project Plan (QAPP), field activity work plans, and reports produced for those activities. He is also responsible for implementing

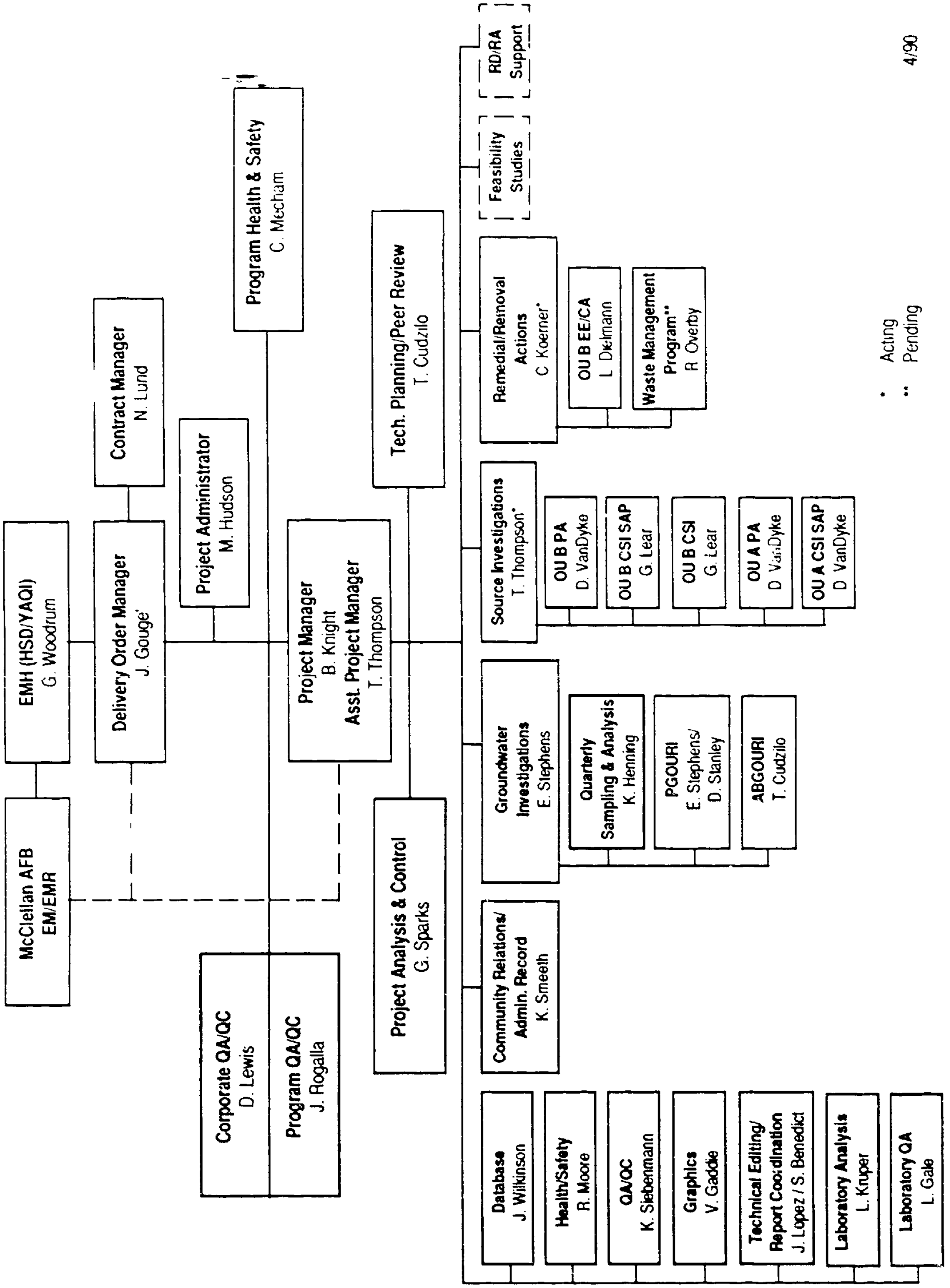


Figure 3-1. Radian Corporation - McClellan AFB - RI/FS Organizational Chart.

standard Radian QA policies. The on-site Quality Control Coordinator is responsible to the QAO. The QAO reports directly to W.N. Kocurek, Corporate Technical Services Staff Vice President.

- Mr. Laird Gale is the Sacramento Radian Analytical Services Laboratory QAO, and has responsibility for the quality and documentation of all laboratory analyses performed by the Sacramento laboratory. His review and documentation are part of the analytical process, and occur before the data are released to the technical staff conducting the sampling task.

- Ms. Joy Rogalla is the independent Program QA/QC Coordinator, and is responsible for planning, implementing, and tracking quality assurance activities and direct communication with the corporate QAO. Her duties include ensuring that quality control data evaluation and reporting procedures are followed, issuing and tracking malfunction report forms, coordinating field sampling audits and updating the QAPP as necessary. The ultimate goal of these activities is to produce data that satisfy the QA objectives for the program.

3.3 Peer Review

- Dr. Tom Cudzilo, R.G., is responsible for technical planning and peer review for all RI/FS activities.

3.4 Health and Safety

- Mr. Clive Mecham is responsible for general health and safety plan development and training for field personnel, including Radian employees and any subcontractors. He is also responsible for ensuring that the health and safety procedures are understood and followed by all field personnel, and for reporting and correcting any violations in these procedures.

3.5 Primary Task Leaders

- Mr. James Wilkinson is responsible for the management and reporting of all data generated by the field tasks. This includes electronic transfer of analytical results from the laboratory.

- Mr. Larry Kruper is responsible for coordinating analyses and reporting all laboratory analytical results produced by the Sacramento laboratory. He is also responsible for ensuring that all information is provided to the QAO, and to follow recommendations made during QA review.

- Mr. Elgar Stephens, R.G., is responsible for technical planning and overall direction of groundwater investigations, including the quarterly sampling and analysis program and operable unit remedial investigations.

- Mr. Tyler Thompson is responsible for technical planning activities for source investigations. This includes preliminary assessments and sampling and analysis plan development.

- Mr. Christopher Koerner, P.E., is responsible for technical direction and planning for remedial/removal actions, including engineering design for remediation activities, and waste management.

As the work plans are developed, project team members will be identified based on their experience and ability to perform the required work. Resumes of all project personnel are available for review.

The task leaders are responsible to review training files for team members, and to conduct training or a refresher course for all members to ensure that all field and QA procedures are understood and will be properly conducted in the field. The team members are responsible for reading and understanding the protocols established in the QAPP; the task leaders and the project manager are responsible to provide time for review and availability to answer questions that may arise during that review.

4.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT AND GEOLOGIC DATA

The purpose of a quality assurance/quality control (QA/QC) program is to produce data of known quality that satisfy the project objectives and that meet or exceed the standard requirements for the analytical methods. The QA/QC program shall:

- Provide a mechanism for ongoing control and evaluation of measurement data quality; and
- Provide an estimate of data quality in terms of accuracy, precision, completeness, representativeness, and comparability, for use in data interpretation.

Quality assurance objectives for accuracy and precision are presented by sample matrix for chemical parameters in Tables 4-1 through 4-9. These values are estimates of the degree of uncertainty that is considered acceptable for the data to fulfill the needs of the Remedial Investigation/Feasibility Study (RI/FS). The QA/QC program focuses on controlling measurement error within these limits, and provides a basis for quantifying the uncertainty associated with the data. In the first step of data validation, measurement data are compared to the quality assurance objectives to determine whether gross performance problems occurred.

The basis for assessing precision, accuracy, completeness, representativeness, and comparability is discussed in the following subsections. Specific calculations for data quality measurements are presented in Section 13.0.

4.1 Precision

Precision measures the reproducibility of repetitive measurements. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. Analytical precision is a measurement of the variability associated with duplicate (2) or replicate (more than 2) analyses of the same sample in the laboratory. Total precision is a measurement of the variability associated with the entire sampling and analysis process. It is determined by analysis of duplicate or replicate field samples, and incorporates the variability caused by matrix variability, field sampling procedures, and

TABLE 4-1. QUALITY ASSURANCE/QUALITY CONTROL OBJECTIVES FOR MEASUREMENTS IN WATER

		Precision Objectives		Accuracy Objectives
Measurement Parameter	Reference Method	Field Replicate Anslyses (RPD in %)	Laboratory Replicate Analyses (RPD in %)	Spike Analyses (Recovery in %)
INORGANICS		<50	<20	N/A
Conductance	U.S. EPA 120.1	±0.2 pH units	±0.1 pH units	±0.2 pH units
pH	U.S. EPA 150.1	<50	<20	85 - 115
TDS	U.S. EPA 160.1	<50	<20	N/A
Temperature	U.S. EPA 170.1	<50	<20	85 - 115
Metals Analysis	SW6010 (ICPES)	<50	<20	85 - 115
Arsenic	SW7060 (Graphite Furnace AA)	<50	<20	85 - 115
Lead	SW7421 (Graphite Furnace AA)	<50	<20	85 - 115
Mercury	SW7470 (Cold Vapor AA)	<50	<20	85 - 115
Selenium	SW7740 (Graphite Furnace AA)	<50	<20	85 - 115
Anions	U.S. EPA 300.0 (IC)	<50	<20	90 - 110
Alkalinity	U.S. EPA 310.1	<50	<20	N/A
Cyanide	SW9010	<50	<20	90 - 110
Nitrates	U.S. EPA 353.2	<50	<20	85 - 115
Radioactivity	U.S. EPA 900/U.S. EPA 900.1	<50	<20	N/A
ORGANICS				
Halogenated Volatile Organics	SW8010	<50	<50	See Tabel ~~1.~~4-4
Total Petroleum Hydrocarbons	SW8015 Modified	<50	<50	75 - 123
Aromatic Volatile Organics	SW8020	<50	<50	See Table ~~1.~~4-5
Phenols	SW8040	<50	<50	See Tabel ~~1.~~4-6
Organochlorine Pesticides & PCBs	SW8080	<50	See Table ~~1.~~4-7	See Table ~~1.~~4-7
GC/MS Volatile Organics	SW8240	<50	<20	See Table ~~1.~~4-8
GC/MS Semivolatile Organics	SW8270	<50	See Table ~~1.~~4-9	See Table ~~1.~~4-9
Dioxins and Furans	SW8280	<50	<50	50 - 150[a]

[a] Estimated range of recovery for surrogate spike standards. Recovery data for specific matrices are given in Method SW8280, Table 6.

U.S. EPA = United States Environmental Protection Agency.
PCBs = Polychlorinated biphenyls.
N/A = Not applicable.
SW = Methods from SW846, Third Edition.
AA = Atomic absorption.

TABLE 4-2. QUALITY ASSURANCE/QUALITY CONTROL OBJECTIVES FOR MEASUREMENTS IN SOIL AND SEDIMENTS

		Precision Objectives		Accuracy Objectives
Measurement Parameter	Reference Method	Field Replicate Anslyses (RPD in %)	Laboratory Replicate Analyses (RPD in %)	Spike Analyses (Recovery in %)
INORGANICS				
Metals	SW6010 (ICPES)	<50	<30	75 - 125
Arsenic	SW7060 (Graphite Furnace AA)	<50	<30	75 - 125
Lead	SW7421 (Graphite Furnace AA)	<50	<30	75 - 125
Selenium	SW7740 (Graphite Furance AA)	<50	<30	75 - 125
Mercury	SW7471 (Cold Vapor)	<50	<30	75 - 125
ORGANICS				
Halogenated Volatile Organics	SW8010	<50	<50	See Table ~~1.~~4-4
Total Petroleum Hydrocarbons	SW8015 Modified	<50	<50	75 - 123
Aromatic Volatile Organics	SW8020	<50	<50	See Table ~~1.~~4-5
Phenols	SW8040	<50	<50	See Table ~~1.~~4-6
Organochlorine Pesticides & PCBs	SW8080	<50	See Table ~~1.~~4-7	See Table ~~1.~~4-7
GC/MS Volatile Organics	SW8240	<50	See Table ~~1.~~4-8	See Table ~~1.~~4-8
GC/MS Semivolatile Organics	SW8270	<50	See Table ~~1.~~4-9	See Table ~~1.~~4-9

SW = Methods from SW846, Third Edition.
AA = Atomic absorption.

TABLE 4-3. QUALITY ASSURANCE/QUALITY CONTROL OBJECTIVES FOR MEASUREMENTS IN AIR

Measurement Parameter	Reference Method	Field Replicate Analyses (RPD in %)	Laboratory Replicate Anslyses (RPD in %)	Control Sample Analyses (Recovery in %)
Volatile Organic Compounds	Radian Method, GC/FID-PID-HECD, stainless steel canister	<50	<50	±30[a]
Organic Vapor Survey	Portable Organic Vapor Analyzer, OVA-FID	<50	N/A	±20[b]

[a] Recovery limit for at least 10 of 12 compounds in daily control samples, and recovery of compounds in performance evaluation audit samples.

[b] Daily calibration check standard, compared to the monthly multipoint response factor.

GC/FID-PID-HECD = Gas chromatography/flame ionization detector-photoionization detector-Hall electroconductivity detector.

OVA-FID = Organic vapor analyzer-flame ionization detector.

N/A = Not applicable.

TABLE 4-4. QUALITY CONTROL ACCEPTANCE CRITERIA FOR METHOD SW8010

Parameter	Accuracy[a] (Recovery in %)	Precision (RPD in %)
Chloromethane	D-193	50
Bromomethane	D-144	50
Vinyl chloride	28-163	50
Chloroethane	46-137	50
Methylene chloride	25-162	50
Trichlorofluoromethane	21-156	50
1,1-Dichloroethene	28-167	50
1,1-Dichloroethane	47-132	50
trans-1,2-Dichloroethene	38-155	50
Chloroform	49-133	50
1,2-Dichloroethane	51-147	50
1,1,1-Trichloroethane	41-138	50
Carbon tetrachloride	43-143	50
Bromodichloromethane	42-172	50
1,2-Dichloropropane	44-156	50
Trichloroethene	22-178	50
Dibromochloromethane	35-146	50
1,1,2-Trichloroethane	24-191	50
trans-1,2-Dichloropropene	39-136	50
2-Chloroethylvinyl ether	22-178	50
Bromoform	14-186	50
Tetrachloroethene	13-159	50
Chlorobenzene	26-162	50
1,1,2,2-Tetrachloroethane	8-184	50
Chlorobenzene	38-150	50
1,3-Dichlorobenzene	7-187	50
1,2-Dichlorobenzene	D-208	50
1,4-Dichlorobenzene	42-143	50
Surrogate		
1-Bromo-4-fluorobenzene	4-140	N/A

[a] SW846, Third Edition.

D = Detected.
N/A = Not applicable.
RPD = Relative percent difference.

TABLE 4-5. QUALITY CONTROL ACCEPTANCE CRITERIA FOR METHOD SW8020

Parameter	Accuracy[a] (Recovery in %)	Precision (RPD in %)
Benzene	39-150	50
Chlorobenzene	55-135	50
1,4-Dichlorobenzene	42-143	50
1,3-Dichlorobenzene	50-141	50
1,2-Dichlorobenzene	37-154	50
Ethylbenzene	32-160	50
Toluene	46-148	50
Surrogate		
1-Bromo-4-fluorobenzene	4-140	N/A

[a] SW846, Third Edition.

N/A = Not applicable.
RPD = Relative percent difference.

TABLE 4-6. QUALITY CONTROL ACCEPTANCE CRITERIA FOR METHOD SW8040

Parameter	Accuracy[a] (Recovery in %)	Precision (RPD in %)
4-Chloro-3-methylphenol	99-122	50
2-Chlorophenol	38-126	50
2,4-Dichlorophenol	44-119	50
2,4-Dimethylphenol	24-118	50
4,6-Dinitro-2-methylphenol	30-136	50
2,4-Dinitrophenol	12-145	50
2-Nitrophenol	43-117	50
4-Nitrophenol	13-110	50
Pentachlorophenol	36-134	50
Phenol	23-108	50
2,4,6-Trichlorophenol	53-119	50
Surrogate		
2-Fluorophenol[b]	20-120	N/A

[a] SW846, Third Edition.
[b] Limits are advisory only.

RPD = Relative percent difference.

TABLE 4-7. QUALITY CONTROL ACCEPTANCE CRITERIA FOR METHOD SW8080

Parameter	Aqueous Matrix		Solid Matrix	
	Accuracy[a] (Recovery in %)	Precision[a] (RPD in %)	Accuracy[a] (Recovery in %)	Precision[a] (RPD in %)
Aldrin	40-120	22	34-132	43
gamma-BHC (Lindane)	56-123	15	46-127	50
DDT	38-127	27	23-134	50
Dieldrin	52-126	18	31-134	38
Endrin	56-121	21	42-139	45
Heptachlor	40-131	20	35-130	31
Surrogate				
Dibutylchlorendate	24-154[b]	N/A	20-150[b]	N/A

[a] CLP SOW 10/86.
[b] Limits are advisory only.

N/A = Not applicable.
RPD = Relative percent difference.

TABLE 4-8. QUALITY CONTROL ACCEPTANCE CRITERIA FOR METHOD SW8240

	Aqueous Matrix		Solid Matrix	
Parameter	Accuracy[a] (Recovery in %)	Precision[a] (RPD in %)	Accuracy[a] (Recovery in %)	Precision[a] (RPD in %)
1,1-Dichloroethene	65-145	20	59-172	22
Trichloroethene	71-120	20	62-137	24
Chlorobenzene	75-130	20	60-133	21
Toluene	76-125	20	59-139	21
Benzene	76-127	20	66-142	21
Surrogate				
Toluene-d_8	88-110	N/A	81-117	N/A
4-Bromofluorobenzene	86-115	N/A	74-121	N/A
1,2-Dichloroethane	76-114	N/A	70-121	N/A

[a] CLP SOW 10/86.

N/A = Not applicable.
RPD = Relative percent difference.

TABLE 4-9. QUALITY CONTROL ACCEPTANCE CRITERIA FOR METHOD SW8270

Parameter	Aqueous Matrix		Solid Matrix	
	Accuracy[a] (Recovery in %)	Precision[a] (RPD in %)	Accuracy[a] (Recovery in %)	Precision[a] (RPD in %)
1,2,4-Trichlorobenzene	39-98	28	38-107	23
Acenaphthene	46-118	31	31-137	19
2,4-Dinitrotoluene	24-94	38	28-89	47
Pyrene	26-127	31	35-142	36
n-Nitroso-di-n-propylamine	41-116	38	41-126	38
1,4-Dichlorobenzene	36-97	28	28-104	27
Pentachlorophenol	9-103	50	17-109	47
Phenol	12-89	42	26-90	35
2-Chlorophenol	27-123	40	25-102	50
4-Chloro-3-methylphenol	23-97	42	26-103	33
4-Nitrophenol	10-80	50	11-114	50
Surrogate				
2-Fluorophenol	21-100	N/A	25-121	N/A
Phenol-d_5	10-94	N/A	24-113	N/A
Nitrobenzene-d_5	35-114	N/A	23-120	N/A
2-Fluorobiphenyl	43-116	N/A	30-115	N/A
2,4,6-Tribromophenol	10-123	N/A	19-122	N/A
Terphenyl-d_{14}	33-141	N/A	18-137	N/A

[a] CLP SOW 10/86.

N/A = Not applicable.
RPD = Relative percent difference.

analytical variability. The results for total and analytical precision must be interpreted by taking into consideration all possible sources of variability. Duplicate (2) samples will be analyzed to assess field and laboratory precision for McClellan Air Force Base (AFB) RI/FS tasks and the results will be reported as the relative percent difference (RPD) between duplicate measurements. In all cases, field precision objectives will be RPD less than 50 percent. Analytical precision objectives are presented for each method and matrix in Tables 4-1 through 4-9.

4.2 Accuracy

Accuracy is a statistical measurement of correctness, and includes components of random error (variability due to imprecision) and systematic error (bias). It, therefore, reflects the total error associated with a measurement. A measurement is accurate when the value reported does not differ from the true value, or known concentration of the spike or standard. Analytical accuracy is typically measured by determining the percent recovery of known target analytes that are spiked into a field sample (a matrix spike) or reagent water (a method spike) before extraction at known concentrations. The stated accuracy limits apply to spiking levels at five times the method detection limits or higher. The individual methods provide equations for acceptance criteria at lower spiking levels. Surrogate compound recovery is also reported and is used to assess method performance for each sample analyzed for volatile and semivolatile compounds. Sampling accuracy is assessed by evaluating results for field and trip blanks.

Both accuracy and precision are calculated for specific sampling or analytical batches, and the associated sample results must be interpreted considering these specific measures. Application of calculated precision and accuracy to measurement sample results was discussed in Section 13.0. An additional consideration in applying accuracy and precision is the concentration level of the samples; a procedure capable of producing the same value within 50 percent would be considered precise for low-level (near the detection limit) analyses of minor constituents, but would be unacceptable, and possibly useless for major constituents at high concentrations.

4.3 Completeness

Completeness is defined as the percentage of valid data reported compared to the total number of samples collected for analysis. Valid data are determined during the data assessment process and are data that satisfy the QA objectives. Completeness is determined after precision and accuracy are calculated. The objective for completeness for all measurement parameters and all sample matrices is 90 percent.

4.4 Representativeness

Objectives for representativeness will be defined for each sampling and analysis task and will be a function of the investigative objectives. Representativeness will be achieved through use of the standard sampling and analytical procedures described in this QAPP.

4.5 Comparability

Comparability is the confidence with which one data set can be compared to other data. The objectives for this QA/QC program are to produce data with the greatest degree of comparability possible. The number of matrices that will be sampled, and the range of field conditions encountered must be considered in ultimately determining comparability. Comparability will be achieved by using standard methods for sampling and analysis, reporting data in standard units, and using standard and comprehensive reporting formats. Analysis of reference samples may also be used to provide additional information that can be used to assess comparability of analytical data produced within Radian analytical services, and among Radian and any subcontracting laboratories that may analyze samples in the future.

4.6 Geologic Data Quality Objectives

Geologic data will be obtained from the drilling of numerous soil borings and monitoring wells during the RI/FS. While it is more difficult to measure the precision, accuracy, completeness, representativeness, and comparability of the data collected from these activities, several steps will be undertaken to ensure the data obtained is representative, standardized, and as accurate as possible. Specifically, all field personnel will review the geologic samples and cores currently available through McClellan AFB Environmental Management (EM). This will familiarize the geologists with the types of lithologies that can be expected to be encountered and allow for an opportunity to standardize sample nomenclature. Additionally, all logged sediments will be identified and described using the Unified Soil Classification System and standard geologic descriptions.

Hydrologic Data

The compilation of hydrologic data will be conducted in several parts of the RI/FS site characterization and hydrogeologic assessment. Hydrologic data to be compiled will consist primarily of water-level measurements collected over specific time intervals. Water levels will be measured in monthly soundings, during monitoring well purging, and during aquifer pumping tests. The water levels will be measured with calibrated electronic sounders for monthly soundings and well purging prior to sampling. Electronic sounders will be checked for accuracy and precision before each use and each sounder will have a unique identification number that can be used to document instrument use and performance. If more than one sounder is used during a monthly sounding event, sounders will be checked for comparability of measurements and calibrated with respect to one standard sounder prior to use.

In cases of water-level measurements during pumping tests, pressure transducers mounted in each observation well will be used to gather readings. Prior to use, the transducers will be calibrated and checked for precision, accuracy, and comparability of pressure readings.

Additional hydrologic data which may be collected during the RI/FS are pump discharge rates measured during well purging or aquifer testing. The methods used to measure pump discharge rates will be determined by the uses of the discharge data. For monitoring well purging, discharge data are needed to demonstrate that the well to be sampled was adequately purged and that the discharge was sufficient to induce groundwater flow from the formation into the well casing. Discharge measurement to assure purging can be obtained with sufficient accuracy by using a bucket of known volume and a stop watch.

For aquifer testing in which high discharge rates are needed to adequately stress an aquifer, a calibrated flow meter is needed to obtain sufficient accuracy, precision, and comparability. A calibrated flow meter capable of reading one gallon per minute of flow will be used to collect total discharge data for aquifer tests.

5.0 FIELD PROCEDURES

This section contains detailed descriptions of field procedures and sampling protocols that will be used during the remedial investigation at McClellan Air Force Base (AFB).

All field personnel, their supervisors, and all project management and administrative personnel will read pertinent sections of the Quality Assurance Project Plan (QAPP). In addition, each team of field personnel will have a copy of the QAPP in their possession.

Sampling containers are purchased precleaned and treated according to United States Environmental Protection Agency (U.S. EPA) specifications for the appropriate methods. Sampling containers that are reused (e.g., soil sleeves) are decontaminated between uses by U.S. EPA-recommended procedures. Cleaned containers are stored in the Radian staging area, which is maintained to prevent exposure to potential contaminants. Amber glass bottles are routinely used where glass containers are specified by the sampling protocol.

5.1 Geophysical Techniques

Borehole geophysical techniques are used to assist in determining subsurface geologic conditions such as strata thickness, lithology, and permeability. These borehole methods may also be valuable in determining the presence and relative natural quality of groundwater. Geophysical logs are generally used in conjunction with borehole lithology logs to refine geologic descriptions. There are several types of borehole geophysical techniques that may be employed during future remedial investigation/feasibility study (RI/FS) site characterization activities at McClellan AFB. These techniques include resistivity logging, spontaneous potential logging, and gamma ray logging, and are discussed below. All geophysical measurements will be collected digitally to allow scale adjustments to be made prior to hard copy reproduction. In addition, any required permits will be obtained before using radioactive sources for geophysical techniques. Much of the text in this section that presents the theory and general procedures for each technique is from Driscoll (1986).

5.1.1 Electric Logs

Borehole Resistivity Logs

A resistivity log can provide a detailed representation of the character and thickness of different strata and an indication of natural groundwater quality by measuring the apparent electrical resistivity of the materials surrounding a borehole. Resistivity logging is typically conducted in conjunction with spontaneous potential logging (discussed below). These two methods, when used together, are commonly referred to as electric or "E" logs. Electric logging has a disadvantage in that the logs can only be used in uncased boreholes that are filled with water or another drilling fluid. Electric logging is typically used to log boreholes drilled with the mud rotary method. Variations in resistivity are caused primarily by differences in the character of the subsurface strata and the mineral content of the associated groundwater.

Factors that influence the response of the resistivity log are relative resistivities of borehole fluids and interstitial fluids, the diameter of the borehole and the distance between the electrodes on the borehole probe. Borehole lithology logs should be used with resistivity logs when attempting to identify formation material because of the factors that influence resistivity values.

Spontaneous Potential Logs

Spontaneous potential (SP) logs are usually run in conjunction with resistivity logs. Spontaneous potential logs measure the naturally occurring electrical potentials (voltage) that result from physical and chemical changes at contacts between differing types of subsurface geologic materials. For example, electrical potentials occur spontaneously at the contact surface between a sand strata and an underlying clay strata, or between sand formations and igneous rock. In a borehole, electrical potentials also occur between the drilling fluid and the formation, and the drilling fluid and the borehole filter cake.

Resistivity and SP surveys will be logged downhole at a common scale whenever possible. The appropriate scale will be determined in the field by conducting offset logs prior to running the final survey. Offset logs are a quality assurance (QA) and calibration step that involves logging an upper or lower portion of the borehole and adjusting the response of the log to obtain the optimum scale. Scales to be adjusted are the horizontal (millivolts for spontaneous potential and ohm-meters for resistivity) and vertical (feet).

The resistivity logs will consist of the short-normal (16-inch) and long-normal (64-inch) configurations. Geophysical logging will be completed in the deepest borehole in selected monitoring well clusters. A total of 11 boreholes will be logged. Geophysical logging will be conducted by a qualified subcontractor. A Radian geologist or engineer will supervise and observe all logging activities, including equipment calibration, to ensure the quality of the data. Cell cables, probes, and other equipment will be thoroughly steam-cleaned prior to being lowered into a borehole.

The E-log data will be evaluated prior to monitoring well construction to optimize the well design. The geophysical logs, in conjunction with lithologic logs, will be used to determine the most appropriate depth intervals for placement of the screen, sand pack, and grout seal.

The following information will be included on the resistivity and SP survey logs:

1) Well number;
2) Date and time;
3) Log recorder;
4) Equipment number;
5) Depth and diameter of borehole;
6) Type of fluid in hole;
7) Instrument length and diameter;
8) Rate of desent and ascent; and
9) Resistivity of drilling mud.

5.1.2 Natural Gamma Ray Logs

Natural gamma ray logging is a borehole geophysical method used to estimate lithologic characteristics of geologic formations by recording gamma radiation emission. Gamma logging may be used in conjunction with spontaneous potential, resistivity, and caliper logs in boreholes drilled by mud rotary methods.

Gamma radiation is emitted from certain elements present in geologic materials that are unstable and decay spontaneously into more stable elements. Certain radioactive elements, such as potassium-40 and the decay products of thorium and uranium, occur naturally in igneous and metamorphic rock and as depositional particles in sedimentary rock. Clay minerals, mica, and feldspar normally emit natural gamma radiation due to the presence of potassium-40. Conversely, quartz contains no potassium. Therefore, gamma ray logs generally indicate more counts per unit of time for sediments such as clay and silt, and fewer counts per unit of time for quartz-rich sand. Interpretive problems can occur when a sand formation includes a significant proportion of feldspar grains. In such cases, it may not be possible to differentiate between fine-grained materials, such as silt and clay, and feldspar-rich sand. Similarly, interpretative problems can arise where silt and clay-size particles contain little or no potassium and respond with low counts per unit time. These lithologic conditions appear to be the case at McClellan AFB. Other factors, including borehole radius and the nature of gamma radiation emission and detection, must be considered when interpreting gamma logs.

If natural gamma ray logs are employed at McClellan AFB during the RI the following information will be provided on the logs:

1) Well number;
2) Date and time;
3) Equipment number;
4) Length and diameter of tool;
5) Location of scintillation probe on tool;
6) Time constant;
7) Velocity of detector; and
8) Casing depth, type, and diameter, and cement type.

5.1.3 Caliper Logs

Caliper logs are used to measure the diameter of a borehole. This method is useful itself and in conjunction with other geophysical methods. This mechanical device, with one to four adjustable legs, consists of a probe that can measure the diameter of the borehole. By knowing the diameter of the borehole, such factors as borehole erosion, the presence of swelling clays or resistant strata, and the volume of filter pack of grout needed for well completion can be determined. Caliper logs are operated by lowering the device into the borehole and recording the measurements as the caliper is withdrawn. The following information will be included on each caliper log:

1) Well number;
2) Date and time;

3) Log recorder's name;
4) Equipment number;
5) Depth of borehole; and
6) Maximum and minimum tool diameters.

5.1.4 Field Procedures

Geophysical logging will be completed at a selected number of boreholes. Typically, only the deepest borehole or well in a monitoring well cluster will be logged. Resistivity, SP, and caliper logs will be run in boreholes drilled by the direct mud-rotary method. Natural gamma logging may also be conducted in boreholes along with resistivity and SP methods to augment the correlation of electric and natural gamma logs that have been completed on various wells and boreholes in the past.

Borehole geophysical logging will be conducted by a qualified contractor under subcontract to either Radian or Radian's drilling subcontractor. A Radian geologist or engineer will supervise and observe all logging activities. Cell cables, probes, and other will be steam-cleaned prior to being lowered into a borehole or monitoring well.

In cases where geophysical logs are being run in an open borehole prior to well construction, the data will be evaluated to optimize the well design. Specifically, the geophysical logs will be used to determine the most appropriate intervals for the screen, sand pack, and bentonite seal.

5.2 Drilling

5.2.1 Site Selection

The selection of locations and depths for monitoring well and subsurface soil sample sites will be a cooperative effort of Radian Corporation, the United States Air Force (USAF), and involved federal and state regulatory agencies.

Criteria for the selection of monitoring well and subsurface sampling locations will be based on specific objectives of each drilling or sampling effort. However, the locations will generally depend upon the following:

- Suspected presence or absence of contamination in the vadose and saturated zones;

- Current or historic groundwater gradients and flow directions;
- Further characterization of the geologic conditions;
- Proximity to past waste disposal sites;
- Favorable access for drilling equipment;
- Presence of overhead power or telephone lines; and
- Location of underground structures such as sewer lines, power lines, and water lines.

Final selection of a site will be dependent on securing all necessary rights-of-entry, clearances, and permits.

Sites selected for monitoring well installation will also be based on review of available hydrogeologic and analytical data. All proposed monitoring well sites and other borehole locations will be evaluated prior to drilling by examining maps and written records, and by walking the site, so the chances of disturbing underground water, sewer, gas, and telephone utilities are minimized.

5.2.2 Drilling Preparation

Prior to beginning drilling activities at any site, the Radian Field Coordinator (FC) will meet with representatives of McClellan AFB to verify that all necessary permits and clearances have been granted for each well. Only then will drilling equipment be mobilized to a well site. Radian will be wholly responsible for obtaining all off-base permits and clearances. United States Air Force protocol requires McClellan AFB Environmental Management (EM) to obtain on-base permits; Radian is responsible to ensure this is done for all on-base locations.

The FC shall be present each time the drill rig is moved to a well site. Prior to positioning the rig, the drill site shall be covered with 6-ml-thick polyethylene film to protect the immediate area from possible contact with contaminated drill cuttings and to facilitate cleanup efforts. The FC shall also supervise positioning of the rig such that the center of the borehole is within 0.5 feet of the predetermined well location (identified by a stake or paint mark). Such accuracy is necessary to avoid underground utilities, possible violation of property lines, rights-of-entry, or other agreements that have been negotiated with private property owners or base personnel.

Prior to drilling a new monitoring well or a temporary borehole, the drill string (casing, auger, bit, etc.) shall be cleaned by a high pressure, hot water wash (>180°F and >200 psi). Exclusion and support zones as referenced in the Health and Safety Plan shall be identified and marked. All health and safety equipment (tables, water, eye wash station, etc.) will also be set up at this time. The Site Safety Officer (SSO), with the assistance of the Supervising Rig Geologist (SRG), shall be responsible for this effort. The SSO will be on site to monitor borehole and cuttings vapors during drilling. If there is no further need for continuous monitoring during well construction as determined by monitoring and otherwise specified in the Health and Safety Plan, the SSO will not stay full-time at the site.

5.2.3 Drilling Methods

Monitoring well drilling and construction methods will be selected to best meet the following criteria:

- Ability to reliably determine the occurrence and thickness of waterbearing zones and interlayered low permeability zones during drilling;
- Ability to accurately place monitoring well screens at desired depths;
- Ability to meet all local, state, and U.S. EPA requirements for well construction and development;
- Ability to obtain samples of geologic material and provide for the preparation of detailed lithologic logs; and
- Speed and overall reliability of the technology.

Prior to field investigations, specific work plans will be written that will identify the drilling method(s) to be used and appropriate protocols for geologic logging, sampling, etc.

Drilling methods that may be used at McClellan AFB for installation of monitoring wells, groundwater level observation wells, and subsurface soil sample recovery include the following:

- Hollow stem auger (HSA);
- Direct rotary (mud or air); and
- Air rotary casing drive.

The hollow-stem auger (HSA) drilling method employs a hollow helical steel drill tool that is rotated to advance the boring and lift formation materials (cuttings) to the surface. This hollow opening allows the insertion of sampling tools (i.e., split spoon sampler) and well completion materials with the augers in place to support the borehole. The HSA technique will be used when collection of analytical samples in the vadose zone is planned or on those occasions when a single monitoring well must be completed at the water table.

The direct mud rotary drilling method employs a rotating bit which attaches to the lower end of a drill pipe and advances the boring as the drill pipe is rotated. In direct rotary drilling, a drilling fluid is pumped down through the drill pipe and out through the ports or jets in the bit. The fluid then flows upward in the annular space between the hole and drill pipe, carrying the cuttings in suspension to the surface. At the surface, the fluid is channeled into a settling pit or pits where most of the cuttings drop out. The fluid is then recirculated down the hole. The use of the direct rotary method will allow resistivity and spontaneous potential geophysical surveys to be conducted. The deepest well in any well cluster will be drilled by direct rotary method. The subsequent geophysical survey will assist in the drilling and construction of the other wells in the cluster.

The air rotary casing drive drilling method consists of a rotating drilling bit placed within a nonrotating drive casing. The drill bit advances simultaneously as the drive casing is driven into the ground. Pressurized air is forced downward through the drilling rods and bit; the air returns to the ground surface through the annulus between the drive casing and the smaller rotating drill rod, bringing continuously up the materials and groundwater cut by the drill bit. The cuttings are discharged into a cyclonic separator which separates the air from the formation cuttings to facilitate sampling and drill cuttings containment. Groundwater produced during drilling will be collected in a tank and transported from the drill site in a vacuum truck.

This method of drilling will be used for all wells not drilled using the direct mud rotary method.

Precautions will be taken with all drilling methods to minimize the potential for cross-contamination of aquifers. These precautions will include constructing monitoring wells and performing grouting in a proficient manner to restore the integrity of the aquifer as quickly as possible. In addition, when drilling with air rotary casing drive, drilling will be conducted so that the drill bit advances no further than 1 foot ahead of the drive casing.

Core samples may be collected while drilling with any of the above drilling methods. The core sampling system selected will depend on the type of drilling method being used and the type of sample that is desired (i.e., a continuous core sample for lithologic logging or a sample from a discrete depth for physical or chemical testing).

Depending on the drilling method being used to perform the coring, the coring methods may be used with drilling fluids (direct rotary or air rotary casing drive), no fluid (hollow-stem auger), or pushed or driven into the formation material to be sampled. Core samplers will be retrieved from the holes using a wire-line setup or a string of drill rods. Various types of samplers will be used depending on the objective of the coring. The sampler types may include split-spoon samplers, core-barrel samplers, or thin-walled (Shelby) tubes. The objective of the coring will be to obtain minimally disturbed samples.

Upon retrieving samples for lithologic logging, the core sample will be removed from the sampler for visual inspection and logging. The core will be split longitudinally to allow logging of as undisturbed and representative a core sample as possible. The core will be logged by the supervising rig geologist using the logging protocol defined in this document. After logging the core, the sample will be placed in a core box, labeled, and stored in the core storage area. Samples for physical or chemical testing will be labeled, packaged, and sent to the laboratory for analysis. Proper chain-of-custody procedures will be followed.

5.2.4 Cuttings and Groundwater Disposal

A licensed hazardous waste transportation company under subcontract to Radian will transport and dispose of all borehole cuttings, drilling fluids, and groundwater removed from the boreholes and completed monitoring wells. A transportation plan will be prepared as needed for disposal of cuttings and groundwater, and detailed in the appropriate work plan. During the drilling operations, the solid cuttings will be monitored for organic vapors, contained in steel, plastic-lined, 55-gallon drums, and transferred to 20-cubic-yard capacity roll-off bins located on McClellan AFB. Bentonite drilling fluids will be put in containers on site. Groundwater produced during the drilling will be collected by vacuum truck and discharged to the Industrial Wastewater Treatment Plant (IWTP) or the Groundwater Treatment Plan (GWTF) at McClellan AFB. This activity will be coordinated through SM-ALC/EM when necessary.

Drilling cuttings will be monitored for organic vapors in the field by Radian personnel. Cuttings from boreholes will be preliminarily characterized for disposal purposes by monitoring for organic vapors with a photoionization detector (PID) or organic vapor analyzer, and, if need be, species-specific Draeger® detector tubes. Cuttings will be sampled and analyzed by methods appropriate for predisposal profiling.

Drilling mud will be put in containers on site and transferred to separate water-tight, large capacity tanks. Upon completion of drilling activities, the drilling mud will be characterized in the same manner as the on-base cuttings.

Any material, nonhazardous or otherwise, being transported off McClellan AFB will be handled according to procedures stipulated by the McClellan AFB Office of Environmental Management. Any hazardous material transported off McClellan AFB will be accompanied by a required California Department of Health Services (DHS) Uniform Hazardous Waste Manifest. McClellan AFB is the generator of these materials and will be responsible for attending to any Hazardous Waste Manifests. Materials deemed hazardous will be transported and disposed of in an appropriate Class I disposal site that complies with Resource Conservation and Recovery Act (RCRA) requirements for waste disposal facilities.

Further discussion of procedures for disposal of potentially hazardous materials generated by field activities can be found in Section 5.5 of this QAPP. Transportation and disposal of cuttings and drilling muds from any projects at McClellan AFB will be described in the Transportation/Disposal Plan Appendix to the project work plan. The Transportation/Disposal Plan will describe in detail the types and numbers of predisposal analyses to be conducted.

5.2.5 Recordkeeping

The Supervising Rig Geologist (SRG) will work under the direct supervision of a California Registered Geologist, although the California Registered Geologist will not be in the field continuously.

The SRG shall be responsible for all recordkeeping associated with the drilling. Examples of forms to be used during drilling projects are illustrated in Figures 5-1 through 5-7. The following forms shall be completed:

- Log of Drilling Operations;
- Well Completion Log;
- Time and Materials Log;
- Daily Field Report including equipment maintenance;
- Well Development Log;
- Photoionization Detector Screening Data Sheet; and
- Direct Reading Indicator Tubes Field Data Sheet.

In addition to filling out these forms, the SRG will be responsible for keeping a daily log of events and observations in a field notebook.

The Log of Drilling Operations will include descriptions of all subsurface materials encountered while drilling. All subsurface materials shall be classified and logged in accordance with Unified Soil Classification (USC) System and Wentworth Scale. The lithology shall be recorded in the field log in the following order:

1) Predominant lithologic type (i.e., gravel, sand, silt, clay);

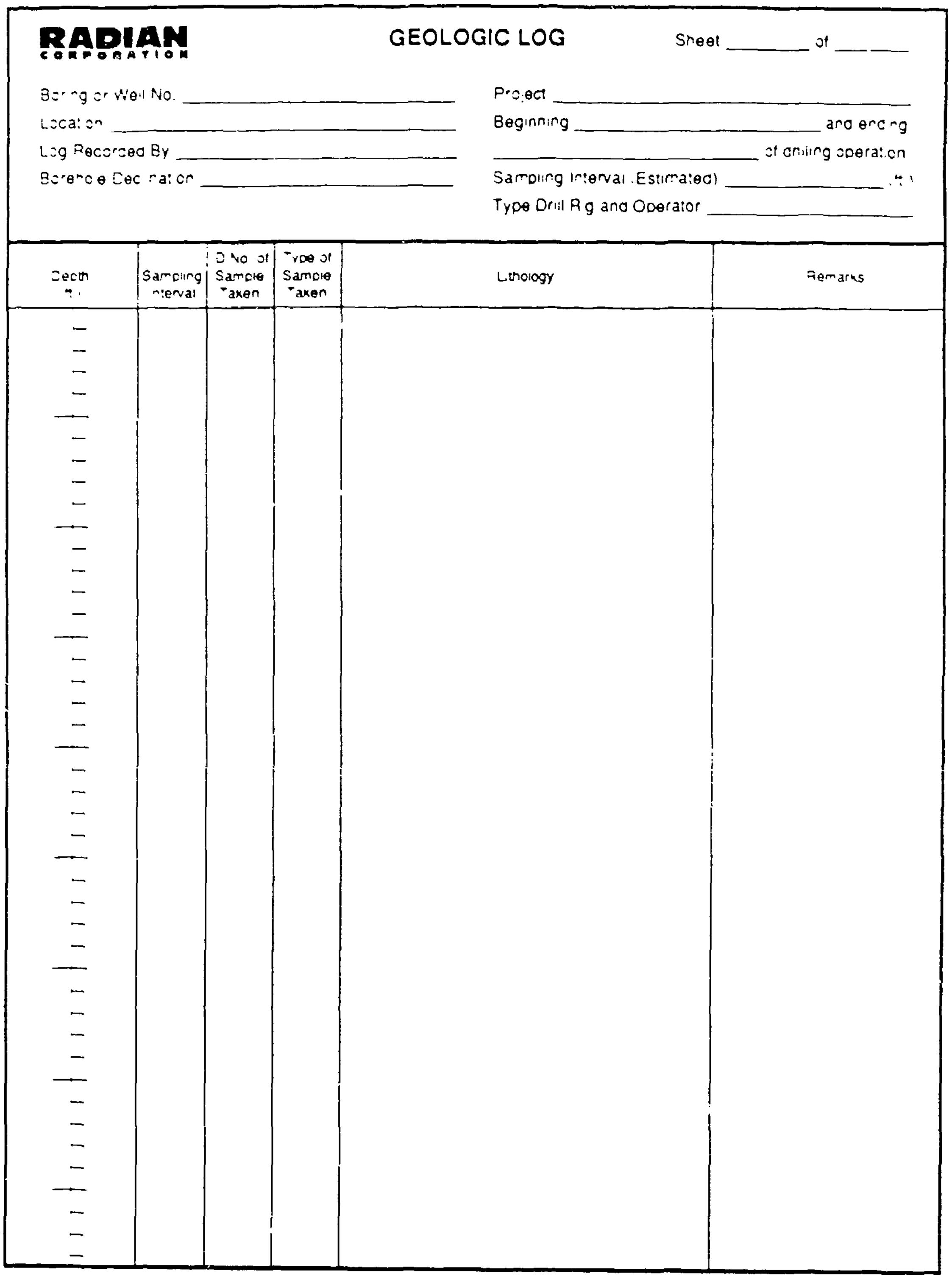
2) Grain size (based on the size scale adopted by Wentworth);

3) Major modifier(s) (i.e., silty, sandy, etc.);

4) Minor modifier(s) (i.e., some silt, trace clay, etc.);

5) Color (based on Munsell Soil Color Chart);

6) Relative moisture content (i.e., dry, damp, moist, wet, saturated); and



RADIAN CORPORATION

GEOLOGIC LOG

Sheet ________ of ________

Boring or Well No. ________
Project ________
Location ________
Beginning ________ and ending
________ of drilling operation
Log Recorded By ________
Sampling Interval (Estimated) ________ (ft)
Borehole Declination ________
Type Drill Rig and Operator ________

Depth (ft)	Sampling Interval	ID No. of Sample Taken	Type of Sample Taken	Lithology	Remarks

Figure 5-1. Log of Drilling Operations.

0489-019-8

WELL COMPLETION LOG

McClellan AFB

Stages 2-4 and 2-5 Monitoring Wells

Well No. ______________ Log Recorded By ______________

Location ______________ Completion Date ______________

Drilling Method ______________

Borehole Depth ______________ Borehole Diameter ______________

Materials:

Casing Diameter/Type ______________

Screen Diameter/Type/Slot Size ______________

Sand/Gravel ______________

Bentonite Seal ______________

Grout ______________

Intervals:

Screen Interval ______________

Casing interval ______________

Sand/Gravel Pack Interval ______________

Bentonite Seal Interval ______________

Grout Interval ______________

Type of Surface Completion ______________

NOTES: ______________

Figure 5-2. Well Completion Log.

WELL COMPLETION LOG

(Continued)

As-Built Schematic:

Figure 5-2. Well Completion Log.
(Continued)

TIME AND MATERIALS LOG

McClellan AFB

Well No. ____________________

Completion Date ____________________

Total Depth Drilled ____________________

Screen Interval ____________________

Supervising Rig Geologist ____

DRILLING TIME:

Mobe ____________________

Rig Setup ____________________

Drilling ____________________

Standby ____________________

Rig Decon ____________________

Other ____________________

Subtotal Drilling ____________________

WELL COMPLETION TIME:

Sand Pack ____________________

Bentonite Seal ____________________

Grout ____________________

Wellhead ____________________

Site Cleanup ____________________

Other ____________________

Subtotal Completion ____________________

TOTAL ____________

NOTES: ____

____

____

____

____

Figure 5-3. Time and Materials Log.

TIME AND MATERIALS LOG

(Continued)

	UNIT	QUANTITY
Screen		
Stainless Steel Casing		
PVC Casing		
Sand		
Bentonite Pellets		
Portland Cement		
Bentonite Powered (Gel)		
Security Cover		
Utility Box		
Lock		

NOTES:

Figure 5-3. Time and Materials Log.
(Continued)

DAILY FIELD REPORT

McClellan AFB

Date ____________________ Reported by ______________________________

S M T W T F S

Summary of Events and Observations:

____

____

____

____

____

____

____

Summary of Subcontractor Activities:

____

____

____

____

____

____

____

Figure 5-4. Daily Field Report.

Rev. 8/86

WELL DEVELOPMENT LOG

McClellan AFB
Stages 2-4 and 2-5 Monitoring Wells

Well No. ____________ Reported by ____________

Screen Type/Interval ____________

Screen Diameter/Slot Size ____________

Static Water Level Prior to Development ____________

Development Started ____________ Ended ____________

Quantity of Water Discharged During Development ____________

Equipment/Tools Used ____________

Time	Development Method	Observations and Remarks

Figure 5-5. Well Development Log.

