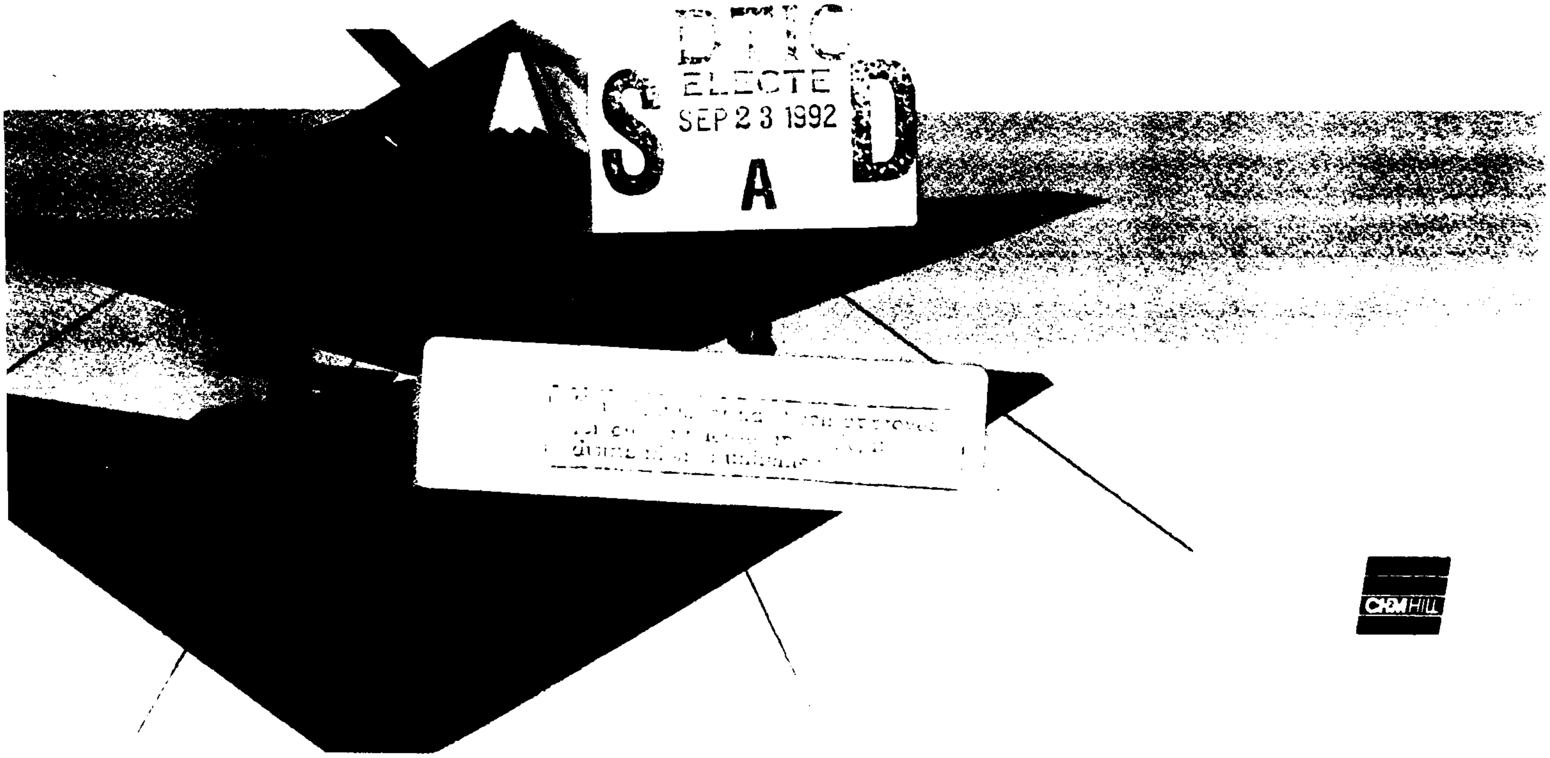
McClellan Air Force Base

Work Plan

Soil Vapor Extraction Treatability Investigation

Site S, Operable Unit D

Delivery Order 5038



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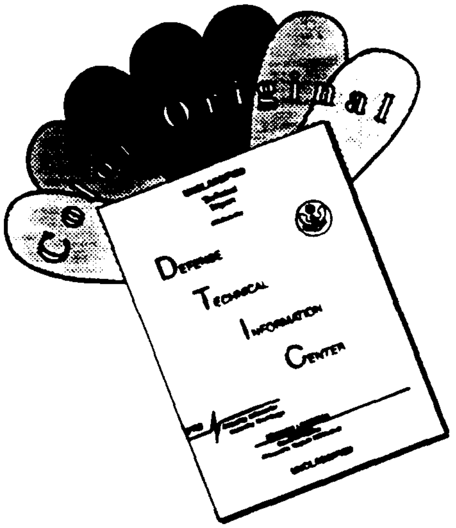

Final

Work Plan

Soil Vapor Extraction Treatability Investigation
Site S Within Operable Unit D
McClellan Air Force Base
Phases II and III
Delivery Order 5038

Prepared For

McClellan Air Force Base
Sacramento, CA

Prepared By
CH2M HILL

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September 1992

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS SACRAMENTO AIR LOGISTICS CENTER (AFLC)
McCLELLAN AIR FORCE BASE, CALIFORNIA 95652-5990

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2. If you have any questions, please don't hesitate to call me at (916) 643-0830.