Rev. 8/86

WELL DEVELOPMENT LOG

(Continued)

Drawdown Data:

Time	Elapsed Time	Discharge Rate (gpm)	Depth to Water	Drawdown	Notes

Figure 5-5. Well Development Log.
(Continued)

PHOTO-IONIZATION DETECTOR
SCREENING DATA SHEET

AREA: ____________________

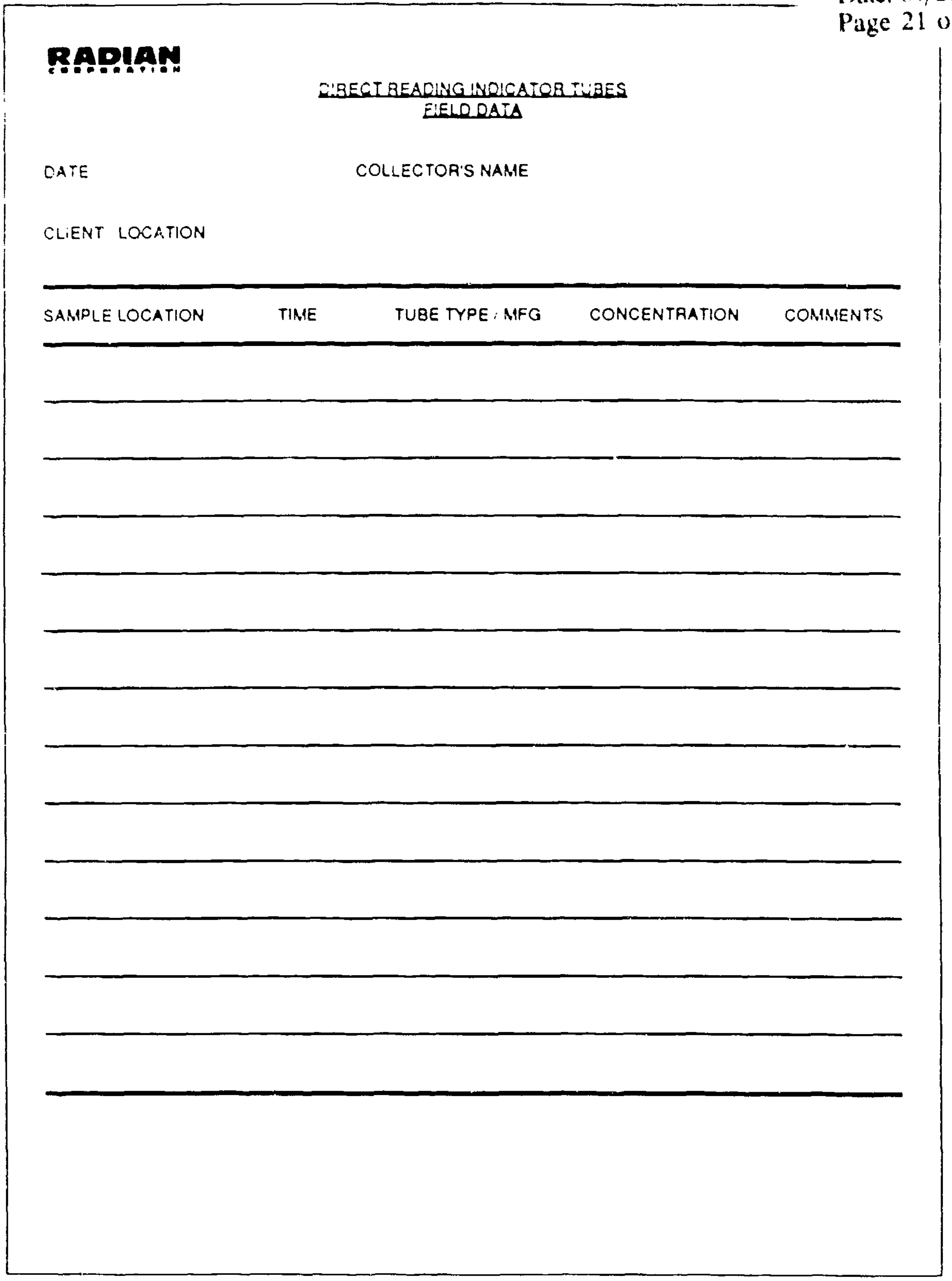
DATE: ____________________ TIME: ____________________

SCREENER'S INITIALS ____________________ INSTRUMENT I.D. ____________________

SPECIFIC LOCATION	SCREENING VALUE (ppmv)
1. Ambient (average background)	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	

Comments:

Figure 5-6. Photoionization Detector Screening Data Sheet.



RADIAN
CORPORATION

DIRECT READING INDICATOR TUBES
FIELD DATA

DATE

COLLECTOR'S NAME

CLIENT LOCATION

SAMPLE LOCATION	TIME	TUBE TYPE / MFG	CONCENTRATION	COMMENTS

Figure 5-7. Direct Reading Indicator Tubes Field Data Sheet.

7) Other descriptive terminology as appropriate such as, but not limited to:

   a) Relative density or consistency;
   b) Observed bedding;
   c) Visual evidence of contamination;
   d) Distinctive mineralogy (i.e., micaceous); and
   e) Sorting or grading.

In addition to continuously logging the encountered subsurface materials, pertinent information regarding drilling operations will also be recorded on the log form. Such entries may document drilling times, rig "down" time, problems with drilling methods, etc. Because many of the boreholes will be drilled to construct monitoring wells, the occurrence and quantity of groundwater encountered while drilling will be documented. Lithologic samples will be collected at a minimum of every 5 feet and stored in labeled sample bags.

When collecting samples during mud-rotary drilling, uphole velocities of the drilling mud will be determined to ensure that samples are obtained from desired depths. One of two methods will be used to determine the uphole velocities. Actual real-time measurements will be made if possible. After each drill pipe connection, the drilling mud will be circulated until air that was entrained in the drill pipe from making the connection travels through the drill pipe, into the borehole, and back to the surface. The travel time will be recorded and used to determine when to collect the sample for a desired depth.

The second method that may be used is to determined uphole velocities based on borehole diameter, drill pipe diameter, and pump output. A nomogram to determine uphole velocities using this information is presented in "Groundwater and Wells" (Driscoll, 1986, p. 387).

The termination depth (TD) for a monitoring well shall be determined by the SRG after consultation and concurrence by the McClellan EM Engineer. Identification of a favorable screen interval in the planned depth range of the well will be the primary factor for selecting TD. Favorable conditions for a screen interval include:

- Presence of groundwater;

- High hydraulic conductivity (i.e., "clean" sand); and

- Adequate penetration into the saturated zone (TD for shallow wells should be a minimum of 10 to 15 feet deeper than water table, if possible).

Should there be any questions regarding selection of a screen interval, the SRG will confer with the FC or Project Director (PD) prior to instructing the driller to terminate a borehole. If possible, the FC should be present as each well approaches TD. A sample of the formation material encountered in the screen interval shall be recovered by the SRG.

5.3 Well Installation

Monitoring well installation procedures in documentation, and materials are described below.

5.3.1 Well Installation and Completion

All groundwater monitoring wells will be constructed in a similar manner, regardless of the drilling method used. The following materials will be used:

- Screen--Johnson Type 304 stainless steel, wire-wrapped, 10-foot lengths, 4-inch inside diameter, 0.020- to 0.010-inch slot sizes. Stainless steel centralizers will be set at top and bottom.

- Casing--Johnson Schedule 5, Type 304 stainless steel, flush-threaded, 10-foot lengths, 4.334 inches over most of length, 4.026-inch inside diameter at fitting. Stainless steel casing will be used between the screen and the highest anticipated groundwater level. Stainless steel casing centralizers will be set at every 40 feet.

- Casing--Johnson Schedule 40 PVC, flush-threaded, 10-foot lengths, 4.026-inch inside diameter in vadose zone of wells less than 200 feet deep. Low carbon steel casing in wells greater than 200 feet deep. Stainless steel casing centralizers will be set at every 40 feet.

- Sand Pack--Monterey sand, 8x16 mesh or Lonestar, Number 1C.

- Sand Bridge--Monterey sand, 30 mesh.

- Bentonite Seal--Pelletized, nonbeneficiated sodium bentonite or bentonite chips.

- Sanitary Seal--Neat mixture of Type I Portland cement with approximately 3 pounds of powdered nonbeneficiated bentonite and 7-1/2 gallons of water per 94-pound sack of cement.

- Security Cap--Six-inch diameter by 5-foot long steel casing with locking lid.

- Utility Box--Will be used to protect wellhead for "flush" completions only.

The preferred slot width of 0.02 inches for factory-prepared perforated casing (screen) was selected on the basis of 1984 Stage 2-1 sieve analysis and the satisfactory performance record of monitoring wells with screens of that slot width. Sieve analyses were performed on samples from 29 reconnaissance borings completed on and adjacent to McClellan AFB in 1984. Analyses of the grain size distribution in those samples indicated that a slot of 0.02 inches would pass ten percent or less of the grains in the waterbearing zone in which the screen was installed. The monitoring wells with 0.02 inch slotted screens, which have been periodically purged and sampled, discharge water at adequate pumping rates without producing measureable amounts of sand or silt.

Seive analyses will be performed in order to select the appropriate filter pack and screen slot size for extraction well construction. The seive analyses will be performed by collecting a sample of the formation material and passing it through a series of seives of progressively smaller size. The cumulative weight of particles retained by each seive will then be plotted as a percent of the total sample weight against grain size to select the appropriate well construction materials. A thorough discussion of the seiving procedure is presented in "Groundwater and Wells" (Driscoll, 1986). Although a sieve analysis of grain size distribution is desirable in construction of a groundwater production well; it is not practical or cost effective to conduct sieve analyses during drilling to optimize the design of a monitoring well. Although it is anticipated that most monitoring wells to be constructed at McClellan AFB will function satisfactorily with 0.02-inch screen slots, 0.01-inch slot screens may be selected in the field when completions are required in finer-grained monitoring zones penetrated in areas or depths not previously investigated. Screen slot sizes of 0.01 to 0.02 inch will be available for construction to ensure a sediment-free, representative groundwater sample for monitoring. Slot size selection will be made in the field on the basis of samples collected during drilling.

Prior to placement of the screen and casing, the borehole depth will be verified with a weighted surveyors tape. The screen and casing will then be placed through the hollow portion of the augers (HSA rig) or into the mud-filled borehole (direct rotary rig) or inside the drive casing (air rotary casing drive rigs). Stainless steel centralizers will be positioned at the top and bottom of the screen and at 40-foot intervals on the well casing. Stainless steel casing will be used to the highest anticipated water table elevation. The highest anticipated water-level elevation is estimated for each monitoring well from: 1) the depth of the saturated stratum first encountered during drilling; 2) the observed decrease in the regional water table elevation of approximately 1 to 2 feet per year; and 3) seasonal fluctuations in static water levels of approximately 1 to 5 feet from March (highest measured annual levels) to September-November (lowest measured annual levels). Polyvinyl chloride casing will be used above the stainless steel casing in wells screened at depths equal to or less than 200 feet. In wells completed at depths greater than 200 feet, low carbon steel casing will be used in the vadose zone because of the greater bearing weight of the steel threads. All screen and casing will be flush-joint threaded.

Once enough sand has been placed to support the screen and casing, the well will be checked for proper alignment by passing a length of PVC pipe (measuring 3.75 x 10 feet) through the casing to the bottom of the well. The sand pack will then be placed around the screen through a tremie pipe to a minimum height ranging from 1 to 2 feet above the top of the screen. The well will then be surged to settle the sand and the height of sand adjusted to be at least 1 and not more than 2 feet above the top of the screen. The drill string will slowly be pulled up and recovered as the sand pack is installed.

After installing the sand pack, a weighted surveyors tape will be used to sound the top of the filter pack. Materials will then be added through the tremie pipe to construct the sand bridge and a 3- to 5-foot bentonite seal. The quantities of sand and bentonite introduced to the well will be measured and compared to a calculated estimate of the materials required based on well dimensions. After sounding the top of the sand bridge and bentonite seal, a cement-bentonite sanitary seal will be pumped into the annulus between the well casing and outer casing. Only nonbeneficiated bentonite will be used in the cement-bentonite grout mixtures. The cement, bentonite, and water will be mixed in the specified ratios to obtain a smooth, thick, pumpable grout mixture that will provide an effective seal and prevent excessive grout loss to the formation. The drill tools will gradually be pulled up and recovered as the level of grout rises in the borehole. Figure 5-8 shows generalized well construction diagram for wells in which the weight of screen and casing does not exceed the bearing strength of PVC threads.

The mud rotary method will be used primarily for the drilling of boreholes to be geophysically logged. Boreholes for construction of monitoring wells will primarily be constructed by other methods described in this section.

The wellheads for monitoring wells will be completed above ground or as flush completions as shown in Figures 5-9 and 5-10, respectively. Monitoring wells completed above ground will have a 6-inch-diameter locking steel casing installed around the PVC monitoring well stick-up. Above-ground completions may be appropriate in locations at which wells have been constructed in topographically low or poorly drained areas and entry of runoff into the wellhead is possible. The protective steel casing will be set in a 2-foot-square cement pedestal. Four 3-inch-diameter steel protective posts will be positioned around those wells where such protection is considered necessary.

The PVC casing for all flush completed wells will be set several inches below grade. Each wellhead will be enclosed within a steel "valve" box equipped with a threaded lid. Each valve box contains a water-tight seal between the box and the lid that prevents surface water from entering the well. The valve boxes will also be set slightly above the surrounding ground surface, so surface water flows away from the wellhead.

The well number will be stamped on the lid of the steel protective casing. All wells will be secured with identically keyed padlocks. Keys will be provided to McClellan AFB EM.

Surveying

The top north side of the PVC well casing will be permanently notched to indicate a reference point from which all future water level measurements will be made. At the completion of drilling operations, a licensed land surveyor will determine the vertical and horizontal position of the reference point. The elevation of each wellhead will be determined to an accuracy of ±0.01 foot. Horizontal control will be provided to ±1.0 foot.

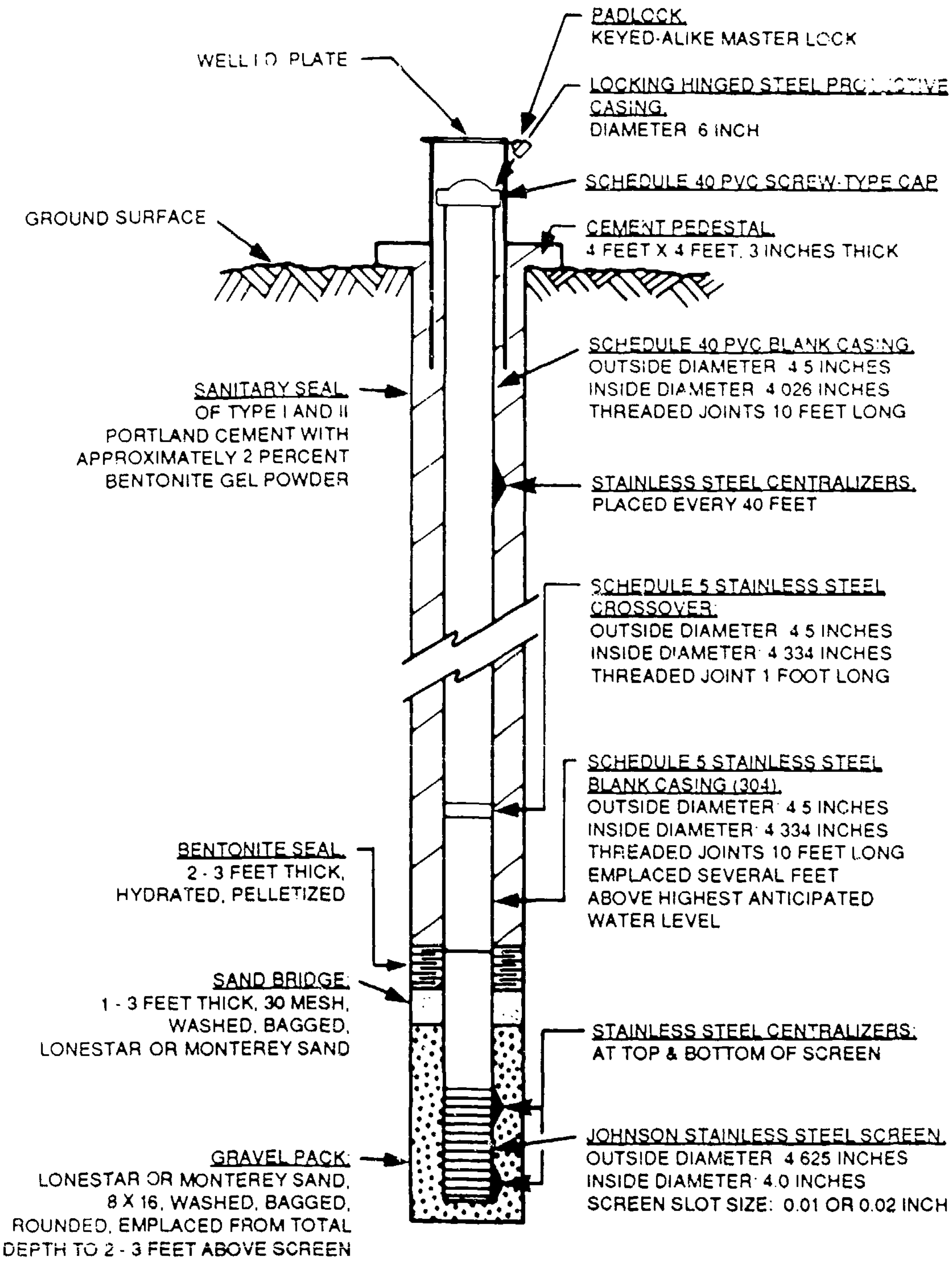


Figure 5-8. Schematic Well Construction Diagram for Groundwater Monitoring Wells.

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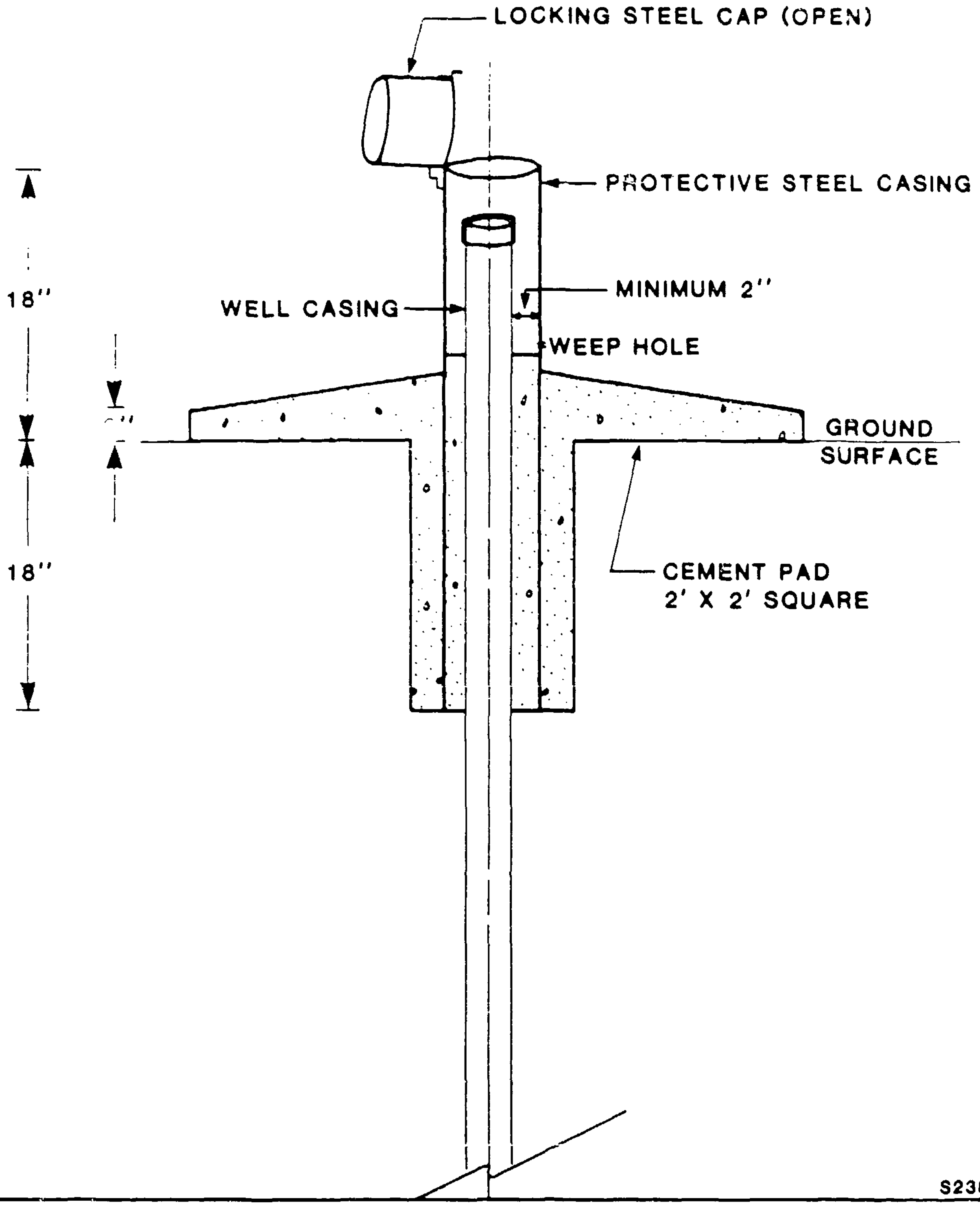

Figure 5-9. Above Ground Completion for Monitoring Wells.

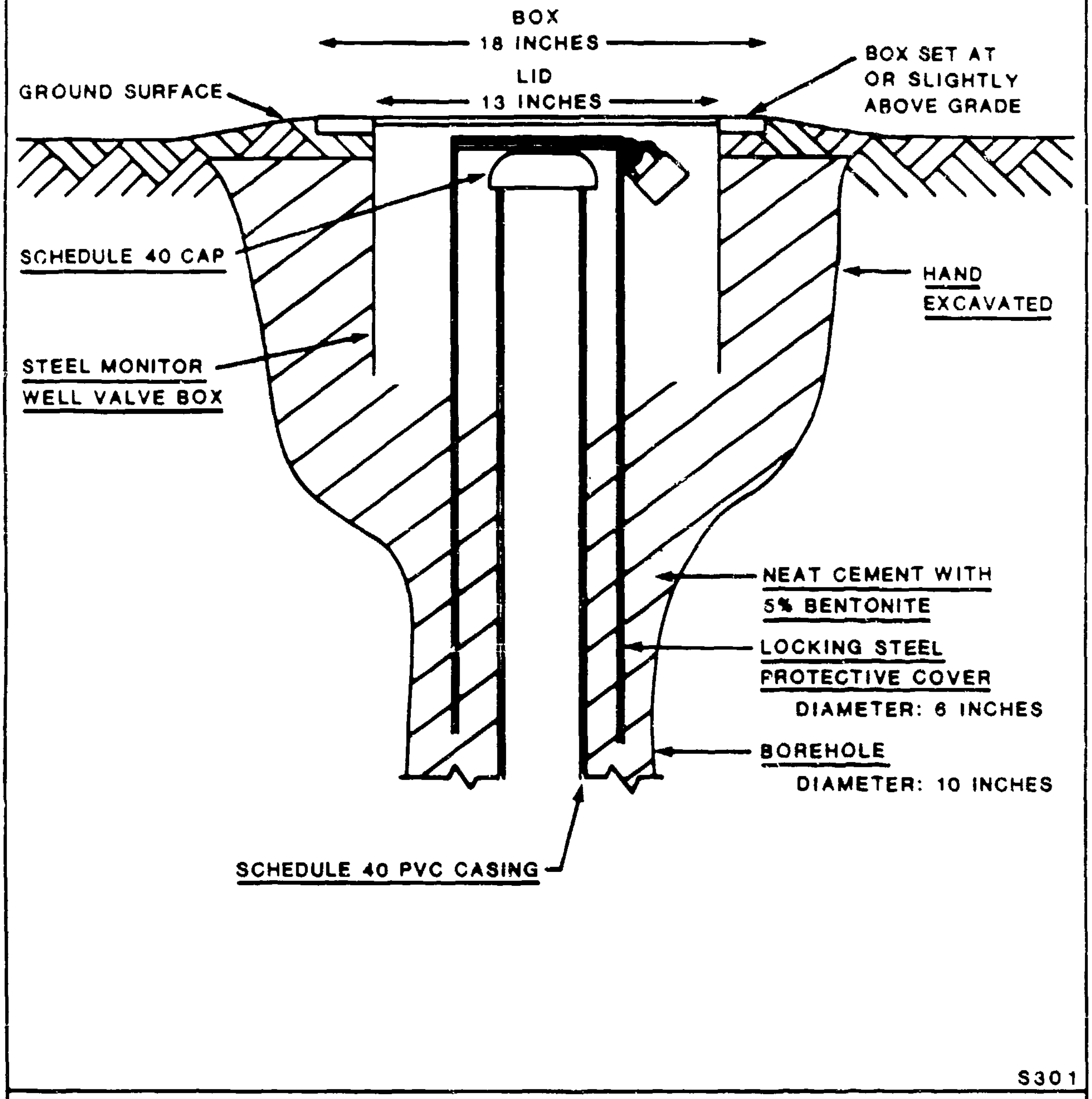

Figure 5-10. Surface Completion for Monitoring Wells.

5.3.2 Monitoring Well Development

All groundwater monitoring wells will be developed to remove any fine-grained sediment from the screen and remove fluids introduced into the formations during drilling. Development will consist of bailing, surging, and pumping, and will be accomplished under the supervision of the SRG. During pumping of the well, drawdown data will be obtained to determine specific capacity and estimate transmissivity and hydraulic conductivity.

Prior to development of each well, total well depth and depth to the static water level will be measured. Development will be initiated by bailing to remove sediment that may have accumulated inside the screen as a result of formation disturbance during drilling. Bailing will be accomplished with a 10-foot-long, 3-inch-diameter, 3.7-gallon-capacity bailer. Bailing will continue until the amount of sediment recovered from the well decreases significantly. After bailing, each well will be surged with a close-fitting, vented, surge block. As a surge block is moved up and down inside the well casing, it forces water back and forth across the screen openings to break down bridging of fine-grained material in the sand pack and adjacent formation. After surging for several minutes, the material brought into the well will be removed by additional bailing. The bailing and surging procedure will be repeated until the amount of sediment entering the well decreases to a level deemed acceptable to the SRG.

Following bailing and surging, each well will be pumped with an electric submersible pump. Wells will be pumped at discharge rates ranging from approximately 2 to 20 gallons per minute. Actual pumping duration and discharge will be controlled by the yield of each well and the amount of development required. All wells will be pumped until they produce water that has stablized conductivity and pH measurements and is free of sediment as determined by visual inspection by the SRG.

5.4 Sample Storage and Preservation Requirements

Table 5-1 contains information about required sample containers, preservation methods, holding times, and storage requirements for all currently anticipated analytical methods. These requirements are compiled from U.S. EPA SW-846 Methods Third Edition or other United States Air Force Occupational and Environmental Health Laboratory (USAFOEHL) approved methods. Sample bottles are precleaned by the manufacturer according to U.S. EPA protocols; stainless steel sleeves are cleaned according to the prescribed methods prior to use.

TABLE 5-1. SAMPLE STORAGE AND PRESERVATION REQUIREMENTS

Reference Parameter	Method(s)	Holding Time	Container(s)[a]	Preservation	Storage Requirements
ORGANICS:					
Purgeable Halocarbons	SW8010	14 days	Three 40-mL glass vials with Teflon® seals (w)[b]; 4-oz widemouth glass bottle with Teflon® liner or stainless steel sleeve (s)[c]	None	4 °C
Total Petroleum Hydrocarbons	SW8015 Modified	14 days	1-Liter glass bottles	None	4 °C
Purgeable Aromatics	SW8020	14 days	Three 40-mL glass vials with Teflon® seals (w); 4-oz widemouth glass bottle with Teflon® liner or stainless steel sleeve (s)	pH <2 with HCl	4 °C
Phenols	SW8040	7 days until extraction, 40 days after extraction	Glass bottles with Teflon® seals (w); 4-oz widemouth glass bottle with Teflon® liner or stainless steel sleeve (s)	None	4 °C
Organochlorine Pesticides and PCBs	SW8080	7 days until extraction, 40 days maximum	Three 40-mL glass vials with Teflon® seals (w); stainless steel sleeve (s)	None	4 °C
Purgeable Organics	SW8240	14 days	Three 40-mL glass vials with Teflon® seals (w); 4-oz widemouth glass bottle with Teflon® liner or stainless steel sleeve (s)	pH <2 with HCl	4 °C

[a] All containers are pretreated and cleaned before being purchased by the laboratory.
[b] Sample container for water samples.
[c] Sample container for soil samples.

(Continued)

TABLE 5-1. (Continued)

Reference Parameter	Method(s)	Holding Time	Container(s)[a]	Preservation	Storage Requirements
ORGANICS: (Continued)					
Base/Neutral and Acid Extractables	SW8270	7 days until extraction, 40 days maximum	Glass bottles with Teflon® seals (w); 8-oz glass bottle with Teflon® liner or stainless steel sleeve (s)	None	4°C
Dioxins and Furans	EPA 8280	30 days maximum	1-Liter glass bottle with Teflon® seals (w and s)	0.008% $Na_2S_2O_3$ if residual chlorine is present	4°C
Volatile Organic Compounds in Air	Radian GC/ FID-PID-HECD Method	14 days	Stainless steel canister	None	None
INORGANICS:					
Anions	EPA 300.0	28 days	Aliquot taken from TDS split (w)	None	4°C
Alkalinity	EPA 310.1	Field Test	500-mL polyethylene bottle (w)	None	N/A
Nitrate	EPA 353.2	28 days	One 500-mL polyethylene bottle (w)	pH <2 with H_2SO_4 (w)	4°C
Total Dissolved Solids	EPA 160.1	7 days	One 500-mL polyethylene bottle (w)	None	4°C
ICP Scan for Metals	SW6010	6 months	One 500-mL polyethylene bottle (w); stainless steel sleeve (s)	HNO_3 Acid to pH <2 (w)	4°C

---

[a] All containers are pretreated and cleaned before being purchased by the laboratory.
[b] Sample container for water samples.
[c] Sample container for soil samples.

GC/ = Gas chromatography with multiple detectors.

(Continued)

TABLE 5-1. (Continued)

Reference Parameter	Method(s)	Holding Time	Container(s)[a]	Preservation	Storage Requirements
INORGANICS: (Continued)					
pH	SW9040	Field Test	500-mL polyethylene bottle	None	None
Conductance	SW9050	Field Test	500-mL polyethylene bottle	None	None
Arsenic	SW7060	6 months	Aliquot taken from 500-mL polyethylene bottle (w); stainless steel sleeve (s)	HNO_3 Acid to pH <2 (w)	4°C
Lead	SW7421	6 months	Aliquot taken from 500-mL polyethylene bottle (w); stainless steel sleeve (s)	HNO_3 Acid to pH <2 (w)	4°C
Mercury	SW7470 SW7471	28 days	Aliquot taken from 500-mL polyethylene bottle (w); stainless steel sleeve (s)	HNO_3 Acid to pH <2 (w)	4°C
Selenium	SW7740	6 months	Aliquot taken from 500-mL polyethylene bottle (w); stainless steel sleeve (s)	HNO_3 Acid to pH <2 (w)	4°C
Cyanide	EPA 9010	14 days	1-Liter polyethylene or glass bottle (w); stainless steel sleeve (s)	NaOH to pH >12 (w)	4°C

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[a] All containers are pretreated and cleaned before being purchased by the laboratory.
[b] Sample container for water samples.
[c] Sample container for soil samples.

(Continued)

TABLE 5-1. (Continued)

Reference Parameter	Method(s)	Holding Time	Container(s)[a]	Preservation	Storage Requirements
INORGANICS: (Continued)					
Gross alpha, beta, gamma radioactivity	EPA 900.0 EPA 901.1	6 months	Glass or polyethylene bottles (w)	HNO_3 to pH <2	4°C

[a] All containers are pretreated and cleaned before being purchased by the laboratory.
[b] Sample container for water samples.
[c] Sample container for soil samples.

NOTE: Sample containers for gas phase samples, air canisters, sorbent tubes, or filters are stored at ambient temperatures and treated according to method specifications.

Sample Container and Trip Blank Preparation

Prior to leaving for the monitoring well sites, trip blank samples will be prepared as required. The purpose and preparation of trip blank samples is discussed in Section 10.0. When possible, sample containers will also be prepared with preservative at this time. Such preparation will save time and promote organization in the field.

5.5 Groundwater Samples

Groundwater samples will be collected from monitoring and extraction wells and analyzed for organic and inorganic constituents as required for each sampling and analysis task.

The objective of the groundwater sampling protocol is to obtain samples that are representative of the groundwater surrounding the well screen, and to analyze these samples in a manner that reflects the composition of the groundwater as accurately as possible. In order to achieve this objective, all factors that may affect the physical and chemical integrity of the sample must be controlled before, during, and after sample collection. These factors are discussed in detail in the following subsections.

Planning and Scheduling

Careful planning of the sampling schedule will optimize the time spent in the field. Planning will include evaluating the condition of the wells to be sampled on a given day and scheduling the sampling in order of priority. The accessibility of the wells with regard to seasonal and other factors will be considered during this process. The wells that will be used for the recovery of QC samples (duplicates and field blanks) will be selected during the planning period of each field effort.

Materials and Supplies

Materials and supplies required for sampling activities will be organized prior to the start of sampling. A materials and supplies list will be reviewed and the items checked before the sampling team leaves for the monitoring well sites. This procedure will encourage efficient use of time during the day. A list of typically required materials and supplies is presented in Table 5-2. In addition, safety equipment, including a first aid kit, will always accompany personnel in the field. A general safety equipment checklist is presented in Table 5-3.

TABLE 5-2. SAMPLING EQUIPMENT CHECKLIST

- Specific instructions and maps for wells to be sampled
- Quality assurance and field sampling procedures (the QAPP)
- Trip blanks
- pH meter
- pH 7, and 10 buffer calibration solutions
- Conductivity meter
- Conductivity calibration solution
- Thermometer
- Chemical preservatives
- Sample containers
- Bailers (if sampling wells without dedicated pumps)
- Type II reagent-grade water
- Laboratory-grade detergent (Alconox®)
- Pesticide-grade methanol and hexane
- Water-level indicator
- Calculator
- Measuring tape (calibrated in hundredths of a foot)
- Field notebook
- Chain-of-custody forms
- Plastic sheeting
- Ballpoint pens
- Sample bottle labels
- Duct tape
- Clear tape
- Tool kit
- Scissors
- Wash tubs, buckets
- Drinking water container
- Handiwipes
- Garbage bags
- Coolers
- Ice
- Protective mesh coverings for glass sample bottles
- Foam containers for VOA vials
- Aluminum foil
- Zip-lock® bags

(Continued)

TABLE 5-2. (Continued)

10% nitric acid
Submersible pump and attachments (if sampling wells without dedicated system)
Operating manuals
Control box
Compressor
Generator

TABLE 5-3. SAFETY EQUIPMENT CHECKLIST

- First aid kit
- Fire extinguisher
- Disposable coveralls
- Safety glasses
- Hard hats
- Steel-toed rubber boots
- Disposable polyvinyl chloride gloves
- Butyl gloves
- Draeger® tubes and pumps
- Respirator and cartridges
- Respirator cleaner
- Heat monitors
- Personal organic vapor badges
- Safety forms
- Copy of Health and Safety Plan

NOTE: Additional equipment may be mandated by future revisions of the Health and Safety Plan.

Recordkeeping

Organized and accurate written records contribute to the reliability and comparability of field data. Field observations and data collected while sampling a well will be entered on well-specific sampling data sheets contained in a bound log book. In addition, a bound master log will be kept to record sample tracking and analysis information, as discussed in Section 6.1.

5.5.1 Groundwater Sampling Equipment

Well Wizard® groundwater sampling equipment manufactured by Q.E.D. Environmental Systems, Inc., will be used to collect groundwater samples from wells that are sampled on a regular basis (i.e., quarterly). The Well Wizard® equipment is designed to be "dedicated" to a monitoring well. This eliminates the need to use one pump in many wells and decreases the probability of cross-contaminating groundwater samples and monitoring wells. The portable components required to operate the Well Wizard® system include the automatic controller and the oil-less air compressor driver.

Not all monitoring wells are equipped with dedicated sampling pumps. A Teflon® bailer will be used to collect groundwater samples from wells without dedicated pumps. Other accessory equipment required for sampling includes a combination pH/conductivity meter, a mercury-in-glass thermometer, an electronic water-level indicator, and a portable peristaltic pump. A listing of model or part numbers for each component or piece of equipment is presented in Table 5-4. The dedicated and portable equipment used during groundwater sample collection is described below.

Dedicated Sampling Pumps

Both the Well Wizard® bladder and purge pumps use the positive gas displacement method to move water from the pump intake to the wellhead. Figure 5-11 illustrates the principle of operation for the gas displacement pumping method. The steps taken in operating the dedicated pump system are detailed in the Operations Manual, which is taken into the field when dedicated system wells are to be sampled.

Bladder Pump

A positive gas displacement bladder pump is used to recover groundwater samples. The bladder pump consists of a stainless steel body with an internal flexible Teflon® bladder. The bladder serves to isolate the groundwater from the drive gas that

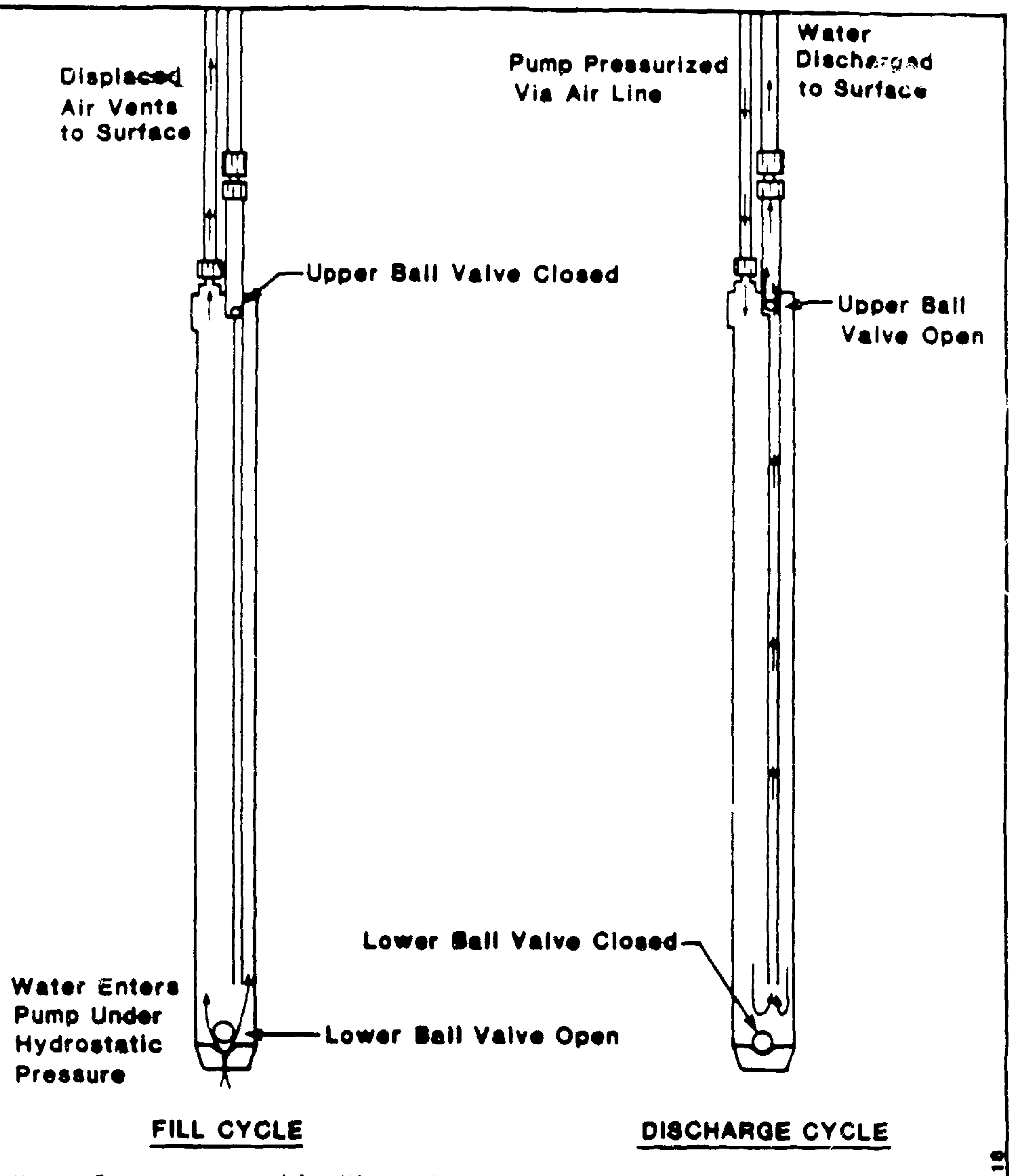
TABLE 5-4.--LIST OF GROUNDWATER SAMPLING EQUIPMENT AND COMPONENTS

Equipment/Component	Model/Part Number	Manufacturer
Bladder pump	T1200	QED Environmental Systems P.O. Box 3726 Ann Arbor, MI 48106 Telephone: 313/995-2547
Bladder pump screen	34873EP	
Purge pump	HR4700	
Driver/controller unit	3111HRM	NOTE: Includes components manufactured by Briggs and Stratton Corporation and Pneumotive Air Power Products (see below)
Air compressor	Model No.: SGH-E101 Part No.: 160939	Pneumotive Air Power Prod. 4601 Central Avenue Monroe, LA 71203 Telephone: 318/387-4280
Gasoline engine	82232	Briggs and Stratton Corp. Milwaukee, WI 53201 Telephone: 414/259-5333
Well cap -- 2-inch for bladder pump only	2120A	
Well cap -- 4-inch for bladder pump only	2120C	
Well cap -- 4-inch for bladder and purge pumps	2150C	
Well cap -- 6-inch for bladder and purge pumps	2150E	
Well cap -- 8-inch for bladder and purge pumps	2150G	
Tubing -- Teflon®-lined polyethylene (1/2-inch O.D. and 1/4-inch O.D.)	PT5100	

(Continued)

TABLE 5-4. (Continued)

Equipment/Component	Model/Part Number	Manufacturer
Tubing -- polyethylene (7/8-inch O.D. and 1/2-inch O.D.)	P5500	
Tubing -- polyethylene (7/8-inch O.D. and 1/2-inch O.D.)	P5500	
Teflon®-coated stainless steel cable	8330	
Teflon® elbow union (for bladder pump)	34469	
Discharge elbow (for purge pump)	34536	
Exhaust adapter	HR3500	
Exhaust adapter hose assembly	34664	
Low submergence adapter	3017	
Water-level indicator	6000	
Teflon® bailer		
pH/Conductivity meter	EP-10/pH (or equivalent)	Myron L Company 6231C Yarrow Drive Carlsbad, CA 92008-4893 Telephone: 619/438-2021
Thermometer	15-000A (or equivalent)	Fisher Scientific 2170 Martin Avenue Santa Clara, CA 95050 Telephone: 408/727-0660



Note: Purge pump used for illustration purposes. Internal flexible bladder used instead of drop tube for bladder pump.

Figure 5-11. Principle of Operation for Bladder and Purge Pumps.

would otherwise promote volatilization of any volatile organic compounds (VOCs) that may be present in the water sample. Each bladder pump is equipped with a stainless steel screen that covers the pump intake. The bladder pumps are installed within the screened intervals of the monitoring well, and are suspended from the well caps bv the air line and discharge tubing.

Purge Pump

Groundwater sampling protocol requires that each monitoring well be purged to ensure that the sample consists of fresh formation water and not stagnant water that has been standing in the casing. Because the purging process often requires the removal of large quantities of water from a well and the bladder pump discharge rate is relatively low, a higher capacity purge pump is used for this purpose. Wells that have more than about 20 gallons of water stored in the casing will be equipped with a positive gas displacement purge pump in addition to the bladder pump discussed above. This will typically include the deep and/or large diameter wells that contain the largest volumes of water.

The purge pump is similar to the bladder pump operationally, but differs in that there is no bladder to prevent contact between the sample and drive gas. The purge pump is constructed of stainless steel and Teflon®. It will generally be installed directly above the bladder pump or at a maximum submergence of about 50 feet, whichever depth is less. Like the bladder pump, the purge pump is suspended in the well by the air line and discharge tubing. However, a Teflon®-coated stainless steel cable is used as a safety line.

Tubing and Well Cap

The bladder and purge pumps each require both a discharge tube for delivery of the sample or purge water and an air tube for pressurizing and venting the pumps. The air line is alternately pressurized and vented at the wellhead to allow the pump to discharge and fill, respectively. The sample discharge line conveys water to the wellhead for the purposes of well purging or sample recovery. Polyethylene tubing will be used for both pumps. Teflon®-lined polyethylene discharge tubing will be used for the bladder pump to reduce the effects that leaching, adsorption, or desorption associated with less inert tubing materials might have on the groundwater sample.

Each well will be equipped with a polyvinyl chloride (PVC) cap. Depending on whether one or two pumps are used in a well, the cap is fitted with either two or four fittings for connection of the discharge tubing and air lines to the controller and driver.

A short length of Teflon®-lined polyethylene tubing is dedicated to each well to direct the bladder pump discharge water from the wellhead to the appropriate containers. This tubing is stored suspended in the well casing, and will be rinsed with Type II Reagent Grade water before each sampling activity. An access port is also provided in the cap to allow the use of a water-level probe without removing the cap.

Driver Assembly

The driver assembly consists of a portable, three to five horsepower, air-cooled, gasoline engine that powers an oil-less, 100 psi, air compressor. The compressor supplies the drive air required to pressurize the bladder and purge pumps, forcing groundwater through the tubing to the surface. The pressure/vent cycle is regulated by the automatic controller device (discussed below).

Automatic Controller

The automatic controller is a portable system component that regulates the air flow from the compressed air source (driver assembly) to the bladder and purge pumps. The automatic controller alternately vents and pressurizes the air line, allowing the pump to fill and subsequently discharge water, respectively.

Low Submergence Adaptor

The low submergence adapter is a portable system component used to increase the discharge rate of those pumps installed with a minimum of submergence below the water level. Water will fill the pump more slowly in low submergence situations because the rate at which the pump will fill is dependent on the hydrostatic head in the well. The low submergence adaptor, when connected to the automatic controller, induces a slight negative pressure in the air line during the fill cycle, thereby decreasing the time required to fill the pump and increasing the overall discharge rate.

Purge Pump Exhaust Adaptor

When the bladder pump fills, exhaust air is forced through the air line and vented at the automatic controller. During operation of the purge pump, an exhaust adapter is used to vent the larger diameter purge pump air line at the wellhead to vent the exhaust air prior to the controller. Like the low submergence adapter, the exhaust adapter decreases the time required for the purge pump to fill and increases the overall discharge rate.

Bailer and Submersible Pump

If monitoring wells are not equipped with a dedicated sampling system, either an electric submersible pump or a Teflon® bailer will be used to purge the well. Typically, the submersible pump will be used to purge the deeper wells with a large water column. When purging is complete and the pump has been removed, the wells will be sampled using a bailer with a braided stainless steel or disposable monofilament line. Shallow wells with a small water column, or wells that produce insufficient water to allow using a pump, will be purged using only a bailer. Before either a submersible pump or bailer is used to purge and sample a well, it will be decontaminated using the procedures described below. A petcock, or flow control valve attachment, will be used to collect samples from the bailer after purging has been completed. This type of attachment allows collecting samples from the bailer with minimal disturbance or agitation that could result in loss of volatile organic compounds.

Equipment Decontamination Procedures

In order to avoid cross contamination, all bailers and water-level indicators will be decontaminated prior to use and between samples using the following procedures. Equipment will be washed using a laboratory-grade detergent (Alconox®) followed by rinses with drinking-quality water, ASTM Type II reagent water, pesticide-grade methanol, and pesticide-grade hexane. Sufficient time will be allowed for the solvent to evaporate and the equipment to dry before the equipment is used. Equipment used to collect water samples for organics analysis will not be allowed to come in contact with plastic (e.g., plastic storage bags).

Before dedicated pumps are installed or submersible pumps are used, they will be steam cleaned. The intake check valve area will receive extra cleaning efforts; if possible, steam will be forced through the pump to clean the interior. The exterior of the pump and discharge hose will also be steam cleaned. Clean, disposable gloves will be worn during and after decontamination so as not to contaminate the equipment.

5.5.2 Field Procedures

Groundwater sampling field procedures include water-level measurements, well purging, and sample collection. Where possible, activities required to sample the monitoring wells will be completed by a field team consisting of at least two people. This will expedite the sample collection process and promote safety at the well site. Water-level measurements, well purging, and sample collection are discussed below.

Water-Level Measurements

The water-level in all monitoring wells will be measured within the first one or two days of sampling for each sampling task. This allows an instantaneous assessment of the potentiometric surface during every sampling effort.

The depth to water will be measured from a reference point at the wellhead (see Section 5.3) of each monitoring well prior to purging or sampling. In wells equipped with dedicated pumps, the water level will be measured from the top of the well cap. The elevation of this surface will be calculated relative to the surveyed reference point and entered into the McClellan AFB database. In wells without dedicated pumps, the depth to water will be measured from the surveyed reference point, a notch on the top north side of the PVC well casing as discussed in Section 5.3. The reference point used for the depth-to-water measurement will be specified on the sample-recovery log.

Water-level measurements will be reported to the nearest 0.01 foot. The measurements are made with QED® electronic water-level meters. This measuring device has a flat polypropylene tape with stainless steel wire in the tape to prevent it from stretching. The visual or audio signal is activated when water is encountered. The depth to water will be taken repeatedly until two consecutive measurements are consistent within 0.01 foot. In new wells or wells where a hydrocarbon layer is suspected, an Oil Recovery Systems® probe will be used. This probe is capable of detecting hydrocarbon layers with a thickness of 1/32 inch (0.003 foot).

The following procedures will be followed when performing water-level measurements:

- Put on protective clothing and equipment as required by the Health and Safety Plan;
- Unlock the well cover;
- Put on new, clean disposable polyvinyl chloride gloves as the outside layer to prevent cross contamination;

- Decontaminate the water-level indicator and last 5 feet of tape using the previously mentioned procedures--since only the probe comes in contact with the well water, this is considered sufficient decontamination;
- Lower the electronic probe into the well until water is encountered and note the depth on the calibrated tape relative to the surveyed reference point;
- Repeat the water-level measurement until two consecutive measurements agree within 0.01 foot;
- Record the depth to water on the sample recovery log form; and
- Decontaminate probe and the first 5 feet of the tape.

To promote organization and consistency in field data collection, one field team member will measure the depth to water and calculate the required purge volume for the well while the other organizes and sets up the sampling equipment, and prepares the field logs.

Well Purging

Well purging is an integral step in recovering samples which are representative of in situ groundwater chemistry. Each monitoring well will be purged immediately prior to sample collection. This will ensure that the sample consists of fresh formation water rather than stagnant water that has been stored in the well casing.

During all sampling activities, well purging equipment will be positioned so that any potential volatile organic sources, such as vehicles, gasoline-driven generators, or air compressors, and fuel tanks are downwind of the well. This will avoid contamination caused by the entrainments of volatile contaminants in the sample. Any potential sources of volatile organics that are unavoidable will be noted on the well purging log. An example of a well purging log is presented on Figure 5-12.

For wells equipped with dedicated pump systems, well purging will be accomplished with a positive gas displacement purge pump, or with the bladder pump if the well is not equipped with a purge pump. If a well is not equipped with a dedicated pump system, it will be purged with a bailer or electric submersible pump. The bailer

McCLELLAN AFB THIRD QUARTER 1988 WELL SAMPLING DATA SHEETS

Well Number: MW-33S

Samplers: ______/______ Date: ____________ Arrived at Well: ________
Sample Time : ________
Weather: ________________________________ Left Well : ________
Total Time : ________

------------------------ Historic Information ------------------------

Well Diameter (inches): 4 Depth to Water: 91.66

Well Volume (gal): 3.48 Date Measured: 06/30/88

Screen Depth (feet): pH: 6.8 Conductivity: 810

Date Sampled: 04/25/88 Sampler's Notes: SPLIT SAMPLES, AMBIENT, 601, 602

------------------------ Sample Specific Information ------------------------

Depth to Water measured from (circle one): Well Wizard Cap / Top of Well / Sounding Tube

Pump Intake Setting (feet):
Total Depth (feet): 97.00

```
Depth to Water (feet): -(         )
                        ----------
                        (         )
                       X    0.65
                        ----------
Well Volume (gal): =    ________(gal) x 3 = Min. Purge Vol.____(gal)
```

Parameters after Purging (circle): 601 602 604 624 625 9010 Metals

Temperature (degrees C) ______ pH: _____ Conductivity (umhos): ______
Purge Pump Controller
Reading (psi): ______ Total Volume Purged(gals): __________

------------------------------------ QA/QC ------------------------------------

( )Field Duplicates	( )Split Samples	( )Trip Blanks in custody	( )Ambient or Equipment Blanks
601 602 604	601 602 604		601 602 604
624 625 9010	624 625 9010		624 625 9010
Metals	Metals		Metals
I.D. __________	I.D. __________	I.D. __________	I.D. __________

(check appropriate QA/QC and circle parameters sampled)

Comments/Field Notes: ____

____

____

____

Figure 5-12. Well Purging Log.

Well Purging Log

Monitoring Well No.: ____________ Date: ____________

Discharge Rate: (gpm) ____________ Purge Method: Bladder, Purge, Bail
(Circle One)

Sampler(s) Initials: ____________

Time	Elapsed Time	Cumulative Volume Purged	pH	Conductivity (micromhos)	Temperature (^{o}C)	Field Notes
	Start-Up of Purge					

Comments:

In those wells where purge pump is used for purging, operate the bladder pump until the stabilized purge parameters are matched. (See Sampling Guidelines)

NOTE WHEN SWITCHED TO BLADDER WAS MADE.

Meter No. ____________

Figure 5-12. Well Purging Log.
(Continued)

(PAGE 2 OF 2)

or submersible pump will be positioned near the middle of the screened interval of the well to ensure that standing water is removed and fresh formation water is drawn into the well. Purged groundwater will be collected in trailer-mounted 565-gallon tanks and discharged into the McClellan AFB Groundwater Treatment Plant for treatment and disposal.

Purging will be considered complete when the indicator parameters of pH, temperature, conductivity, and color have stabilized <u>and</u> a minimum of three wetted casing volumes have been removed from the well. The wetted casing volume of a well can be calculated by using the following equation:

$$V = 3.14\ r^2\ L \times 7.48\ \text{gallons/ft}^3$$

where:

V = One wetted casing volume (gallons);
r = Inside radius of casing (feet); and
L = Height of water column in well (feet).

To determine when stabilization has occurred, pH, temperature, and conductivity will be monitored on a regular basis until two successive readings of all three parameters do not vary by more than ±0.1 pH unit, ±0.5°C, and ±10 micromhos, respectively. The volume of water discharged between the last two readings used to verify stabilization will be no less than 20 percent of the total amount of water purged. In low-yield wells which are purged with a bailer, the well may be evacuated before three well volumes can be removed. In such cases, the water level will be allowed to recover twice before the well is sampled. Data collected while purging will be recorded on the well purging log.

A 5-gallon bucket (or similar container of known capacity) will be used to measure the amount of water being removed from the well during the purging process. Elapsed time will be noted as the container is filled, thereby allowing the calculation of the discharge rate.

During purging, one field team member will be responsible for handling field equipment and taking field measurements. The other will be responsible for recording observations and measurements.

Sample Collection

Groundwater samples will be recovered in a prearranged priority so that all collection and handling takes place as efficiently as possible. Although the actual sample collection protocol will depend on the analytes of interest, it is important to be consistent in general sample collection procedures. Typically, samples for volatile constituents will be collected first. During sample collection, one member of the field team will oversee the operation of field equipment and collection of samples. The other team member will be responsible for recording field data, container labeling, etc. Such consistency will help minimize any errors which may compromise data validity or promote bias in the analytical results.

During the sampling procedure for wells equipped with dedicated pump systems, special attention will be given to the pump discharge rate. Samples for volatile organic constituents will be collected only after slowing the delivery rate to 100 ml/min or less, or until nonturbulent flow (no bubbles) is obtained, to avoid aeration of the sample. For other analytes, the discharge rate will be adjusted in accordance with the size of the sample container being filled. A slow rate of 150 ml/min or less will allow for easy filling of smaller bottles. Large volume bottles can be filled at a greater flow rate. However, the sample delivery rate should not exceed the pumping rate used during well purging.

Wells not equipped with a dedicated pump system will be sampled using a decontaminated Teflon® bailer. A new monofilament line or braided stainless steel line will be securely attached to the bailer. The bailer will be lowered slowly into the well; care will be taken so as to cause as little disturbance as possible to the water surface. Water will be collected from the middle of the screened interval of the well. As the bailer is lowered and raised, care will be taken to keep the line clean and off the ground surface. To minimize this problem, the monofilament line can be directed into a clean bucket or similar container as the bailer is being raised in the well. The bailer will be filled and emptied twice with well water to condition it before collecting samples.

Volatile organics will be collected from the discharge line of the dedicated bladder pump after the flow is steady and no air bubbles can be observed or from a petcock or flow control valve attached to the bottom of the bailer. Samples are collected from bailers using the flow control valve by attaching the valve to the bailer after purging is completed, and then slowly opening the valve until smooth, steady flow is obtained. The sample bottle is then placed directly under the bailer and attachment so that a minimum free-fall distance is allowed during sample collection. This will minimize the potential for agitation or aeration of that samples that may cause loss of volatile organic compounds.

Prior to using the bailer, or collecting a sample from the discharge line, new, clean disposable polyvinyl chloride gloves will be put on to avoid cross contamination. The bottle will then be filled slowly to prevent the entrapment of air bubbles; splashing or agitating the water will be avoided. Care will be taken to avoid touching the mouth of the discharge line, the top of the sample bottle, the inside of the cap, or the Teflon® septa. A septa that falls out of the cap onto the ground will not be used.

The bottle will be filled completely such that a meniscus forms. The cap will be screwed on and the bottle will be turned upside down, tapped firmly, and checked for the presence of air bubbles. If a bubble is present, the sample will be discarded and a new sample collected; new preservatives will be added if appropriate. If a bubble appears a second time in the same bottle, that bottle will be discarded and a new one prepared. Accurate analytical results for volatile organic compounds may be compromised if there is any free air trapped in the sample container.

Conductivity, pH, and Temperature

Conductivity, pH, and temperature of water can change over the sample holding time. Consequently, these parameters will be determined in the field at the time of sample collection. The pH and conductivity probes or cells will be rinsed at least two times with the water to be tested prior to making the measurements. Groundwater temperature will be taken concurrently with pH and conductivity measurements. Values for pH, conductivity, and temperature will be measured and recorded with a minimum accuracy of ±0.1 pH unit, ±10 micromhos, and ±0.5°C, respectively.

The pH meters will be calibrated daily using two buffers of pH 7 and pH 10. The conductivity meters will be calibrated daily using a KC1 solution of known conductivity; temperature will be recorded using a mercury-in-glass thermometer calibrated in degrees Celsius.

Sample Labeling

All samples will be clearly labeled with the following information:

- Project name/client;
- Well number or sample location;

- Sample type (analytical method);
- Preservatives used;
- Sampler's name and initials; and
- Date.

Labels will be filled out with a ballpoint pen and securely attached to the sample jar. Permanent markers (i.e., Sharpies) will not be used in the vicinity of sample collection activities because they contain volatile organic compounds that may contaminate the sample. To ensure future legibility and limit the potential for cross contamination in case of breakage, all sample jars will be transported in individual Zip-lock® bags.

Filtration

Filtration is required for samples recovered for metals analyses. Filtration will be accomplished in one of two ways. Disposable 0.45 micron in-line filters will be used if dedicated pump systems are utilized. The filter is fitted to the discharge line immediately before collecting the samples which require filtration. If a well is sampled with a bailer, filtration will be accomplished by pumping the sample through a 0.45 micron filter using a portable peristaltic pump. If required, preservation of the sample will be conducted at this time. All filtration equipment will be decontaminated prior to use, and rinsed with a 10 percent nitric acid wash.

Sample Storage and Transportation

All samples will be stored at approximately 4°C from immediately after collection until analysis. In the field, samples will be stored with ice in coolers (ice chests). Protective foam or styrofoam packing will be used to minimize the risk of breakage during transport, and to ensure that the samples do not freeze.

When packaging samples for commercial transport, an absorbent material such as vermiculite will be used to minimize the effect of any breakage. Sample containers will be packed in the upright position and separated by padded materials. Sample packaging requirements for hazardous materials requiring interstate transport are defined in the Code of Federal Regulations (CFR) 49, Chapter 1, Part 171 and will be utilized during sample transport. These requirements outline in detail the proper classification and procedures for transportation of hazardous materials and are included by reference.

5.6 Surface Water Sampling

Water samples will be collected from surface water drainages according to the following procedures.

Sample Locations

Surface water drainages to be sampled include on-base storm drainage systems of Magpie Creek, Arcade Creek, and the "Unnamed Stream." Emphasis will be placed on drainages that cross the base boundaries and that potentially receive contaminants from former waste disposal sites. Specific sample locations and analytical parameters will be identified in the work plan prepared for the surface water survey. All sample sites will be confirmed by visual inspection during the preparation of the work plan.

Sample Collection

Grab samples will be collected by hand from the midpoint of each drainage sampled. Prior to sample collection, field personnel will re-suit with new, clean, polyvinyl chloride surgical-type gloves in order to avoid cross-contamination of the sample or bottle. Water samples for volatile organic compounds will be collected by submerging the sample containers. A decontaminated stainless steel bucket will be used to collect a composite sample for nonvolatile parameters, or if there is not adequate stream-flow to submerge the sample container. Water collected in the bucket will be carefully decanted into the proper sample containers. Streambed augmentation will be used if samples are to be collected for volatile analyses, and the flow or depth is not great enough to submerge the sample container. This consists of briefly damming the flow, or creating a depression in the streambed. The sample will be collected after the disturbed sediment clears.

After collection of each sample, all sampling equipment and boots and waders will be decontaminated according to the following three-step process: 1) wash equipment in detergent and potable water solution using a brush, 2) rinse with potable water, and 3) rinse with deionized water. Before equipment is used to collect additional samples, it will be further decontaminated according to the procedures described in Section 5.4.

Water Blanks and Duplicates

Ambient (field) blanks are collected by pouring ASTM Type II Reagent Water (prepared in the Radian Analytical Laboratory) directly into the sample container in the field. A trip blank, a sealed vial of Type II Reagent Water, will accompany volatile organics samples sent to the laboratory. Surface water duplicates will be collected as aliquots of a composite sample, except for volatile parameters that must be collected as sequential samples from the water body. Requirements for blanks and duplicates are presented in Section 11.0, Internal Quality Control.

Field Measurements

For all surface water bodies sampled, the depth of water, temperature, pH, and specific conductance will be measured prior to collecting samples for laboratory analyses. The pH/conductivity meter will be rinsed with Type II reagent water prior to sampling each surface water drainage.

Portable real-time organic vapor analyzers will be used to perform real-time screening of total hydrocarbon vapors. A Foxboro Century Systems organic vapor analyzer (OVA) with a flame ionization detector and a range of 1 to 10,000 ppm will be used to detect total hydrocarbons. In addition to the OVA, an HNU Systems photoionizer, with a range of 0 to 2,000 ppmv will be used to detect non-methane hydrocarbons. The instruments will be calibrated daily using certified methane-in-air (OVA) or TCE-in-air (HNU) gas standards. Further details on these instruments can be found in Section 8.4 of this QAPP.

Radioactive material may be present at specific sampling locations, therefore, a geiger counter will be available for use.

Recordkeeping and Sample Handling Procedures

All data collected in the field will be recorded on sample recovery log forms. Pertinent field information and sample control information will be kept in a master log. Chain-of-custody records will be completed subsequent to the collection of each sample. Data collection and chain-of-custody forms are described in more detail in Section 6.0.

All samples will be stored at approximately 4°C from immediately after collection until analysis. In the field, samples will be kept in coolers (ice chests) kept cool with ice. The chain-of-custody record accompanies sealed samples to the laboratory and must be kept with the samples at all times.

5.7 Soil Samples

Surface and subsurface soil samples will be collected during various phases of the RI. The rationale for sample collection, including sampling locations, analytical parameters, and number and type of samples will be established in each phase specific work plan. Sample collection will be documented using sample logs and chain-of-custody forms as described Section 6.0. In addition, field data will be documented on data sheets prepared for each sampling task and sampling locations will be noted on site-specific maps. The field data sheets will be described in the individual work plans. Lithologic logs will be prepared during all drilling operations. Preparation of lithologic logs is discussed in Section 5.2.

Surface and near-surface soils may be collected by a number of techniques, including surface scraping, hand augering, and core sampling. Subsurface soil samples will be collected during drilling operations. The principal drilling technique to be used for subsurface soil sampling will be hollow-stem augering, although air rotary and dual tube air percussion may be used in some cases. Samples will be collected using split-spoon samplers, modified California (Dames & Moore) samplers, Shelby tubes, or directly from cuttings. All of these methods can be used to collect discrete or composite soil samples. Soil samples to be analyzed for nonvolatile parameters can be composited either in the field or the laboratory; soil samples to be analyzed for volatile parameters cannot be composited because of potential loss of those compounds.

Surface Scraping

Surface scraping may be used to collect soil samples from the ground surface, sidewalls and bottom of trenches or excavations, and scale or sediment from tanks, ponds, impoundments, or streams. The samples will be collected using the following procedure:

1. Check all equipment and sample containers to ensure that the equipment is clean and that the containers are new and have been properly prepared.

2. Label container and initiate the chain-of-custody process and task/sample specific data sheet, as applicable.

3. Prepare surface for sampling by removing any vegetation, sticks, stones, etc.

4. For discrete samples:

    a. Scrape a thin layer of soil directly into the sample container using a stainless steel spoon. This should be done as quickly and with as little disturbance as possible in order to minimize the loss of volatile and semivolatile organics.

    b. Cap the container with a Teflon®-lined cap and place in a cooler at 4°C.

5. For laboratory composited samples:

    a. Collect individual samples at each location to be composited as described in 4) above.

    b. In the laboratory, combine an equal weight of each sample to be included in the composite.

6. For field composited samples for nonvolatile parameter analysis:

    a. Collect an approximately equal amount of soil from each location to be included in the composite by scraping a thin layer of soil from each location into a stainless steel bowl using a stainless steel spoon. It may be advantageous in some cases to collect the equal amount of soil from each location into separate sample jars, and then empty all of the jars into the bowl after all locations have been sampled.

    b. Homogenize the soil by thoroughly mixing with a stainless steel spoon.

    c. Divide the homogenized soil into four equal quarters and collect the composite sample from one of the quarters.

d. Cap the container with a Teflon®-lined cap and place in a cooler at 4°C.

7. Complete chain-of-custody and field data sheets. Log sample into log book.

8. Decontaminate sampling equipment between each sample by 1) wash in detergent and potable water solution using a brush, 2) rinse with potable water, and 3) rinse with deionized water.

9. Document sample locations on a map.

Hand Augering

Hand augering will be used to collect soil samples to a depth of up to about 10 feet below land surface (bls), although the technique can sometimes be used to a depth as great as 30 feet bls. This method is not appropriate for collecting samples for volatile parameter analysis becuase undisturbed samples are not obtained, and volatile compounds may be lost (see the core sampling method following). Hand augers equipped with 3-inch diameter cylindrical stainless steel bits will be used. A typical hand auger kit is shown in Figure 5-13. Soil will be collected as follows:

1. Check all equipment and sample containers to ensure that the equipment is clean and that the containers are new and have been properly prepared.

2. Label container and initiate chain-of-custody and task/sample specific data sheet, as applicable.

3. Auger to the desired sampling depth. Soil for lithologic inspection should be placed on plastic sheeting.

4. For discrete samples:

   a. At the desired sampling depth, collect soil in the bit and empty into an stainless steel bowl. Typically, a 1-foot column of soil will be collected. However, if only a short column of soil is desired, the soil can be emptied directly into the sample container.

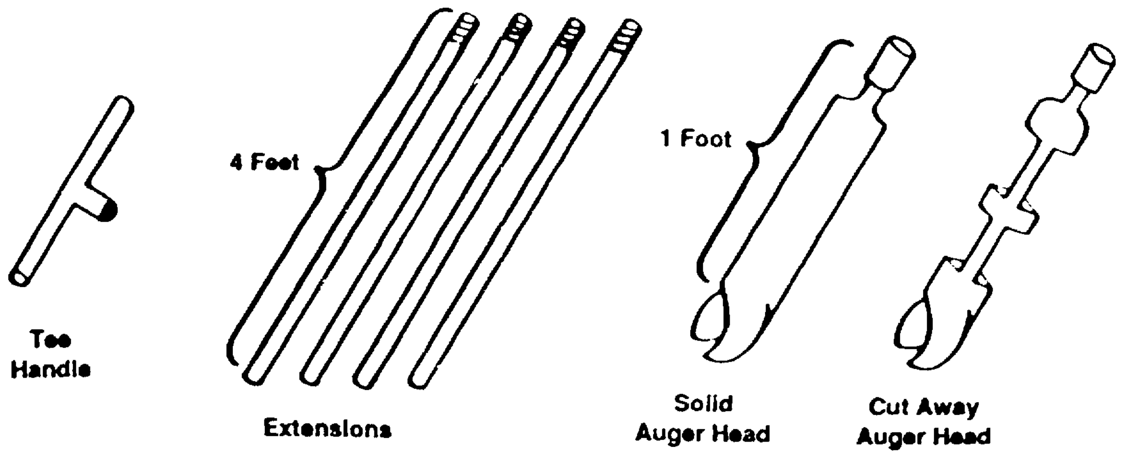


Figure 5-13. Hand Augering Equipment.

b. Homogenize the soil by mixing with a stainless steel spoon. Minimize mixing as much as possible, or eliminate when sampling for volatile and semivolatile organics.

c. Divide the homogenized soil into four equal quarters and collect the sample from one of the quarters. More than one quarter may be used if additional sample is needed for all parameters.

d. Cap the container with a Teflon®-lined cap and place in a cooler at 4°C.

5. Backfill hole with native material, or fill hole with cement grout, if required by the task specific work plan.

6. For laboratory composited samples:

   a. Collect individual samples at each location to be composited as described in 4) above.

   b. In the laboratory, combine an equal weight of each sample to be included in the composite.

7. For field composited samples (nonvolatile parameters only):

   a. Collect an approximately equal amount of soil from each location to be included in the composite. If soil from different depths within the same auger hole are to be composited, place soil from each depth into an stainless steel bowl. If soils from the same depth in different auger holes are to be composited, collect soil from each location as described in 4) above and place in separate sample containers. Then empty all of the samples into the metal bowl after all locations have been sampled.

   b. Homogenize the soil by thoroughly mixing with an stainless steel spoon.

c. Divide the homogenized soil into four equal quarters and collect the composite sample from one of the quarters.

d. Cap the container with a Teflon®-lined cap and place in a cooler at 4°C.

8.Complete chain-of-custody and field data sheets. Log sample into log book.

9. Decontaminate sampling equipment between each sample by 1) wash in detergent and potable water solution using a brush, 2) rinse with potable water, and 3) rinse with deionized water.

10. Document sample locations on a map.

Core Sampler with Soil Sleeves

Core sampling with soil sleeves will be used to collect soil samples to depth up to about 10 feet below land surface (bls). The core sampler with slide hammer handle is designed to collect relatively undisturbed soil samples by driving a cylindrical cup (similar to the bit of a split-spoon sampler) into the ground using a sliding, weighted handle. This method is appropriate for collecting samples for volatile and semi- or nonvolatile parameter analysis. The 6-inch-long cup contains stainless steel soil sleeves in which the soil is retained. Soil sleeves from 1 to 6 inches in length and 2 inches in diameter are available. Sampling subsurface soil requires drilling to the desired sample depth with a hand auger. The soil lithology is recorded on the boring log shown in Figure 5-2. Soil samples are collected as follows:

1. Check all equipment and soil sleeves to ensure that the equipment, including the sleeves have been properly cleaned. Ensure that the containers are new and have been properly prepared.

2. Initiate chain-of-custody and task/sample specific data sheet, as applicable.

3. Drill to the desired sampling depth with a hand auger, if necessary. Soil for lithologic inspection should be placed on plastic sheeting.

4. At the desired sampling depth, drive the core sampler into the ground with a sliding hammer action.

5. Remove the core sampler and open the cup. Remove the soil sleeves from the cup and cap with Teflon® caps or Teflon® tape covered with PVC caps. The sleeve is placed in a Zip-lock® bag if the caps have the potential to fall off.

6. Label each soil sleeve and place samples in a cooler at 4°C.

7. Backfill hole with native material, or fill hole with cement grout if required in the task-specific work plan.

8. For laboratory composite samples:

    a. Collect individual samples at each location to be composited as described above; and

    b. In the laboratory, combine an equal weight of each sample to be included in the composite.

9. For field composited samples (nonvolatile parameters only):

    a. Collect individual samples at each location to be composited as described above;

    b. Remove soil, or an approximately equal weight of soil if discrete samples will also be retained, from each sleeve to be composited and place in an stainless steel bowl;

    c. Homogenize the soil by thoroughly mixing with an stainless steel spoon;

    d. Divide the homogenized soil into four equal quarters and collect the composite sample from one of the quarters; and

    e. Cap the container with a Teflon®-lined cap and place in a cooler at 4°C.

10. Complete chain-of-custody and field data sheet.

11. Decontaminate sampling equipment between each sample depth by 1) wash in detergent and potable water solution using a brush, 2) rinse with potable water, and 3) rinse with deionized water.

12. Stainless steel soil sleeves are cleaned prior to sampling by the following four-step process:

    a. Wash sleeves in a solution of non-phosphate detergent and potable water;

    b. Rinse with potable water;

    c. Rinse with distilled or deionized water; and

    d. Bake at 160°C for a minimum of 8 hours.

Hollow-Stem Augering and Split-Spoon Sampling

Hollow-stem augering will be used to collect subsurface soil samples to depths exceeding 180 feet bls. The sampling sites will be marked and surveyed according to the procedure described in Section 5.2. Hollow-stem augering will be used in conjunction with a split-spoon sampler to collect soil samples as follows:

1. Initiate chain-of-custody and boring log. Initiate task sample specific data sheet, if any.

2. By using a conventional drill rig as shown in Figure 5-14, a hole (typically 8 or 10 inches in diameter) will be bored to the required sampling depth. At the desired depth, the drive tip of the bit (and drive shaft) will be removed from the hole. A downhole hammer (or a drill stem with an external hammer) fitted with a split-spoon sampler will be lowered inside the Figure 5-14 auger stem to the sampling depth. The sampler will be driven into the soil approximately 18 inches and then removed, with the soil sample retained in the split spoon.

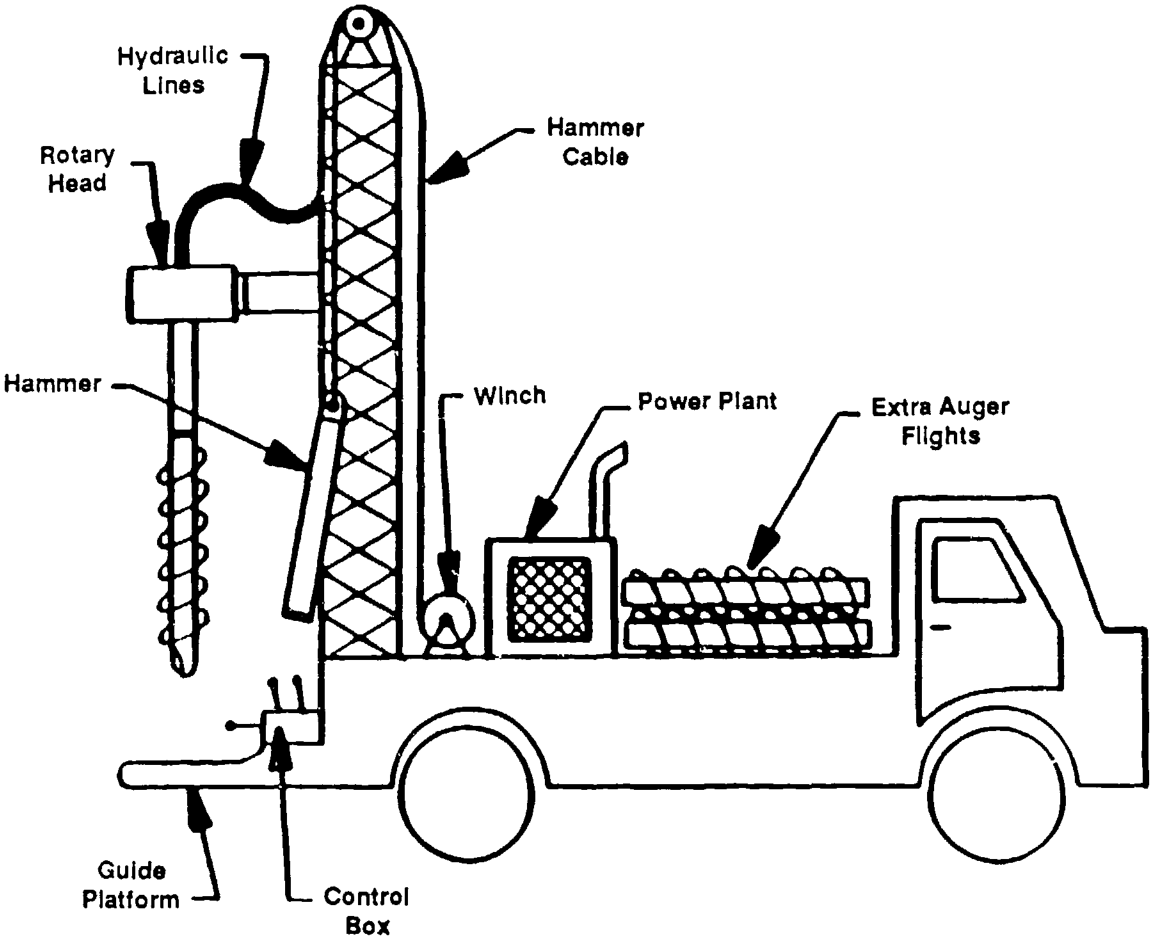


Figure 5-14. Typical Hollow-Stem Auger Rig.

3. A Dames & Moore (D&M) split-spoon sampler (Figure 5-15) with stainless steel liners will be used to obtain samples at 5-foot intervals for chemical analysis, visual observation, lithologic characterization, and soil vapor screening. This type of sampler allows for the collection of relatively undisturbed samples and minimizes losses of volatile and semivolatile species.

   The sampler is 18 inches long and 3 inches in diameter and contains six stainless steel liners approximately 3 inches long. The sampler is split lengthwise to insert/remove the liners. As the sampler is driven into the soil, samples are retained in the stainless steel liners.

4. After the sampler is removed from the hole, liners are separated, removed from the holder, and those selected for anlaysis are capped with Teflon® caps or Teflon® tape covered with PVC caps. The liner is placed in a Zip-lock® bag if the caps have the potential to fall off.

5. If samples are to be retained for nonvolatile chemical analysis, the soil will either be left in the liner and capped, or placed in an appropriate container with a minimal disturbance. The container will be sealed with a Teflon®-lined cap.

6. A portion of the sample will be collected in properly marked sample bags and retained for visual inspection. Information on the soil lithology will be recorded on a boring log (Figure 2.2-2).

7. After each sample is collected, the D&M split-spoon and tip will be decontaminated by 1) wash in detergent and potable water solution using a brush, 2) rinse with potable water, and 3) rinse with deionized water. Clean liners will then be loaded into the sampler for the next sample. After completion of the boring, the sampler will be decontaminated by steam-cleaning.

8. The stainless steel liners will be prepared prior to use by the following four-step process:

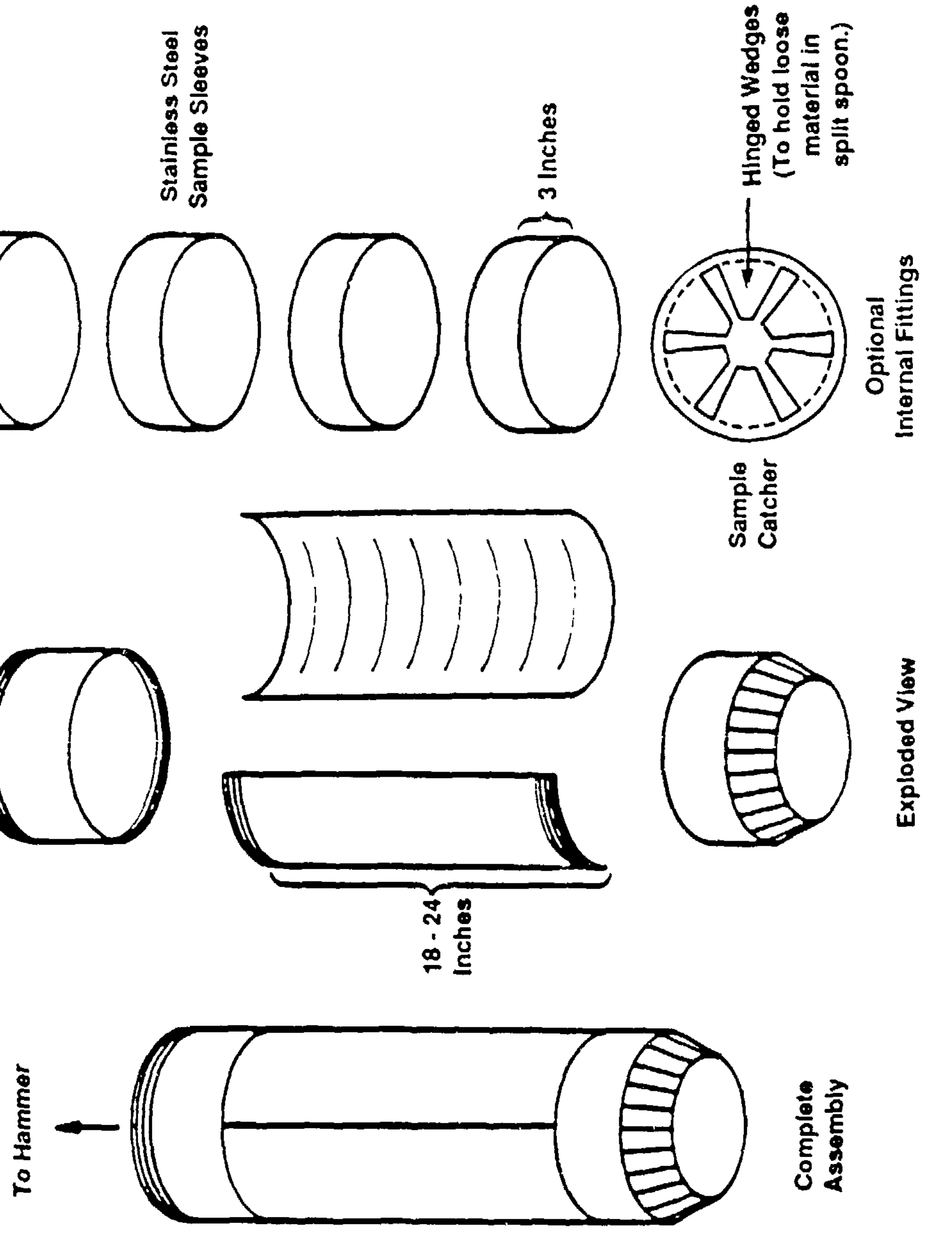


Figure 5-15. Split Spoon Sampler.

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  a. Washing in a solution of detergent and potable water;
  b. Rinsing with potable water;
  c. Rinsing with deionized water;
  d. Baking at 106°C for a minimum of 8 hours.

9. In loose formations, a split-spoon sampler equipped with a sample catcher will be used to prevent sample loss. The catcher will be decontaminated in the same manner used to decontaminate the split-spoon sampler.

10. Label sleeves and place samples in cooler at 4°C.

11. The hollow-stem auger flights and split-spoon sampler will be steam-cleaned between borings.

12. At the completion of each boring, the borehole will be abandoned by backfilling with native material to a depth of 10 feet bls or 10 feet below the lowest extent of visible contamination, whichever is deepest, and grouting to the surface with cement.

13. Complete chain-of-custody. Complete boring log and field data sheets.

5.8 Sediment Sampling

Sediment samples may be collected from dry streambeds by surface scraping, hand augering, and core sampling using a core sampler with stainless steel sleeves. These methods have been previously described in Section 5.6. Sediment samples may be collected using a PVC tube or Ponar dredge when water present in the stream prevents the use of the above referenced sampling methods. Each of these techniques allows for the collection of discrete samples, with the option of compositing samples in either the field or the laboratory. The selection of the optimum sediment sampling technique will depend on the field conditions and the desired sample depth. The rationale for sample collection, including sample locations, analytical parameters, type of equipment, and number and type of samples will be described in the detailed work plan developed for each sample task.

PVC Tube

A PVC or stainless steel tube may be used to collect sediment samples from beneath a liquid layer. The tube is driven down through the liquid into the underlying sediment to the desired sampling depth; a rubber mallet is used if necessary. A peristaltic pump is used to remove the liquid from the casing. If there is any difficulty in removing the liquid (i.e., there is an insufficient seal on the bottom), the casing can be driven down further. After the liquid has been removed, the PVC tube can be withdrawn with the sediment sample plug in the bottom. If the sediment is too fluid to remain in the tube, a hand auger barrel can be extended down through the casing to collect a sediment sample. The sediment is placed directly into the sample container or a stainless steel bowl for compositing.

Ponar Dredge

A Ponar dredge (Figure 5-16) may be used to collect sediment samples from impoundments or flowing streams. This type of sampler has a jaw-type mechanism that is tripped from above to collected the sediment sample. The dredge is lowered through the liquid to the sediment with the jaws in the open position. The dredge is lowered slowly to minimize disturbance of the sediment upon contact. As the dredge is retrieved, the jaws close and the isolated sediment is brought to the surface, where the sample is transferred to the sample container or stainless steel bowl.

5.9 Soil Vapor Sampling

Soil vapor sampling will be performed during the remedial investigation using a variety of sampling techniques. These techniques may include measuring vapor concentrations at the ground surface; in a slide hammer or hand-auger hole; in split-spoon samplers; in shallow monitoring probes; and in soil vapor monitoring wells. Additionally, flux emission measurements can be made at the ground surface, in shallow probes, down a hollow-stem auger, or in an exposed trench. Measurements can be made using portable real-time vapor analyzers, or soil vapor samples can be collected in a syringe or direct reading sorbent for field analysis, or in a stainless steel canister or sorbent for analysis in the laboratory. The analytical methods currently anticipated for use with soil vapor samples in the McClellan AFB RI/FS program are discussed in Section 8.0.

The selection of the optimum soil vapor sampling technique will depend on the operation being performed and the intended use of the analytical results. The

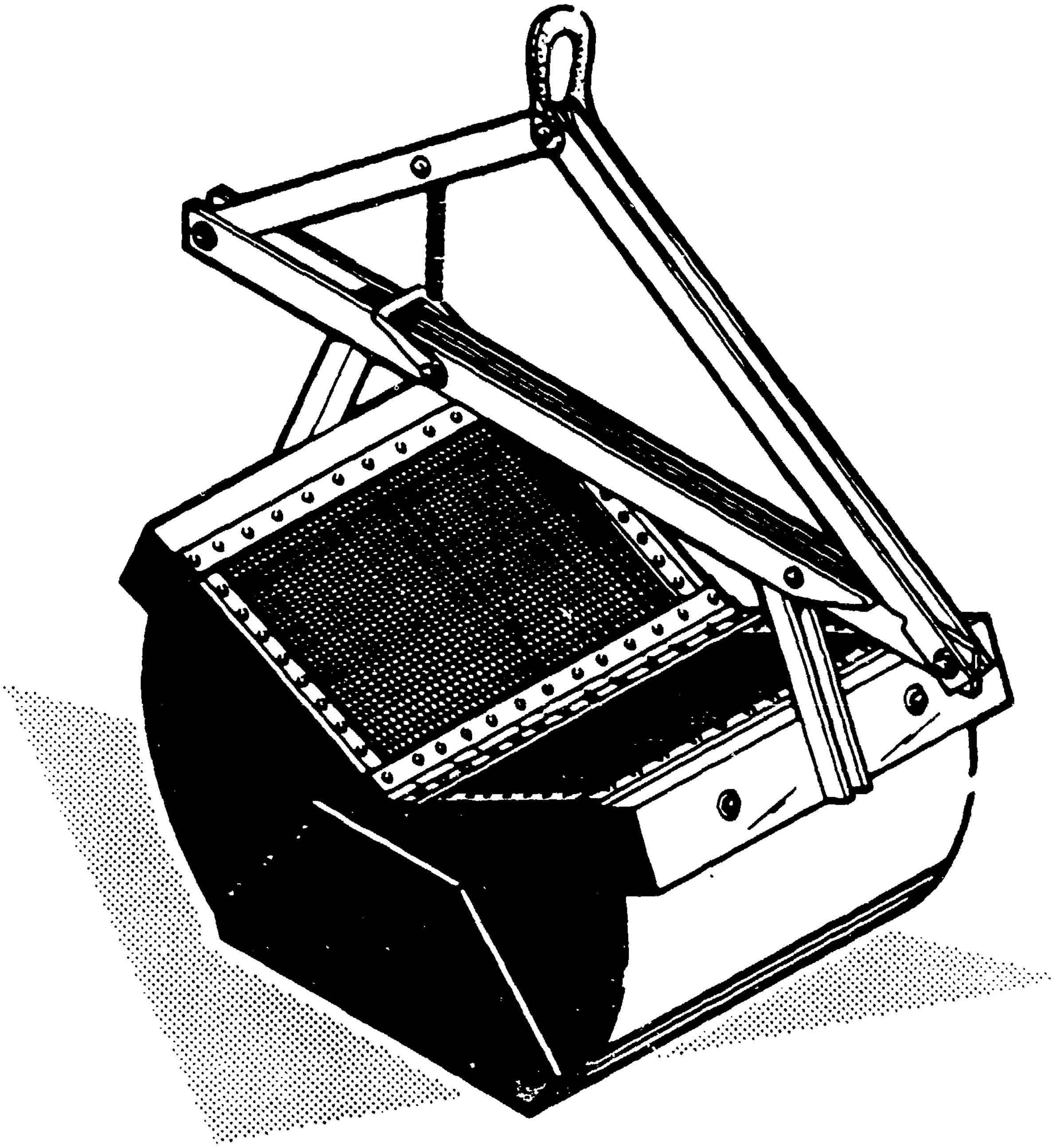


Figure 5-16. Ponar Dredge.

rationale for sample collection, including sample locations, analytical parameters, type of field instruments used, and number and type of samples, will be described in the detailed work plan developed for each sampling task. The selected analytical parameters will determine the quantity of the sample, the container or media type, and the preservation required. Sample collection will be documented using sample logs, field data forms, and chain-of-custody forms.

5.9.1 Ground Surface Screening

The measurement of vapor concentrations at the ground surface is performed in the initial phase of testing for potential surface emissions. Surface screening is performed by walking across a site on a grid pattern, using a sampling instrument to detect areas which have elevated concentrations of vapor near the surface. Sampling can be performed by using portable real-time analyzers such as an OVA and HNU, or AID, or a portable sampler such as an evacuated stainless-steel canister or pump with sorbent tubes. The sampling is performed as follows:

1. Initiate field data sheet/map. Ensure that instrument is properly calibrated and operating correctly (refer to Section 7.2 of this QAPP). If samples are to be collected, initiate chain-of-custody and ensure that all sampling equipment is clean.

2. Standing upwind of the site, hold the input probe in the air, approximately 10 feet above the ground, and away from any equipment, etc. Note the reading, or average reading after one minute. This is the initial ambient reading. Record location and reading on site map/data sheet.

3. Walk the site on a grid pattern with the inlet probe of the sampling device within 3 inches of the surface. Walk the site slowly, noting any reading exceeding three times the ambient reading. After verifying the reading by remeasuring the vapor at that location, record exceedances on a site map/data sheet.

4. After walking site, repeat ambient reading at the same location as the initial measurement, provided that the wind direction has not changed. If the wind direction has changed, select a new upwind location for the final ambient measurement. Record location and reading on site map/data sheet.

5. Complete data sheet.

6. If samples were collected, complete chain-of-custody and label sample. Purge sampling equipment with upwind ambient air for 5 minutes or until out reading is at ambient level, whichever is longer, before initiating next sample.

5.9.2 Slide Hammer Sampling

Shallow soil vapors may be sampled using a slide hammer to drive a hole into the ground. The slide hammer is a steel rod with a weighted sliding handle used to drive the rod into the ground, as shown in Figure 5-17. The rod is 3 to 6 feet in length with a 5/8-inch diameter head. The weighted handle of the rod is used to drive the rod into the ground with a hammering action. The field sampling procedure for the slide hammer is as follows:

1. Initiate field data sheet and chain-of-custody.

2. The slide hammer is driven into the ground to the desired depth. The rod is removed and a 1/4-inch diameter stainless steel or Teflon® tube is inserted into the hole.

3. Soil vapors are measured by drawing samples through the 1/4-inch tube using the field instrument. If more than one field instrument is used, connect each instrument individually to tube for one minute in order to take a reading.

4. If sampling is desired, remove instrument and connect sampling device to tube. For syringe sample, a septum should be fitted in the tube upstream of the instrument, and the instrument left in place during sampling.

5. Complete field data sheet and chain-of-custoday, if applicable.

6. Decontaminate the slide hammer by washing with laboratory detergent followed by rinses with potable and distilled water.

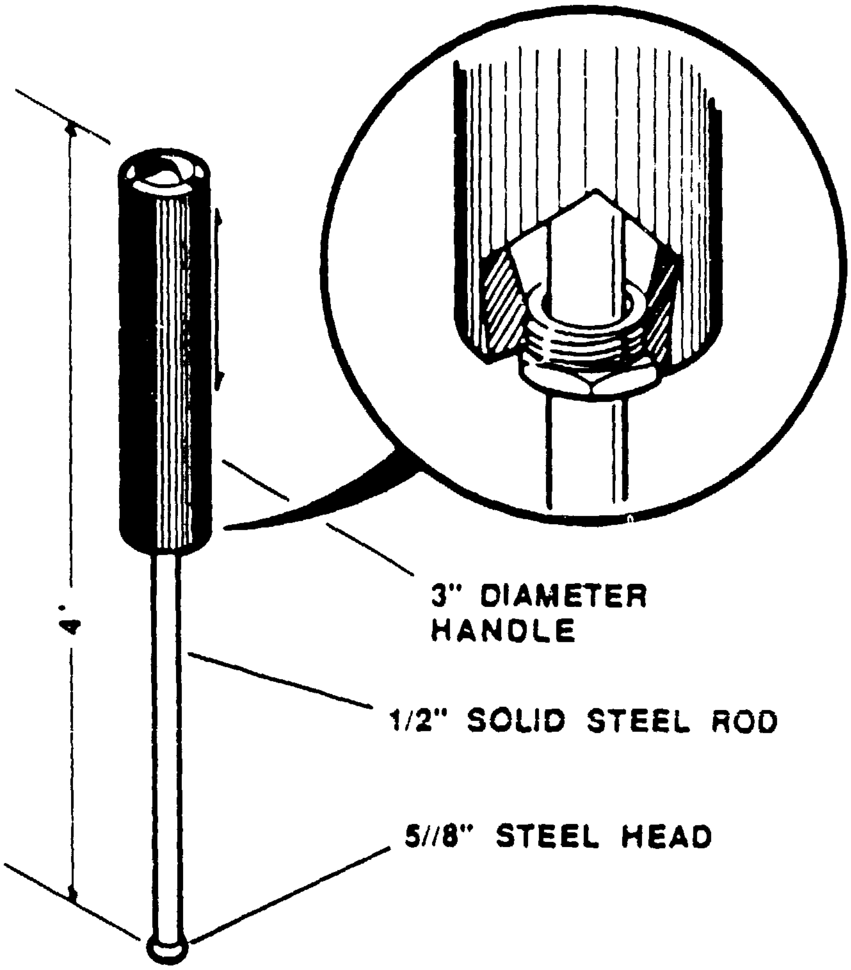


Figure 5-17. Slide Hammer Sampling Device.

7. Decontaminate tube by purging with ambient air for five minutes or until readings are at ambient levels, whichever is longer. The field instrument is used to purge the tubing.

5.9.3 Hand Auger Sampling

Shallow soil vapors may be measured and collected from hand auger holes in conjunction with soil sampling. Sampling can be performed at several depths within each hole, if desired. The field procedure for hand auger vapor sampling is as follows:

1. Initiate field data sheet and chain-of-custody, if applicable. A hand auger is used to drill a hole to the desired depth; samples are usually collected at 2-foot intervals.

2. Soil vapors are measured by drawing samples through a 1/4-inch Teflon® or stainless steel tube connected to the field instrument.

3. If sampling is desired, disconnect instrument and connect the sampling device.

    a. Cover the surface of the hole with wood or plastic so that vapors do not readily mix with the ambient air or escape from the hole.

    b. Sample by pulling vapors through the tube at a rate specified for the sampling apparatus and/or analytical method.

    c. If syringe samples are to be collected, install a septum in the tube upstream of the instrument and leave the instrument connected.

4. Purge the sampling tube by pulling ambient air through the tube with the field instrument. Purge for 5 minutes or until readings are at ambient levels, whichever is longer.

5. Complete chain-of-custody, if applicable, and field data sheet.

5.9.4 Split-Spoon Sampling

Soil vapor concentrations may be measured and sampled during drilling operations by using a split-spoon sampler to obtain soil samples from below the ground surface. The soil vapors are measured with portable field instruments by opening the split-spoon sampler and inserting the probe of the instrument(s) between two sampling sleeves. Dispersion of the vapors is minimized during sampling by shielding the sampler to prevent wind dispersion (using a field notebook, etc.). The data are recorded on the log for the borehole.

5.9.5 Shallow Soil Probes

Shallow soil probes and vapor sampling provide a means of mapping the horizontal extent of soil vapor contamination in near-surface soils. There are two methods of installing shallow probes: driving them by hand, or using a hydraulic driving mechanism to push the probe into the ground. Typically, hand-driven probes are used when only a few measurements are required, and a portable vapor analyzer is used to purge the probe. For more extensive investigations, it is usually more effective to use a mechanical system, with field laboratory equipment used to provide more complete real-time speciation of the soil vapor.

Hand-Driven Soil Probes and Gas Concentration Measurement

Hand-driven soil probes can be used for field screening or to obtain soil vapor measurements from selected locations at a site. Additionally, the probes can be used in conjunction with a mechanical system in locations which are not accessible to vehicles.

The hand-driven soil probes consist of a hollow 3/4-inch inside diameter steel rod with detachable drive point. The rods are driven into the ground to a depth of up to 5 feet bls using a fence post driver and/or sledgehammer. The desired depth depends on where the highest soil vapor concentrations are measured during prior screening activities, and also on the soil conditions (i.e., the presence of cobbles). The probe is retracted a few inches to detach the drive point and allow soil vapors to enter at the bottom of the probe.

The probe is capped with a rubber stopper through which passes a 1/8-inch outside diameter Teflon® tube. The Teflon® tube is connected to the real-time instruments to verify that soil vapors are present before sampling. The instrument provides the driving force for evacuating the ground probe. A second Teflon® tube may be used to inject ultra-pure sweep air for emission measurements. The sampling procedure is as follows:

1. Initiate field data sheets and chain-of-custody.
2. Drive the probe and drive point into the soil to the desired sampling depth; typically 5 feet bls. The probe is driven with a post-hole driver or sledgehammer. A metal cap can be placed on the top of the probe to prevent damage.
3. Retract the probe approximately 1 to 2 inches.
4. Install stopper with sampling tube, and if applicable for emissions measurement, sweep air inlet tubing.
5. Attach the field instrument to the sampling line and observe soil vapor readings for approximately one minute to purge the probe. Continue purging until vapor levels stabilize. Note peak and steady-state values; these may be equivalent.
6. To collect syringe samples for field gas chromatographic analysis:
    a. Install a septum in the sampling line upstream of the field instrument. The field instrument is left in place during sampling to assure the continued flow of soil vapors at the septum;
    b. Purge the syringe three times with soil vapors; and
    c. Collect a sample.
7. To collect canister or sorbent samples:
    a. Disconnect the field instrument from sampling line,

b. Connect the sampling device (canister or inlet to sorbent tube) to the sampling line; a Swagelok® "T" fitting can be used to preconnect the canister or sorbent tube; and

c. Collect the sample.

8. Following sample collection, reattach the field instrument to verify that soil vapors are still present and have been collected.

9. Withdraw the soil probe from the ground; the drive point is expendable and is left in the ground.

10. Purge the sampling line with the field instrument for five minutes or until concentrations are at ambient levels, whichever is longer, before reusing; discard if tubing appears contaminated.

11. Complete chain-of-custody and field data sheet.

12. Decontaminate the probe by steam cleaning between sampling locations.

Mechanically-Driven Soil Probes

Radian will subcontract with a qualified soil vapor sampling contractor for more extensive shallow, subsurface vapor sampling investigations. The subcontractor must be equipped with mechanical probe driving capability and field laboratory instrumentation to provide a means of obtaining low-level soil vapor speciation by real-time field analysis.

The subcontractor will provide a mobile field laboratory consisting of a vehicle equipped with gas chromotographs (GC) using flame ionization (FID), photoionization (PID), and electron capture (ECD) detectors. Both packed and capillary columns will be used. The equipment will be operated by a chemist and hydrogeologist, under the supervision of Radian field personnel.

Samples of the soil vapor are collected from the vadose zone through a steel probe. A specialized hydraulic mechanism will be used to push and withdraw the sampling probes by transferring the weight of the vehicle onto the probe. The probes are 7-foot lengths of 3/4-inch diameter steel pipe fitted with detachable drive points. A percussion hammer can be used to assist in driving probes through cobbles or through unusually hard soil. The vehicle will have gasoline-powered generator(s) to provide the electrical power (110 volts AC) to operate the field equipment.

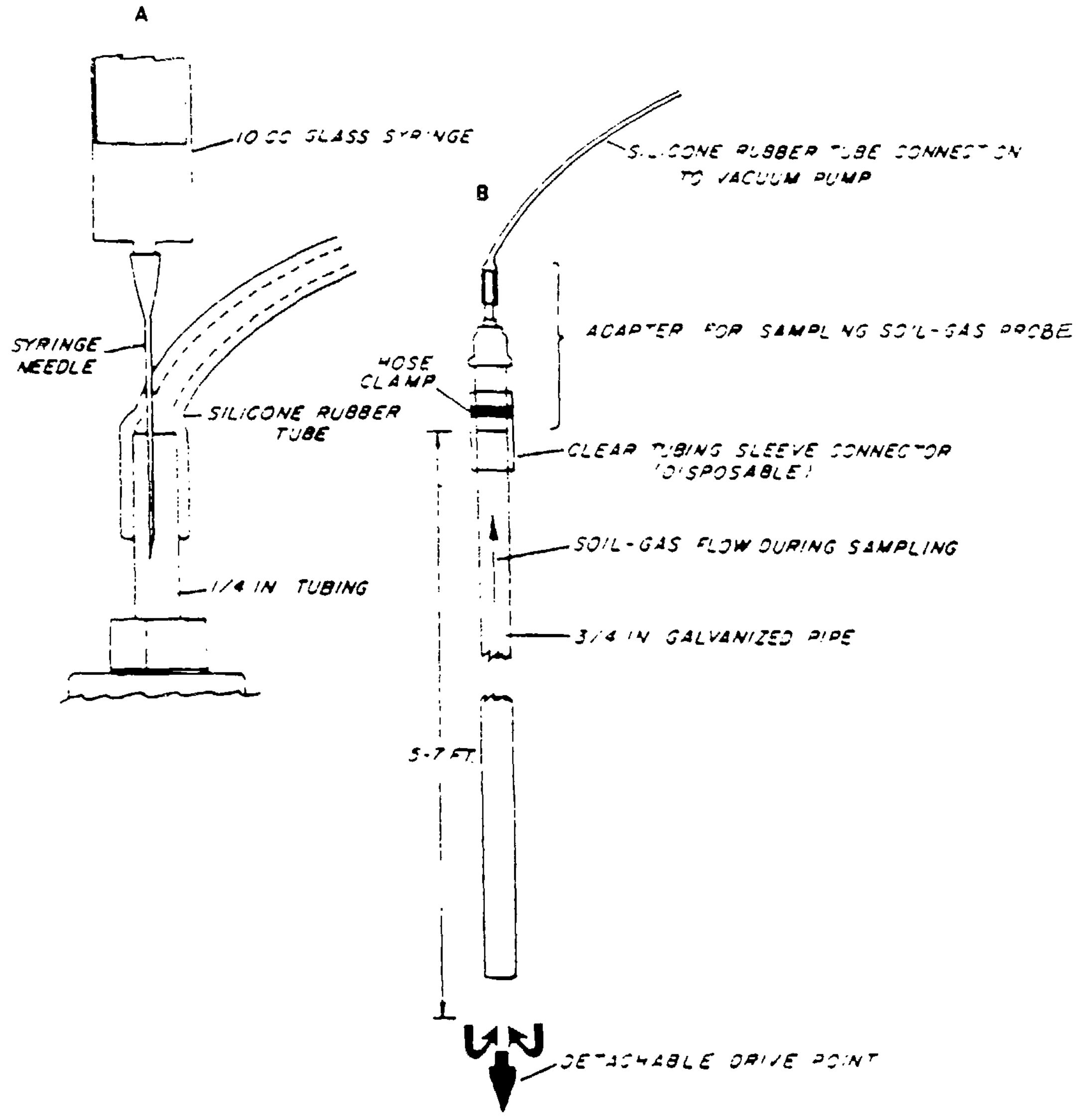
The probes, shown in Figure 5-18, are driven into the soil to a depth of 5 to 8 feet below land surface by the hydraulic pusher/puller mechanism. The probe is then retracted a few inches to allow soil vapors to enter and be purged by withdrawing two probe volumes before sampling. A gas sample is then taken using a glass syringe inserted through a section of silicon tubing. Gas samples only come into contact with steel surfaces, and are never in contact with potentially sorbing materials. A vacuum gauge monitors the negative pressure in the sampling line to assure that there is no impedance to vapor flow. The gas samples are injected into the GC for immediate analysis.

One or two 10-ml air samples are collected from each sampling probe after 1 to 4 minutes of pumping. These 10 ml samples are subsampled according to analytical requirements, and replicates are injected into the gas chromatograph for documentation of reproducibility. Where there are multiple contaminants which require different sample sizes for chromatographic analysis, more than two injections may be necessary.

Below is a description of the Standard Operating Procedure.

A. Probe Placement

1. A clean probe (pipe) is removed from the "clean" storage area.
2. The soil gas probe is placed in the pusher/puller mechanism.
3. A drive point is attached to the bottom of the probe.
4. A driving mechanism is used to push the probe into the ground.
5. If the mechanism cannot push the probe into the ground a sufficient depth for sampling, a hydraulic hammer is used to pound the probe into the ground.



A. Close up of syringe soil gas sampling through evacuation line.

B. Diagram of soil gas sampling probe with adapter for sampling and evacuation of the probe after it is driven into the ground.

Figure 5-18. Soil Vapor Sampling Probe.

B. Sample Extraction

1. An adaptor (Figure 5-18) is put onto the top of the soil gas probe.

2. A vacuum pump is hooked onto the adaptor.

3. The vacuum pump is turned on and used to evacuate soil gas.

4. Evacuation takes at least 30 seconds, but never more than 5 minutes, for samples having evacuation pressures less than 15 inches of mercury. Evacuation times are at least 1 minute, but no more than 5 minutes, for samples having evacuation pressures greater than 15 inches of mercury.

5. Gauges on the vacuum pump are checked for excessive soil resistance by monitoring pressure reading (inches of mercury). A gauge reading of at least 2 inches of mercury less than the maximum observed value is required to extract sufficient soil gas to collect a valid sample.

C. Sample Collection

1. With the vacuum pump running, a hypodermic syringe needle is inserted through the silicone rubber and into the stainless steel tubing of the adaptor (Figure 5-18).

2. Gas samples only come into contact with steel surfaces, never with potentially sorbing materials (i.e., tubing, hose, pump diaphragm).

3. The syringe is purged with soil gas. Without removing the syringe needle from the adaptor, a 10 ml soil gas sample is collected.

4. A second 10-ml sample is collected using the same procedure.

D. Demobilization

1. Following analysis, the vacuum pump is turned off and disconnected from the adaptor.

2. The adaptor is removed and stored with equipment to be cleaned.

3. The probe is removed from the ground and stored in the "used" probe tube.

4. The probe hole is backfilled, if required.

E. Documentation

1. Log Book, Field Data Sheet Notations, and chain-of-custody form will be used and include the following information:

    - Time (military notation);
    - Sample number;
    - Location;
    - Sampling depth;
    - Evacuation time before sampling;
    - Inches of mercury on vacuum pump gauge;
    - Probe and adaptor numbers;
    - Number of sampling points used;
    - Observations (i.e., ground conditions, concrete, asphalt, soil appearance, surface water, odors, vegetation, etc.);

- Backfill procedure and materials, if used; and
- Site map.

F. Decontamination

1. Steel probes are used only once and then washed with high-pressure soap and hot water spray or steam-cleaned to eliminate the possibility of cross contamination.
2. Probe adaptors (steel reducer and tubing) are used once during the course of the day and cleaned at the end of each working day by baking in the Gas Chromatography oven. The tubing is replaced periodically as needed during the job to ensure cleanliness and good fit.
3. Silicon tubing (connecting the adaptor to the vacuum pump) is replaced as needed to ensure proper sealing around the syringe needle. This tubing does not directly contact soil gas samples.
4. Glass syringes are usually used for only one sample per day and are washed and baked out at night. If they need to be used twice, they are purged with carrier gas (nitrogen) and baked out between probe samplings.
5. The septa through which soil gas samples are injected into the chromatograph are replaced daily to prevent possible gas leaks from the chromatographic column.
6. Microliter-size subsampling syringes are reused only after a nitrogen carrier gas blank is run to ensure they were not contaminated by the previous sample.

5.9.6 Soil Vapor Monitoring Wells

Soil vapor monitoring wells are used to provide long-term monitoring of soil vapor concentrations in much the same manner that groundwater monitoring wells are used. The wells are usually used to monitor the effectiveness and aid in the operation of soil vapor recovery systems. Monitoring well screens are installed at varying depths to provide a three-dimensional understanding of soil vapor distribution.

A soil vapor well differs from a groundwater well in two ways; the soil vapor well is installed in the vadose zone, and the screened interval is isolated from the rest of the well casing by a bulkhead. A schematic representation of the typical vapor monitoring well is shown in Figure 5-19.

Soil vapor monitoring wells are installed in a borehole drilled to the proper depth using a hollow-stem auger. The wells are fabricated using 2-inch diameter PVC casing fitted with a 3-foot screen at the bottom of the casing. The well is constructed with a sealed bulkhead positioned at the top of the screened casing to provide an enclosed screened interval for vapor sampling. Stainless steel sample lines (1/4-inch outside diameter) extend through the bulkhead into the screened area, and are used to transport vapor samples to the surface for analysis. Soil vapor sampling from the well may be accomplished using canisters, syringes, real-time instruments, and sorbent tubes. Additionally, if two vapor lines are installed in a well, they can be used to monitor emission rates.

Sampling of vapor wells will be conducted as follows:

1. Initiate chain-of-custody. Record the location, number, date, time, and barometric pressure on the field data sheet.

2. Prior to each use of the sampling system (Figure 5-20), purge it with ambient air (or UHP air) and ensure that the background level as measured with the field instrument is at ambient concentration. Do

   not sample well unless the ambient level is acceptable. Record the sampling system ambient concentration.

3. Check the sampling manifold for leaks by plugging the inlet and observing an attached rotameter; the flow should slowly drop to zero indicating that the system is airtight.

4. Set a Magnahelic® (not part of sampling manifold) up in a level position so that it can be connected to the well. Zero the

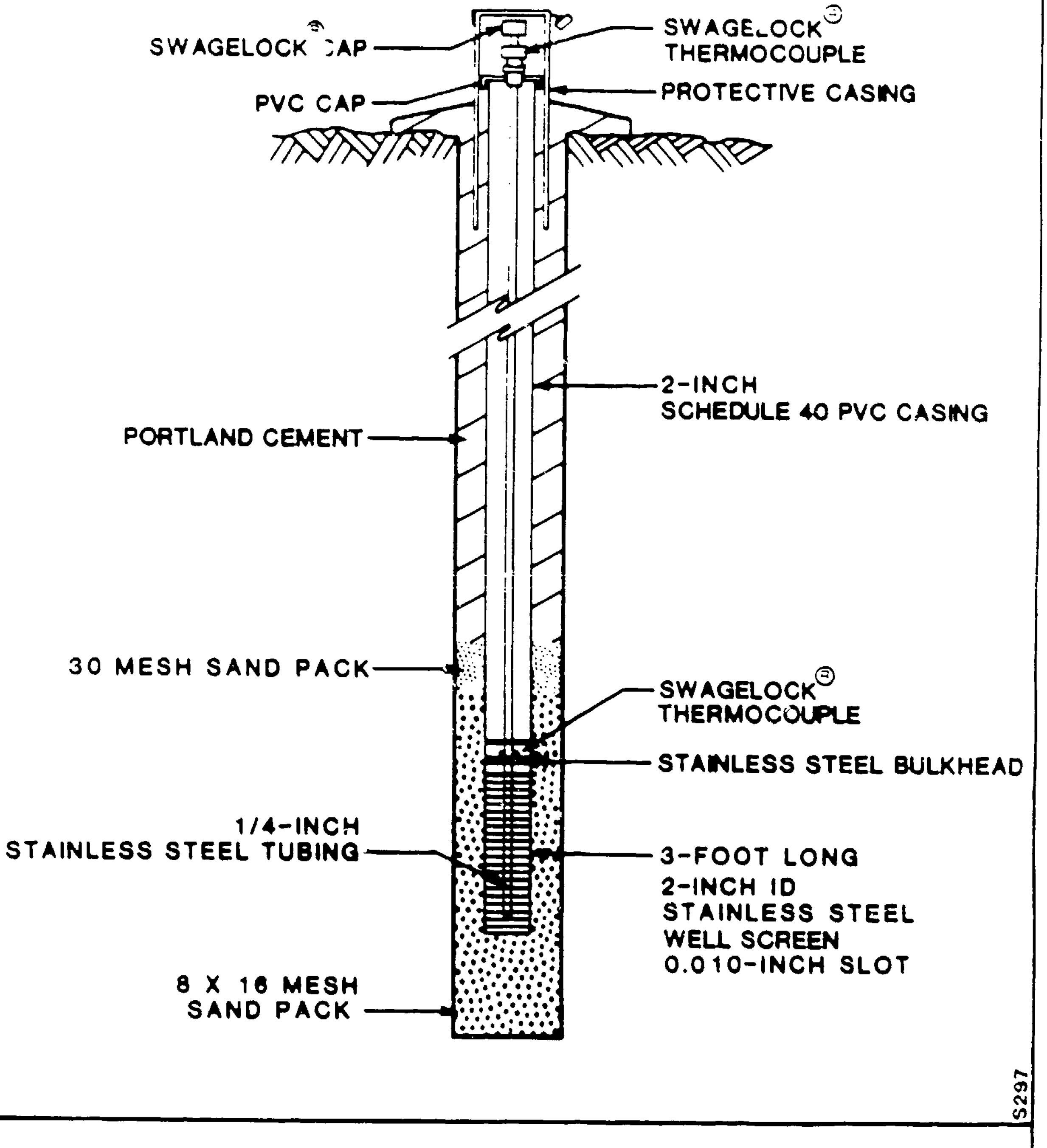


Figure 5-19. Soil Vapor Monitoring Well.

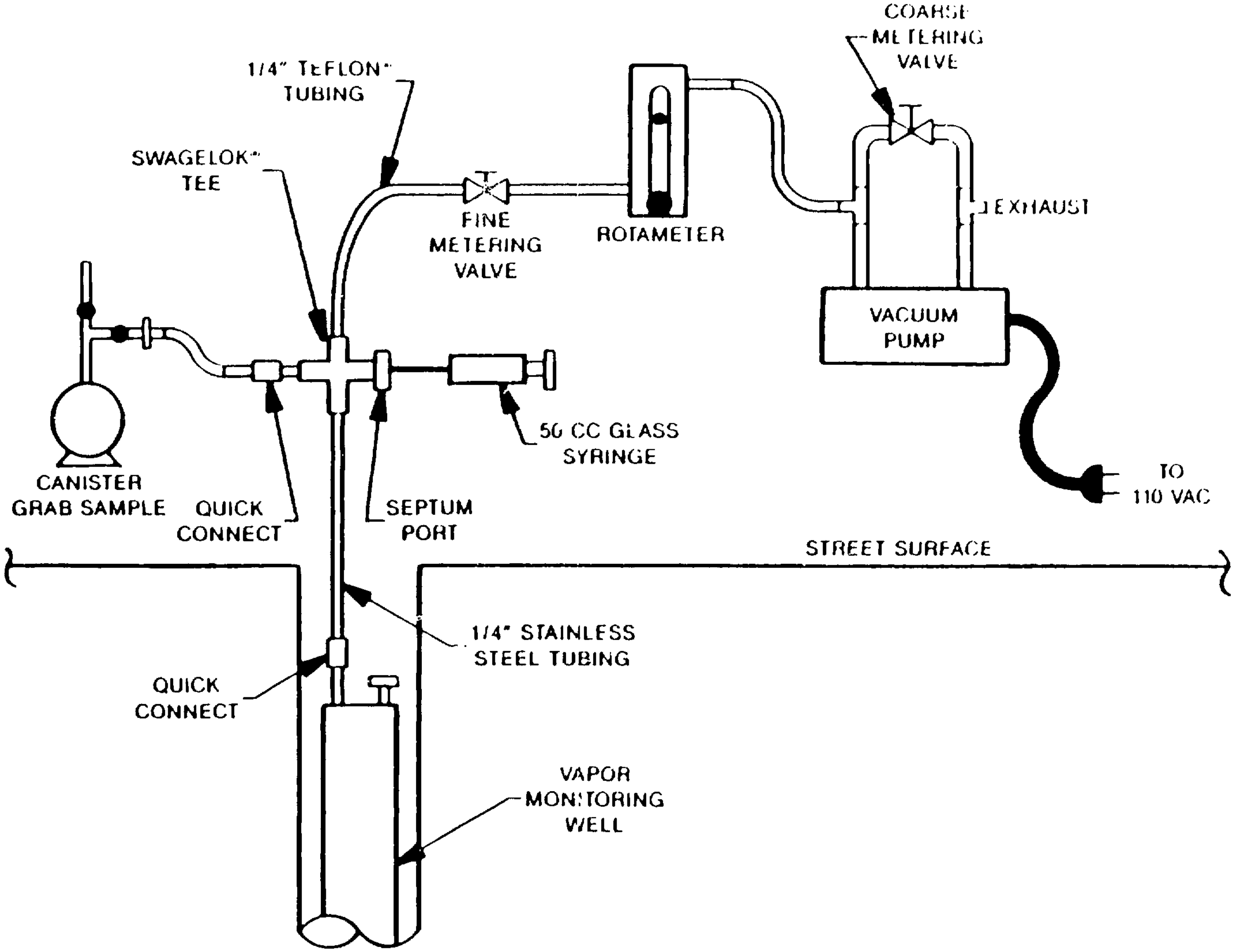


Figure 5-20. Soil Vapor Monitoring Well Sampling Manifold.

Magnahelic® gauge. This gauge is used to measure pressure differentials in the well that are used to calculate airflow and determine sample volumes.

5. Attach the Magnahelic® gauge to the well and record the differential pressure of the well.

6. Attach the sampling system to the well. Ensure that the sampling system is not open to the atmosphere.

7. Turn on the sampling pump and adjust the well purge rate to 100 cc/min. Record the purge rate and begin an elapsed timer.

Syringe Sampling

8. Purge the syringe three times beginning at 8-1/2 minutes. To accomplish this, pierce the septum with the syringe and withdraw sample slowly (i.e., a 50 cc syringe should be filled every 1/2 minute period). Filling and emptying the syringe constitutes one purge cycle.

9. Purge the well of at least three well volumes at 100 cc/min purge rate and withdraw a syringe sample. The syringe sample should be withdrawn slowly as described above. When a full syringe has been collected, remove it from the sampling septum. Record the elapsed purge time at which the sample was obtained.

10. If a duplicate syringe sample is to be collected, collect both syringes simultaneously. Clearly indicate on the chain-ofcustody forms for both samples that these are duplicates so that the analyst will know to perform duplicate analyses of these samples (nested duplicates: laboratory duplicate analysis of field duplicate samples).

11. Turn the sample pump off and shut the manifold valve.

Canister Sampling

12. If a canister sample is to be collected, connect the canister and open the valve on the canister and allow sufficient time for the

sample to be collected. The vacuum flow regulator for the canister should be set nominally at <500 cc/min. Therefore, approximately 15 minutes will be required to collect the sample if a 6-liter canister is used. If duplicate canisters are to be collected, they should be collected simultaneously. To accomplish this, both canisters must be connected to the sampling system with a tee, with the flow controller connected upstream of the tee. If a field blank is required, a clean canister will be filled with UHP air in the field.

13. Complete the canister sample chain-of-custody form. If duplicate canister samples are required, complete a chain-of-custody form for each canister. If the samples are duplicates, clearly indicate this on the chain-of-custody forms so that the analyst may select these samples for nested analysis.

Sorbent Sampling

14. If sorbent samples are to be collected, attach the sorbent sampling train and collect the sample with a sampling pump.

15. After the samples are collected, connect the field instrument to the sampling system. The instrument is connected in place of the canister for shallow wells and to the exhaust port of the sampling pump for deep wells. Open the manifold valve and, for deep wells, turn the sampling pump on to assist the instrument pump.

16. Monitor the readings from the field instrument and record the average value. If the readings vary more than 50 percent, record the range of the readings in the comments portion of the sampling data sheet.

17. Disconnect the sampling system from the well. Purge ambient air through the sampling system.

18. Complete the syringe sample(s) and canister sample(s) chain-of-custody forms.

5.9.7 Emission Flux Measurements

The emission flux (flow per unit area) sampling methods are direct vapor emissions measurement techniques for determining the emission flux of surface and subsurface vapors. The technique utilizes an isolation flux chamber of known volume to isolate a known surface area. Depending on the type of chamber used, the technique is applicable for measuring emissions at the ground surface, shallow, or deeper subsurface, or in trenches. In the chamber, ultra-pure hydrocarbon free air (sweep air) is mixed with emitted soil vapors. The sweep air flow rate is controlled to prevent inducement or suppression of vapor emission. The vapor/air mixture can then either be measured by a field instrument or collected in an evacuated canister, syringe, or sorbent for laboratory analysis. An emission rate is calculated from the measured concentrations of contaminants in the chamber exhaust gas, the sweep air flow rate, and the surface area of the exposed soil.

Surface Emission Flux Measurement

The surface emission flux sampling method is a direct surface vapor emission measurement technique for determining vapor emission rates to the atmosphere. The chamber can also be used in trenches or on liquid surfaces to make emission measurements. The technique utilizes the surface isolation flux chamber shown in Figure 5-21. The chamber is fabricated from a 9-inch-high by 16-inch-diameter Plexiglas dome and a 6-inch-high by 16-inch-diameter stainless steel ring. The resulting exposed surface area is 0.13 m^2 and the resulting volume is approximately 31 liters. The clear Plexiglas top allows solar heating at the soil surface, and minimizes disruption of natural surface conditions. Sweep air is introduced from a supply bottle, regulator, and rotameter through 1/4-inch Teflon® tubing leading to the instrument. The sweep air flow rate used is approximately 5 liters per minute, resulting in a 6-minute residence time within the chamber. Residence time is determined by dividing the chamber volume (v) by the sweep air flow rate (Q).

The emission flux is calculated as:

$$E_x = \frac{C_x Q}{A}$$

where:

E_x = Emission flux of species X ($\mu g/m^2$ -min)
C_x = Measured concentration of species X (ppmv converted to $\mu g/m^3$)

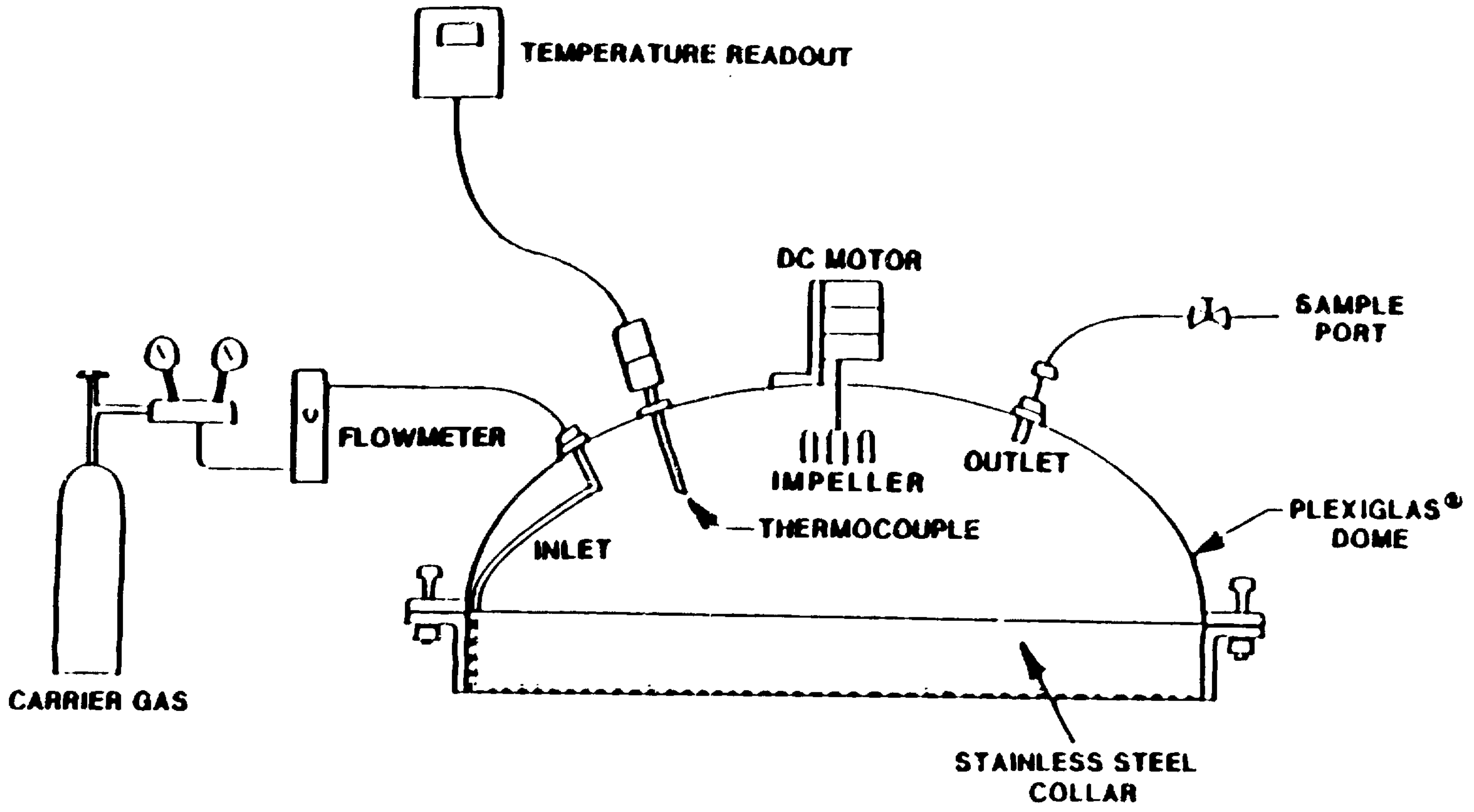


Figure 5-21. Surface Emission Isolation Flux Chamber.

Q = Sweep air flow rate (m^3/min)
A = Surface area exposed (m^2)

The field operation procedure for vapor emissions sampling is as follows:

1. Initiate field data sheet.

2. The chamber is placed over the target surface. No attempt is made to force seal the chamber.

3. The sweep air flow and impeller are started, and the time is recorded. Check the rotameter to ensure correct sweep air flow rate (5 liters per minute).

4. Field information (location, date, site description, etc.), and the soil vapor concentration resulting from peak as well as steady-state emission are recorded on an emission measurement field worksheet (Figure 5-22). If more than one field instrument is used, each instrument should be connected to the output manifold individually so that the instruments do not compete for flow or effect conditions within the chamber. Connect each instrument for one minute to take readings. Then remove and connect next instrument.

5. Samples are collected for analysis, if required, when steady-state conditions are reached (typically 18 to 24 minutes or 3 to 4 residence time units). Remove instrument from outlet manifold and connect inlet of sampling device manifold. For syringe sampling, a septum should be installed in the sampling line upstream of the instrument, and the instrument left connected during sampling.

6. After sampling, the chamber is removed, wiped clean, and prepared for the next location. Purge the outlet manifold by pulling ambient air through the manifold for 5 minutes or until readings are equal to ambient air, whichever is longer. Leave the chamber bottom exposed to ambient air while purging.

ISOLATION FLUX CHAMBER

Date: ________ Time: ________ Sampler's Initials: ________________

Location: ____________________ Well #: ________ Depth: ________

Concurrent Activity: ________________________________

Surface Description: ____________________ OVA ID#: ________________

Time	Purge Air or Flowrate	Residence Time Number(T)	Temp. °C Surface	Air	Gas Data ppmv Peak (Time)	Steady State	Air Sample Number

Comments:

Ambient: ____________
Maximum Peak (Time): ____________
Steady State: ____________

Figure 5-22. Emission Measurement Field Worksheet.

Downhole Emission Flux Measurement

The downhole emission flux (DHEF) sampling method is a direct soil vapor emissions measurement technique that uses the downhole isolation flux chamber shown in Figure 5-23. The chamber isolates a known soil surface area at a desired depth within the hollow-stem auger. The DHEF chamber is fabricated from a 2-1/2-inch inside diameter (I.D.), 3-inch outside diameter (O.D.) Plexiglas® cylinder with a 1/4-inch thick, 3-inch diameter Plexiglas® plate cemented on the top. The total volume of the chamber is 0.643 liters. The chamber input and output lines are assembled in sections allowing the use of the shortest line needed for any individual measurement. Sweep air is introduced from a supply bottle to the bottom of the chamber in close proximity to the exposed surface. The sweep air flow rate should be set to approximately match the instrument flow rate (typically 0.6 to 1.0 liter per minute) as monitored by a calibrated rotameter, resulting in an approximately 1-minute retention time in the chamber. The calculation of emission flux for the DHEF measurement is identical to that for the surface emission flux measurement.

The field procedure for DHEF vapor measurement and sampling is as follows:

1. Initiate a field data sheet. Initiate a chain-of-custody form if sampling is desired. The hole is drilled to the desired depth and the auger flight is disconnected from the drive shaft. The tip of the drive bit is removed, exposing soil at the bottom of the borehole;

2. The downhole flux chamber is lowered inside the hollow-stem auger with the sweep air flowing. After the chamber reaches the bottom of the borehole, no attempt will be made to force seal the chamber on the exposed bottom surface. The time is recorded when the chamber is seated at the core depth and the field instrument is connected;

3. The soil vapor concentration is monitored over a 15- to 20-minute period, and the peak as well as the steady-state values are recorded on a downhole emission measurement worksheet (Figure 5-22);

4. Samples will be collected for analysis, if required, when steady-state conditions are reached (typically after 15 to 20 minutes);

5. Samples are collected by disconnecting the field instrument and connecting the output manifold to the sampling device. Samples should be collected slowly at a rate of 0.64 liters per minute (1-minute retention time), except for sorbent sampling where the analytical method may specify a sampling rate. For syringe samples, a septum must be installed upstream of the instrument, and the instrument left in place during sample collection.

6. Remove the DHEF chamber and clean it by wiping with a clean towel. If visibly contaminated, decontaminate the chamber by washing with laboratory grade detergent and rinsing with potable water and distilled water. Purge the chamber and outlet line with ambient air until the next measurement using the instrument. At a minimum, purge with ambient air for 5 minutes or until the instrument reading is at ambient level, whichever is longer; and

7. Complete the field data sheet, and chain-of-custody, if applicable.

5.10 Ambient Air Monitoring

Ambient air sampling will be performed during various phases of the remedial investigation. The selection of the ambient air sampling techniques and the sampling media will depend on the intended use of the data. The rationale for sample collection, including sampling locations, analytical parameters, number of samples, and type of samples, will be determined as each detailed work plan is developed. The selected analytical parameters will determine the sample quantities, sampling media, and preservation requirements. Sample collection will be documented using sample master logs and chain-of-custody forms as described in Section 6.0 of this QAPP, and on field data sheets prepared for each sampling task.

Ambient air sampling will be performed for a variety of tasks including: ambient air quality assessment, contaminant emission rate determinations, exposure assessment, health and safety monitoring during sampling activities, and community protection during site disturbance activities. The selection of the sampling locations for ambient air sampling will be determined by the data needs and the selected assessment techniques. Sampling locations for air quality assessment and emission estimates are a function of the indirect models or direct sampling technique being used. Established models include concentration-profile, transect, upwind/downwind, and other direct emissions area source techniques. Monitoring may require only a single, near site downwind station, or may require several sampling stations. The modeling techniques used to select sampling locations will be discussed in the detailed work plans for each investigation.

There are several sampling techniques available for ambient air sampling, most of which are differentiated by the sampling media on which or within which the air sample is collected. Ambient air sampling may consist of measuring ambient air constituents by real-time analyzers or collecting ambient air samples in evacuated stainless steel canisters. Specific air constituents may be collected using solid sorbents, filters, dosimeters, or liquid media. Particulates may be sampled by passing air through filters. In general, the standardized methods specify sampling parameters such as sampling media, sample flow rate, sample quantity, length of sampling interval, and preservation requirements. Specific sampling protocols will be added to the QAPP as they are required by work plans.

Real-Time Instruments

Real-time instruments may be used for ambient air quality assessment and for health and safety monitoring during site disturbances to provide instantaneous, and, if necessary, continuous measurements. Real-time instrumentation may include species specific instruments such as SO2, CO2, or H2S monitors, or non-specific instruments such as total hydrocarbon monitors, non-methane hydrocarbon monitors, and explosivity meters. Data obtained from these instruments allow for comparison to health and safety standards, and evaluation of variations in species concentrations with time.

Portable field instruments using flame ionization (FID) and photoionization (PID) detectors can be used to measure soil vapors with most of the techniques described above. The portable FID to be used is the Foxboro Corporation Model OVA-108 Organic Vapor Analyzer. This instrument is a product of Foxboro Analytical (The Foxboro Company), and was previously known as the Century System Model OVA-108. A Model OVA-88 or OVA-128 may be used in place of the OVA-108. The OVA-108 has a calibrated range of 1 to 10,000 parts per million volume total hydrocarbon (calibrated as methane in air).

The portable PID to be used is an HNU Model PI-101 gas analyzer, a product of HNU Systems, Inc. The PI-101 has a calibrated ranges of 0 to 2000 ppmv non-methane hydrocarbons, typically calibrated as trichloroethene or benzene in air.

These instruments are typically attached to the sampling line with Swagelok® fittings which provide an air tight seal. The general procedure for sampling is:

1. Attach instrument to sampling line;
2. Observe direct read-out until reading stabilizes, typically 10 seconds to 1 minute; and
3. Record peak and steady-state reading.

Four situations to be avoided with field instruments are:

1. Sampling systems under vacuum or where sampling lines are greater than 6 feet. The vacuum or drag in the sampling line may be too great for the instrument pump, resulting in insufficient flow through the instrument. Pump noise or flow meters may indicate this condition. The result is inaccurate readings.
2. Sampling systems under pressure. Excess flow through the instrument from a pressurized system may damage the system. Excess flow typically results in inaccurate readings.
3. Systems with little or no oxygen or with high moisture content. FID systems typically use the oxygen in the sample for combustion, and will not function in low oxygen environments. The moisture may also extinguish the flame or reduce combustion temperature in FID systems. In PID systems, the moisture will coat the ionizing tube, preventing ionization of molecules in the vapor stream. In all cases, inaccurate readings will result.
4. Allowing the sampling probe to get too close to soil or liquid, causing particles or liquid to be drawn up into the instrument. If this condition occurs, the equipment filters and/or lines should be cleaned immediately.

Stainless Steel Canisters

Air samples will be collected using evacuated stainless-steel canisters for off-site laboratory analysis as discussed in Section 8.5 of this QAPP. The canister samples allow for identification and quantification of C1 through C_{12} species, and can be used to collect integrated samples over time periods ranging from nearly instantaneous to 24 hours. The sampling interval will be determined during task planning activities, and will be dictated by the sampling program objectives, analytes of interest, and expected concentration range. Grab sampling may be used to obtain instantaneous concentrations, or integrated sampling may be used to obtain a time-averaged concentration. Each canister is fitted with a 7-micron, stainless-steel filter to prevent the collection of particulates. The canisters may also be fitted with stainless steel vacuum flow controllers to conduct time-integrated sampling. Canister sizes of 2.5, 6, and 15 liters are available. The appropriate size canister to use for specific sampling efforts will be determined by the length of the sampling period and concentrations and compounds of interest. Directional actuators can also be used with the canisters for collection of samples only during specified wind directions; this ensures samples are representative of air upwind or downwind of a specific operation during sampling.

Before sampling, each canister will be cleaned and evacuated, and the absolute pressure will be recorded in the laboratory. Stainless-steel 7-micron filters will be attached to the canister inlet to remove particulate material. Vacuum flow regulators may be used to provide a constant sampling flow over the sampling period. The flow is set prior to sample collection by means of calibrated flow meters.

To collect samples:

1. The canister pressure (vacuum) is checked prior to sampling and recorded. The initial pressure should be -27 inches of mercury. However, the canister will be considered acceptable if the value is <-24 inches of mercury.

2. Attach canister to sampling line as necessary.

3. Open canister inlet valve slowly. A slight hissing sound can be heard during sampling by placing an ear against the canister.

    a. Grab canister samples should typically be collected over a 1 to 3 minute period. Sample time is controlled by slowly opening the inlet valve so that the hissing sound is barely audible or the vacuum gauge begins to drop. A stopwatch or watch with a second hand should be used.

b. For time integrated samples, a vacuum flow regulator should be used. The regulator should be adjusted to collect 70 to 80 percent of the canister volume during sampling interval. This will ensure that the integrated sample has a start and stop time and that the container is not filled to atmospheric pressure.

4. After sample collection is completed, the canister inlet valves are closed and the canisters disconnected from sample lines.

5. The absolute canister pressure is then again measured and recorded.

6. Prior to transporting to the laboratory, all canister valves will be tightened and stem nuts sealed with Swagelok® plugs.

Syringe Sampling

Syringe sampling can be performed for most of the sampling approaches previously described. Syringe sampling is conducted when field analysis with a mobile gas chromatograph (GC) is to be performed. Syringes may be either glass or stainless steel, and may vary in size from microliter to greater than 100 milliliter or more depending on the sample concentration and GC requirements.

Syringe sampling is usually performed to measure contaminants detected by a real-time portable field instrument. The field instrument can also be used to maintain a continuous flow of vapors past the syringe sampling port.

1. Install a septum in a Swagelok® fitting upstream of the field instrument measurement port.

2. Measure vapor concentrations with field instrument.

3. Insert syringe needle through septum.

4. Purge syringe at least three times with sample. Typically the syringe is purged without removing the syringe from the needle, or the needle from the septum. Instead, the purge is reinjected into the sample line and removed by the field instrument. However, specific conditions may require releasing the purged sample to the air. Purging to the air is preferred if a stopcock is present between the needle and syringe. Then the stopcock is closed, the syringe removed from the stopcock, and emptied. This approach prevents air from entering the sampling line.

5. After the sample is collected, the syringe and needle are removed from the septum and capped, or if a stopcock is present it is closed before the needle is withdrawn from the septum.

6. Analyze sample as quickly as possible, and always within 2 hours of collection, to prevent loss of species by adsorption to the syringe wall or thermal or ultraviolet radiation degradation. Keep all syringes out of sunlight by using a shield or box and keep in a cool place.

The basic requirement is to collect a sample without introducing air to the syringe or system. The available equipment will determine the best purging technique.

Sorbents and Filter Media

Air constituents may be sampled using a variety of solid and liquid sorbents and filters. Sorbents may be used when a limited set of species of interest are to be studied or where the species of interest cannot be collected efficiently by another method. Sorbents are usually a solid matrix, such as charcoal or Tenax®, or a liquid. Sample collection consists of placing the sampling media upstream of a calibrated pump. Air is drawn through the solid sorbent; air constituents are sorbed on to the sorbent and then chemically desorbed in the laboratory for quantitation. The pump flow rate and the length of the sampling interval are defined by the method or the anticipated concentration of the constituent.

Filters can be used to collect particulates for particle size distribution anaysis, and chemical speciation, including adsorbed and absorbed organics. Filters are also used as solid sorbents for semivolatile species. Filters are available in a variety of materials including polyurethane foam (PUF) and glass fiber filters (GFF).

6.0 SAMPLE CUSTODY

Sample possession during all sampling efforts must be traceable from the time of collection until the results are verified and reported. The sample custody procedures provide a mechanism for documentation of all information related to sample collection and handling to achieve this objective.

The field sampling task leader will be responsible to see that the field team adheres to proper custody and documentation procedures for all sampling operations. Preformatted field data and Chain-of-Custody forms will be used as the primary documentation mechanism to ensure that information pertaining to each sample is recorded. In addition, a master sample logbook will be maintained for all samples collected. Examples of these data documentation forms are presented in this section. Copies of the Chain-of-Custody forms and the field logs will be retained in the project file.

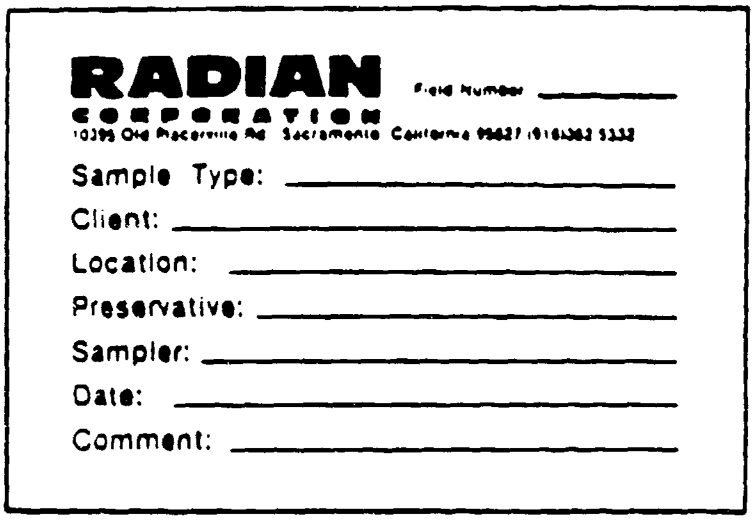
6.1 Documentation Procedures

Field Records

Field personnel will be required to keep accurate written records of their daily activities in a bound logbook. All entries will be legible, written in waterproof ink, and contain accurate and inclusive documentation of an individual's field activities, including field data and observations, any problems encountered, and actions taken to solve the problem. The type of data recorded in the field logbook includes field measurements (pH, conductivity), ambient conditions, and any other information pertinent to sample collection. Entry errors or changes will be crossed out with a single line, dated, and initialed by the person making the correction. Entries made by individuals other than the person to whom the logbook was assigned will be dated and signed by the individual making the entry. Field logbooks will be available for review by the wuality assurance (QA) coordinator. This documentation should improve quality control (QC) and provide verification of sampling procedures.

Sample Labels

Each collected sample will receive a sample label (Figure 6-1). Sample labels identify the sample by documenting the unique sample identification number, the sample type, the sampler's name(s), date collected, and the preservation method used. These labels are completed with a ballpoint pen and affixed to the sample container.



RADIAN Field Number ________
CORPORATION
10395 Old Placerville Rd. Sacramento California 95827 (916)362 5332

Sample Type: ______________________
Client: ______________________
Location: ______________________
Preservative: ______________________
Sampler: ______________________
Date: ______________________
Comment: ______________________

Figure 6-1. Radian Sample Label.

Sample Master Logbook

A sample master log will be maintained at the on-base staging area for all samples taken. Each sample will be assigned a unique identification number and a full description of the sample, its origin, and disposition, and will be included in the log entry. Figure 6-2 shows the master log form. Because of the long-term nature of this program and the large number of samples expected, the master log will be kept with the Project Director or Task Leader (depending upon the sampling program) when no field activities are taking place.

6.2 Chain-of-Custody Procedures

After the samples are collected and documented in the sample log, a Chain-of-Custody form (Figure 6-3) will be completed, and accompany the samples to the laboratory. Team members collecting the samples are responsible for the care and custody of the samples until they are transferred or dispatched to the laboratory. When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the record. This record documents sample possession from collection to the laboratory sample control center.

When the samples are received in the Radian laboratory, the Sample Control officer will verify the Chain-of-Custody form against the sample containers received. If any discrepancies are observed, they will be recorded on the Chain-of-Custody form, and the appropriate sampling team leader will be notified to correct the problem. A laboratory chain-of-custody record is then initiated by sample control, using the electronic Sample and Analysis Management System (SAM®). The SAM® system is used to track the status of the sample analysis and to report the results. Further discussion on the SAM® system is found in Section 9.0 on data reduction, validation, and reporting. Subcontracting laboratories will be required to follow the established chain-of-custody procedures, and provide proof of sample custody as part of contractual requirements.

Photographs

When photographs, slides, or movies are taken for the purpose of visual documentation of a site or procedure, they will be numbered to correspond to the field logbook entries. If possible, a reference point (building, sign, etc.) will be included to assist in verifying the location of the photograph and provide an approximate scale. The name of the photographer, date, time, site location, and site description will be entered

FIELD INFORMATION

Sample No.	Date Sampled	Time Sampled	Location	Initials	Parameters Collected	Dup.	Sample Quantity	Matrix	Project Director	Comments

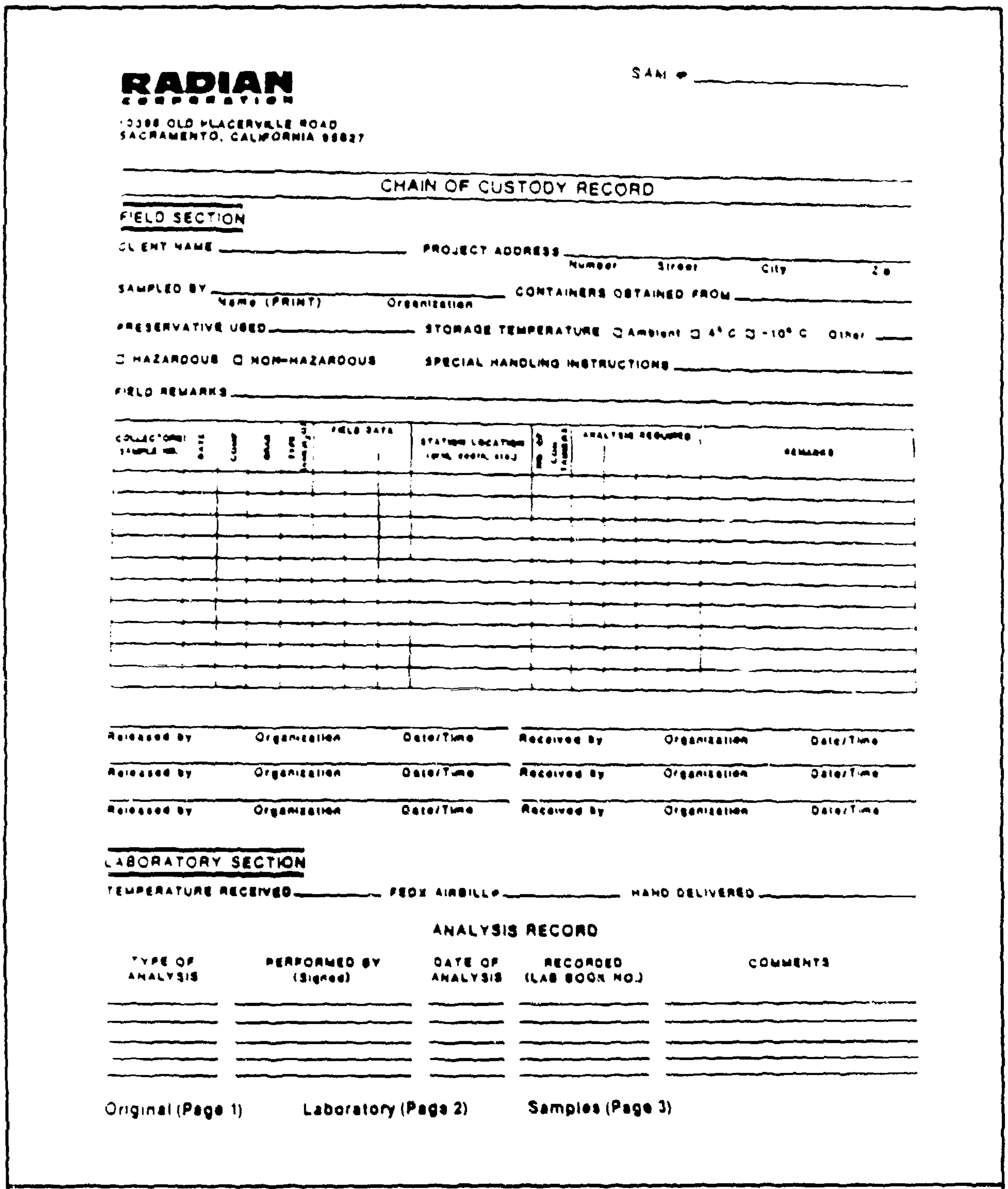
Not for entry of real time data

Figure 6-2. Sample Collection Master Log.

SAMPLE CONTROL INFORMATION

Date Shipped	Lab Name	Lab ID	Fed.Ex. Airbill	✓ Samp. Rcvd.	Tests Performed	Date Extract.	Date Analyzed	Final Report	✓ Comp.	Comments	Sample No.

Figure 6-2. Sample Collection Master Log.
(Continued)



RADIAN
CORPORATION
10389 OLD PLACERVILLE ROAD
SACRAMENTO, CALIFORNIA 95827

SAM # ____________

CHAIN OF CUSTODY RECORD

FIELD SECTION

CLIENT NAME ____________ PROJECT ADDRESS ____________
Number Street City Zip

SAMPLED BY ____________
Name (PRINT) Organization

CONTAINERS OBTAINED FROM ____________

PRESERVATIVE USED ____________ STORAGE TEMPERATURE ☐ Ambient ☐ 4° C ☐ -10° C Other ____

☐ HAZARDOUS ☐ NON-HAZARDOUS SPECIAL HANDLING INSTRUCTIONS ____________

FIELD REMARKS ____________

COLLECTOR'S SAMPLE NO.	DATE	COMP	GRAB	TYPE	[illegible]	FIELD DATA	STATION LOCATION	[illegible]	ANALYSIS REQUIRED	REMARKS

Released by Organization Date/Time Received by Organization Date/Time

Released by Organization Date/Time Received by Organization Date/Time

Released by Organization Date/Time Received by Organization Date/Time

LABORATORY SECTION

TEMPERATURE RECEIVED ________ FEDX AIRBILL # ________ HAND DELIVERED ________

ANALYSIS RECORD

TYPE OF ANALYSIS	PERFORMED BY (Signed)	DATE OF ANALYSIS	RECORDED (LAB BOOK NO.)	COMMENTS

Original (Page 1) Laboratory (Page 2) Samples (Page 3)

Figure 6-3. Radian Chain-of-Custody Form.

sequentially in the logbook as photos are taken. Photographs will be coordinated with McClellan Air Force Base (AFB) Environmental Management (EM) to ensure adherence to United States Air Force (USAF) procedures.

Shipment

All sample shipments will be accompanied by the Chain-of-Custody record, which identifies its contents. The original record will accompany the shipment, and a copy will be retained in the project file.

When samples are split for duplicate analysis, a separate Chain-of-Custody record will be prepared. The person relinquishing the samples to the facility or agency will request the signature of a representative to acknowledge receipt of the samples. If a representative is unavailable or refuses to sign, this is noted in the "Received By" space. When appropriate, as in the case of overnight shipment, the custody record should contain a statement that the samples were delivered to the designated location and the date and time noted. Sample collection and shipment will be coordinated to ensure that the receiving laboratory has staff available to process the samples according to method specifications.

All shipping containers will be locked and secured with Chain-of-Custody seals for transportation to the laboratory. The method of shipment, courier name(s), and other pertinent information is entered in the "Remarks" section when the samples are to be shipped (i.e., Federal Express, Express Mail, etc.) instead of hand-delivered.

6.3 Sample Handling Procedures

The objective of sample handling procedures is to ensure that samples arrive at the lab intact, at the proper temperature, and free of external contamination. With the exception of split samples, all samples will be delivered to the Radian Analytical Services Laboratory by the field sampling personnel. Split samples will be shipped via overnight Express Mail to the subcontracting laboratory, according to Department of Transportation standards. Chain-of-custody procedures will be followed during transport.

Sample packaging requirements for hazardous materials requiring interstate transport are defined in the Code of Federal Regulations 40 (CFR) 49, Chapter 1, Part 171. These requirements outline in detail the proper classification and procedures for transportation of hazardous materials that will be used for transport of the samples.

Since all samples are required to be stored at 4°C or less, generous amounts of ice will be packed with the samples. When the samples are delivered to the Radian Laboratory they will be immediately placed in the sample refrigerator. Samples prepared for shipment will be packed with ice packs sufficient to maintain the proper storage temperature until they reach the laboratory.

The following procedures will be used to prevent bottle breakage and cross-contamination:

- All samples will be transported inside hard plastic coolers;
- Samples that are known or suspected to be highly contaminated (based on field screening data or observation) will be packaged and shipped separately from other samples;
- All 40-mL volatile organic analysis (VOA) bottles will be placed in blocks of foam;
- All other glass bottles are placed in plastic mesh sleeves to prevent glass-to-glass contact;
- Plastic sample bottles, chunks of ice, and foam blocks will be used to separate glass bottles;
- For samples to be shipped, vermiculite will be used to isolate the bottles from each other. The coolers will be taped shut and sealed with chain-of-custody tape to prevent accidental opening; and
- If samples are known or suspected to be highly contaminated, laboratory sample control will be notified, so those samples can be stored separately from less contaminated samples, minimizing the potential for contamination. Additionally, all samples are to be individually sealed inside plastic bags before storage in the laboratory sample control refrigerators, and refrigerator blanks are routinely analyzed.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

Calibration procedures for laboratory and field instrumentation are performed to ensure that the instruments are operating properly, and can produce data that satisfy the objectives of the sampling program.

7.1 Laboratory Instrument Calibration

Laboratory instruments are calibrated according to manufacturers' specifications, and in compliance with the analytical method requirements. Detailed calibration procedures and recommended frequencies are included in the analytical standard operating procedures (SOPs). A short description of calibration procedures along with the analytical methodology for each method is included in Section 8.0.

Stainless Steel Canister Analysis

Detailed calibration procedures for the analysis of stainless steel canister samples are discussed in detail in the specific analytical SOP, contained in the Appendix A of this Quality Assurance Project Plan (QAPP). A summary is included in Section 8.5.

7.2 Field Instrument Calibration

Water Sampling Field Instruments

Field pH and conductivity meters will be routinely used for surface water and groundwater sampling. The pH meters will be calibrated using two buffers of pH 7 and pH 10. The conductivity meters will be calibrated daily using a KC1 solution of known conductivity; temperature will be recorded with the conductivity.

Real-Time Portable Organic Vapor Analyzers

Two portable field instruments using flame ionization (FID) and photoionization (PID) detectors will be used to measure organic soil gas. Details on the use and operation of these instruments can be found under Analytical Procedures, in Section 8.4.

A factory calibration of the Century Organic Vapor Analyzer (OVA) will be conducted on a quarterly basis. Each month, a multipoint calibration check will be performed using a zero and at least three different concentrations of certified methane-in-air gas standards. The concentration of the standards will range from 10 to 10,000 ppmv methane (or 100,000 ppmv, depending on the range of the instrument). The standard will enter the normal sampling port of the probe at atmospheric pressure by using a "tee" to vent excess pressure from the delivery line. The observed responses will be recorded on a calibration and daily quality control (QC) data form, and a plot of known concentration versus instrument response will be prepared to visually check the linearity of instrument response. The linearity of the calibration curves will be evaluated using linear regression analysis. If the correlation coefficient (r) is $\geq$ 0.9950, the instrument response will be considered linear, and the instrument ready for field use. If this criterion is not met, the calibration will be repeated (after instrument maintenance, if necessary) until r $\geq$ 0.9950. Once linearity is considered acceptable, an average response factor (RF) will be calculated based on the multipoint data.

Prior to sampling each day, the electronic calibration of the instrument will be checked and adjusted, if necessary. Ultra high purity (UHP) air will then be analyzed to check the zero, and the mid- and high-level calibration standards will be analyzed using methane-in-air at concentrations of 100 and 10,000 ppmv. When sampling activities have been completed, another multipoint calibration test will be performed to note if any deviation exists. The response factors obtained for the calibration standards analyzed before and after daily sampling must be within $\pm$20 percent of the monthly multipoint response factor. If the correlation coefficient at the end of sampling is less than 0.9950, the field data will be noted accordingly.

Calibration procedures for the HNU trace gas analyzer will be essentially the same as the calibration for the OVA, except that certified trichloroethene-in-air gas standards will be used in the range of 10 to 2,000 ppmv. The 10.2 electron volt (v) lamp is used for calibration because it covers a wide range of detectable species.

Field Gas Chromatograph Calibration

A three-point calibration from standards prepared specifically for the investigation will be performed every day. These standards will be a mix of all target analytes, including at a miminum, trichloroethene, 1-1-1-trichloroethane, tetrachloroethene, 1-1-dichloroethene, 1-1-dichloroethane, 1-2-dichloroethane, benzene, toluene, and xylenes. Response factors and linearity for each compound will be developed based on this calibration.

A calibration check will be performed after every five samples by injecting one of the calibration standards. If the results do not fall within 15 percent of the original calibration, the instrument will be recalibrated and new response factors determined.

Flow Controller Calibration

The flow controllers used with the evacuated stainless steel canisters will be calibrated prior to each sampling event using a Mini-Buck® primary gas flow calibrator. This calibration is performed so that the flow into the evacuated canister is constant, as required in the Compendium of Methods for the Determination of Toxic Compounds in Ambient Air (EPA-600/4-84-041, April 1984) for whole air sampling. The calibrator is attached to the intake port of the flow controller by Teflon® tubing and Swagelok® connecting hardware. A charcoal tube and a bubble trap are included to ensure that soap bubbles do not enter the flow controller (Figure 7-1). The bubble trap consists of a 500-ml Erlenmeyer vacuum flask with a one-holed rubber stopper. A stainless steel outlet tube is positioned 1 inch from the bottom of the flask, passes through the rubber stopper, and is attached to the Teflon® tubing. The side port of the flask is attached to the Mini-Buck® Calibrator by a 3-inch piece of Tygon® tubing. Hash marks are etched into the valve adjustment screw and the housing of the flow controller, so the screw adjustment can be determined and calibration settings can be reset in the field.

Ultrapure air is used throughout the calibration procedure to avoid contamination of the flow controllers. Pre-sampling calibration (i.e., in the lab) consists of three replicate measurements that provides a flow rate within 6.6 to 8.3 ml/min. The flow setting position will initially be determined by calibrating the flow controller at several settings to determine the appropriate setting for 8.3 ml/min. The Mini-Buck® displays the flow in cc (ml) per minute. Recorded values are rounded to the nearest tenth of a ml/min.

Field calibration will consist of a single flow measurement; a value within ±5 percent of the initial value will be required. In-field calibration will be performed at the beginning of sampling, after 1 hour of sampling, after 20-22 hours of sampling, and at the completion of sampling. Additional measurements may be performed during sampling if the sampling stations are accessible for the full sampling interval.

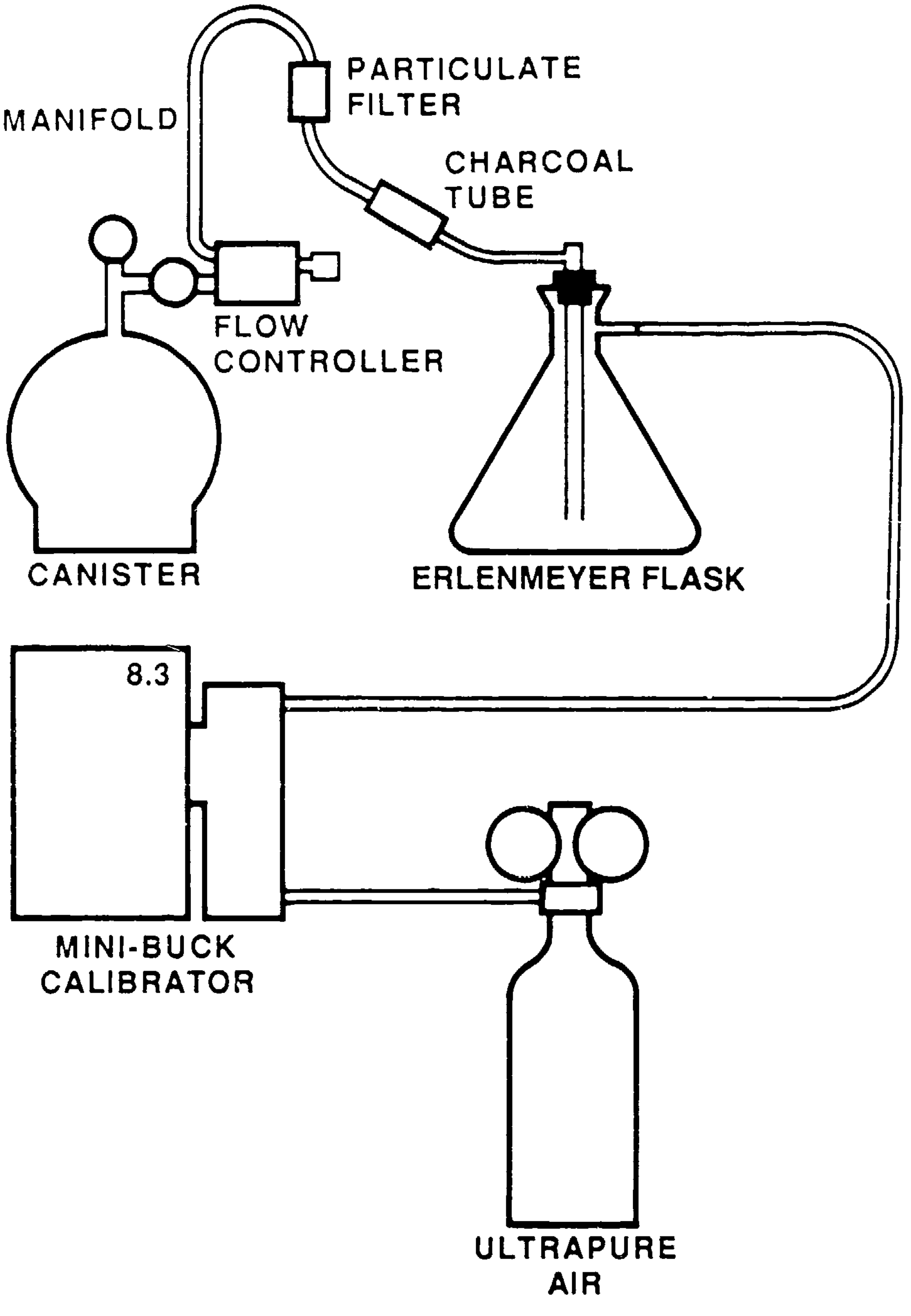


Figure 7-1. Flow Controller Calibration Schematic.

Field pump calibration procedures consist of Mini-Buck® calibration to the appropriate flow rate. Field calibration is identical to the flow controller field check procedure.

8.0 ANALYTICAL PROCEDURES AND CALIBRATION

This section contains brief descriptions of calibration procedures and analytical methodology for the analysis of water, soil, and air samples that will be collected during various phases of the remedial investigation (RI). The analogous water and soil methods are described together and appropriate detection limits are tabulated for each method. The laboratory methods identified in this document were published by United States Environmental Protection Agency (U.S. EPA) in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846," Third Edition, revised November 1986. Additional methods identified were published in "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater" (EPA-600/4-85 054), U.S. EPA Methods for Analysis of Water and Wastes (EPA-600/4-79-020, 1979), in Title 22, Article 11 of the California Administrative Code, "Criteria for Identification of Hazardous and Extremely Hazardous Wastes," "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act," 40 CFR, Part 136, Federal Register 49 (209), 26 October 1984, and the Compendium of Methods for the Determination of Toxic Compounds in Ambient Air (EPA-600/4-84-041, April 1984).

Method Detection Limits

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The laboratory performs MDL studies on an annual or quarterly basis (depending on the method) to demonstrate that it can meet or exceed the method recommended MDLs. The U.S. EPA procedure used for establishing MDLs is described in Appendix B to Part 136 "Definition and Procedure for the Determination of the Method Detection Limit - Revision 1.1," 40 CFR 136, 1984. This procedure consists of analyzing seven aliquots of a standard spiked at three to five times the expected MDL, which is taken through all the sample processing steps of the analytical method. The MDL is defined as three times the standard deviation of the mean value for the seven analyses. In the few cases where the experimentally determined MDLs are higher than recommended method detection limits, the method recommended MDL is shown in parentheses.

8.1 Laboratory Standards and Reagents

Laboratory standards and reagents are obtained from the following suppliers:

- For organic analysis, analytical standards are obtained from U.S. EPA sources and SUPELCO. Spectral grade and reagent grade solvents and reagents are obtained from Aldrich, Sigma, and Burdick and Jackson.

- For inorganic analysis, standard reference materials are obtained from the National Bureau of Standards (NBS) and SPEX. Spectral grade and reagent grade standards are obtained from SPEX, Fisher and Ricca.

All standards and laboratory reagents, with the exception of common laboratory solvents, are dated upon receipt. The preparation and use of all standards are recorded in bound laboratory notebooks that document standard traceability to U.S. EPA or NBS standards. Additional information recorded includes date of preparation, concentration, name of the preparer, lot or cylinder number, and expiration date, if applicable.

8.2 Extraction Methods

Extraction methods for liquid and solid matrices are briefly described in this section.

SW1310
Extraction Procedure Toxicity Test Method

This method is employed to determine whether a waste exhibits the characteristic of Extraction Procedure (EP) Toxicity. If a representative sample of the waste contains >0.5 percent solids, the solid phase of the sample is ground to pass a 9.5 mm sieve and extracted with deionized water that is maintained at a pH of 5.0 ±0.2, with acetic acid. Wastes that contain <0.5 percent solids are not subject to extraction, but are directly analyzed. Monolithic wastes, which can be formed into a cylinder, may be evaluated using the Structural Integrity Procedure instead of being ground to pass a 9.5 mm sieve.

Waste Extraction Test - California Administrative Code

The Waste Extraction Test (WET), described in the California Administrative Code, Title 22, Article 11, Section 66700, can be used to determine the amount of extractable substance in a waste or other material.

Method SW3020
Acid Digestion for Metals

Method 3020 prepares waste samples for total metals determination by graphite furnace atomic absorption (AA) spectroscopy. The samples are vigorously digested with nitric acid followed by dilution with nitric acid.

Method SW3010
Acid Digestion for Metals

Method 3010 prepares waste samples for total metal determination by flame AA and inductively coupled argon plasma emission spectroscopy (ICPES). The samples are vigorously digested with nitric acid followed by dilution with hydrochloric acid.

Method SW3005
Acid Digestion of Aqueous Samples

This method is an acid digestion procedure used to prepare water samples for metals analysis. The digested samples can be analyzed for total recoverable and dissolved metals determination by either flame (FLAA) or furnace (GFAA) atomic absorption spectrophotometry or ICPES. Samples may be analyzed for the following metals:

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Molybdenum
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

For analysis of total recoverable metals, the entire sample is acidified at collection time with nitric (HNO_3) acid. At the time of analysis, the sample is heated with acid and reduced to a specific volume. The sample must not be boiled because antimony is volatile and easily lost. The digestate is then filtered and diluted to the desired concentration for analysis.

For analysis of dissolved metals, the samples are filtered through a 0.5um filter immediately upon collection, and acidified with nitric (HNO_3) acid. For analysis, the sample is heated with acid and reduced in volume. The digestate is again filtered (if necessary) and diluted to volume.

Method SW3050
Acid Digestion for Solids, Sediments, and Sludges for Metals Determinations

Method SW3050 is applicable to the preparation of sediment, sludge, and soil samples for metals analysis by FLAA or GFAA or ICPES.

A 1 g (wet weight) sample is treated and digested in nitric acid and hydrogen peroxide. The digestate is then refluxed with nitric or hydrochloric acid, depending on the type of analysis to be performed. When using HCl as the final refluxing acid, do not boil because antimony is volatile and easily lost. A separate sample is dried for a total solids and/or percent moisture determination.

Some sludge samples can contain diverse matrix types, which may present specific analytical problems. Spiked samples and any relevant standard reference material should be processed to aid in determining whether Method SW3050 is applicable to a given waste.

SW3500 Series Methods
Organic Extraction and Sample Preparation

The SW3500 series methods are used to quantitatively extract nonvolatile and semivolatile organic compounds from various sample matrices. Prior to analysis, a sample of a known volume or weight is solvent extracted, then dried and concentrated in a Kuderna-Danish apparatus.

Method SW3510
Separatory Extraction

Method SW3510 is designed to quantitatively extract nonvolatile and semivolatile organic compounds from liquid samples using standard separatory funnel techniques. The sample and extracting solvent must be immiscible in order to yield recovery of target compounds. Subsequent cleanup and detection methods are described in the organic analytical method that will be used to analyze the extract.

Samples are adjusted to a specified extraction pH and extracted with the appropriate solvent for the analytical method. Methylene chloride should be employed when a solvent is not specified. Samples are extracted three times, and the combined extracts are dried with anhydrous sodium sulfate and concentrated in a Kuderna-Danish apparatus.

Method SW3520
Continuous Extraction

Method SW3520 is designed to quantitatively extract nonpurgeable organic compounds from liquid samples using a continuous extraction apparatus. The method minimizes emulsion formation, and thus improves recovery of target compounds. The sample and extracting solvent must be immiscible in order to yield recovery of target compounds. Subsequent cleanup methods and detection are described in the analytical methods.

The method is designed for extraction solvents with greater density than the sample, although continuous extraction devices are available for extraction solvents that are less dense than the sample. The analyst must demonstrate the effectiveness of any such automatic extraction device before employing it in sample extraction.

Each sample is placed into a continuous extraction apparatus adjusted to the specified extraction pH, and extracted with the appropriate solvent. Methylene chloride should be employed when a solvent is not specified. The extraction pH and solvent to be used are listed in the quantification method. Samples are extracted for 18 hours; the extract is collected, dried with anhydrous sodium sulfate, and concentrated with a Kuderna-Danish apparatus. In some cases, the sample pH is adjusted after the first extraction, and continuous extraction is carried out for an additional 18 hours to recover another class of compounds.

Method SW3530
Acid-Base Cleanup

The Method SW3530 cleanup procedure is employed to remove interferences that prevent direct chromatographic measurement, and is based on the differential solubility between the compounds of interest and the interfering species. The method allows for a choice of solvents to optimize extraction of specific species.

An aliquot of the sample is mixed in a separatory funnel with solvent and distilled water, and the pH adjusted to 12-13 with sodium hydroxide. After extraction, the aqueous phase is collected. The solvent phase is extracted twice more with distilled water and the aqueous extracts are combined. The analyte of interest will reside in either the organic or aqueous phase. If it is in the aqueous phase, that phase is then solvent extracted at pH 2 and the extract is concentrated in a Kuderna-Danish apparatus using a three-ball Snyder column. If the organic phase contains the analyte of interest, only the concentration phase is required.

Method SW3540
Soxhlet Extraction

Method SW3540 is a procedure for extracting nonvolatile and semivolatile organic compounds from solids such as soils and sludges. The Soxhlet extraction process ensures intimate contact of the sample matrix with the extraction solvent. Extraction is accomplished by mixing the solid sample with anhydrous sodium sulfate, placing it in an extraction thimble or between two plugs of glass wool, and extracting it for 16 to 24 hours with an appropriate solvent in the Soxhlet extractor. Methylene chloride should be employed when a solvent is not specified. The extract is dried and concentrated, and then treated using a clean up method, or analyzed directly by the appropriate measurement technique.

Method SW3550
Sonication Extraction

Method SW3550 is a procedure for extracting nonvolatile and semivolatile organic compounds from solids such as soils and sludges. The sonication process ensures intimate contact of the sample matrix with the extraction solvent.

A weighed sample of the solid waste is ground, mixed with the extraction media, then dispersed into the solvent using sonication. The extract is then dried with anhydrous sodium sulfate and concentrated with a Kuderna-Danish apparatus. The resulting solution may then be cleaned up or analyzed directly using the appropriate technique. Methylene chloride is typically used as the solvent, although other solvents may be used for specific analytical applications.

Method SW5030
Purge-and-Trap Method

Method SW5030 is used to determine the concentration of volatile organic compounds (VOCs) in a variety of liquid and solid waste matrices. It is based upon a purge-and-trap gas chromatographic procedure. The method is applicable to nearly all types of samples, including aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, water, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments. The success of this method depends on the level of interferences in the sample; results may vary due to the large variability and complexity of matrices of solid wastes samples.

A direct purge-and-trap can be performed for low concentration samples. If higher concentrations are expected, a portion of the solid sample is dispersed in methanol to dissolve the volatile organic constituents. A portion of the PEG, tetraglyme, or methanol solution is combined with water in a purging chamber. An inert gas is then bubbled through the solution at ambient temperature to transfer the volatile components to the vapor phase. The vapor is swept through a sorbent column where the volatile components are trapped. After purging is completed, the sorbent column is heated and backflushed with inert gas to desorb the components onto a gas chromatographic column. For SW8020 and SW8030, drying of the trap for four minutes under helium flow is required. The gas chromatographic column is heated to elute the components that are detected by the appropriate detector (SW8010, SW8020, SW8030).

8.3 Organic and Inorganic Analytical Methods for Water and Soil Samples

These subsections contain brief descriptions of the currently anticipated analytical methods that will be used for samples collected during the RI. The minimum detection limits reported are the most recent values reported by Radian Analytical Services Laboratories, determined by routine detection limit studies as previously described.

U.S. EPA Method 120.1
Conductance

Sample conductance is measured on site according to U.S. EPA Method 120.1. Standard field meters are used, and the electrode is rinsed with sample prior to measuring conductance; temperature is also reported. The meters are standardized using KCl solutions of known conductance.

U.S. EPA Method 150.1/SW9045
pH

Field and laboratory pH measurements may be taken for water samples; the pH of soil samples is measured in the laboratory. All measurements are determined electrometrically using either a glass electrode in combination with a reference potential, or a combination electrode. The meters are calibrated daily using a minimum of two buffer solutions. The calibration readings must be within 0.05 units of the known buffer pH.

U.S. EPA Method 160.1
Total Dissolved Solids

Total dissolved solids in water are determined using U.S. EPA Method 160.1. In this gravimetric method, the sample is filtered, transferred to a pre-weighed evaporating dish, and evaporated to dryness at 103-105°C. The sample is cooled, and then weighed; the drying cycle is repeated until a constant weight is obtained.

U.S. EPA Method 170.1
Temperature

On-site water temperature is measured using U.S. EPA Method 170.1. A standard mercury thermometer is rinsed twice with sample prior to recording the temperature. Thermometer calibration is checked against an NBS traceable standard thermometer.

Method SW6010
Trace Elements (Metals) by ICPES for Water and Soil, CLP Modified

Samples are analyzed for trace elements or metals, using SW6010 for water and soils, with QC acceptance criteria modifications for compliance with the U.S. EPA contract laboratory program (CLP). Analysis for most metals requires digestion of the sample by nitric acid. This digestion is performed as U.S. EPA Method 3005 for water or U.S. EPA Method 3050 for soil. Following digestion, the trace elements are simultaneously or sequentially determined using ICPES. The elements and corresponding detection limits for this method are listed in Table 8-1.

Calibration--Detailed calibration procedures for ICPES systems are described in SW846, Third Edition. A response factor is calculated daily for each metal based on three exposures of a calibration standard and calibration blank. The RF is calculated and stored in the ICPES computer. Following calibration, a mid-level calibration check sample is analyzed; agreement between the measured value and the expected value must be within 5 percent for analyses to proceed. Calibration is verified by analyzing a QC check standard (prepared independently of calibration standards)

TABLE 8-1. SW6010 (CLP MODIFIED) TRACE ELEMENTS (METALS), AND U.S. EPA GRAPHITE FURNACE METALS ANALYSIS MINIMUM DETECTION LIMITS

	Minimum Detection Limits[a]	
Analyte	SW6010 (ICPES) (mg/L)	Graphite Furnace (mg/L)
Aluminum	0.05	
Antimony	0.03	
Arsenic		0.004 (SW7060)
Barium	0.06	
Beryllium	0.001	
Boron	0.05	
Cadmium	0.004	
Calcium	0.05	
Chromium	0.007	
Cobalt	0.007	
Copper	0.006	
Iron	0.008	
Lead		0.002 (SW7421)
Magnesium	0.03	
Mercury		0.0005 (SW7470/SW7471)
Molybdenum	0.008	
Nickel	0.015	
Potassium	0.005	
Selenium		0.004 (SW7740)
Silicon	0.06	
Silver	0.007	
Sodium	0.03	
thallium	0.09	
Vanadium	0.008	
Zinc	0.003	

[a] These methods have only estimated detection limits for water. Due to the complexity of the soil matrix, detection limits in soil are expected to be 50 to 100 times higher.

every 10 samples; agreement within ±10 percent of the expected value is required for all metals analyzed by ICPES.

Graphite Furnace Atomic Absorption Metals Analyses, SW7060 for Arsenic, SW7421 for Lead, and SW7740 for Selenium

Graphite furnace AA spectrometry is used to measure concentrations of Arsenic (As), Lead (Pb), and Selenium (Se) in water and soil samples. The samples are extracted using SW3005 or SW3050 as appropriate. Discrete aliquots of sample extract are deposited in a graphite tube furnace in microliter amounts. The graphite tube is resistively heated by an electrical current. The sample solution is dried and charred to remove sample matrix components, and then atomized at temperatures sufficient to vaporize the element of interest. Matrix modification is used to eliminate interference effects, and may also enhance the vaporization efficiency and allow lower detection limits. This method usually has a linear analysis range at the ppb or sub-ppb level. Minimum detection limits for these methods are listed along with those for U.S. EPA Method 6010 (ICPES) on Table 8-1.

Calibration--The calibration procedures for the graphite furnace and cold vapor AAS systems are described in the respective method in SW846, Third Edition. A multi-point calibration curve is generated for each element using a calibration blank and three upscale standards. The correlation coefficient for the linear regression equation must exceed 0.995 to be acceptable. Calibration will be verified every 10 samples by analyzing a QC check sample and calibration blank. Agreement within ±15 percent of the expected value is required; otherwise, a new calibration curve must be generated.

Method SW7470-7471
Mercury - Manual Cold-Vapor Technique

Water and soil samples are analyzed for mercury using SW7470 and SW7471, respectively. This method is a cold-vapor flameless AA technique based on the absorption of radiation by mercury vapor. Mercury is reduced to the elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an AA spectrophotometer. Mercury concentration is measured as a function of absorbance. The detection limit for this method is included in Table 8-1.

Calibration--The calibration procedure for the cold-vapor technique is identical to that of the graphite furnace method. See the previous discussion.

U.S. EPA Method 300.0
Anions by Ion Chromatography

Water samples are analyzed for fluoride, chloride, nitrate, and sulfate anions by ion chromatography using U.S. EPA Method 300.0. Ion chromatography is a rapid method for separating and analyzing complex solutions of ionic species. The technique employs a carbonate/bicarbonate eluent and ion exchange resins to separate individual ions, and a suppressor column to remove the eluent ions. The detection and quantitation of the anions is performed conductimetrically. Detection limits for this method are listed below:

Analyte	Minimum Detection Limit (mg/L)
Chloride	.5
Fluoride	.25
Nitrate	.5
Sulfate	2.5

Calibration--Each analyte of interest is calibrated by generating a calibration curve using three concentrations of that analyte and a blank. This curve is verified each day and/or once every 20 samples. Agreement must be ±10 percent of the expected value, or a new calibration curve must be generated.

U.S. EPA Method 310.1
Alkalinity

Water samples are analyzed for alkalinity using U.S. EPA Method 310.1. An unaltered sample is titrated to an end point of pH 4.5 using a standard (0.02N) hydrochloric or sulfuric acid. This method is applicable for all concentration ranges; however, the sample aliquot should be adjusted so that the final titrated volume does not exceed 50 ml. The samples should be analyzed in the field

Calibration--The acid titrant is standardized daily against reagent sodium carbonate. A quality control check sample will be analyzed once per batch; recovery must be within ±15 percent of the expected value.

Method SW9010
Total Cyanide

Water and waste samples will be analyzed for total cyanide using SW9010. The colorimetric procedure is sensitive to about 0.02 mg/L and is used when cyanide concentrations are below 1 mg/L. The cyanide as hydrocyanic acid (HCN) is released from cyanide complexes by means of a reflux-distillation operation and absorbed in a scrubber containing sodium hydroxide solution. The cyanide ion in the absorbing solution is then determined colorimetrically using a spectrophotometer.

Total cyanide in soils is determined colorimetrically after acidification of the soil with sulfuric acid, distillation, and mixing in an NaOH scrubber as above.

Calibration--A daily calibration curve must contain a minimum of a blank and three standards, with a correlation coefficient greater than 0.995. A quality control check sample should be analyzed every 10 samples.

U.S. EPA Method 353.2 Nitrate-Nitrite

Water samples are analyzed for nitrate and nitrite using Method EPA 353.2. A filtered sample is passed through a column containing granulated copper-cadmium to reduce nitrate to nitrite. The nitrite (that originally present plus reduced nitrate) is determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye, which is measured colorimetrically. The typical minimum detection limit is 0.01 μg/L. Separate, rather than combined nitrate-nitrite, values can be obtained by running the procedure first with, and then without, the reduction step.

Analysis should be made as soon as possible. When analysis can be done within 24 hours, samples should be preserved by refrigeration at 4°C. When samples must be stored for more than 24 hours, they should be preserved with 2 ml of sulfuric acid (H_2SO_4) per liter and refrigerated.

Calibration--A calibration curve will be generated daily using a reagent blank and five or more standards. The correlation coefficient must exceed 0.995 for the calibration equation. A quality control check sample will be analyzed for every 10 samples; recovery must be within ±15 percent of the expected value.

Method SW8010
Halogenated Volatile Organics

Halogenated volatile organics in water and soil samples are analyzed using Method SW8010. This method is a purge-and-trap (SW5030) gas chromatographic method. An inert gas is bubbled through a water matrix to transfer the volatile halocarbons from the liquid to the vapor phase. The volatile compounds are removed from the inert gas by passing it through a sorbent trap, which is then backflushed onto a gas chromatographic column with an electrolytic conductivity detector to separate and quantify the compounds of interest. Soil samples are analyzed by direct purge-and-trap (for low-level samples) or by extraction of the sample with 5 mls of methanol and diluting a minimum of 1:50 in reagent water. The 28 chemical compounds routinely identified by this method are listed in Table 8-2.

This method provides for the use of a second gas chromatographic column of dissimilar phase to resolve compounds of interest from interferences that may occur. When second column analysis is performed, retention times on both columns must match or the chromatographic peaks are considered interferences.

Calibration--Calibration standards at five concentration levels are prepared in reagent water by dilution of stock standards. The average calibration factor is acceptable if the RSD for the calibration factors at each level does not exceed 20 percent, otherwise linear regression is used. Daily calibration checks are conducted, and instrument performance is considered acceptable if the daily response falls within the method-defined recovery windows.

SW8015 Modified
Total Petroleum Hydrocarbons, Luft Field Manual 7/87

Gasoline and volatile aromatics, benzene, toluene, xylenes, and ethyl benzene (BTXE), are analyzed by the direct purge-and-trap technique described in Method SW5030, followed by a modified approach to SW8020 and SW8015. Either 5 ml of water or 5 grams of soil/sludge is placed in the purge-and-trap sparge vessel. In the case of soil/sludge, 5 mls of reagent grade organic-free water is also added to the sparger. Analysis is conducted using a gas chromatograph equipped with an inlet splitter, two fused silica megabore columns, and FID and PID detectors. The BTXE components are confirmed on a second GC column of dissimilar phase and retention characteristics. Method detection limits for BTXE, gasoline, and extractable TPH are provided in Table 8-3.

TABLE 8-2. SW8010 HALOGENATED VOLATILE ORGANICS MINIMUM DETECTION LIMITS

	Minimum Detection Limits	
Analyte	Water (μg/L)	Soil[a] (μg/kg)
Chloromethane	0.50	63
Bromomethane	1.00	125
Vinyl chloride	0.20	25
Chloroethane	0.50	63
Methylene chloride	0.40	50
Trichlorofluoromethane	0.10	13
1,1-Dichloroethene	0.10	13
1,1-Dichloroethane	0.10	13
trans-1,2-Dichloroethene	0.10	13
Chloroform	0.10	13
1,2-Dichloroethane	0.10	13
1,1,1-Trichloroethane	0.20	25
Carbon tetrachloride	0.20	25
Bromodichloromethane	0.10	13
1,2-Dichloropropene	0.10	13
cis-1,3-Dichloropropene	0.40	50
Trichloroethene	0.20	25
Dibromochloromethane	0.20	25
1,1,2-Trichloroethane	0.20	25
trans-1,3-Dichloropropene	0.40	50
2-Chloroethylvinyl ether	2.00	250
Bromoform	2.00	250
1,1,2,2-Tetrachloroethane	0.20	25
Tetrachloroethene	0.10	13
Chlorobenzene	0.20	25
1,3-Dichlorobenzene	0.50	63
1,2-Dichlorobenzene	0.20	25
1,4-Dichlorobenzene	0.20	25

[a] Soil limits are based on 2.0 g methanol extraction followed by a 1:50 dilution prior to analysis by the purge-and-trap method.

TABLE 8-3. SW8015 (MODIFIED) TOTAL PETROLEUM HYDROCARBONS MINIMUM DETECTION LIMITS (LUFT FIELD MANUAL - 7/87)

	Minimum Detection Limits	
Analyte	Water (μg/L)	Soil[a] (μg/kg)
Benzene	0.5	0.5
Toluene	0.5	0.5
Total xylenes	0.5	0.5
Ethyl benzene	0.5	0.5
Gasoline	50	50
Extractable TPH	50	5,000

[a] Soil BTXE and gasoline are analyzed via direct soil sparging of 5 g sample.

Detection limits for extractable TPH are based on the extraction of 10 g of soil and are approximately 100 times that for water.

Kerosene, diesel, motor oil, and other high molecular weight extractable petroleum products are analyzed via Method SW3520 (continuous liquid/liquid extraction) for water based matrices or SW3550 (sonication extraction) for soil/sludge matrices. Hexane is used as the extracting solvent. One liter of water or 10 grams of soil/sludge are extracted and concentrated to a volume of 5 mls. Analysis is accomplished on a gas chromatograph equipped with a capillary or megabore column and a FID detector.

Calibration--Calibration of the gas chromatograph is achieved via the external standard technique using a minimum of five concentration levels. The average calibration factor is used if the RSD for the calibration factors at each level does not exceed 20 percent, otherwise linear regression is used. The working calibration factor is verified on each working day by analyzing a single-point calibration standard. If the response for the single-point calibration standard varies from the predicted response by more than ±15 percent, a new multipoint calibration factor will be generated. A QC check standard consisting of the mid-level standard is run at the beginning of every working day and after every 10 samples. The system is considered out-of-control and must be recalibrated if the response varies by more than 15 percent.

Method SW8020
Aromatic Volatile Organics

Aromatic volatile organics in water and soil samples are analyzed using Method SW8020. This method, also known as BTX since the compounds of interest include benzene, toluene, and xylene, is a purge-and-trap gas chromatographic method. An inert gas is bubbled through a water matrix to transfer the volatile aromatic hydrocarbons from the liquid to the vapor phase. The aromatics are removed from the inert gas by passing it through a sorbent trap, which is then backflushed onto a gas chromatographic column with a photoionization detector to separate and quantify the compounds of interest. Soil samples are analyzed via extraction with methanol and diluted a minimum of 1:50 in reagent water. The ten chemical compounds routinely identified are listed in Table 8-4.

This method provides for a second chromatographic column of dissimilar phase to resolve compounds of interest from interferences that may occur. When second column analysis is performed, retention times on both columns must match or the chromatographic peaks will be considered interferences.

TABLE 8-4. SW8020 AROMATIC VOLATILE ORGANICS MINIMUM DETECTION LIMITS

	Minimum Detection Limits	
Analyte	Water (µg/L)	Soil[a] (µg/kg)
Benzene	0.10	13
Toluene	0.30	38
Ethylbenzene	0.10	13
Chlorobenzene	0.10	13
m-Xylene	0.30	38
o-Xylene	0.40	50
p-Xylene	0.10	13
1,4-Dichlorobenzene	0.20	25
1,3-Dichlorobenzene	0.40	50
1,2-Dichlorobenzene	0.20	25

[a] Soil limits are based on 2.0 g methanol extraction followed by a 1:50 dilution prior to analysis by the purge-and-trap method.

Calibration--Calibration standards at five concentration levels are prepared in reagent water by dilution of stock standards. The average calibration factor is used if the RSD for the calibration factors at each level does not exceed 20 percent otherwise, linear regression is used. Daily calibration checks are conducted, and the instrument performance is considered acceptable if the daily response falls within the method defined recovery windows.

Method SW8040
Phenols

Phenols in water and soil samples are analyzed using Method SW8040. This analytical method involves acidification of the sample, followed by a methylene chloride extraction of the phenols. After separation, the methylene chloride is exchanged to 2-propanol and concentrated. The phenols are separated and quantified by gas chromatography with flame ionization detection. The 11 compounds routinely identified are listed in Table 8-5.

The method provides for a second gas chromatographic column of dissimilar phase to resolve compounds of interest from interferences that may occur. When second column analysis is performed retention times on both columns must match or the chromatographic peaks are considered interferences.

Calibration--Calibration standards will be prepared at five concentration levels through dilution of stock standards with 2-propanol. If the relative standard deviation of the calibration factors is less than 20 percent, the average calibration factor will be used; if not, linear regression is used. The working calibration factor will be verified on each working day by analyzing a single-point calibration standard. If the response for the single-point calibration standard varies from the predicted response by more than ±15 percent, a new multipoint calibration factor will be generated.

Method SW8080
Organochlorine Pesticides and PCBs

Organochlorine pesticides and polychlorinated biphenyls (PCBs) in water and soil samples are analyzed using Method SW8080. This analytical method involves extraction of the sample with methylene chloride, followed by exchange to hexane and concentration of the extract. The pesticides and PCBs are separated and quantified by gas chromatography using electron capture detection. The 28 compounds routinely

TABLE 8-5. SW8040 PHENOLS MINIMUM DETECTION LIMITS

	Minimum Detection Limits[a]	
Analyte	Water (μg/L)	Soil[b] (μg/kg)
Phenol	0.20	20
2-Chlorophenol	0.20	20
2-Nitrophenol	2.0	200
2,4-Dimethylphenol	0.30	30
2,4-Dichlorophenol	0.5	50
4-Chloro-3-methylphenol	0.4	40
2,4,6-Trichlorophenol	0.6	60
2,4-Dinitrophenol	13.0	1,300
4-Nitrophenol	2.5	250
2-Methyl-4,6-dinitrophenol	16.0	1,600
Pentachlorophenol	7.5	750

[a] Sensitivity of the method depends on the level of interferences rather than instrumental limitations. Typical waste samples may have higher MDLs and may require additional cleanup techniques.

[b] Detection limits for soil are based on the extraction of 10 g of soil and are approximately 100 times those for water.

identified by these methods are listed in Table 8-6. Both neat and diluted liquids may be analyzed by direct injection on to the chromatographic column.

Calibration--The external standard quantitation discussed in the method is used to quantitate all pesticides/PCBs. Calibration standards at five concentration levels are prepared in reagent hexane by dilution of stock standards. The average response factor is used if the RSD for the calibration factors at each level does not exceed 20 percent, otherwise linear regression is used.

Confirmation analysis by gas chromatograph/mass spectrometer (GC/MS) techniques may be conducted if the concentrations are greater than the GC/MS detection limits. Breakdown of 4,4'-DDT and endrin will also be monitored. Breakdown may not exceed 20 percent.

U.S. EPA Methods SW8240
Volatile Organics

Volatile, or purgeable, organics in water and soil samples are analyzed using Method SW8240, with QC acceptance criteria modifications for compliance with the U.S. EPA CLP. This method uses a purge-and-trap GC/MS technique. An inert gas is bubbled through the water samples, or a soil-water slurry for soil samples, to transfer the purgeable organic compounds from the liquid to vapor phase. Soil samples with higher contaminant levels are extracted using methanol before purging. The vapor is then swept through a sorbent trap where the purgeable organics are trapped. The trap is backflushed and heated to desorb the purgeable organics onto a gas chromatographic column where they are separated and then detected with a mass spectrometer. The species detected and minimum detection limits for this method are listed in Table 8-7.

Alternate methods for determination of these species are the GC methods SW8010 and SW8020, which generally yield slightly lower detection limits and have lower costs. Nonspecified compounds cannot be determined using GC. Acrolein and acrylonitrile can be determined using SW8240 if specifically requested.

Calibration--The mass spectrometer is tuned daily to give an acceptable spectrum for bromofluorobenzene (BFB). Relative ion abundance criteria for BFB are given in SW846, see Table 8-8.

TABLE 8-6. SW8080 ORGANOCHLORINE PESTICIDES AND PCBs MINIMUM DETECTION LIMITS

	Minimum Detection Limits[a]	
Analyte	Water (μg/L)	Soil[b] (μg/kg)
alpha-BHC	0.01	1
gamma-BHC (Lindane)	0.01	1
beta-BHC	0.01	1
Heptachlor	0.01	1
delta-BHC	0.01	1
Aldrin	0.01	1
Heptachlor epoxide	0.01	1
Endosulfan I	0.01	1
4,4'-DDT	0.02	2
Dieldrin	0.01	1
Endrin	0.01	1
4,4'-DDD	0.01	1
Endosulfan II	0.03	3
4,4'-DDE	0.01	1
Endrin aldehyde	0.02	2
Endosulfan sulfate	0.05	5
Methoxychlor	0.05	5
Endrin ketone	0.05	5
Chlordane	0.05	5
Toxaphene	0.50	50
PCB-1016	0.10	10
PCB-1221	0.20	20
PCB-1232	0.20	20
PCB-1242	0.10	10
PCB-1248	0.10	10
PCB-1254	0.20	20
PCB-1260	0.20	20

[a] Sensitivity of the method depends on the level of interferences rather than instrumental limitations. Typical waste samples may have higher MDLs and may require additional cleanup techniques.

[b] Detection limits for soil are based on the extraction of 10 g of soil and are approximately 100 times those for water. In some cases, lower detection limits may be achieved by extracting 30 g of sample.

TABLE 8-7. SW8240 METHOD DETECTION LIMITS (EXTENDED SW846 3RD EDITION ANALYTE LIST)[a]

Analyte	Water[b] (μg/L)
Chloromethane	5.0
Bromomethane	5.0
Vinyl chloride	5.0
Chloromethane	5.0
Methylene chloride	2.8
Acetone	7.5
Carbon disulfide	1.7
Trichlorofluoromethane	5.0
1,1-Dichloroethene	4.7
1,1-Dichloroethane	2.8
1,2-Dichloroethene (total)	1.6
Chloroform	1.6
1,2-Dichloroethane	2.8
2-Butanone	10
1,1,1-Trichloroethane	3.8
Carbon tetrachloride	2.8
Vinyl acetate	6.9
Bromodichloromethane	2.2
1,2-Dichloropropane	5.0
cis-1,3-Dichloropropene	5.0
Trichloroethene	1.9
Dibromochloromethane	3.1
1,1,2-Trichloroethane	5.0
Benzene	4.4
trans-1,3-Dichloropropene	5.0
2-Chloroethylvinylether	5.0
Bromoform	4.7
2-Hexanone	10
4-Methyl-2-pentanone	10
Tetrachloroethene	4.1
1,1,2,2-Tetrachloroethane	5.0
Toluene	5.0
Chlorobenzene	5.0
Ethylbenzene	5.0
Styrene	3.0
Total xylenes	4.6

(Continued)

TABLE 8-7. (Continued)

Analyte	Water[b] (μg/L)
Additional Analytes:	
Dichlorodifluoromethane	3.9
Iodomethane	5.7
Acrolein	75
Acrylonitrile	80
Propanenitrile	43
Allyl chloride	3.7
Acetonitrile	6.5
Dibromomethane	5.0
trans-1,2-Dichloropropene	5.0
1,2-Dibromoethane	4.8
total-1,4-Dichlorobutene	2.6
Methyl methacrylate	28
1,1,1,2-Trichloropropane	3.9
1,2,3-Trichloropropane	4.0
Ethyl methacrylate	17
1,2-Dibromo-3-chloropropane	6.9

[a] This analyte list meets Appendix IX requirements.

[b] Detection limits are for both soil and water provided 5 g of soil and 5 mL of water are used.

TABLE 8-8. BFB KEY ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
50	15 to 40% of mass 95
75	30 to 60% of mass 95
95	Base peak, 100% relative abundance
96	5 to 9% of mass 95
173	Less than 2% of mass 174
174	Greater than 50% of mass 95
175	5 to 9% of mass 174
176	Greater than 95%, but less than 101% of mass 174
177	5 to 9% of mass 176

System performance is verified initially and after every 12 hours to ensure a minimum average response factor of 0.3 (0.25 for bromoform) for the following system performance check compounds (SPCCs):

- Chloromethane;
- 1,1-Dichloroethane;
- Bromoform;
- 1,1,2,2-Tetrachloroethane; and
- Chlorobenzene.

A five-point calibration, used for generating response factors, is performed initially using 20, 50, 100, 150, and 200 µg/L standards. The relative standard deviation (RSD) must be less than 30 percent for the five response factors calculated for each of the following calibration check compounds (CCCs):

- 1,1-Dichloroethene;
- Chloroform;
- 1,2-Dichloropropane;
- Toluene;
- Ethylbenzene; and
- Vinyl chloride.

The continuing (every 12 hours) calibration check is performed, following the system performance check, using the CCCs listed above. A single concentration of each CCC is analyzed and a response factor calculated. The single-point RF for each CCC must be within 25 percent of the average five-point RF; otherwise, a new five-point calibration must be generated.

Method SW8270
Semivolatile Organics Analysis

Semivolatile organics, also known as base/neutral and acid extractables (BNA), in water and soil samples are analyzed using Method SW8270, with QC acceptance criteria modifications for compliance with the U.S. EPA CLP. These techniques quantitatively determine the concentration of a number of semivolatile organic compounds. Organic compounds are extracted from the sample with methylene chloride at pH greater than 11 to obtain base/neutral extractables. Acid extractable compounds are obtained from the sample by extraction with methylene chloride at pH 2 or less. Both base/neutral and acid extracts are then concentrated by removal of the methylene chloride through evaporation. Compounds of interest are separated and quantified using a GC/MS. The compounds that can be detected using Method SW8270 and the minimum detection limits are listed in Table 8-9.

Alternate methods for determination of these species are the GC methods, SW8010, SW8040, and SW8080. These GC techniques generally yield slightly lower detection limits and have lower costs. Many of the base/neutral extractable species have no corresponding GC method, and nonspecified compounds cannot be determined using GC.

Calibration--The mass spectrometer is tuned daily to give an acceptable spectrum for decafluorotriphenyl phosphene (DFTPP). Decafluorotriphenyl phosphene ion abundance criteria are given in SW846, see Table 8-10.

System performance is verified initially and after every 12 hours to ensure a minimum average response factor of 0.050 for the following system performance check compounds (SPCCs):

- N-nitroso-di-n-propylamine;
- Hexachlorocyclopentadiene;
- 2,4-Dichlorophenol; and
- 4-Nitrophenol.

A five-point calibration, used for generating response factors, is performed initially using 20, 50, 80, 120, and 160 μg/L standards. The variability for specific ion response factors for the SW8270 calibration check compounds must be less than 30 percent RSD over the range calibrated.
The CCCs are:

- Phenol;
- 1,4-Dichlorobenzene;
- 2-Nitrophenol;
- 2,4-Dichlorophenol;
- Hexachlorobutadiene;
- 4-Chloro-3-methylphenol;
- Acenaphthene;
- 2,4,6-Trichlorophenol;
- N-nitroso-di-n-phenylamine;

TABLE 8-9. SW8270 METHOD DETECTION LIMITS (EXTENDED SW846 3RD EDITION ANALYTE LIST)

Analyte	Water (μg/L)	Soil[a] (μg/kg)
Base/Neutral Extractables		
Acenaphthene	1.9	190
Acenaphthylene	3.5	350
Aniline	10	1,000
Anthracene	1.9	190
Benzidine	44	4,400
Benzo(a)anthracene	7.8	780
Benzo(b)fluoranthene	4.8	480
Benzo(k)fluoranthene	2.5	250
Benzo(ghi)perylene	4.1	410
Benzo(a)pyrene	2.5	250
Benzyl alcohol	10	1,000
bis(2-Chloroethoxy)methane	5.3	530
bis(2-Chloroethyl)ether	5.7	570
bis(2-Chloroisopropyl)ether	5.7	570
bis(2-Ethylhexyl)phthalate	2.5	250
4-Bromophenyl phenyl ether	1.9	190
Butyl benzyl phthalate	2.5	250
4-Chloroaniline	10	1,000
2-Chloronaphthalene	1.9	190
4-Chlorophenyl phenyl ether	4.2	420
Chrysene	2.5	250
Dibenz(a,h)anthracene	2.5	250
Dibenzofuran	10	1,000
Di-n-butylphthalate	2.5	250
1,2-Dichlorobenzene	1.9	190
1,3-Dichlorobenzene	1.9	190
1,4-Dichlorobenzene	4.4	440
3,3'-Dichlorobenzidine	17	1,700
Diethyl phthalate	1.9	190
Dimethyl phthalate	1.6	160
2,4-Dinitrotoluene	5.7	570
2,6-Dinitrotoluene	1.9	190
Di-n-octylphthalate	2.5	250
Fluoranthene	2.2	220
Fluorene	1.9	190
Hexachlorobenzene	1.9	190
Hexachlorobutadiene	0.90	90
Hexachlorocyclopentadiene	6.0	600
Hexachloroethane	1.6	160
Indeno(1,2,3-cd)pyrene	3.7	370
Isophorone	2.2	220

(Continued)

TABLE 8-9. (Continued)

Analyte	Water (µg/L)	Soil[a] (µg/kg)
Base/Neutral Extractables (Continued)		
2-Methylnaphthalene	10	1,000
Naphthalene	1.6	160
2-Nitroaniline	50	5,000
3-Nitroaniline	50	5,000
4-Nitroaniline	50	5,000
Nitrobenzene	1.9	190
n-Nitrosodimethylamine	10	1,000
n-Nitrosodiphenylamine	1.9	190
n-Nitrosodipropylamine	10	1,000
Phenanthrene	5.4	540
Pyrene	1.9	190
1,2,4-Trichlorobenzene	1.9	190
Acid Extractables		
Benzoic acid	50	5,000
4-Chloro-3-methylphenol	3.0	300
2-Chlorophenol	3.3	330
2,4-Dichlorophenol	2.7	270
2,4-Dimethylphenol	2.7	270
4,6-Dinitro-2-methylphenol	24	2,400
2,4-Dinitrophenol	42	4,200
2-Methylphenol	10	1,000
4-Methylphenol	10	1,000
2-Nitrophenol	3.6	360
4-Nitrophenol	2.4	240
Pentachlorophenol	3.6	360
Phenol	1.5	150
2,4,5-Trichlorophenol	10	1,000
2,4,6-Trichlorophenol	2.7	270
ADDITIONAL ANALYTES		
Base/Neutral Extractables		
Acetophenone	2.8	280
4-Aminobiphenyl	3.0	300
1-Chloronaphthalene	2.1	210
Dibenzo(a,j)acridine	2.2	220
p-Dimethylaminoazobenzene	3.4	340
7,12-Dimethylbenz(a)anthracene	1.4	140
9,9-Dimethylphenethylamine	7.5	750
Diphenylamine	2.0	200
Ethyl methanesulfonate	3.4	340

(Continued)

TABLE 8-9. (Continued)

Analyte	Water (μg/L)	Soil[a] (μg/kg)
ADDITIONAL ANALYTES (Continued)		
Base/Neutral Extractables (Continued)		
Methyl methanesulfonate	4.9	490
1-Naphthylamine	5.7	570
2-Naphthylamine	13	1,300
n-Nitroso-di-n-butylamine	3.1	310
n-Nitrosopiperidine	2.9	290
Pentachlorobenzene	1.5	150
Pentachloronitrobenzene	2.6	260
2-Picoline	2.4	240
Proamide	1.8	180
1,2,4,5-Tetrachlorobenzene	1.5	150
Acid Extractables		
2,6-Dichlorophenol	6.8	680
2,3,4,6-Tetrachlorophenol	6.8	680

[a] Detection limits for soil are based on the extraction of 10 g of sample and are approximately 100 times those for water. In some cases, lower detection limits may be achieved by extracting 30 g of sample. Gel permeation chromatography (GPC) cleanup of samples, if necessary, raises detection limits twofold.

TABLE 8-10. DFTPP KEY ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
51	30 to 60% of mass 198
68	Less than 2% of mass 69
70	Less than 2% of mass 69
127	40 to 60% of mass 198
197	Less than 1% of mass 198
198	Base peak, 100% relative abundance
199	5 to 9% of mass 198
275	10 to 30% of mass 198
365	Greater than 1% of mass 198
441	Present, but less than mass 443
442	Greater than 40% of mass 198
443	17 to 23% of mass 442

- Pentachlorophenol;
- Fluoranthene;
- Di-n-octylphthalate; and
- Benzo(a)pyrene.

A continuing (every 12 hours) calibration check is performed, following the system performance check, using the CCCs listed above. A single concentration of each CCC is analyzed and a response factor calculated. The single-point RF for each CCC must be within 30 percent of the average five-point RF; otherwise, a new five-point calibration must be generated.

Method SW8280
Polychlorinated Dibenzo-p-Dioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs)

Method SW8280 is used to analyze for PCDDs and PCDFs in water, soil, and waste. This is a GC/MS Method that uses matrix-specific extraction, analyte-specific cleanup, and high-resolution capillary column GC/low resolution MS techniques to separate and identify the analytes of interest. The sensitivity of the method is dependent on the level of matrix interference; selected cleanup methods may be used to reduce or eliminate interferences. Target analytes include all congener classes, tetra- through octa-dioxins and furans. Proposed detection limits for target analytes were 2 ppb in soils, 10 ppb in other solid waste, and 10 ppt (0.1 μg/L) in water. Achieved detection limits vary according to matrix and analyte. Because of the extreme toxicity of these compounds, the analyst must take appropriate precautions during preparation and analysis to prevent accidental exposure.

Calibration--Calibration is performed similarly to the procedures used for SW8240 and SW8270, with appropriate standards.

Two types of calibration procedures are required. One type, initial calibration, is required before any samples are analyzed and is required intermittently throughout sample analysis as dictated by results of routine calibration procedures. The other type, routine calibration, consists of analyzing the column performance check solution and a concentration calibration solution 500 ng/mL. The mass spectrometer is tuned daily to give an acceptable spectrum for DFTPP.

Multi-level calibration standards contain the 13 compounds listed in the method. They are prepared at 200, 500, 1,000, 2,000, and 5,000 ng/mL for the initial calibration. From injections of the five calibration standards, the relative response factors (RRFs) of analytes are calculated versus the appropriate internal standards. The relative percent standard deviations (based on triplicate analysis) of the RRFs for each calibration standard will be less than 15 percent or the calibration procedure is repeated. For routine calibration checks, the 500 ng/L standard is injected. The measured RRF for each analyte must be within ±30 percent of the initial values or calibration must be repeated.

U.S. EPA Method 900.0
Gross Alpha and Gross Beta Radioactivity

This method provides a rapid screening analysis for gross alpha and gross beta radioactivity in water. Results of the analysis may indicate that more specific analyses are required. For this analysis, an aliquot of sample is evaporated to a small volume and quantitatively transferred to a counting planchet. The sample residue is dried to constant weight, and then counted for alpha or beta radioactivity using a gas-flow proportional counting system or a scintillation detector system. High dissolved solids interfere with counting for gross alpha activity, and sample size must be adjusted accordingly. Radionuclides that are volatile under sample preparation conditions will not be counted. Samples with a solids content greater than 500 ppm should be counted using U.S. EPA Method 900.1.

Calibration--A blank planchet is spiked with a known concentration of amerecium-241 and strontium-90. The gross alpha and beta radioactivity is counted and must meet an acceptance criterion of 30 percent of the known value or a blank check, background check, or recount must be performed.

U.S. EPA Method 901.1
Gamma Emitting Radionuclides in Water

This method measures gamma photons in water samples using gamma spectroscopy. The sample is put into a standard geometry and counted using a lithium drifted germanium detector, Ge(Li). The counting efficiency for the geometry is compared to the efficiency determined for a standard (known) radionuclide activity. The sample aliquot is counted long enough to meet the required sensitivity of the measurement, specified in the SOP.

Calibration--A standard of radium-226 in a barium sulfate precipitate is counted and must meet an acceptance criterion of 30 percent of the known value or a blank check and reanalysis must be done.

8.4 Real-Time Portable Organic Vapor Analyzers

Two types of portable analyzers will be used to perform real-time non-specific analyses of hydrocarbon vapors. The instruments include a Foxboro Century Organic Vapor Analyzer (OVA), which utilizes the technique of flame ionization detection (FID), and an HNU Systems (HNU) trace gas analyzer which uses the technique of photoionization detection (PID). One or both of these instruments may be used at a specific site, depending upon the contaminant species of interest. When used together, the instruments provide complementary information because they are sensitive to different types of hydrocarbon vapors.

The portable analyzers will be used as a screening tool to help determine the optimum locations for the collection of samples. Field data recorded on the Chain-of-Custody forms will give the laboratory chemists an indication of the approximate concentration of contaminants and will aid in calculating dilution factors prior to analysis. Additionally, the real-time instruments will be used to aid in the selection of the proper level of protection and for monitoring air emissions during sampling activities.

Organic Vapor Analyzer

The Foxboro Century Organic Vapor Analyzer (OVA) uses the principle of hydrogen flame ionization for the detection and measurement of total hydrocarbon vapors. The OVA has a dynamic operating range from 1 to 10,000 ppmv or 100,000 ppmv, depending on the instrument, and provides a non-specific response to total hydrocarbons. If concentrations in excess of the range of the instrument are encountered, a dilution probe will be attached to the OVA to allow measurement of elevated vapor concentrations. The instrument is highly sensitive to compounds such as methane, benzene, and acetone, but is less sensitive to alcohols and halogenated compounds.

During operation, a sample is drawn into the probe and transmitted to the detection chamber by an internal pumping system. Inside the chamber, the sample is exposed to a hydrogen flame that ionizes the organic vapors. As the organic vapors burn, the ions produced are collected on an electrode in the chamber, and a current proportional to the hydrocarbon concentration is generated. This current is measured and displayed on the meter.

HNU

The HNU Systems trace gas analyzer (HNU) uses the principle of photoionization for the detection and measurement of non-methane hydrocarbon vapors. The HNU has a dynamic operating range from 0.5 to 2000 ppmv. The HNU is highly sensitive to aromatic compounds such as benzene and toluene; moderately sensitive to unsaturated chlorinated hydrocarbons such as trichloroethylene and dichloroethylene and unsaturated hydrocarbons; and less sensitive to aliphatic hydrocarbons with 1 to 7 carbons and ammonia.

During operation, a gas sample is drawn into the probe and past an ultraviolet (UV) light source by an internal pumping system. Contaminants in the sample are ionized, producing an instrument response if their ionization potential is equal to or less than the ionizing energy supplied by the UV lamp being used. The radiation produces a free electron for each molecule of ionized contaminant, which generates a current directly proportional to the number of ions produced. This current is measured and displayed on the meter.

The HNU can be used with one of three different probes, each with a different ionizing energy: 9.5, 10.2, or 11.7 electronic volts (eV). Normally, the HNU is used with the 10.2 eV lamp, which ionizes many of the common air contaminants. Species that have a very high ionization potential, greater than the lamp rating, will display a poor instrument response, or no response at all. Using the 11.7 eV lamp will ensure the greatest range of detectable species; however, it requires constant maintenance and frequent replacement.

The HNU is an excellent survey tool, but there are some limitations: the response to a single compound may radically change if it is mixed with other compounds, indicating considerably more or less than the true total, depending upon calibration; radio frequency interference may produce an error in response; the lamp window must be periodically cleaned to ensure ionization of the air contaminants; and the response to compounds may not be linear over the full range of the instrument.

8.5 Air Analysis

Multiple Detector Gas Chromatography of Vapors By Stainless Steel Canister - Radian Methodology

This subsection briefly describes the canister analysis procedure for air samples that was developed by Radian Corporation. The canister method has been accepted by the U.S. EPA and the California Department of Health Services (DHS), and follows the guidelines established in U.S. EPA's Compendium of Methods for the Determination of Toxic Compounds in Ambient Air (EPA-600/4-84-041, April 1984). The complete method description is presented in Appendix A.

Ambient air samples for detailed speciation of volatile organics will be collected in evacuated stainless steel canisters. Canister samples returned to Radian's Austin, Texas, chromatography laboratory will be analyzed using a dual-column, multiple detector gas chromatography technique (GC-MD). Three detectors are used: flame ionization, photoionization, and halide specific (GC/FID-PID-HSD).

When a sample is received from the field, it is first assigned a code number and logged into a master log notebook. The final pressure is then measured and logged into a separate sample analysis notebook before pressurizing the canister with ultra high purity nitrogen (UHP N_2) to 10-15 psig. The final pressure is then measured and recorded. Nitrogen is added to the canisters to provide positive pressure for removing the sample and to dilute oxygen and moisture in the sample and minimize sample component reactions.

To achieve the desired detection levels, volatile organic species are separated from the ambient air matrix and concentrated. The analytical procedure consists of the following operations:

- Collection of VOCs through a Permapure® drier onto a cryogenic trap;
- Flash thermal desorption onto a fused silica capillary GC column;
- Detection of the VOCs by flame ionization detector (FID), photoionization detector (PID), and Hall electrolytic conductivity detector (HSD); and
- Computer-assisted data reduction.

Calibration--The canister calibration is performed by a monthly generation of a calibration curve using various standards, depending upon the detector. The FID and PID detectors are calibrated using a multipoint propane/hexane concentration curve plus an ultra high purity air blank. The correlation coefficient must be greater than or equal to 0.9950. A daily response factor check and monthly retention time check ensures continuing performance.

The halide specific detector (HSD) is calibrated with a multipoint halogenated standard, with the curve having a correlation coefficient of greater than or equal to 0.9950. Daily response factor checks ensure continuing performance.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

The data reduction, validation, and reporting procedures described in this section will ensure that complete documentation is maintained, that transcription and data reduction errors are minimized, that the quality of the data is reviewed and documented, and that the reported results are properly qualified. The laboratory references in this section pertain to Radian Laboratories; however, equivalent laboratory data reduction and verification procedures are required for data produced by contracting laboratories. The contracting laboratories will be required to provide documentation to support their procedures.

9.1 Data Reduction

The reduction of raw data generated at the laboratory bench is the responsibility of the analyst producing it. The data interpretation that is required to calculate sample concentrations follows the methodology described in the specific analytical standard operating procedure (SOP). After all analyses have been completed, a preliminary report is generated for review by the laboratory supervisors who verify that the analyses were properly performed and interpreted. After the final review by the laboratory supervisor, the raw data is transferred to Sample Control and presented for review by the Quality Assurance Officer. Raw data, together with all supporting documentation, are stored permanently in confidential files by Sample Control.

The Quality Assurance Officer reviews the data for adherence to the quality control limits for the method. Additionally, the data are reviewed for the presence of outliers. An outlier is an unusually large (or small) value in a set of observations. There are many possible reasons for outliers, among which are:

- Faulty instruments or component parts;
- Inaccurate reading of a record, dialing error, etc;
- Errors in transcribing data; or
- Calculation errors.

Sometimes analysts or operators can identify outliers by noting the above types of occurrences when they record observations. In these instances, the errors are corrected, or if correction is not possible, the suspect observations may be removed from the data before calculations are performed. If no such information exists, the Dixon

Criteria are used to test suspected outliers at the 5 percent significance level if there are three or more points in the data set containing the outlier. Outliers identified by this method may be removed from the data before further processing (W.J. Dixon, "Processing Data for Outliers," Biometrics, 1953, Vol. 9, No. 1, 74-89).

9.2 Data Transfer and Verification

The Sample and Analysis Management System (SAM®) is used to store and transfer analytical data from the laboratory. Sample control staff are responsible for entering and verifying the entry of sample and result information into the system and generating hard copies of the analytical results (called SAM® data sheets). Additionally, a series of programs, called EXPORT®, produces formatted files containing the results on floppy disks.

Both the SAM® data sheets and EXPORT® data files are transferred to the project QA coordinator and/or data management staff. The laboratory provides additional documentation regarding extraction dates, Chain-of-Custody procedures, etc., that are not transmitted via the SAM® sheets or EXPORT® files. The information on the floppy disks is uploaded to the project database by using a set of programs to read, check, and append the analytical results to the database; data received via hard copy only is manually entered. The SAM® data sheets are used to manually verify the electronic transfer process, and are then permanently stored in project files.

Data Entry Using SAM® Data Sheets

The SAM® data sheet format is shown in Figure 9-1. When small batches of analyses are run, the SAM® data sheets will be provided in place of the mass data transfer floppies from SAM®/EXPORT®. Data from SAM® sheets will be entered and verified using a data entry program. Individual SAM® sheet data entry into the McClellan Air Force Base (AFB) database is accomplished by this four-step procedure:

Step 1: Run data entry program.

Step 2: Enter data from SAM® sheet as required by program.

Step 3: QA - Errors detected by data entry program must be checked for entry errors or with laboratory staff for corrective action.

Step 4: Commit new data to McClellan AFB database and/or terminate new data entry.

Manual Data Entry Procedures

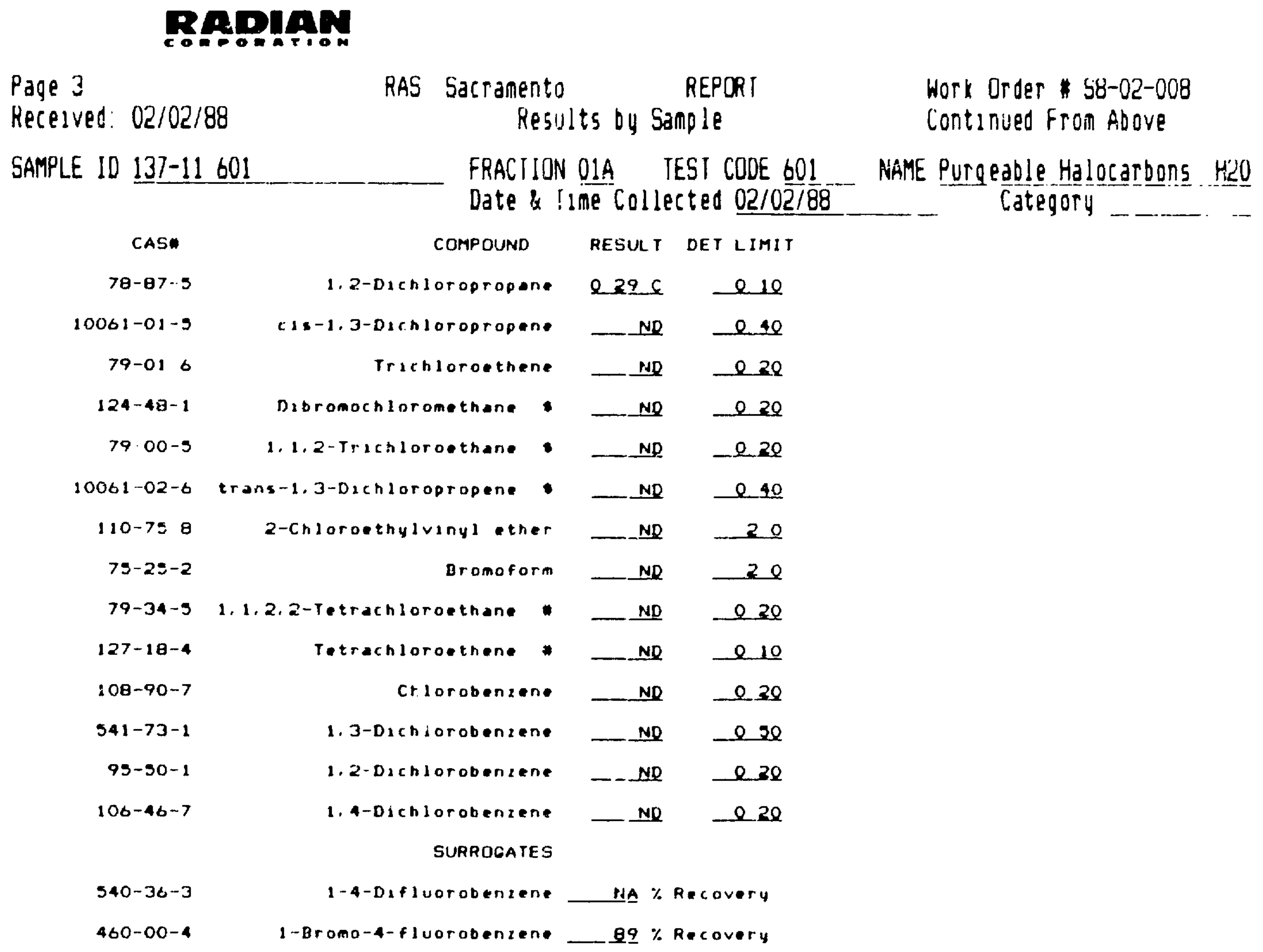
Manual entry of field data and data received from other laboratories will be required. Data entry programs for each type of data request the information for each record. A range check is conducted for numeric parameters, and the operator corrects any errors identified by the check. The records are printed, and must be verified by the person requesting the data entry before the new records are appended to the database.

9.3 Data Validation

The QA Coordinator, or a designee, will review field documentation and all measurement data for acceptable sample collection and analysis procedures, consistency with expected results or other results, adherence to prescribed QA procedures, and agreement with the acceptance criteria described in Section 4.0.

Initially, the reviewer will determine whether hold times were met, and that all required analytical QC checks were reported with the data. Then all QC sample results will be reviewed to evaluate the sampling and analytical performance. Reagent and field blank results will be evaluated to identify any systematic contamination; spike and duplicate results will be compared to the QA objectives presented in Section 4.0, and the results used to calculate precision and accuracy for the data set. This process will identify analytical methods and compounds for which the QA objectives are not satisfied, and corresponding sample data will be qualified with a "flag" indicating the problem. Samples collected on the same day, or analyzed in the same run or batch, or individual samples may be flagged, depending on the type of problem that has been identified. Re-analysis or resampling may be recommended at this time if data are determined to be unacceptable for the intended application.

The qualifier codes, or "flags," will be stored with the data in the McClellan AFB database, and will be printed with the data when reported or transferred for any purpose. The specific statistical procedures and qualifier codes used in the validation process are described in detail in Section 13.0. After data are received from the laboratory, entered, checked, and qualified, they are a permanent part of the database and cannot be deleted or altered.



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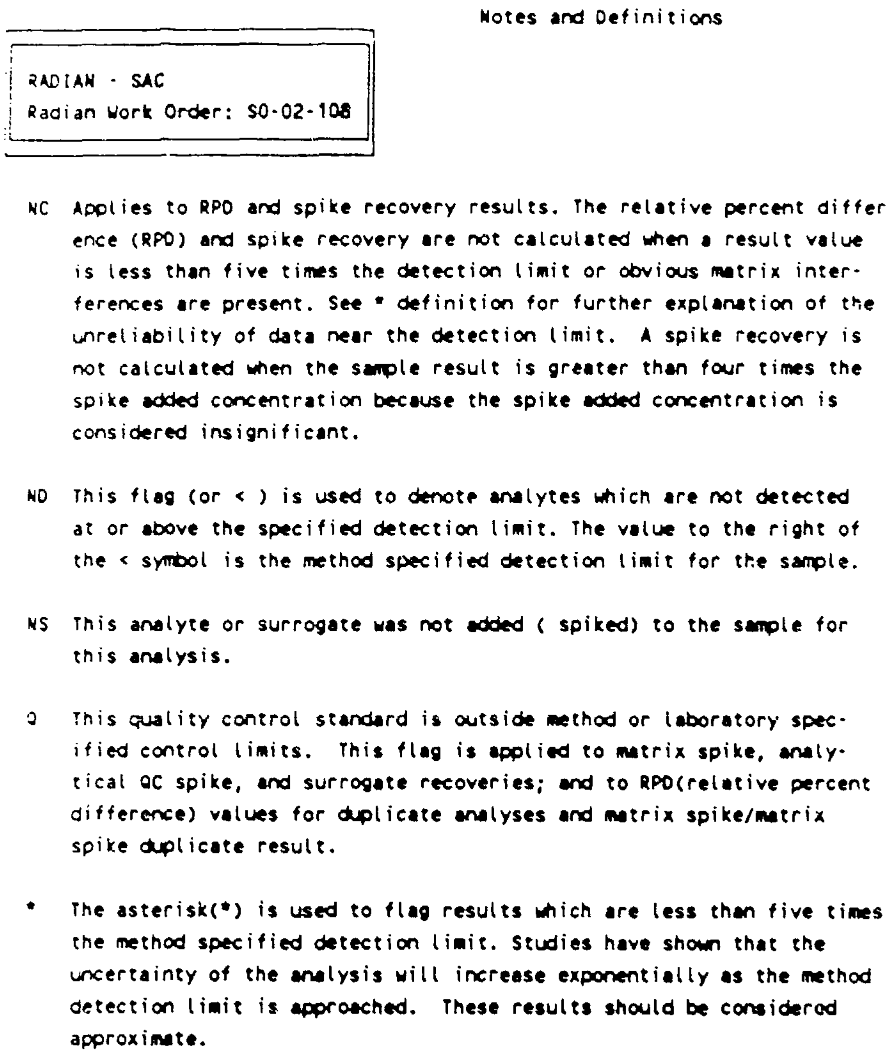
Page 3	RAS Sacramento	REPORT	Work Order # 58-02-008
Received: 02/02/88		Results by Sample	Continued From Above

SAMPLE ID 137-11 601 FRACTION 01A TEST CODE 601 NAME Purgeable Halocarbons H20
Date & Time Collected 02/02/88 Category

CAS#	COMPOUND	RESULT	DET LIMIT
78-87-5	1,2-Dichloropropane	0.29 C	0.10
10061-01-5	cis-1,3-Dichloropropene	ND	0.40
79-01-6	Trichloroethene	ND	0.20
124-48-1	Dibromochloromethane *	ND	0.20
79-00-5	1,1,2-Trichloroethane *	ND	0.20
10061-02-6	trans-1,3-Dichloropropene *	ND	0.40
110-75-8	2-Chloroethylvinyl ether	ND	2.0
75-25-2	Bromoform	ND	2.0
79-34-5	1,1,2,2-Tetrachloroethane *	ND	0.20
127-18-4	Tetrachloroethene *	ND	0.10
108-90-7	Chlorobenzene	ND	0.20
541-73-1	1,3-Dichlorobenzene	ND	0.50
95-50-1	1,2-Dichlorobenzene	ND	0.20
106-46-7	1,4-Dichlorobenzene	ND	0.20
	SURROGATES		
540-36-3	1-4-Difluorobenzene	NA % Recovery	
460-00-4	1-Bromo-4-fluorobenzene	89 % Recovery	

Figure 9-1. SAM® Data Sheet Used for Reporting Analytical Results.



Notes and Definitions

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NC Applies to RPD and spike recovery results. The relative percent difference (RPD) and spike recovery are not calculated when a result value is less than five times the detection limit or obvious matrix interferences are present. See * definition for further explanation of the unreliability of data near the detection limit. A spike recovery is not calculated when the sample result is greater than four times the spike added concentration because the spike added concentration is considered insignificant.

ND This flag (or <) is used to denote analytes which are not detected at or above the specified detection limit. The value to the right of the < symbol is the method specified detection limit for the sample.

NS This analyte or surrogate was not added (spiked) to the sample for this analysis.

Q This quality control standard is outside method or laboratory specified control limits. This flag is applied to matrix spike, analytical QC spike, and surrogate recoveries; and to RPD(relative percent difference) values for duplicate analyses and matrix spike/matrix spike duplicate result.

* The asterisk(*) is used to flag results which are less than five times the method specified detection limit. Studies have shown that the uncertainty of the analysis will increase exponentially as the method detection limit is approached. These results should be considered approximate.

Figure 9-1. SAM® Data Sheet Used for Reporting Analytical Results. (Continued)

9.4 Reporting

Data reporting for this project will consist of Quality Assurance Reports (refer to Section 15.0), investigative data reporting, QC data reporting, Installation Restoration Program (IRP) reporting, and Installation Restoration Program Information Management System (IRPIMS) support.

General reporting practices for measurement data will include:

- Heading information identifying the sample batch and the analytical method;
- Unique sample identification number or code;
- Consistent units of measure;
- Consistent number of significant figures;
- No blank or dashed places reported; all spaces will contain a designation (i.e., not analyzed, not sampled, etc.);
- Explanation of outlier values or the cause for deviation from historical data;
- Comparison with regulatory threshold values if applicable;
- Quality assurance flags; and
- Quantification of accuracy and precision for analytical data.

Investigative Data Reporting

Measurement data generated during the course of an investigation will be reported in tabular form from the computerized database. The formats of the reports will vary, depending on the objectives of the investigation. In general, data will be presented according to sampling location, analytical method, parameter, and/or matrix. All data will be reported with the qualifiers discussed above, and units will be specified.

Commonly used reporting formats will be catalogued and used repeatedly. Specialized formats will be developed as needed.

Installation Restoration Program Information Management System (IRPIMS)

The data collected during past and ongoing efforts for the McClellan AFB Remedial Investigation/Feasibility Study (RI/FS) will also be provided in a format compatible with the standard IRPIMS as requested. The IRPIMS is a data management system designed to accommodate all types of data collected for IRP RI/FS programs. Specific codes and data forms have been developed to allow consistent and efficient input of information to the system. The McClellan AFB database information will be provided to the U.S. Air Force via ASCII flat files in specified IRPIMS formats on floppy diskettes. The information transferred will include all technical data such as site information, well characteristics, hyrogeologic, geologic, and physical and chemical analysis results.

Installation Restoration (IRP) Program Report Formats

The U.S. Air Force IRP Program requires a number of specialized reports that are consistent among all IRP sites. These requirements will be incorporated into the reporting activities as appropriate. These requirements are listed below.

- Analytical parameters and detection limits achieved;
- Analytical protocols for chemical analysis of water and sediments;
- Data tables presenting field measurements (pH, conductivity, temperature) and analytical test results for water, soil, sediment, air and biological samples;
- At each individual site, list of contaminants detected above action levels or standards;
- Measurements of water-level data for wells;
- Methods of analysis for recommended sample parameters;

- Organic vapor detection levels measured in boreholes;
- Precipitation data for various months and years prior to investigation;
- Priority ranking of potential contamination sources;
- Stream flow measurements;
- Table of ARARs used for each IRP site;
- Table of sites to be included in each operable unit; and
- Tables of summary statistics for important analyses.

General Reporting Procedures

The procedures employed by Radian to ensure report quality are:

- Calculation Check--Any calculations and measurements are verified by recalculation by the person initially providing data. The calculations and measurements are then checked by another individual who signs and dates the calculation sheets. Any calculations and measurements that differ from the initial totals are resolved by both individuals. Once the calculations and measurements are included in an internal working copy of a document, the figures are rechecked during Radian peer review. If there are many such calculations within a report, a certain percentage (10 to 50 percent) are checked again during peer review.
- Numerical values presented in reports and comparisons of numbers appearing in text, tables, and appendices are addressed in the manner discussed above. Technical editors check all reports for proper format, grammatical correctness, and correspondence between text references to figures, tables, sections, or appendix labels.

QC Data Reporting

QC results will be reported by sample matrix and method in tabular form. How these QC results influence the measurement data will be delineated. For example, matrix spike interference will influence specific samples, while laboratory blank contamination will influence all samples extracted or analyzed on a specific day or during a specific analytical run. Two levels of tables may be constructed for each type of QC check. The first level table will contain all QC data, and will present one line per parameter or analysis. First level table formats will be used in presenting duplicate samples and analyses, matrix and method spikes, and trip, ambient, and reagent blank results. First level QC data tables will be generated for all investigations, and computer programs will be developed and cataloged for continuing use.

In cases where there are a large number of QC analyses of one type, a second level, or summary, table may be constructed. The summary tables will typically report mean or pooled statistics to describe the overall performance of the method. For example, the summary table of duplicate sample results might report the average RPD for all duplicates measured for the compound, and indicate the number of individual RPDs that did not meet the acceptance criteria. This type of table can serve as an indication of the overall QC results. Second level QC data tables will be generated directly from the computerized database in order to expedite statistical calculations. However, these applications will often have to be developed or modified from existing programs for individual investigations. A summary assessment of the data presented in these tables will be prepared for each phase of sampling, or specific RI/FS task, as appropriate.

Finally, specially developed table formats will be used occasionally as an aid to interpretation of the investigative data. The particular format will depend on how the QC results are expected to influence the investigative data. This type of table might be used to identify corresponding investigative results (samples analyzed on corresponding dates), which may be inaccurate. Specialty tables will be generated automatically or manually, depending on the volume of data to be processed and the complexity of the calculations.

10.0 INTERNAL QUALITY CONTROL

Internal quality control (QC) consists of collecting and/or analyzing a series of duplicate, replicate, blank, spike, and spike duplicate samples to ensure that the analytical results are within quality control limits specified for the program. Laboratory QC samples are documented at the bench, and reported with the analytical results. The QC sample results are used to quantify precision and accuracy, and identify any problems or limitations in the associated sample results. Field QC samples will be documented in field logbooks and submitted "blind" to the laboratory. These components of the sampling program will help produce data of known quality throughout the sampling and analysis component of the remedial investigation (RI).

10.1 Analytical Laboratory Quality Control Samples

Laboratory QC is necessary to control the analytical process, to assess the accuracy and precision of analytical results, and to identify assignable causes for atypical analytical results. The QC checks in the laboratory protocol are specific to the analytical method and generally include the use of one or more of the following QC samples.

Calibration Standards

Initial calibration is performed as required for each analytical method, usually using a range of calibration standards with the low standard near the detection limit for the compound. These standards are used to determine the linear dynamic range for the initial instrument calibration. Calibration is discussed in more detail in Sections 7.0 and 8.0.

Quality Control Check Samples

Quality control check samples are standard solutions containing the analytes of interest at a specified concentration, usually in the mid-calibration range. These samples are prepared independent of the calibration standard, and are used to demonstrate that the instrument is operating within acceptable accuracy and precision limits. Quality control check samples are required for gas chromatography (GC), gas chromatography/mass spectrometer (GC/MS), inductively coupled argon plasma emission spectroscopy (ICPES), and atomic absorption (AA) analyses, and their preparation and the required frequency of analysis is described in each analytical standard operation procedure (SOP). They are usually analyzed at the beginning, after every 10 samples, and at the end of each analytical run.

Reagent Blanks

A reagent blank is a sample composed of all the reagents (in the same quantities) used in preparing a real sample for analysis. It is carried through the same sample preparation (digestion, extraction) procedure as a real sample. As stated in the SW846 Method 8000 procedures, reagent blanks are used to ensure that interferences from the analytical system, reagents, and glassware are under control. The required frequency for analyzing reagent blanks is specified in the analytical SOP for each method, and generally consists of one per day for each method/instrument and/or one per extraction batch.

For gas phase analyses using the GC/MD analytical system, reagent or method blanks are performed. This type of reagent blank is a sample of ultrapure nitrogen gas that is carried through the entire analytical scheme. The N_2 blank volume is roughly equal to 1 liter and is from the same nitrogen source that is used to dilute the samples. A reagent blank analysis is performed daily or immediately after analysis of any sample exhibiting a single peak area exceeding 10^6 area counts. Reagent blanks are analyzed until the total nonmethane hydrocarbon (TNMHC) value is less than 25 ppbv-c.

Matrix Spike/Matrix Spike Duplicates

A matrix spike is a solution of target analytes at known concentrations that is spiked into a field sample before sample preparation and analysis. Two aliquots of the sample are spiked for the duplicate analysis. The results of the analysis of the duplicate spiked samples are used to measure the percent recovery of each spiked compound, and to compare the recovery between samples, which provides and estimate of the accuracy and precision of the method. The calculations for accuracy and precision are outlined in Section 13.0, and the quality assurance objectives for accuracy are listed in Tables 4-1 through 4-3. The frequency for matrix spike analysis is 5 percent of samples analyzed for each method where spikes are performed.

Surrogate Spikes

Surrogate spikes are a group of compounds other than target analytes that are not otherwise found in nature that have been selected for each organic analysis. A solution of known concentration is prepared and spiked into each sample prior to sample preparation and analysis. The recovery of the surrogate spike compounds is reported for each sample, and the results are compared to the recovery objectives established for the method. Surrogate recoveries are used to prepare control charts to monitor laboratory performance (using a minimum of 30 results) which is compared to limits in the analytical SOP.

Laboratory Duplicates (Duplicate Analyses)

Laboratory duplicates are repeated but independent determinations of the samesample, by the same analyst, at essentially the same time and under the same conditions. The sample is split in the laboratory and each fraction is carried through all stages of sample preparation and analysis. Duplicate analyses measure the precision of each analytical method. The method of calculation for precision is outlined in Section 13.0, and the quality control objectives for precision are listed in Tables 4-1 through 4-3. Laboratory duplicate analyses are performed for 10 percent of samples analyzed, or at least one per day, for analytical methods that do not require matrix spike-matrix spike duplicates.

Tables 10-1 through 10-12 summarize the specific internal QC check performed as required for the analytical method. These tables also include information relating to the initial calibration and ongoing calibration checks.

10.2 Field Quality Control Samples

Field Duplicate Samples

A field duplicate sample is a second sample collected at the same location as the original sample. Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process for water or air samples. Duplicate samples will be collected simultaneously or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis.

Precision of soil samples to be analyzed for volatile organic compounds (VOCs) will be assessed from co-located samples because the compositing process required to obtain uniform samples could result in loss of the compounds of interest. The co-located samples will otherwise be handled and analyzed in the same manner.

TABLE 10-1. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW8010

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8010	Purgeable Halocarbons	5-point calibration (for all analytes)	Initial calibration	Use curve if r ≥.990 or use single point if response factor variation ≤20%	Repeat after corrective action
	Refer to: SW846-5030[a] SW846-8000[a]	Second source QC check sample (for all analytes)	Day of 5 point	+/- 40%	1) Repeat test 2) Perform maintenance 3) Repeat calibration
		On-going QC check sample (for all analytes)	Daily prior to analysis of samples and at 10% sample frequency minimum of two per set (matrix spike may substitute for one QC check sample)	Recovery Limit Table (SW846)	1) Repeat test 2) Perform maintenance 3) Repeat calibration
		Reagent blank	1 per day	N/A	Report all results above MDL.
		Matrix spike Duplicate (1 to 5 times background level)	5%	Recovery Limit Table, SW8010. See Section 4.0	Limits are advisory only; flag data

[a] Test Methods for Evaluating Solid Waste, U.S. EPA, SW846, November 1986.

N/A = Not applicable.

TABLE 10-1. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8010 (Continued)		Surrogate standard spike	All samples	Limits determined as per SW8000 and SW8010	Limits are advisory only; flag data
		Second-column confirmation, to meet California Department of Health Services Requirements	100% for all positive results	Analysis of standards and samples performed on a second GC column of dissimilar phase and retention characteristics	N/A
		Retention time (RT) windows	One 72-hour study	RT Window = +/- 1% to 2% absolute RT packed column	1) Repeat test 2) Perform maintenance
		MDL study	Once per year	See MDL Table	N/A

[a] Test Methods for Evaluating Solid Waste, U.S. EPA, SW846, November 1986.

N/A = Not applicable.

TABLE 10-2. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW8015 MODIFIED

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
Total Petroleum Hydrocarbons	BTXE Gasoline Diesel Fuels	5-point calibration (for all analyses)	Initial calibration	Use curve or use single point if response factor variation ≤20%	Repeat after corrective action
Refer to: LUFT Field Manual (State of California 1987)		Ongoing QC check sample (for all analytes)	Daily prior to analysis of samples and at 10% sample frequency--minimum of two per set (matrix spike may be substitute for one QC check sample)	±15%	1) Repeat test 2) Perform maintenance 3) Repeat calibration
		Reagent blank	One per day	N/A	Report all results above MDL
		Matrix spike (>5 times MDL)	10%	Not specified by method	N/A
		Duplicate analysis	10%	Not specified by method	N/A
		Second column confirmation (BTXE)	100% for all positive results above method MDL	Analysis of standards and samples performed on a second GC column of dissimilar phase and retention characteristics	N/A

NA = Not applicable.

(Continued)

TABLE 10-2. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
		Retention time (RT) windows	Directly determined from 5 point	S = ±1% to 2% packed column	1) Repeat test 2) Perform maintenance
		MDL study	Once per year	See MDL Table	N/A

N/A = Not applicable.

TABLE 10-3. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW8020

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8010	Purgeable Aromatics	5-point calibration (for all analytes)	Initial calibration	Use curve if r $\geq$.990 or use single point if response factor variation $\leq$20%	Repeat after corrective action
	Refer to: SW846-5030[a] SW846-8000[a]	Second source QC check sample (for all analytes)	Day of 5 point	+/- 40%	1) Repeat test 2) Perform maintenance 3) Repeat calibration
		On-going QC check sample (for all analytes)	Daily prior to analysis of samples and at 10% sample frequency minimum of two per set (matrix spike may substitute for one QC check sample)	Recovery Limit Table (SW846)	1) Repeat test 2) Perform maintenance 3) Repeat calibration
		Reagent blank	1 per day	N/A	Report all results above MDL
		Matrix spike Duplicate (1 to 5 times background level)	10%	Recovery Limit Table, SW8010. See Section 4.0	Limits are advisory only; flag data

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[a] Test Methods for Evaluating Solid Waste, U.S. EPA, SW846, November 1986.

N/A = Not applicable.

(Continued)

TABLE 10-3. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8010 (Continued)		Surrogate standard spike	All samples	Limits determined as per SW8000 and SW8020	Limits are advisory only; flag data
		Second-column confirmation, to meet California Department of Health Services Requirements	100% for all positive results	Analysis of standards and samples performed on a second GC column of dissimilar phase and retention characteristics	N/A
		Retention time (RT) windows	One 72-hour study	RT Window = +/- 1% to 2% absolute RT packed column	1) Repeat test 2) Perform maintenance
		MDL study	Once per year	See MDL Table	N/A

[a] Test Methods for Evaluating Solid Waste, U.S. EPA, SW846, November 1986.

N/A = Not applicable.

TABLE 10-4. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW8040

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8040	Phenols	5-point calibration (for all analytes)	Initial calibration	Use curve if r ≥.990 or use single point if action response factor variation ≤20%	Repeat after corrective action
Refer to: SW846-8000[a]		On-going calibration (for all analytes)	Daily and once every 10 samples (minimum of two per set)	+/- 15%	1) Repeat test 2) Repeat calibration
		Reagent blank	1 per extraction batch	N/A	Report all confirmed results above MDL
		Matrix spike duplicate	5%	Recovery Limit Table, SW8040. See Section 4.0	Limits are advisory only; flag data
		Second column confirmation, to meet California Department of Health Services requirements	100% for all positive results	Analysis of standards and samples performed on a second GC column of dissimilar phase and retention characteristics	N/A
		Retention time (RT) windows	Initial calibration	Directly determined from 5-point	N/A
		MDL and IDL study	Once per year	See MDL Table	N/A

[a] Test Methods for Evaluating Solid Waste, U.S. EPA, SW846, November 1986.

N/A = Not applicable.

TABLE 10-5. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW8080

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8080 (CLP Modified)	Pesticides and PCBs	5-point calibration (for all analytes)	Initial calibration	Use curve if r ≥.990 or use single point if response factor variation ≤20%	Repeat after corrective action
Refer to: SW-846-8000[a] CLP exhibits D,E		On-going calibration (for all analytes[b])	Daily and once every 10 samples (minimum of two per set)	+/- 15%	1) Repeat test 2) Repeat calibration
		Breakdown check (Endrin and DDT)	Daily prior to analysis of samples and as needed during analysis	≤20%	1) Clean injection port 2) Replace front 2 inches of column packing 3) See EPA SW846-8000[a]
		Reagent blank	1 per extraction batch	N/A	Report all confirmed results above MDL
		Matrix spike duplicate	5%	+/- 50%	Limits are advisory only
		Surrogate standard spike	All samples	Dibutylchlorendate 24-154% water 20-150% soil	Limits are advisory only

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[a] Test Methods for Evaluating Solid Waste, U.S. EPA, SW846, November 1986.
[b] U.S. EPA Contract Laboratory Program, Statement of Work for Organics Analysis, October 1986.

N/A = Not applicable.

(Continued)

TABLE 10-5. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8080 (Continued)		Second column confirmation	100% for all positive	Analysis of standards and samples performed on a second GC column of dissimilar phase and retention characteristics	N/A
		Retention time (RT) windows	One 72-hour study RT DDT ≥12 min.	RT Window = +/- 1% to 2% absolute RT packed column	1) Repeat test 2) Perform maintenance
		MDL and IDL study	Once per year	N/A	N/A

[a] Test Methods for Evaluating Solid Waste, U.S. EPA, SW846, November 1986.
[b] U.S. EPA Contract Laboratory Program, Statement of Work for Organics Analysis, October 1986.

N/A = Not applicable.

TABLE 10-6. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW8240

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8240 (CLP Modified)	Purgeable Organics	Check of Mass Spectral Ion intensities using BFB	At least daily or once per 12 hours	Refer to CLP[a] Method (see E-16)	1) Retune instrument 2) Repeat BFB analysis
		Mass Scale Calibration using PFTBA	As needed	N/A	Repeat calibration
		5-Point Calibration (See CLP[a], E-22A)	Initial calibration	CCC's[b] +/- 30% RSD, SPCC's[c] ≥0.3[d] Response factor. (See CLP[a], E-27)	Repeat after corrective action
		On-going calibration verification	Once per each 12 hours (see CLP[a], E-26)	CCC's[b] +/- 25% RSD, SPCC's[c] ≥ 0.3[d] Response factor.	1) If CCC is out, run method spike 2) If SPCC is out, repeat after corrective action
		Acceptability tests (Method Spike)	As needed, according to SPCC recovery in each analysis	Refer to SW846 method	Repeat test
		Surrogate Standard Spike	All samples	Based on CLP[a] limits (E-29)	Flag results as outside data control limits

---

[a] All CLP references refer to Mod 10 of CLP.
[b] CCC's Calibration Check Compounds.
[c] SPCC's System Performance Check Compounds.
[d] SPCC for Bromoform is ≥ 0.250.

N/A = Not applicable.

(Continued)

TABLE 10-6. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8240 (Continued)		System Blank Analysis	Daily prior to sample analyses and once each 12 hours	See CLP[a] Method (E-28)	1) Clean system 2) Repeat blank analysis
		Matrix Spike Duplicate Analysis	5%	See SW846	Analyze Method Spike (QC check standard) SW8240

[a] All CLP references refer to Mod 10 of CLP.
[b] CCC's Calibration Check Compounds.
[c] SPCC's System Performance Check Compounds.
[d] SPCC for Bromoform is ≥ 0.250.

N/A = Not applicable.

TABLE 10-7. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW8270

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8270 (CLP Modified)	Semivolatile Organics	Check of Mass Spectral Ion intensities using DFTPP	At least daily or once per 12 hours	Refer to CLP[a] Method (see E-8)	1) Retune instrument 2) Repeat DFTPP analysis
		Mass Scale Calibration using PFTBA	As needed	N/A	Repeat calibration
		5-Point Calibration (See CLP[a], E-22A)	Initial calibration	CCC's[b] +/- 30% RSD, SPCC's[c] ≥0.05 Response factor (see CLP[a], E-24, and E-27)	Repeat after corrective action
		Ongoing calibration verification	Once per each 12 hours (see CLP[a], E-26)	CCC's[b] +/- 25% RSD, SPCC's ≥ 0.05 Response factor.	1) If CCC is out, flag as outside limit 2) If SPCC is out, repeat after corrective action
		Acceptability tests (Method Spike)	As needed, according to SPCC recovery	Refer to SW8270	Repeat test

[a] All CLP references refer to Mod 10 of CLP.
[b] CCC's Calibration Check Compounds.
[c] SPCC's System Performance Check Compounds.

N/A = Not applicable.

(Continued)

TABLE 10-7. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8270 (Continued)		Surrogate Standard Spike	All samples	Based on CLP limits See Table IV (CLP Method[a], E-29)	1) If recovery is <10%, re-extract and re-analyze 2) Flag results as outside data control limits
		Duplicate Analyses (Not part of CLP or 625)	See project QAPP	N/A	N/A
		System Blank Analysis	One per extraction batch	See text (CLP[a], E-28)	1) Clean system 2) Repeat blank analysis
		Matrix Spike Duplicate Analysis	5%	See SW8270	Analyze Method Spike (QC check standard) SW8270

[a] All CLP references refer to Mod 10 of CLP.
[b] CCC's Calibration Check Compounds.
[c] SPCC's System Performance Check Compounds.

N/A = Not applicable.

TABLE 10-8. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW8280

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8280	Dioxins and furans	Mass scale calibration using PFTBA	Daily prior to sample analysis	Refer to method	Repeat calibration
		Initial calibration multipoint, 5 levels in triplicate	Prior to method validation, annually, and as required by single-point check	Relative standard deviation (RSD) <30%	1 Repeat initial calibration 2) If still unacceptable, make necessary adjustment 3) Repeat initial calibration
		Single-point check	Daily	Agreement within 30% of value predicted from multipoint calibration curve	1. Repeat single-point check 2. If still unacceptable, perform new multipoint calibration
		TCDD chromatography check	Daily	25% valley between 1,2,3,4-TCDD and 2,3,7,8-TCDD	Replace column
		PCDD/PCDF retention time window check	Daily unless retention times are stable	Less than +/- 0.2 min. variation on internal standards	Return retention time standard, adjust SIM windows
		Sensitivity check	Daily	50:1 S/N from 200 ng/mL 2,3,7,8-TCDD standard	Evaluate instrument; take corrective action

(Continued)

TABLE 10-8. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW8280 (Continued)		QC sample	Once every project	Refer to method	1) Repeat test 2) Repeat calibration 3) See lab manager
		Extraction blank	5%	None	Used to assess memory effects
		Duplicate analyses	5%	Refer to method	Obtain third value
		Surrogate spike recovery	Every sample	Refer to method	1) Evaluate system 2) Flag data

TABLE 10-9. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR SW6010

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
SW6010 (CLP Modified)	Trace Metals	Control Sample	Daily	Within +/- 10% of true value	1) Prepare new calibration standard 2) Repeat calibration
		Duplicate Analysis	10%	Agreement within +/- 20%	Repeat sample analysis
		Duplicate Samples	10%	N/A	Used to determine sampling analytical variability
		Field Blanks	Minimum of 1 in 20	N/A	Used to determine sources of contamination
		Method Blank	Daily	Refer to Method	Repeat analysis
		Interference Check	Daily	Results within +/- 25% of true value	Repeat calibration
		Spiked Sample	10%	Recovery between 75% - 125%	Repeat analysis
		Limit of Detection	Quarterly	None	Used to verify current LOD
		Method Spike	Daily	Results within +/- 25% of the value	Repeat analysis

N/A = Not applicable.

TABLE 10-10. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR GRAPHITE FURNACE FOR ATOMIC ABSORPTION METHODS

Parameter	Analytical Method	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
Metals - AA As Se Hg Pb	 7060 or 206.2 7740 or 270.2 7471 or 245.1 7421 or 239.1 AA	Multipoint calibration	Daily prior to analyses	r ≥0.995	Repeat calibration
		Calibration check	10%	±15% recovery	Recalibrate
		Preparation blank	10%	≤5 x method detection limit	1) Reextract 2) Reanalyze
		Calibration blank	10%	≤5 x method detection limit	1) Rerun 2) Clean system 3) Rerun samples back to last clean blank
		Matrix spike analysis	10%; minimum one per set	±15% - water ±25% - solid	Flag data
		Matrix spike duplicate	10%; minimum one per set	RPD ≤20% - water RPD ≤30% - solid	Flag data
		Limit of detection check	Quarterly	≤MDL	Used to verify current LOD

TABLE 10-11. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR CANISTERS

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
GC-FID/PID/ HSD	Comprehensive Speciation (canister samples)	Method blank analysis	Daily prior to sample analyses, then after sample with >10^6 area counts	<0.2 ppbv for each target compound	1) Repeat blank analysis 2) Clean system and check for leaks
		Linearity check (multipoint calibration check) using target compound standards	Weekly	Correlation coefficient ≥0.995 for target compounds	1) Repeat calibration 2) Repeat linearity check
		Single point response factor (RF) check using target compounds	Daily	Response for target compounds within ±30% of current multipoint slope; ±50% for oxygenated compounds	1) Repeat RF check 2) Repeat calibration
		Retention time check using 38-component hydrocarbon standard	Monthly	Agreement with preestablished relative retention times	Adjust GC conditions and repeat RT check
		Control sample analyses (FID/PID only)	Daily, prior to sample	1) Correct identification of 10 to 12 components 2) 10 to 12 hydrocarbons measured concentrations within ±30% of certified value	1) Repeat control sample analysis 2) Repeat RF check 3) Repeat RT check 4) Repeat calibration

(Continued)

TABLE 10-11. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
		Duplicate analyses	10%; minimum of 1 per set	CV ≤50% for four major sample components	Repeat sample analyses
		Canister/flow controller system blank	All prior to sampling	Depends on type of sample to be run	1) Reclean canisters and flow controllers 2) Repeat analysis
		Duplicate samples	10%; minimum of 1 per program	N/A	Will be used to determine sampling/analytical variability
GC/MS	Comprehensive speciation (canister samples) Quantitative analysis (target list)	Method blank analysis (zero air, humidified, in a cleaned canister)	Daily, prior to sample analysis; after sample with target levels >50 ppbv	No target compound present at a level >0.2 ppbv	1) Clean system and check for leaks 2) Repeat blank analysis
		Calibration check (at 5 ppbv, using all targets)	Daily, prior to analysis	correlation coefficient >0.995; retention times ± -5 sec of established retention times	1) Repeat analysis of calibration sample 2) Analyze reprepared calibration sample 3) Recalibrate
		Control sample analysis	As supplied or requested	Recoveries of 75% to 125%	1) Repeat control sample analysis 2) Analyze reprepared control sample 3) Repeat calibration check 4) Recalibrate

(Continued)

TABLE 10-11. (Continued)

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
		New multipoint calibration	Weekly	Correlation coefficient >0.995	1) Analyze additional calibration samples 2) Reprepare and reanalyze calibration samples
		Duplicate analysis	10% or a minimum of 1 per sample set	CV ≤=50% for four major sample components	Repeat sample analysis

FID = Flame ionization detector.
PID = Photoionization detector.
GC = Gas chromatograph.
RT = Retention time.
RF = Response factor.
N/A = Not applicable.
GC/MS = Gas chromatography/mass spectrometer.
CV = Coefficient of variation.

TABLE 10-12. SUMMARY OF CALIBRATION AND INTERNAL QUALITY CONTROL PROCEDURES FOR RADIONUCLIDE ANALYSES

Analytical Method	Applicable Parameter	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
900.0	Gross alpha and beta radioactivity	1) Standard planchet with amerecium-241 and strontium-90 2) Blank planchet 3) Background planchet containing carbon-14, amerecium std. lead-210 and chlorine-36	10% 2-3 weeks	± 20% of known spike value	1) Check blank 2) Check background 3) Recount 4) Prepare new sample
900.1	Gamma emitting radionuclides	1) Standard of radium-226 in a barium sulfate precipitate 2) Blank	10%	± 20% of known spike value	1) Check blank 2) Reanalyze sample 3) Analyze duplicate sample

Soil samples to be analyzed for nonvolatile compounds will be recovered by collecting a single sample, and dividing it into equal portions for laboratory analysis.

Recovery and analysis of 10 percent or at least one duplicate sample per day for each method will be performed. The sample containers will be assigned a control number such that they cannot be identified (blind duplicate) as duplicate samples by laboratory personnel performing the analysis.

Ambient Blank

Ambient blanks are samples of purified water that are collected and processed using the same sampling and handling procedures as other samples. Ambient blanks are used to assess the potential introduction of contaminants to the samples during sample collection and analysis, and are prepared only for VOC samples. The frequency requirements for preparing ambient blanks will be specified in the scope of work for each sampling and analysis task. The ambient blank will consist of purified laboratory water that has passed through filtration, deionization, and distillation. Water to be used for the sensitive gas chromatography analysis (SW8010 and SW8020) will also be boiled for at least 20 minutes and kept under positive pressure by purging with nitrogen. This water is tested by GC analysis prior to its use in the field blanks to ensure complete purity.

Equipment Blanks

Equipment blanks consist of a sample of Type II reagent water poured into the groundwater sampling device, collected in the sample bottle, and transported to the laboratory for analysis. One set of equipment blanks will be collected for each day groundwater samples are collected using bailers.

Trip Blanks

A trip blank is a sample of purified water (prepared as for ambient blanks) that is placed in the sample bottle in an uncontaminated area in the laboratory prior to going in the field. Trip blanks are subjected to the same handling as other samples and serve to identify contamination from sample containers or transportation and storage procedures. Trip blanks consisting of evacuated stainless steel canisters will be used during gas phase sampling. One trip blank per day or one per batch of samples will be collected for methods that analyze for the presence of volatile organic compounds.

Field Blanks

A field blank is a sample of UHP air collected in the field. Field blanks are collected in stainless steel canisters in association with gas phase sampling programs. The field blanks are collected and processed using the same sampling and handling procedures as field samples, and the results are used to identify sources of contamination in sample collection and handling procedures. Field blanks are generally collected at a frequency of 10 percent of the total number of field samples.

11.0 PERFORMANCE AND SYSTEMS AUDITS

Systems audits, performance audits, and data quality audits are independent assessments of sample collection and analysis procedures. Audit results are used to evaluate the ability of the system to produce data that fulfill the objectives established for the program, satisfy the quality control criteria, and identify any areas requiring corrective action. A systems audit is a qualitative review of the overall sampling or measurement system, while a performance and data quality audit is a quantitative assessment of a measurement system.

The frequency of each type of audit will be established during planning for sampling and analysis tasks. General guidelines for conducting audits are to perform technical systems audits of field procedures for large (more than 50 samples) and/or ongoing sampling programs (i.e., the quarterly groundwater monitoring program). These audits will be conducted during initial stages of field work to identify and correct problems as quickly as possible.

Custom performance evaluation (PE) audit samples will also be submitted and analyzed for sampling and analysis programs. General guidelines for submitting PE samples are a large (more than 50 samples) and/or ongoing sampling program. The custom PE samples are prepared by Radian's Austin QA Group using certified materials. The analytes and concentrations of interest will be determined by the project director and QA officer based on historical or anticipated conditions.

The custom PE samples will be developed from NBS standard reference materials, NBS traceable materials, U.S. EPA QC materials, or neat compounds of the highest purity available. The PE sample results provide a point-in-time evaluation of data quality related to the program QA objectives. If questions about the PE samples arise, they can be analyzed independently by referee laboratories (at additional cost) to provide confirmation of the compounds and concentrations in the prepared samples. The samples are prepared in a clean matrix or media which allows evaluation of the analytical success of the method assuming no matrix interferences. The samples are submitted "double blind," so the results provide a realistic assessment of the accuracy of the field samples they were submitted with.

Data quality audits will be performed for every sampling and analysis project. The specific samples or groups of samples to be audited will be determined during planning stages for each task. The audits will be performed on data for samples collected or analyzed during a specific period of time, or analytical batches or work orders will be selected at random for each task.

Audit programs are currently in place for the quarterly groundwater sampling and analysis program and the Operable Unit B Phase I Remedial Investigation. The following audits are planned for the quarterly groundwater sampling and analysis program:

- Biannual technical systems audits of groundwater sampling procedures.
- Performance evaluation samples submitted quarterly, consisting of low and high level and blank samples for SW8010, SW8020, and SW6010 analyses. The PE samples for analysis by Method SW8010 will be submitted each quarter, with PE samples for Methods SW8020 and SW6010 submitted on alternating quarters.
- Data quality audits consisting of complete evaluation and verification of field and laboratory data for two work orders each quarter. There will be a minimum of 10 samples on each work order audited.

The following audits are planned for the Operable Unit B Phase I Remedial Investigation:

- Technical systems audits will be performed during the initial stages of field work for soil and soil gas sampling procedures.
- Two sets of PE samples will be submitted for soil and soil gas matrices; one near the beginning of the program, and one near the mid-point of the Phase I field program (expected to last two quarters).
- Two data quality audits will be performed for soil sample analyses; one during each quarter the program is active.

- Data quality audits of the field soil gas analyses will be performed with varying frequencies during the length of the program. Biweekly audits will be conducted initially, with audit frequencies decreasing to weekly and then bimonthly by the eighth week of sampling.

In addition to audits conducted for McClellan Air Force Base (AFB) tasks, the laboratory annually undergoes an internal systems and performance audit conducted by the independent Quality Assurance Group in Radian's Austin, Texas office. Audits for certification in the Contract Lab Program (CLP), various state agencies, and private clients are also conducted as requested for these programs. The Radian-Sacramento laboratory is a CLP-certified laboratory for organic analyses, and is certified by the State of California to perform hazardous waste testing for water samples. All audit results are available for review upon request.

Audit records for contracting laboratories will be reviewed by the Radian Quality Assurance Officer (QAO) to determine whether data produced by the laboratory fulfills the objectives of the program. An audit will be conducted or additional information will be requested if data quality problems are indicated by the review.

Audits are conducted by a person(s) who is familiar with the objectives, principles, and procedures being reviewed, but is not directly involved in the program. A detailed audit checklist is prepared and used for each audit, and contains items that delineate the critical aspects of the procedure under review. All observations are documented, and the checklist is submitted along with the auditor's written assessment and recommendations to the QAO, project manager, representatives of the audited sampling or analytical task and other participants as appropriate.

More detailed descriptions of the established audit procedures are provided in the following subsections.

11.1 Technical Systems Audit

A technical systems audit is an on-site, qualitative review of the sampling or analytical system. Sampling systems will be audited, preferably at the beginning of the sampling task by the Quality Assurance (QA) Coordinator or a qualified senior technical staff member. The QA Coordinator or senior staff member conducting the audit is not responsible to project management and can, therefore, act independently.

The internal laboratory systems audit results will be used to review laboratory performance. These audits are conducted by members of the Research and Engineering QA Group. Research and Engineering is a separate corporate department from the laboratory, which is part of the Chemistry Department. Because the QA group is not responsible to the Chemistry Department management or project staff, the audits can be conducted independently.

Critical items for a laboratory systems audit include:

- Calibration procedures and documentation;
- Completeness of data forms, notebooks, and other reporting requirements;
- Data review and validation procedures;
- Data storage, filing, and recordkeeping procedures;
- Sample custody procedures;
- Quality control procedures, control limits, and documentation;
- Operating conditions of facilities and equipment;
- Documentation of maintenance activities; and
- Systems and operations overview.

Critical items for a sampling systems audit include:

- Calibration procedures and documentation for field meters;
- Complete documentation of field logbooks and sampling data sheets;
- Organization and minimization of potential contamination sources while in the field;

- Proper sample collection, storage, and transportation procedures; and

- Compliance with the established chain-of-custody procedures for sample documentation and transfer to the laboratory.

The checklist for each audit will contain detailed questions regarding the critical items, requesting yes/no answers and comments. Examples of standard sampling audit checklists are shown in Figures 11-1 and 11-2. A debriefing session is held for all participants to discuss the preliminary audit results. The auditor then completes the audit evaluation and submits an audit report including observations of strengths, deficiencies, and recommendations for improvements.

11.2 Performance Audits and Data Quality Audits

Performance audits and data quality audits quantitatively assess the data produced by a measurement system. A performance audit involves submitting accepted reference standards for analysis for each analytical method and/or analytical instrument. The standards for each matrix are selected to reflect the range of concentrations expected for the sampling program. The performance audit answers questions about whether the measurement system is within control limits and whether the data produced meet the analytical quality assurance specifications. The data quality audit evaluates data quality indicators, and identifies limitations that may be encountered in data applications.

More specifically, critical items for performance evaluation audits are:

- Accuracy and precision of the measurement system;

- The quality control data as compared to the actual data collected;

- The measurement system as a function of established control limits; and

- Significant deviations of quality over time.

GENERAL WATER, SOIL, WASTE, AND WASTEWATER SAMPLING SYSTEMS AUDIT CHECKLIST

Contract: ______________________ Date: ______________________

Site: ______________________ Auditor: ______________________

Yes	No	Comments	Operation
			PRESAMPLING OPERATIONS
_____	_____	______________	1. Sample type? (specify)
_____	_____	______________	2. Qualified personnel?
_____	_____	______________	3. Adequate facilities, equipment, and supplies?
_____	_____	______________	4. Sampling locations properly specified?
_____	_____	______________	5. Copy of task instructions or QAPP? Revision #____
_____	_____	______________	6. Copy of daily sampling schedule?
			SAMPLING OPERATIONS
_____	_____	______________	1. Samples collected at proper sampling locations?
_____	_____	______________	2. Rinse probe with DI $H_2 0$ prior to placement?

Draw diagram describing equipment as used for sampling in the space below.
(Example: type of sample --> Equipment used --> Final packaging.)

(Continued)

Figure 11-1. Sampling Systems Audit for General Water, Soil, Waste, and Wastewater Sampling

GENERAL WATER, SOIL, WASTE, AND WASTEWATER SAMPLING SYSTEMS AUDIT CHECKLIST
(Continued)

Yes	No	Comments	Operation
			SAMPLING OPERATIONS (Continued)
			3. Purge appropriate volume prior to sampling (3 well volumes) For this well #____ = ____ gallons.
			4. Appropriate sampling technique used to obtain representative sample?
			5. Appropriate techniques used to ensure sample integrity and avoid contamination?
			6. At least 10% duplicate samples collected?
			7. Sufficient volume of sample collected?
			8. Suitable sample container used for storage?
			9. Sample bottles properly labeled?
			10. Sampling data sheet completed in a timely manner? (Within five minutes of activity.)
			11. OVA measurements taken and recorded prior to sampling and every 30 minutes during sampling?

(Continued)

Figure 11-1. (Continued)

GENERAL WATER, SOIL, WASTE, AND WASTEWATER SAMPLING SYSTEMS AUDIT CHECKLIST
(Continued)

Yes	No	Comments	Operation
			<u>POSTSAMPLING OPERATIONS</u>
			1. Decontamination performed according to current procedure? (Soap/water, potable water, Type I or II, reagent grade water, methanol, hexane.)
			2. Well capped immediately following removal of pump and prior to decontamination?
			3. Sampling date, time, and location properly recorded in logbook?
			4. Suitable sample shipping container label used?
			5. Chain-of-custody form filled out?
			6. Chain-of-custody seal affixed to sample container?
			7. Refrigerated sample storage?
			8. Overall recordkeeping procedure adequate?

Additional comments: ______________________________

Figure 11-1. (Continued)

VOC SAMPLING SYSTEMS AUDIT CHECKLIST

Contract: ______________________ Date: ______________

Site: ______________________ Auditor: ______________

Yes	No	Comments	Operation
			<u>PRESAMPLING OPERATIONS</u>
______	______	________________	1. Qualified Personnel?
______	______	________________	2. Spare parts and support equipment available?
______	______	________________	3. Sampling apparatus properly assembled and components correctly positioned?
______	______	________________	4. Documentation of sample canister preparation?
______	______	________________	5. Equipment calibration documentation available?
______	______	________________	6. Canister properly labeled?
______	______	________________	7. Canisters evacuated and pressure measured?
______	______	________________	8. Flow of vacuum regulators set prior to sampling (within QC specifications on control chart)?
______	______	________________	9. Sampling system properly purged?
			<u>SAMPLING OPERATIONS</u>
______	______	________________	1. Start/finish times noted and recorded?
______	______	________________	2. Coordination of sampling activities?

(Continued)

Figure 11-2. VOC Sampling Systems Audit Checklist for Canister Sampling.

VOC SAMPLING SYSTEMS AUDIT CHECKLIST
(Continued)

Yes	No	Comments	Operation
			SAMPLING OPERATIONS (Continued)
			3. Duplicate samples collected?
			4. Blank samples collected?
			5. Appropriate sampling information recorded in field sample logbook or on field data sheet?
			6. Data acquisition system activating samples?
			POSTSAMPLING OPERATIONS
			1. Postsampling canister pressure determined?
			2. Canister pressure QC chart completed?
			3. Samples properly packaged for shipment?
			4. Chain-of-custody documentation completed?
			5. Master sample logbook?
			6. Bill of lading filed? Laboratory informed of incoming samples and time requirements for next samples?

Additional comments: ______________________________

Figure 11-2. (Continued)

These items can identify when a system is outside of acceptable control limits; however, the appropriate corrective action may not always be evident. Appropriate corrective action must be identified in conjunction with the results from the systems or data quality audit.

Specific items for data quality audits include:

- Adequacy of data recording and transfer;
- Precision and bias of resultant data;
- Adequacy of data calculation, generation, and processing;
- Documentation of procedures; and
- Identification of data quality indicators to inform users of limitations and applicability.

Audits of data quality answer questions of whether the data collection efforts need modifications, and whether the use and documentation of quality control procedures are adequate.

The results of all audits performed for the McClellan AFB Remedial Investigation/Feasibility Study (RI/FS) will be summarized by the auditor, and reviewed by the QAO. Copies of the audit results and summary will be transmitted to the project manager, Quality Control (QC) Coordinator, and United States Air Force Occupational and Environmental Health Laboratory (USAFOEHL). This will also include discussion of recommended corrective actions or procedural changes, as indicated by the audit results. The audit results and discussion will be incorporated into the QA report for the task or sampling effort (see Section 15.0) and the original audit report will be retained in the project file.

12.0 PREVENTIVE MAINTENANCE

The primary objective of a preventive maintenance program is to help ensure the timely and effective completion of a measurement effort. Radian's preventative maintenance program is designed to minimize the down time of crucial sampling and/or analytical equipment due to expected or unexpected component failure. In implementing this program, efforts are focused in three primary areas:

- Establishment of maintenance responsibilities;
- Establishment of maintenance schedules for major and/or critical instrumentation and apparatus; and
- Establishment of an adequate inventory of critical spare parts and equipment.

Each of these is discussed in the following subsections.

12.1 Maintenance Responsibilities

Equipment and apparatus used in Radian's environmental measurement programs fall into two general categories:

- Equipment that is permanently assigned to a specific laboratory (e.g., gas chromatography (GC) laboratory, gas chromatography/mass spectrometry (GC/MS) laboratory, etc.); and
- Field sampling equipment that is available for use on an as-needed basis (e.g., field meters, pumps, vehicles, etc.).

Maintenance responsibilities for laboratory instruments are assigned to the respective laboratory managers. The laboratory managers then establish maintenance procedures and schedules for each major equipment item. Responsibility for specific items may be delegated to laboratory personnel, although the laboratory managers retain responsibility for ensuring adherence to prescribed protocol. Radian laboratories and other contracting laboratories are bound by contractual agreements to maintain the ability to produce data that meets the project objectives and to follow method specifications. This ensures that adequate spare parts, maintenance, schedules, and emergency repair services are available.

Maintenance responsibilities for field equipment are assigned to the project director and task leaders for specific sampling tasks. However, the field team using the equipment is responsible for checking the status of the equipment prior to use and reporting any problems encountered. The field team is also responsible for ensuring that critical spare parts are included as part of the field equipment. Critical spare parts are included on the field equipment checklist used for sampling preparation.

12.2 Maintenance Schedules

The effectiveness of any maintenance program depends to a large extent on adherence to specific maintenance schedules for each major equipment item. A specific schedule is established for all routine maintenance activities. Other maintenance activities are also identified as requiring attention on an as-needed basis. Manufacturers' recommendations provide the primary basis for the established maintenance schedules, and manufacturers' service contracts provide primary maintenance for many major instruments (e.g., GC/MS instruments, atomic absorption spectrometers, analytical balances, etc.). Maintenance activities are documented in a maintenance log that indicates the required frequency for each procedure and provides for dated entries.

12.3 Spare Parts

Along with a schedule for maintenance activities, an adequate inventory of spare parts is required to minimize equipment downtime. This inventory should emphasize those parts (and supplies) that:

- Are subject to frequent failure;
- Have limited useful lifetimes; or
- Cannot be obtained in a timely manner should failure occur.

Field sampling task leaders and the respective laboratory managers are responsible for maintaining an adequate inventory of necessary spare parts. In addition to spare parts and supplies inventories, Radian's nonassigned equipment represents an in-house source of backup equipment and instrumentation.

Table 12-1 lists the maintenance tasks, schedule, spare parts, and standard operating procedures for field equipment.

TABLE 12-1. PREVENTIVE MAINTENANCE SCHEDULE AND CRITICAL SPARE PARTS FOR McCLELLAN AFB RI/FS FIELD EQUIPMENT

Equipment	Maintenance Task	Frequency	Critical Spare Parts	SOP
Well Wizard Engine	Check oil level	Weekly	Oil	Refill if necessary
	Quarterly tuneups (includes cleaning, oil change, air filter replacement	Quarterly - after each sampling round	Spark plugs Air filters Backup available on site	Tuneup is done by local repair shop Backup engines
Well Wizard Compressor	Replace air filter and drive belt	As needed	Air filter belt	Send to manufacturer for other repairs
Well Wizard Control Box	Release moisture vent	Hourly	Backup available over night	Send to manufacturer for repairs
pH Meters	Keep electronic parts dry	Daily	Backup available on site	Send to manufacturer for repairs
	Keep pH sensor wet	Continuously		
Conductivity Meter	Keep electronic parts dry	Daily	Backup available on site	Send to manufacturer for repairs
Well Wizard Bladder Pump	Repair broken bladder	As needed	Backup available on site	Replace and send to manufacturer for repairs
Water-Level Meters	Replace battery	As needed	Backup available on site	Replace and send to manufacturer for repairs
Water Wagon Pump	Tune-up	Yearly		Send to manufacturer for repair
	Check oil level	Weekly	Oil	
OVA	Primary filter cleaned and air sampling systems checked for leaks	Daily	"O" rings	Send to manufacturer for repair, backup meters available
	Multipoint calibration	Weekly		
	Hydrogen gas cylinder purged	Bi-monthly		

(Continued)

TABLE 12-1. (Continued)

Equipment	Maintenance Task	Frequency	Critical Spare Parts	SOP
HNU	Glass plate and grill in probe cleaned	Daily	Photoionization lamp batteries	Send to manufacturer for repair, backup meters available
	Multipoint calibration	Weekly		
Sampling Vehicles	Tune-up	Yearly or as needed	Oil, spare tire	Small took kit in vehicle
	Check oil level	Monthly		

13.0 DATA ASSESSMENT PROCEDURES

The assessment of measurement data is required to ensure that the quality assurance (QA) objectives for the program are met, and that quantitative measures of data quality are provided. The data assessment calculation and applications used for the McClellan Air Force Base (AFB) Remedial Investigation/Feasibility Study (RI/FS) are based on the United States Environmental Protection Agency (U.S. EPA) Guidelines for Assessing and Reporting Data Quality for Environmental Measurements, January 1983.

A distinction must be made between routine quality control and data assessment that is conducted as a part of laboratory operations, and the project-related data assessment process conducted after the data have been reported. It must be assumed that the planning and monitoring that have gone into the sampling and analysis process have served to control the process as much as possible to produce data of sufficient quality for project needs. After the data have been reported, it is necessary to identify any part of the process that could not be controlled, and to what extent that may affect the quality of the reported data.

The routine quality control procedures conducted in the laboratory are established in the analytical standard operating procedures (SOPs). The laboratory is responsible for following those procedures and operating the analytical systems within statistical control limits. These procedures include proper instrument maintenance, calibration and calibration checks, and internal quality control sample analyses at the required frequencies (i.e., reagent blanks, surrogate spikes, matrix spike/matrix spike duplicate (MS/MSD), laboratory duplicates). One of the additional ongoing data assessment processes is maintaining control charts for representative quality control (QC) sample analyses to monitor system performance. This provides verification that the system is in statistical control, and indicates when performance problems occur, so the problems can be corrected as soon as possible. When reporting the sample data, the laboratory is required to provide the results of associated QC sample analyses.

Problems occur in spite of all precautions taken in planning and execution of the sampling and analysis task. In these cases, the data assessment conducted by the project QA staff after the data have been reported must identify the problem, determine which data are affected, and state how these data may be limited for use in the intended applications.

The discussion of data assessment presented in this section pertains to the project-related assessment of data that have been reported after laboratory analyses have been completed.

Data assessment procedures established for the McClellan AFB RI/FS include:

- Evaluation of blank results to identify systematic contamination;
- Statistical calculations for accuracy and precision using the appropriate quality control sample results;
- Estimates of completeness, in terms of the percent of valid data; and
- Assigning data qualifier flags to the data as necessary to reflect limitations identified by the process.

Qualified data will be discussed in the task reports, and data flags will be transmitted to uses via data tables from the database and in analytical data reports.

Some basic statistical calculations used in the data assessment process are presented in Table 13-1, and a discussion of specific applications to environmental sample results is presented.

13.1 Blank Data Assessment

Reagent blank results indicate whether any of the contaminants reported in sample results may be attributed to laboratory sources (reagents, glassware, instrumentation) and were not likely present in the sampled medium. The most common laboratory contaminants are methylene chloride, phthalates, acetone, and toluene; these are recognized as being ubiquitous in the laboratory environment and controlling them to within acceptable low levels is part of standard laboratory procedure.

If contamination from these compounds is reported in reagent blanks, the samples associated with the blank, either the same analytical or extraction batch, may be qualified to indicate that some or all of these compounds may be from laboratory

TABLE 13-1. STATISTICAL CALCULATIONS

Statistic	Symbol	Formula	Definition	Uses
Mean	$\overline{X}$	$\left(\sum_{i=1}^{n} X_i\right) \Big/ n$	Measure of central tendency	
Standard Deviation	S	$\left[\sum_{i=1}^{n} \left(X_i - \overline{X}\right)^2 / n-1\right]^{1/2}$	Measure of relative scatter of the data	
Relative Standard Deviation	RSD	$\left(S / \overline{X}\right) \times 100$	Relative standard deviation, adjusts for magnitude of observations	Used to assess precision for replicate results
Pooled RSD	RSD_p	$\left[\sum_{i=1}^{n} (RSD_i)^2 \, df_i \Big/ \sum_{i=1}^{n} df_i\right]^{1/2}$	Measure of overall variability of a series	Used to assess overall performance for compounds with multiple measurements
Relative Percent Difference	RPD	$\left[(X_1 - X_2) \Big/ \left((X_1 + X_2) \big/ 2\right)\right] \times 100$	Measure of variability that adjusts for the magnitude of observations	Used when there are only two observations; directly related to RSD

(Continued)

TABLE 13-1. (Continued)

Statistic	Symbol	Formula	Definition	Uses
Relative Percent Difference	RPD	$RSD\,(2)^{1/2}$	SAME AS ABOVE	SAME AS ABOVE
Average Relative Percent Difference	$\overline{RPD}$	$\frac{RPD}{n}$	Average relative percent difference--parallel to pooled RSD for duplicate measurements	Used to assess overall performance for compounds with multiple measurements
Confidence Interval	CI	$X \pm t_{(\alpha,n-1)}S \Big/ n^{1/2}$	Interval about X that contains the true value, with probability α	Assign intervals or error bars to measurement data
Percent Recovery	R	$(X_{meas} \Big/ X_{true})\ \text{x}\ 100$	Recovery of spiked compound in pure matrix	Recovery of QCCS, method spikes
Percent Recovery	R	$\left\lvert \text{value of spiked sample} - \text{value of unspiked sample} \right\rvert \Big/ \text{Value of added spike}\ \text{x}\ 100$	Recovery of spiked compound in sample matrix	MS and MS/MSD recovery

X = Observation (concentration)
n = Number of observations
df = Degrees of freedom, usually (n-1)
t = Statistic from Students' "t" distribution

sources. If the concentrations reported in the samples are similar to the blank concentrations, it is likely that all of the contamination was introduced, and this assessment is made in the QA report for the sampling task.

In some cases, where there is a large sampling task and reagent blank results indicate a more significant contamination problem, a more systematic approach may be applied. This approach is only used when a series of reagent blanks analyzed over a period of time are reported. The assessment criterion is calculated from reagent blank results as the mean concentration plus three standard deviations for each contaminant reported. The sample data are assessed using this criterion. Sample concentrations below the criterion are considered to be most likely from laboratory sources, and at least some of the sample concentrations higher than that are considered to be from the sampled medium (aquifer, soil, etc.). This semi-quantitative approach is used only as a tool to screen the sample results and provide a common basis for further assessment; none of the results are censored or changed in any way in the database or for reporting. The assessment is discussed in the QA report for the sampling task. Samples with blank contamination problems will be assigned a data qualifier flag of "B."

Results for other types of blanks such as equipment, ambient, or trip blanks are assessed individually. The probable source of contamination is identified and the associated sample results are qualified as necessary. For example, if equipment blank results show contamination, and the sample collected from the bailer shows the same compound, the sample results will be qualified to indicate the probable level of introduced contamination.

13.2 Accuracy

As previously defined, accuracy is associated with correctness, and is a comparison between a measured value and a known, or 'true' value. Accuracy is calculated from method spike (spikes of the pure matrix) or matrix spike results.

Spike results are reported by the laboratory as percent recovery and are compared to the accuracy objectives stated in Section 4.0. Results that do not satisfy the objectives are assigned a data qualifier flag (A) to indicate uncertainty associated with inaccuracy.

Method spikes are spikes of a reference material into a water matrix, and if recovery is outside the established limits, samples from the same extraction batch may be qualified. Matrix spike results are generally more sample-specific. If matrix spike recovery is outside the established limits, results for samples collected from similar conditions and/or handled in the same batch will be examined. If any results appear atypical and could be related, those results may also be qualified. The flagged data will be discussed in the QA report for the sampling task, and specific limitations such as poor or enhanced recovery for specific compounds will be stated.

Surrogate spike results are also reported and used to assess recovery of target analytes on a sample by sample basis and provide a measure of system performance. Surrogate spike recoveries are compared to recovery limits. Any results outside the limits are flagged with a "Q" on laboratory reports and in the database. Any corrective action taken in the laboratory is documented in laboratory performance records and/or discussed in the comment section of the data report.

Confidence intervals can be calculated for an analytical method if performance evaluation samples are submitted. These samples are prepared from reference standards, and are analyzed three or more times. The results are used to define confidence intervals (see Table 13-1) for the recovery of each compound analyzed.

13.3 Precision

Precision is a measure of variability between duplicate or replicate analyses, and is calculated for field and laboratory replicates. By definition, field precision incorporates laboratory precision. Precision is calculated as the relative percent difference (RPD) between duplicate analyses or matrix spike/matrix spike duplicates as appropriate. The calculated RPDs are compared to the objectives stated in Section 4.0. Results that do not satisfy the objectives are assigned a data qualifier flag indicating uncertainty associated with imprecision (P).

An average RPD may be calculated and reported as a measure of overall analytical precision for compounds with multiple measurements. The specific samples collected or analyzed in duplicate are flagged if they do not satisfy the QA objectives. In addition, associated samples may be flagged to indicate variability due to poor precision. For poor field duplicate precision, samples collected by the same sampling team, from the same equipment, or on the same day may be affected; close evaluation of those results should indicate the most likely source of variability, and the corresponding samples will be qualified as warranted. For poor laboratory precision, samples processed and analyzed in the same batch will be more closely evaluated, and any anomalous results will be qualified.

Table 13-2 lists the data qualifier flags discussed in this section, and flags used to designate quality control data. The QA coordinator is responsible for ensuring that these codes are assigned to the data as required by the established QC criteria, and that they are reported and understood by project staff using the data for specific applications. The QA coordinator is also responsible for initiating corrective actions for analytical problems identified during the QC data assessment process. These corrective actions range from verifying that the method was in statistical control during the analytical runs, to re-analysis of the sample, or resampling.

13.4 Completeness

Completeness is after the QC data have been evaluated, and the results applied to the measurement data. In addition to results identified as being outside of the QC limits established for the method, the occurrence of matrix effects, broken or spilled samples, or samples that could not be analyzed for any other reason are included in the assessment of completeness. The percentage of valid results is reported as completeness.

TABLE 13-2. DATA QUALIFIER CODES

Type of Data	Sample Code	Description
Sample Data	ND	Not quantitative - below detection limit.
	NA	Not analyzed.
	NS	Not sampled.
	P	Precision - precision of laboratory duplicates fell outside of RPD limits for the method.
	A	Accuracy - matrix spike or method spike results indicated recovery outside of the established limits for the method.
	B	Blank contamination indicated.
	Q	Surrogate spike outside recovery limits.
	b	Hold time limits exceeded for extraction and/or analysis.
Quality Control Data	FB	Field blank (equipment blank).
	TB	Trip blank.
	AB	Ambient blank.
	RB	Reagent blank.
	FD	Field duplicate.
	LD	Laboratory duplicate.
	MS	Matrix spike.
	MSD	Matrix spike duplicate.

14.0 CORRECTIVE ACTION

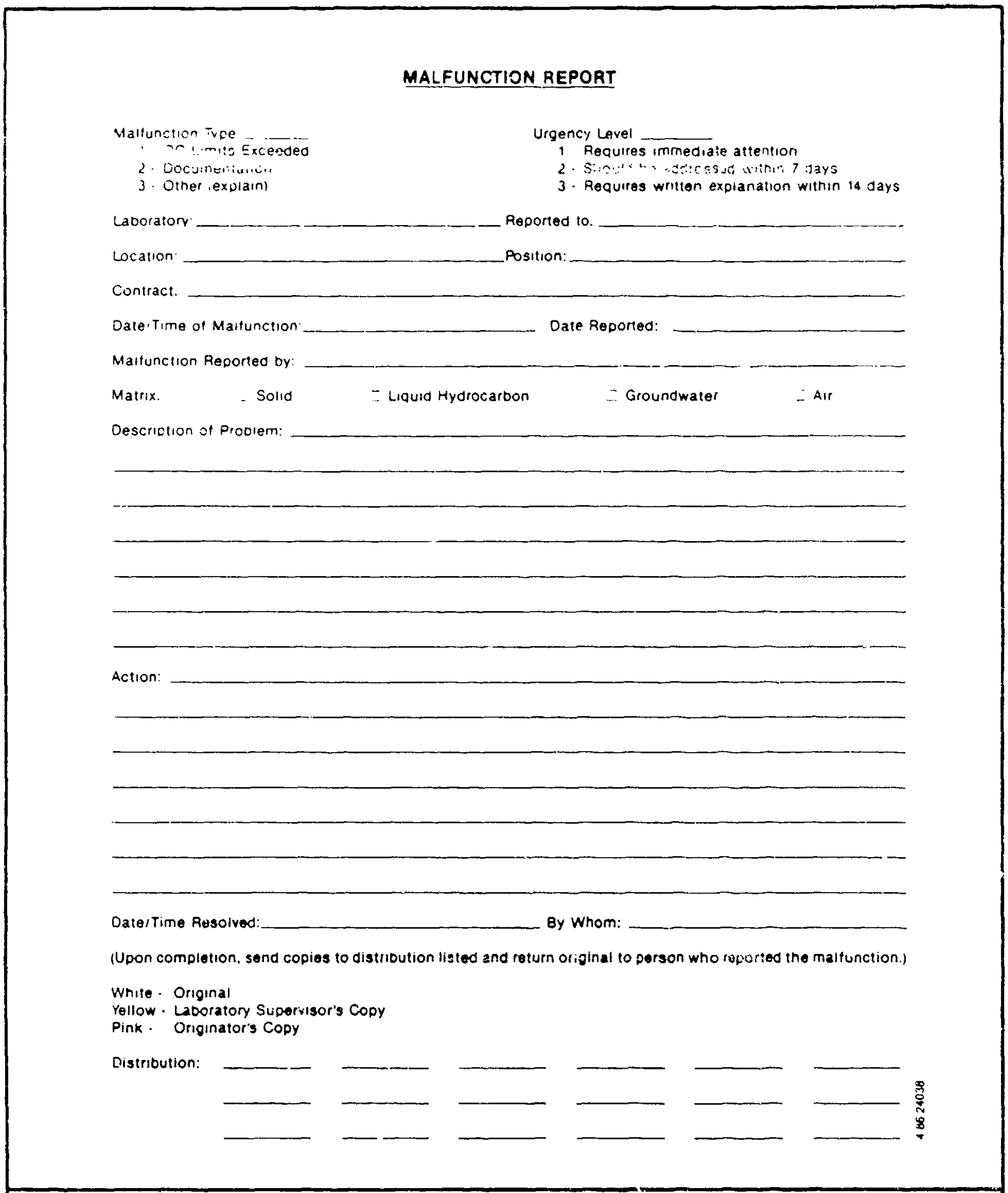
During the course of the McClellan Air Force Base (AFB) Remedial Investigation/Feasibility Study (RI/FS) Program, it is the responsibility of the Project Manager, Task Leaders, Quality Assurance (QA) Coordinator, and sampling team members to see that all measurement procedures are followed as specified and that measurement data meet the prescribed acceptance criteria. In the event a problem arises, it is imperative that prompt action be taken to correct the problem.

14.1 Malfunction Report Form (MFR)

Problems that require corrective action will be documented by the use of Malfunction Report Forms as presented in Figure 14-1. The on-site QA Coordinator, task leaders, or other project members will initiate the corrective action request in the event that quality control (QC) results exceed acceptability limits, or upon identification of some other problem or potential problem. Corrective action is also initiated by the QA Coordinator based upon QC data or audit results. Corrective actions range from use of data qualifier flags, to re-analysis of the sample or samples affected, to resampling and re-analysis, depending upon the severity of the problem.

14.2 Recommendation for Corrective Action (RCA)

In addition to the malfunction reporting system for addressing problems identified through the internal quality control system, a system for issuing formal Recommendations for Corrective Action (RCAs) exists for addressing problems identified through independent quality assurance review. Recommendations for corrective actions are issued only by a member of the Quality Assurance (QA) Group, or a designee in a specific QA role. Each RCA addresses a specific problem or deficiency, usually identified during QA audits of laboratory or project operation. An example RCA form is presented as Figure 14-2. Each of these formal written recommendations requires a written response from the responsible party (i.e., to whom the RCA was issued). A summary of the "unresolved" RCAs is prepared by the QA group on a monthly basis and issued to Radian management. These reports list all RCAs that have been issued, the manager responsible for the work area, and the current status of each RCA. Each RCA requires the response and verification by the QA group that the corrective action has been implemented before the status is changed on the monthly report. In the event that there is no response to an RCA within 30 days, or the proposed corrective action is disputed, the recommendation and/or conflict is pursued to successively higher



MALFUNCTION REPORT

Malfunction Type ______
1 - QC Limits Exceeded
2 - Documentation
3 - Other (explain)

Urgency Level ______
1 - Requires immediate attention
2 - Should be addressed within 7 days
3 - Requires written explanation within 14 days

Laboratory: ______________________ Reported to: ______________________

Location: ______________________ Position: ______________________

Contract: ______________________

Date/Time of Malfunction: ______________ Date Reported: ______________

Malfunction Reported by: ______________________

Matrix: ☐ Solid ☐ Liquid Hydrocarbon ☐ Groundwater ☐ Air

Description of Problem: ______________________

Action: ______________________

Date/Time Resolved: ______________ By Whom: ______________

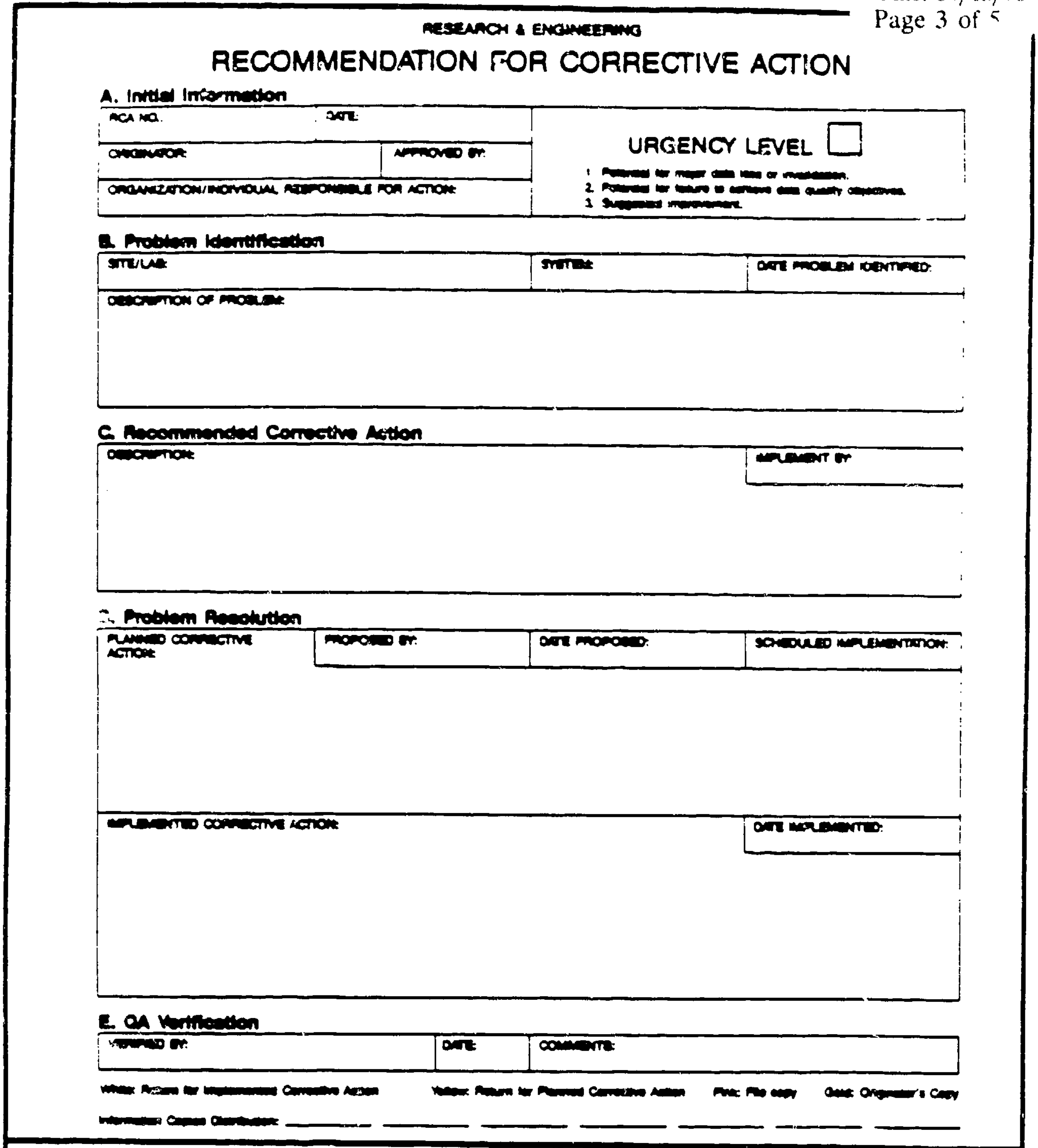
(Upon completion, send copies to distribution listed and return original to person who reported the malfunction.)

White - Original
Yellow - Laboratory Supervisor's Copy
Pink - Originator's Copy

Distribution: ______ ______ ______ ______ ______ ______

4 86 24038

Figure 14-1. Radian Malfunction Report Form.



RESEARCH & ENGINEERING

RECOMMENDATION FOR CORRECTIVE ACTION

A. Initial Information

RCA NO.:	DATE:	URGENCY LEVEL ☐
ORIGINATOR:	APPROVED BY:	1. Potential for major data loss or invalidation. 2. Potential for failure to achieve data quality objectives. 3. Suggested improvement.
ORGANIZATION/INDIVIDUAL RESPONSIBLE FOR ACTION:		

B. Problem Identification

SITE/LAB:	SYSTEM:	DATE PROBLEM IDENTIFIED:
DESCRIPTION OF PROBLEM:		

C. Recommended Corrective Action

DESCRIPTION:	IMPLEMENT BY:

D. Problem Resolution

PLANNED CORRECTIVE ACTION:	PROPOSED BY:	DATE PROPOSED:	SCHEDULED IMPLEMENTATION:
IMPLEMENTED CORRECTIVE ACTION:			DATE IMPLEMENTED:

E. QA Verification

VERIFIED BY:	DATE:	COMMENTS:

White: Return for Implemented Corrective Action Yellow: Return for Planned Corrective Action Pink: File copy Gold: Originator's Copy

Information Copies Distribution: ________ ________ ________ ________ ________ ________ ________

Figure 14-2. Radian Recommendation for Corrective Action Form.

management levels until the issue is resolved. The corrective action scheme is shown in the form of a flow chart in Figure 14-3.

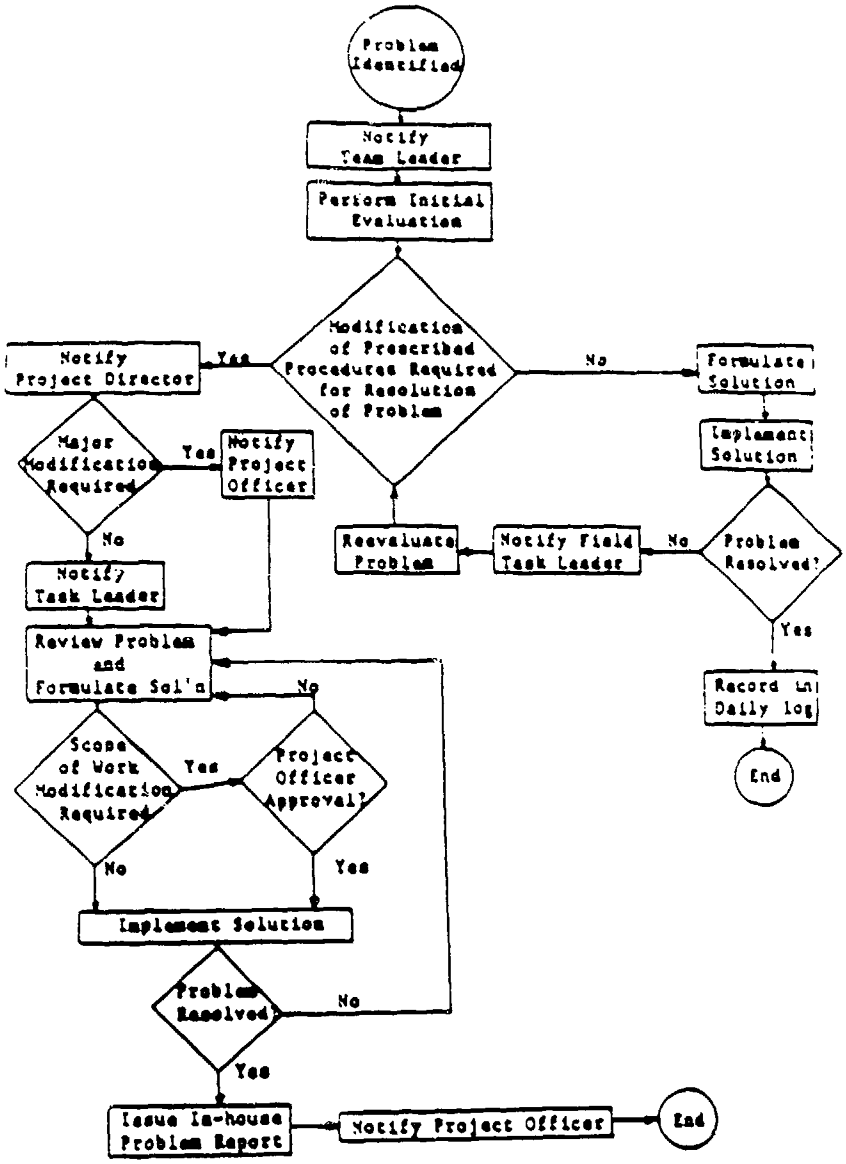


Figure 14-3. Radian Corrective Action Flow Chart.

15.0 QUALITY ASSURANCE REPORTS

The Quality Assurance (QA) Coordinator will issue quality assurance reports to the project management, task leaders, and laboratory supervisors describing the results of quality control (QC) measurements, performance audits, and systems audits performed for each sampling and analysis task. Quality assurance reports for tasks that involve collecting samples over a long-term period (one quarter or longer) will be prepared on a monthly or quarterly basis as appropriate. Audit results will be summarized in the reports; detailed audit results and checklists will be submitted according to the procedures described in Section 11.0. The information presented in the quality assurance reports will be incorporated as an appendix into the reports prepared for the task, and follow United States Environmental Protection Agency (U.S. EPA) format or a format specified in the scope of work (SOW) for the task.

In addition to reporting QA activities and QC data assessment results in technical reports and memoranda as described, a summary of QA/QC activities for all current RI/FS activities will be provided in the monthly progress reports. This will include discussion of audits conducted or planned, any specific problems identified or resolved during the reporting period, and provide an overview of general QA/QC activities conducted in support of field work and reporting for all RI/FS tasks.

The content and format for the Quality Assurance Reports are presented in the following outline:

McCLELLAN AIR FORCE BASE
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
QUALITY ASSURANCE REPORTS

1.0 Summary of sampling and analytical activity and highlights of quality assurance results

2.0 Measurement data accuracy, precision, and completeness (per sample matrix and method)

3.0 Results of systems audits

4.0 Results of performance audits

5.0 Significant quality assurance problems and recommended action

15.1 Quality Assurance and Quality Control Reporting Formats

Two types of quality control results will be reported:

- Sampling Quality Control
    - -- Field blank analyses
    - -- Trip blank analyses
    - -- Ambient blank analyses
    - -- Field duplicate sample analyses

- Analytical Quality Control
    - -- Method spike analyses
    - -- Laboratory duplicate analyses
    - -- Matrix spike analyses
    - -- Reagent blank analyses
    - -- Matrix spike duplicate analyses

These data will be reported in tables by method and matrix, as described in Section 9.0.

A table summarizing all QC data for the task will be prepared. The range of the results for each type of data (blanks, spikes), the total number of samples, and number of acceptable results will be indicated.

16.0 SITE MANAGEMENT

This section will briefly discuss the general aspects of Site Management.

1. Base Point of Contact (BPOC)

SM - ALC/EMR, QA Officer
Building 250 HH
McClellan AFB, CA 95652-5990
(916) 643-1250

The QA Officer will observe field activities to ensure tasks are conducted according to Project Work Plans and Quality Assurance Project Plan (QAPP).

2. Coordination of Field Activities

Field tasks such as the implementation of the pathways preliminary assessment and the hydrogeologic assessment will require the organization, scheduling and other field logistics for several Radian personnel and up to four separate subcontractors. An experienced Radian geologist will provide program logistics and communication between the Air Force, the field teams, subcontractors, county inspection personnel, and Radian task management regarding the routine, daily activities. The field coordinator will be equipped with a telephone paging device which will improve field communications.

3. Location of Field Office Facilities

Radian has an office trailer located south of Building 685 in an area that will be designated as the task storage and staging area. Although not staffed full-time, this facility will provide Radian and subcontractor personnel telephone access.

4. Site and Equipment Security

Certain field activities will require the use of a drilling or similar subcontractor. The subcontractor will erect a temporary chain link fence in the vicinity of Building 685 in which to store equipment and supplies. When activities require equipment to be left overnight at a site on base, all equipment and vehicles will be secured to prevent any unauthorized removal. In the event that equipment is required to be left overnight at a site off base, the subcontractor will be responsible for providing security.

5. Sources of Potable Water

There are two sources of base-supplied potable water in the vicinity of the equipment staging area located west of Building 685. There is a spigot and an overhead tank filling discharge line located within a few hundred feet west of Building 685.

6. Location of Decontamination Area

Decontamination of field equipment suspected of being contaminated will occur on the vehicle wash pad located north (behind) Building 685. The cleaning up of field equipment known to be not contaminated will occur on the gravel lot adjacent to the staging area.

7. Site Access

Sites requiring access will occur both on and off base. Access for sites on base will be coordinated through McClellan AFB per Air Force policy. This includes obtaining digging permits, and coordination with facilities and units where site activities will take place. Off-base site access and acquisition of required property easements will be conducted by the U.S. Army Corp of Engineers in coordination with the Air Force. Radian will assist these organizations whenever possible and will obtain the Sacramento County Health Department application and water well permits.

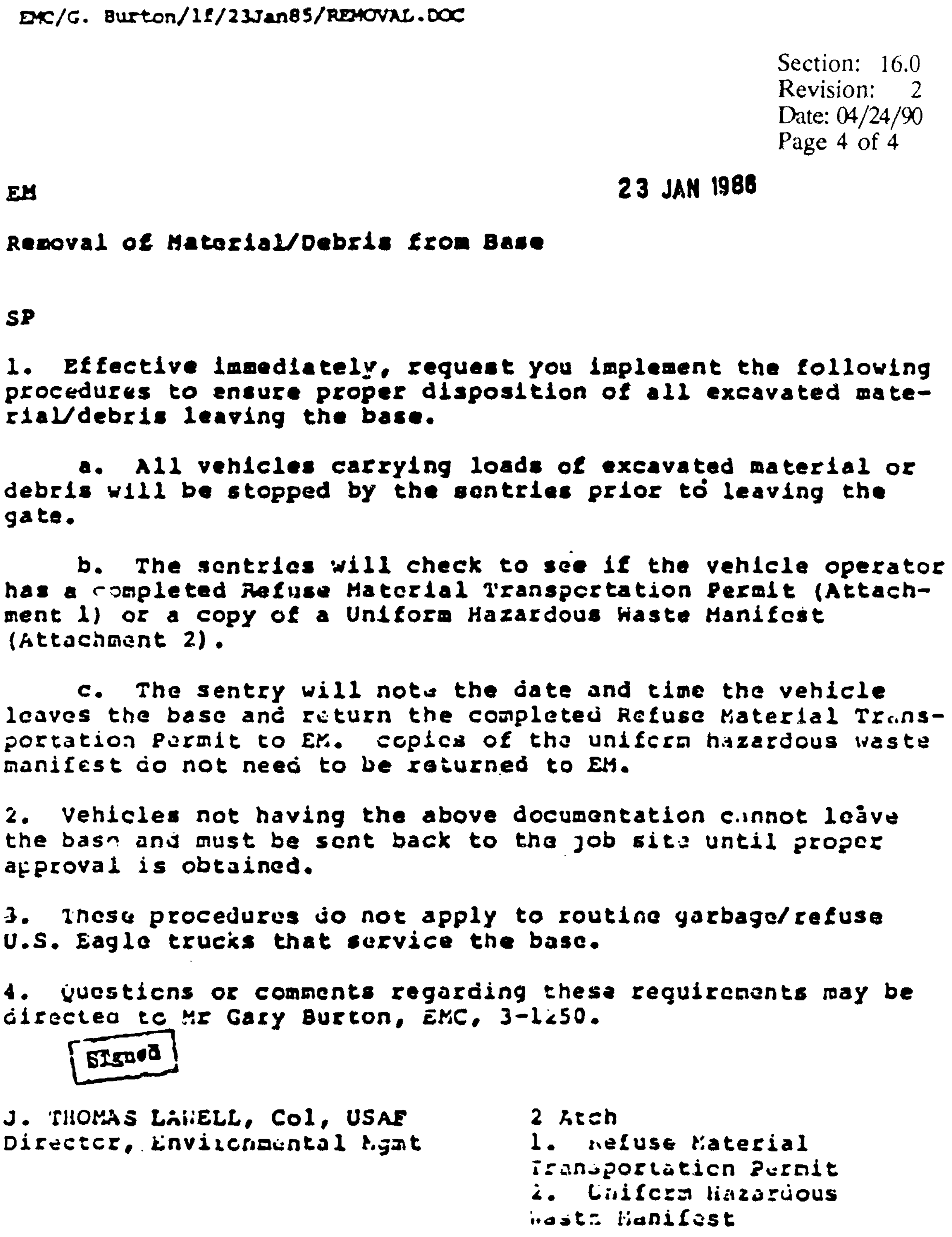
8. Cuttings and Groundwater Disposal

Soil cuttings produced during drilling operations will be screened for the presence of volatile organic compounds (VOCs) and stored in designated waste bins on base, as described in Section 5.2. These materials will be removed from the base for appropriate disposal according to the protocol prescribed in the following document (Figure 16-1).

Groundwater collected during drilling or sampling operations will be transported to the McClellan AFB Groundwater Treatment Plant for disposal according to base protocol.

9. Site Health and Safety

A detailed discussion of site and project health and safety is presented in the Remedial Investigation/Feasibility Study (RI/FS) Health and Safety Plan (Radian, 1988).



EMC/G. Burton/lf/23Jan85/REMOVAL.DOC

EM 23 JAN 1986

Removal of Material/Debris from Base

SP

1. Effective immediately, request you implement the following procedures to ensure proper disposition of all excavated material/debris leaving the base.

a. All vehicles carrying loads of excavated material or debris will be stopped by the sentries prior to leaving the gate.

b. The sentries will check to see if the vehicle operator has a completed Refuse Material Transportation Permit (Attachment 1) or a copy of a Uniform Hazardous Waste Manifest (Attachment 2).

c. The sentry will note the date and time the vehicle leaves the base and return the completed Refuse Material Transportation Permit to EM. copies of the uniform hazardous waste manifest do not need to be returned to EM.

2. Vehicles not having the above documentation cannot leave the base and must be sent back to the job site until proper approval is obtained.

3. These procedures do not apply to routine garbage/refuse U.S. Eagle trucks that service the base.

4. Questions or comments regarding these requirements may be directed to Mr Gary Burton, EMC, 3-1250.

Signed

J. THOMAS LAWELL, Col, USAF
Director, Environmental Mgmt

2 Atch
1. Refuse Material Transportation Permit
2. Uniform Hazardous Waste Manifest

Figure 16-1. Protocol for Removal of Material.

APPENDIX A

Sampling and Analysis Procedures for Volatile Organics in Air

RADIAN CORPORATION
SAMPLING AND ANALYSIS PROCEDURES FOR VOLATILE ORGANICS IN AIR

1.0 BACKGROUND

Radian Corporation has developed a multiple detector gas chromatographic system (GC/MD) for the analysis of volatile organic compounds (VOC) in air in the ppbv range. Compounds found in the samples are identified by retention time relative to toluene and by the ratio of response between the FID and PID detectors normalized to toluene. The database used contains 170 different compounds. Halogenated compounds are confirmed by the Hall Electrolytic Conductivity Detector (HECD) operating in the Halide Specific Detection (HSD) mode. Compounds of interest are C_2 through C_{10}+, aliphatic, aromatic, olefinic, and oxygenated hydrocarbons plus the halocarbons.

The development of Radian's VOC system was partially funded by the U.S. EPA and has been utilized on many EPA contracts. Radian's canister methodology is described as Method T014 in the EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air.

2.0 SAMPLING

Samples are collected in evacuated stainless steel canisters. The canisters are evacuated to a known pressure, sample is allowed to flow into the canister until atmospheric pressure is reached and the pressure is again measured to determine the volume of sample collected. The sample is pressurized to a known pressure prior to analysis to facilitate loading the cryogenic loops.

Samples may be collected as grab samples by simply opening the valve and allowing sample to enter the canister. Vacuum flow regulators may also be used to meter a known amount of sample into the canister and thus collect a time integrated sample. Canister sizes of 2.8, 6, and 15 liters are available.

Samples are easily transported in the canisters. Halocarbons, aliphatic, aromatic, and olefinic compounds are stable in the canister for more than two weeks. Oxygenated compounds give variable recoveries from stainless steel canisters depending on the compound and its polarity.

Canister samples are returned to Radian's Austin, Texas, chromatography laboratory for analysis using a dual-column, multiple detector gas chromatography technique (GC-MD). Three detectors are used: flame ionization, photoionization, and halide specific (GC/FID-PID-HSD).

When a sample is received from the field, it is first assigned a code number and logged in SAM (sample and analysis management), Radian's sample tracking, reporting, and invoicing system. The final pressure is then measured and logged into a separate sample analysis notebook before pressurizing the canister with ultra high purity nitrogen (UHP N_2) to 10-15 psig. The final pressure is then measured and recorded. Nitrogen is added to the canisters to provide positive pressure for removing the sample and to dilute oxygen and moisture in the sample, thereby minimizing sample component reactions.

3.0 ANALYTICAL PROCEDURES

To achieve the desired detection levels, volatile organic species are separated from the ambient air matrix and concentrated. The analytical procedure consists of the following operations:

- Collection of VOCs through a Permapure® drier onto a cryogenic trap;
- Flash thermal desorption onto a fused silica capillary GC column;

- Detection of the VOCs by flame ionization detector (FID), photoionization detector (PID), and Hall electrolytic conductivity detector (HECD); and

- Computer-assisted data reduction.

Table 1 presents the detailed analytical conditions for each of these operations.

The sample is loaded onto cryogenic loops cooled to liquid Argon temperatures by reducing the pressure in the system to a known value. Sample flows through the cryogenic traps from the pressurized canister until the desired amount of sample has been collected, generally 0.4 to 0.8 liters. The pressure is again measured and the differential pressure corresponds to the amount of sample loaded. Two separate cryogenic loops are loaded with sample; one for the PID and FID and the second for the HECD. The sample is thermally desorbed from the cryogenic loops at 180°C and refocused on the fused silica capillary columns which are at -50°C.

The effluents of the two analytical columns will be analyzed by three separate detectors. The first column will be split (5:1) to a flame ionization detector (FID) to detect and quantitate hydrocarbons and to a photoionization detector (PID) to generate toluene-normalized response (TNR) factors. TNRs are the PID/FID response ratio for a given compound normalized to the PID/FID response ratio for toluene. Different classes of compounds product characteristic TNRs which are used along with relative retention times (RRT) for qualitative sample analysis. RRTs will be calculated based on the retention time for toluene. The second column will be interfaced to an HECD operated in the halogen specific mode (HSD). This provides specific detection of halogenated compounds for quantitation and identification.

TABLE 1. GC/MD ANALYTICAL CONDITIONS

Instrument: HP 5880 and LAS data system

Detectors: FID, PID, HSD

FID/PID Split Ratio. 5:1

GC Column: (2) 60m x 0.32mm I.D. DB-5 fused silica capillary columns, $d_f = 1$ um

GC Carrier Gas: Helium @ 2 mL/min

Column Head Pressure: 20 psig

Injector: Cryogenic trap

Sample Loop: One-eighth inch cryogenic loop packed with 100 to 120 mesh salonized glass beads

Transfer Lines and Valve Oven Temperature: 170°C

Cryotrap Desorb Temperature: 180°C

Detector Temperatures: FID/PID 220°C
HSD 830°C

GC Program: -50°C to 150°C @ 6°/min, IH - 2 min.,
150 to 220°C @ 25/min

4.0 DATA REDUCTION

The FID/PID data from the gas chromatography will be processed with a Hewlett-Packard (H-P) 3357 Laboratory Automation System (LAS). This LAS provides peak areas and retention times. Computer programs on an H-P 1000 computer will be used to identify peaks on the basis of RRTs and TNRs and to compute quantitative results by comparing peak areas with previously established response factors (RF). Quantitation of compounds is achieved using the FID RF for hexane. The standard RFs are calculated on a response per carbon atom basis. Compounds are first quantified in units of parts-per-billion volume-carbon (ppbv-C) and converted to ppbv by division by the number of carbon atoms present in the compound. This approach assumes that FID response is a linear function of a carbon number for each compound.

The HECD output is recorded and integrated with a Hewlett-Packard 3357 Data System that identifies and quantifies those compounds in the calibration standard. Unidentified compounds are quantitated using an average response factor for the compounds in the quantitative standard. The HECD is calibrated daily with halogenated standards.

The concentrations of compounds identified in a sample will be calculated using the external standard method based on chromatographic peak areas and response factors obtained from a calibration standard according to the following equation:

$$C = \frac{Ax}{RF} DF$$

where, C = concentration of analyte X in ng-C/mL,
Ax = peak area for analyte X,
RF = response factor for the appropriate quantitative standard in area counts/ng-C, and
DF = dilution factor.

When a VOC is identified on both the HSD and FID/PID, the HSD concentration value will be reported. When a halogenated VOC is identified by FID/PID, but not confirmed by HSD, it will be reported as an unidentified VOC.

A preliminary report is generated which includes the following information:

- Compound name;
- Concentration (in ppbv-C);
- Relative retention time (relative to toluene);
- Absolute retention time; and
- Toluene normalized response.

This report is reviewed by the analyst and any misidentifications or errors are corrected. Background subtractions are performed at this time. A final report is then prepared listing compounds detected and concentrations in ppbv-species.

5.0 QUALITY CONTROL

This section outlines the minimum quality control (QC) operations necessary to satisfy the analytical requirements associated with the determination of compounds by GC/MD. The QC operations include:

- Sample documentation;
- Calibration;
- Reagent blank analyses (method blank); and
- Internal QC.

For each of these activities, a report form will be used to record the QC data.

For each QC activity, criteria have been established which define acceptable performance. Various corrective measures are employed to respond to values outside the established QC limits. Any corrective actions will be determined by a meeting of the responsible analyst and the analytical Task Leader. The corrective action performed will be recorded on the QC report form.

In addition to the specific QC activities described in this section, standard laboratory procedures consistent with good laboratory practices will be used.

5.1 Sample Documentation

Each sample will be logged into a central sample control system and assigned a unique laboratory code number. A chain-of-custody form will be generated which will follow the sample from the cleaning and preparation of the canister, to the collection of the field sample, to receipt of the sample in the laboratory, and finally, through analysis and disposition of the sample.

All laboratory activities will be documented through the use of standardized forms and personal laboratory notebooks. Hard copies of raw data (chromatograms, etc.) will be maintained in a laboratory file. In addition, a project file will contain originals of all deliverable reports and copies of all correspondence and memoranda.

Each sample (sub-sample, blank, etc.) scheduled for analysis will have a worksheet which accompanies the sample through the various analytical steps. This worksheet has three major sections for recording information about the sample (ID, sample type, etc.), sample preparation, and analysis.

Operations logbooks will be maintained at each instrument. The operations log contains information concerning the instrument performance, operating conditions, instrument maintenance, and samples analyzed.

5.2 Calibration Procedures

Calibration procedures are performed on a daily, weekly, and monthly basis to ensure that the qualitative and quantitative information the system produces is correct. Table 2 lists the calibration procedures and frequency.

For the FID/PID detector system, a multipoint calibration/linearity check will be performed monthly using three concentrations of a propane/hexane standard plus a helium background blank. This multipoint check will be considered acceptable if the correlation coefficient for the resulting calibration curve is >0.9950.

A single-point response factor for hexane, determined by analysis of the mid-level calibration standard, will be used for quantitation of all sample components. The weekly response factor will be compared to the latest multipoint slope response factor and must agree within ±30% before sample analyses may proceed.

A 12-component hydrocarbon standard is used as a daily control check. The compounds are listed in Table 3. In order for analysis to proceed, 10 of 12 must meet correct identification and quantitation requirements. If the control check does not conform, the calibration is repeated until correct conditions are attained.

A 38-component hydrocarbon standard will be used to evaluate any shifts in compound retention times or column separation efficiency. Sample components of this standard are listed in Table 4. Sample components will be identified based on pre-established retention times relative to toluene and isobutane, using a computerized auto-identification scheme.

The halide specific detector (HSD) will be calibrated by multipoint calibration monthly, at a minimum of three concentrations consisting of ultrapure air using a gas standard containing halogenated compounds plus an

TABLE 2. CALIBRATION PROCEDURES AND FREQUENCY

Analytical Method	Calibration	Frequency	Acceptance Criteria
Radian-GC/FID-PID	Multipoint, propane/hexane at 3 concentrations, plus UHP blank	Monthly or after maintenance	Correlation coefficient $\geq$0.9950
	Single point RF check	Weekly	Agreement within ±30% of most recent multipoint slope RF
	Retention time check (38-component hydrocarbon standard)	Monthly	Agreement with preestablished relative retention times
	Control sample	Daily	1. Correct identification of 10 out of 12 components 2. 10 of 12 hydrocarbons within ± 30% of certified value
Radian-GC/HSD	Multipoint, at least 3 concentrations (halogenated standard)	Monthly or after maintenance	Correlation coefficient $\geq$0.9950
	Single point RF check	Daily	Response factors for chloromethane, 1,2-dichloroethane, 1,1,1-trichloroethane, and tetrachloroethane within ±50% of most recent multipoint slope RF

TABLE 3. FID/PID/HSD QUALITY CONTROL CHECK SAMPLE

Ethane
Propane
1-Butene
n-Butane
1-Hexane
n-Hexane
Benzene
Toluene
n-Oxane
Ethyl benzene
Propyl benzene
n-Decane

TABLE 4. COMPONENTS OF THE FID/PID MULTIPOINT RETENTION TIME STANDARDS

Capillary Column STD (PID/FID)
Component
Ethane
Ethylene
Acetylene
Propane
Propylene
Isobutane (2-Methylbutane)
1-Butene
n-Butane
trans-2-Butene
cis-2-Butene
Isopentane (2-Methylpentane)
2-Methyl-2-butene
2-Methyl-1-butene
n-Pentane
trans-2-Pentene
cis-2-Pentene
Cyclopentene
Isohexane (2-Methylhexane)
3-Methylpentane
n-Hexane
Methylcyclopentane
Benzene
1,2-Dimethylpentane
Isoheptane (2-Methylheptane)
3-Methylhexane
2,2,4-Trimethylpentane
n-Heptane
Methylcyclohexane
Toluene
Ethylbenzene
m-Xylene
p-Xylene
o-Xylene
n-Nonane
n-Propylbenzene
p-Ethyltoluene
1,3,5-Trimethylbenzene
1,2,4-Trimethylbenzene

ultrapure N_2(He). The components of this standard are listed in Table 5. Calibration will be checked daily by analysis of the mid-level halogenated standard concentration. The daily response factors for chloromethane, 1,2-dichloroethane 1,1,1-trichloroethane, and tetrachloroethylene will be compared to the latest multipoint slope response factor of each compound, and must agree within $\pm 50\%$ before sample analysis may proceed.

Linearity Checks

Each time a multipoint calibration of the FID using the hexane/propane is conducted, the linearity of the calibration curves will be evaluated by linear regression analysis. A correlation coefficient for both parameters of R ≥ 0.9950 will be required for calibration acceptance. If this criterion is not met, the calibration will be repeated (after instrument maintenance, if necessary) until R ≥ 0.9950. Linearity for the HSD will be checked for each of the 17 compounds listed in Table 5. The mass acceptance criteria of a correlation coefficient ≥ 0.9950 will be required.

5.3 Reagent Blank (Method Blank) Analyses

A method (N_2) blank is a sample of ultrapure N_2 carried through the entire analytical scheme. The N_2 blank volume is roughly equal to one liter and is from the same N_2 source used to dilute the samples. A reagent blank analysis is performed daily or immediately after the analysis of any sample exhibiting a single peak area exceeding 10^6 area counts. Nitrogen blanks will be analyzed until the total non-methane hydrocarbon (TNMHC) value is less than 25 ppbv-C. If compounds are detected in the blank analysis, the following guidelines are employed:

1. If the concentration in the blank is less than 50% of the sample value, the blank value is subtracted from the sample value. This reported value should be noted as being corrected for the blank value.

TABLE 5. COMPONENTS OF THE HALOGENATED CALIBRATION STANDARD

1,2-Dichloropropane
Trichloroethylene
1,1,2-Trichloroethane
Tetrachloroethylene
Chlorobenzene
Chloromethane
Vinyl chloride
Dichlorodifluoromethane
1,1-Dichloroethylene
Methylene chloride
t-1,2-Dichloroethylene
1,1-Dichloroethane
Chloroform
1,2-Dichloroethane
1,1,1-Trichloroethane
Carbon tetrachloride
Fluorotrichloromethane

2. If the concentration in the blank is greater than 50% of the reported value, the compounds should be reported as "not detected," with a note indicating blank contamination for this compound.

3. If the TNMHC value for the nitrogen blank consistently exceeds 25 ppbv-C, sample analyses must be suspended and corrective action implemented. After corrective action, sample analyses will be repeated back to the last blank analysis within the acceptance criteria.

5.4 Internal Quality Control

The internal quality control consists of several procedures that are designed to detect and correct any out-of-control situations in the lab. This kind of quality control includes the following procedures:

- Response factors (RF) checks;
- Retention time (RT) checks;
- Control sample analyses;
- Duplicate analyses; and
- Canister/flow controller system blanks.

In addition, a field duplicate is required for field quality control. Each procedure and the acceptance criteria will be discussed in this section and are summarized in Table 6.

Response Factor (RF) Checks

Once a week prior to sample analyses, the RF for the FID is checked by analyzing the low- or mid-level propane/hexane calibration standard. The RF calculated for this analysis must be within ±30% (RPD) of the average RF developed for each parameter at the most recent multipoint calibration to be

TABLE 6. SUMMARY OF INTERNAL QUALITY CONTROL PROCEDURES FOR RADIAN CANISTER METHOD (GC-FID/PID/HSD)

Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
Method blank analysis	Daily prior to analyses, then after sample with $>10^6$ counts	Total $\leq$20 ppbv-C	1) Repeat blank analysis 2) Clean system and check for leaks
Linearity check (at multipoint calibration) using halogenated standard	Monthly or after maintenance	Correlation coefficient $\geq$0.995	1) Repeat calibration 2) Clean detector, check flow 3) Replace reactor tube
Single point response factor (RF) check using propane/hexane standard (FID/PID)	Weekly or when detectors are altered	Response factor agreement within $\pm$30% of most recent average RFs for multipoint calibration for FID and PID	1) Repeat RF check 2) Repeat calibration
Single point response factor (RF) check using halogenated standard (HSD)	Daily	Response for chloromethane, 1,1,1-trichloroethane, trichloroethene, and 1,2-dichloroethane within $\pm$50% of current multipoint slope	1) Repeat RF check 2) Repeat calibration
Retention time check using 38-component hydrocarbon standard	Monthly	Agreement with pre-established relative retention times	Adjust GC conditions and repeat RT check
Control sample analyses (FID/PID only)	Daily, prior to sample analyses	1) Correct identification of 10 of 12 components 2) 10 of 12 hydrocarbons measured concentrations within $\pm$30% of certified value	1) Repeat control sample analysis 2) Repeat RF check 3) Repeat RT check 4) Repeat calibration
Duplicate analyses	10% minute of 1 per set	CV $\leq$50% for four major sample components	Repeat sample analyses
Canister/flow controller system blank	Minimum of 1 prior to sampling round	Total $\leq$20 ppbv-C	1) Repeat analysis 2) Reclean canisters and flow controllers
Duplicate samples	10% minimum of 1 per program	CV $\leq$50% for 75% of sample components	Will be used to determine sampling/analytical variability

acceptable. If this criterion cannot be met, the instrument must be calibrated by multipoint calibration before sample analyses may continue. The HSD RFs are checked daily or whenever the cell is cleaned. The standards in Table 5 are analyzed in a low- or mid-concentration range and the calculated RFs for chloromethane 1,1,1-trichloroethane, trichloroethylene, and 1,2-dichloroethane must be within ±50% (RPD) of the slope calculated from the multipoint calibration. If this criterion is not met after two analyses of the standard, a multipoint calibration must be performed before sample analyses may continue.

Retention Time (RT) Checks

The performance of the GC/FID-PID system will be checked on a monthly basis by analyzing a 38-component gas standard. This standard is used to evaluate column efficiency and to verify compound identification by relative retention time. The compounds comprising the retention time standard are listed in Table 4. Sample components will be identified based on pre-established retention times relative to toluene and isobutane, using a computerized auto-identification scheme. The acceptance criteria for this test include the following:

1. Positive identification of 90% of the components; and

2. A maximum 20% decrease in separation number (SN) for selected pairs of peaks.

The separation number will be calculated using the following equation based on select pairs of peaks (hexane/heptane, pentane/hexane, or ethylbenzene/-propylbenzene):

$$SN = \frac{t_{R_2} - t_{R_1} - 1}{W_2 + W_1}$$

where, SN = separation number,
t_{R_2} = retention time for peak 2 (minutes),
t_{R_1} = retention time for peak 1 (minutes),

W_2 = width of peak 2 at half height (minutes), and
W_1 = width of peak 2 at half height (minutes).

Results for these checks will be maintained in the routine system documentation.

Control Sample Analyses

Immediately following daily instrument calibration, and prior to analysis of any samples, a quality control check sample will be analyzed. This control check sample provides an indirect RF check, and a direct RT check. This control sample will be a 12-component hydrocarbon mixture containing the compounds listed in Table 3. These analyses will be required to meet both qualitative and quantitative acceptance criteria. First, correct identification of 10 of the 12 hydrocarbon components will be required. Second, a 30% control limit will be used for quantitation of the control sample components. Ten of the 12 hydrocarbon components will be required to meet these criteria.

If these criteria cannot be met, the control sample will be analyzed again to verify the initial response. Sample results for any component falling outside these limits again will be flagged as questionable. At this point, a full-scale Response Factor (RF) and Retention Time (RT) check should be repeated and the instrument recalibrated if necessary to bring performance within the acceptance criteria.

Duplicate Analyses

A minimum of 10% of the samples will be analyzed in duplicate. For all duplicate analyses, the acceptance criteria will be a coefficient of variation (CV) $\leq$50% for the 4 major components in the sample. TNMHC will be used as an initial indicator of this agreement.

Canister/Flow Controller System Blanks

One canister/flow controller system will be blank tested prior to each sampling event. The system will be filled with ultrapure N_2, and carried through the analytical scheme. The N_2 used will be from the same source used to dilute samples. The blank will be acceptable if the TNMHC value is less than 25 ppbv-C. If the blank is not acceptable, the analysis will be repeated. If the criteria is still not met, all canisters and flow controllers will be recleaned, and the blank analysis repeated.

Field Duplicates

One sampling location will be sampled in duplicate for each round of sampling. A second ambient air sampling stand will be temporarily assembled at the location selected for duplicate sampling. The duplicate samples are collocated by closely placing the inlets of the two canisters so that a homogeneous sampling of the matrix is achieved.

6.0 REPORTING

Prior to reporting of the analytical data for a sample, the computer-generated summary report for the FID/PID and the HECD will be reviewed to ensure that accurate VOC identifications and quantitations have been made.

6.1 Final Quality Control

A review of the data will be conducted by personnel who were not involved in the initial data reduction. Quality control measures for verification of data include a review of all samples. Compound identifications and quantitations that were performed manually will be verified and independently calculated. Any changes made during the QC review will be documented and placed in the file.

6.2 Data Storage

Two types of files will be maintained for each VOC program; project files and sample files. Project files will be organized by contract number and will contain a data package consisting of the following:

- Program instruction;
- Cross reference table (sample field ID/sample lab code #);
- Chain-of-custody forms;
- QC summary tables; and
- Project reports and correspondence.

Each sample file will contain all hard copied data obtained from a sample analysis. These files will constitute a subset of the project file and will be organized by lab code number. The data stored in these files will include, at a minimum, the following:

- Original chromatograms;
- Raw data summaries;
- Sample worksheets; and
- Other relevant information.

These files will be maintained in the laboratory for a period of 90 days after submission of the project final report. After 90 days, the files will be transferred to a warehouse for archival storage unless otherwise specified by the Project Manager.

7.0 ANALYTE LIST AND DETECTION LIMITS

Table 7 is the list of the 170 compounds analyzed for by the canister method, and Table 8 lists the approximate detection limits by compound class. As in all environmental samples, often the detection limit depends on the specific matrix, so these detection limits are estimates.

TABLE 7. STANDARD ANALYSIS OF VOLATILE ORGANIC COMPOUNDS USING STAINLESS STEEL CANISTER SAMPLERS AND GC/MD ANALYSIS

CAS #	Number	Compound Name
	1	C-2 VOC
74-85-1	2	Ethylene
74-86-2	3	Acetylene
74-84-0	4	Ethane
	5	C-3 VOC
115-07-1	6	Propylene
74-98-6	7	Propane
74-99-7	8	Propyne
74-87-3	9	Chloromethane
75-28-5	10	Isobutane
75-01-4	11	Vinyl Chloride
75-07-0	12	Acetaldehyde
115-11-7 + 106-98-9	13	Isobutene & 1-Butene
106-99-0	14	1,3-Butadiene
106-97-8	15	n-Butane
74-93-1	16	Methyl Mercaptan
624-64-6	17	Trans-2-Butene
74-83-9	18	Bromomethane
463-82-1	19	Neopentane
107-00-6	20	1-Butyne
590-18-1	21	cis-2-Butene
75-00-3	22	Chloroethane
67-56-1	23	Methanol
75-71-8	24	Dichlorodifluoromethane
563-45-1	25	3-Methyl-1-Butene
78-78-4	26	Isopentane
123-38-6	27	Propionaldehyde
67-64-1	28	Acetone
75-69-4	29	Trichlorofloromethane

(Continued)

TABLE 7. (Continued)

CAS #	Number	Compound Name
109-67-1	30	1-Pentene
75-08-1	31	Ethyl Mercaptan
503-17-3	32	2-Butyne
64-17-5	33	Ethanol
563-46-2	34	2-Methyl-1-Butene
109-66-0	35	n-Pentane
78-79-5	36	Isoprene
N/A	37	Dimethylsulfide
75-05-8	38	Acetonitrile
75-35-4	39	1,1-Dichloroethylene
646-04-8	40	trans-2-Pentene
60-29-7	41	Diethyl Ether
627-20-3	42	cis-2-Pentene
513-35-9	43	2-Methyl-2-Butene
75-09-2	44	Methylene Chloride
67-63-0	45	2-Propanol
75-83-2	46	Neohexane
78-84-2	47	Isobutyraldehyde
142-29-0	48	Cyclopentene
691-37-2	49	4-Methyl-1-Pentene
287-92-3	50	Cyclopentane
156-60-5	51	trans-1,2-Dichloroethylene
79-29-8	52	2,3-Dimethylbutane
73513-42-5	53	Isohexane
691-38-3	54	cis-4-Methyl-2-Pentene
674-76-0	55	trans-4-Methyl-2-Pentene
71-23-8	56	1-Propanol
123-72-8	57	Butyraldehyde
96-14-0	58	3-Methylpentane

(Continued)

TABLE 7. (Continued)

CAS #	Number	Compound Name
78-93-3	59	Butanone
763-29-1	60	2-Methyl-1-Pentene
592-41-6	61	1-Hexene
760-21-4	62	2-Ethyl-1-Butene
110-54-3	63	n-Hexane
7642-09-3	64	cis-3-Hexene
67-66-3	65	Chloroform
625-27-4	66	2-Methyl-2-Pentene
4050-45-7	67	trans-2-Hexene
7688-21-3	68	cis-2-Hexene
N/A	69	C-3-Methyl-2-Pentene
96-37-7	70	Methylcyclopentane
107-06-2	71	1,2-Dichloroethane
108-08-7	72	2,4-Dimethylpentane
71-55-6	73	1,1,1-Trichloroethane
590-86-3	74	Isovaleraldehyde
71-43-2	75	Benzene
27476-50-2	76	Methylcyclopentene
56-23-5	77	Carbon Tetrachloride
110-82-7	78	Cyclohexane
31394-54-4 + 565-59-3	79	Isoheptane + 2,3-Dimethylpentane
110-83-8	80	Cyclohexane
107-87-9	81	2-Pentanone
78-87-5	82	1,2-Dichloropropane
589-34-4	83	3-Methylhexane
71-36-3	84	1-Butanol
110-62-3	85	Valeraldehyde
96-22-0	86	3-Pentanone
79-01-6 + 75-27-4	87	Trichloroethylene + Bromodichloromethane

(Continued)

TABLE 7. (Continued)

CAS #	Number	Compound Name
592-76-7	88	1-Heptene
540-84-1	89	2,2,4-Trimethylpentane
123-91-1	90	1,4-Dioxane
109-79-5	91	Butyl Mercaptan
592-78-9	92	3-Heptene
142-82-5	93	n-Heptane
592-77-8	94	2-Heptene
	95	Bichloromethyl Ether
107-39-1	96	2,4,4-Trimethyl-1-Pentene
108-87-2	97	Methylcyclohexane
10061-01-5	98	cis-1,3-Dichloropropene
107-40-4	99	2,3,4-Trimethyl-2-Pentene
108-10-1	100	Methylisobutylketone
592-13-2	101	2,5-Dimethylhexane
110-75-8	102	2-Chloroethyl Vinyl Ether
10061-02-6	103	trans-1,3-Dichloropropene
79-00-5	104	1,1,2-Trichloroethane
565-75-3	105	2,3,4-Trimethylpentane
554-14-3	106	2-Methylthiophene
108-88-3	107	Toluene
616-44-4	108	3-Methylthiophene
591-49-1	109	1-Methylcyclohexene
124-48-1	110	Dibromochloromethane
N/A	111	3,5,5-Trimethylhexene
589-81-1	112	3-Methylheptane
66-25-1	113	Hexanal
110-01-0	114	Tetrahydrothiophene
3522-94-9	115	2,2,5-Trimethylhexane
111-66-0	116	1-Octene

(Continued)

TABLE 7. (Continued)

CAS #	Number	Compound Name
127-18-4	117	Tetrachloroethylene
111-65-9	118	n-Octane
7642-04-8	119	cis-2-Octene
541-31-1	120	Isopentyl Mercaptan
108-90-7	121	Chlorobenzene
100-41-4	122	Ethylbenzene
106-42-3 + 108-3-3	123	p-Xylene + m-Xylene
100-42-5	124	Styrene
95-47-6	125	o-Xylene
79-34-5 + 75-25-2	126	1,1,2,2-Tetrachloroethane + Bromoform
124-11-8	127	1-Nonene
2198-23-4	128	4-Nonene
638-02-8	129	2,5-Dimethylthiophene
111-84-2	130	n-Nonane
98-82-8	131	Isopropylbenzene
80-56-8	132	a-Pinene
95-49-8	133	o-Chlorotoluene
108-41-8	134	m-Chlorotoluene
106-43-4	135	p-Chlorotoluene
103-65-1	136	n-Propylbenzene
620-14-4	137	m-Ethyltoluene
622-96-8	138	p-Ethyltoluene
111-44-4	139	Dichloroethyl Ether
108-67-8	140	1,3,5-Trimethylbenzene
611-14-3	141	o-Ethyltoluene
127-91-3	142	b-Pinene
98-06-6	143	t-Butylbenzene
95-63-6	144	1,2,4-Trimethylbenzene
541-73-1	145	m-Dichlorobenzene

(Continued)

TABLE 7. (Continued)

CAS #	Number	Compound Name
872-05-9	146	1-Decene
106-46-7	147	p-Dichlorobenzene
538-93-2	148	Isobutylbenzene
124-18-5	149	n-Decane
526-73-8	150	1,2,3-Trimethylbenzene
95-50-1	151	o-Dichlorobenzene
99-87-6	152	p-Isopropyltoluene
496-11-7	153	Indane
95-13-6	154	Indene
138-86-3	155	Limonene
141-93-3	156	m-Diethylbenzene
104-51-8	157	n-Butylbenzene
105-05-5	158	p-Diethylbenzene
821-95-4	159	1-Undecene
1120-21-4	160	n-Undecane
91-20-3	161	Naphthalene
75-34-3	162	1,1-Dichloroethane
74-82-8	163	Methane
100-52-7	164	Benzaldehyde
107-13-1	165	Acrylonitrile
156-59-2	166	cis-1,2-Dichloroethylene
108-94-1	167	Cyclohexanone
106-93-4	168	1,2-Dibromoethane
110-02-1	169	Thiophene
564-02-3	170	2,2,3-Trimethylpentane