Jerald E Styles

JERALD E. STYLES
Team Leader, Operable Unit Team 2
Environmental Restoration Division
Directorate of Environmental Management

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Final Work Plan

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Preface

CH2M HILL is a contractor for the Remedial Design/Remedial Action alternate technology program at McClellan Air Force Base in California. The specific technology addressed is soil vapor extraction. This document is a secondary document to the primary Operable Unit B Remedial Investigation/Feasibility Study (RI/FS) Report/Proposal Plan. The work is being conducted under Air Force Contract No. F04699-90-0035, Delivery Order No. 5038.

The Soil Vapor Extraction (SVE) Pilot-Scale Treatability Investigation is one of several projects within Operable Unit D (OU D). Concurrent with the SVE Pilot-Scale Treatability Investigation, off-base soil gas migration is being evaluated, as well as the measurements of crawl space and ambient air volatile organic compound (VOC) contamination at off-base residences. The OU D RI/FS will culminate in a Record of Decision in 1994. The results of this pilot-scale treatability study will be used in the OU D feasibility study, as well as other feasibility studies at McClellan AFB.

Key CH2M HILL project personnel are:

Starr J. Dehn—Program manager
John Lucero—Subprogram manager
Gerald R. Tracy—Project manager
Joseph P. Danko—SVE technical coordinator
Donna Morgans—Data validation
Calvin Noling—Assistant project manager and data coordinator
Ken White—Field task leader
Mollie Netherland—Health and safety

CH2M HILL would like to acknowledge the cooperation of the McClellan AFB Office of Environmental Management for assistance in expediting this project. In particular, CH2M HILL acknowledges the assistance of Mr. Steve Hodge, Mr. Fran Slavich, and Mr. Jerry Styles.

The work discussed in this document is being conducted between June 1992 and May 1993.

Executive Summary

CH2M HILL is currently preparing a treatability investigation of soil vapor extraction (SVE) at Site S in Operable Unit (OU) D at McClellan Air Force Base near Sacramento, California. This work plan describes activities to be conducted during Phases II and III of the SVE treatability investigation. A brief description of each of these phases is presented below:

- Phase II. Phase II activities include installation of SVE wells and process equipment, and preoperation soil sampling.

- Phase III. Activities to be conducted during Phase III include operation of the SVE pilot plant, performance sampling during and after the pilot system operation, and equipment demobilization. This phase will be concluded with a *Pilot System Evaluation Final Report.*

Site S encompasses a previously activated waste pit used for disposal of solvents and fuel.

The SVE pilot treatment system will be comprised of a network of soil gas extraction wells set at various depths in the vadose zone. A vacuum will be applied to the wells to remove volatile organic compounds (VOCs) from the soil. The extracted offgas flow rate and chemical composition will be monitored and emissions treated using an onsite catalytic oxidation system.

The pilot treatability investigation has nine main objectives. These objectives are summarized below and detailed in Section 3 of this Work Plan.

1. Quantify the mass of contaminants removed during operation of the pilot-scale system.

2. Evaluate the reduction of specific contaminants in the waste pit and alluvial deposits.

3. Evaluate the benefits of hot air injection as an enhancement to SVE in the waste pit.

4. Evaluate vadose zone transport processes to identify major mechanisms controlling contaminant migration and document the reasons for discounting other migration mechanisms.

5. Evaluate the degree of biodegradation.

6. Identify strata from which contaminants are difficult to remove by SVE.

7. Evaluate performance of the SVE offgas emission control system.

8. Evaluate the applicability of SVE to OU D and collect sufficient operational data to support the detailed analysis of SVE as a remedial action alternative in the feasibility study for OU D.

9. Assess general applicability of SVE at other McClellan AFB sites.

Soil, soil gas, and emissions samples will be collected and analyzed at various times during the treatability investigation to support evaluation of these objectives.

Soil samples will be tested for analyses of the following items:

- Physical properties, including permeability, porosity, grain size distribution, percent saturation, and bulk density

- Total petroleum hydrocarbon

- Chemical oxygen demand
- Moisture content
- pH
- Ammonia nitrogen
- Nitrate nitrogen
- Ortho-phosphate phosphorous
- Microbial assay

Over 500 analyses will be conducted on soil samples.

Soil gas, SVE offgas, and emission control samples will be tested with an onsite gas chromatograph for volatile organic compounds. Additional canister samples will be collected for confirmation analyses of volatile organic compounds by Method TO-14, and for total nonmethane hydrocarbons by Method TO-12. Emission control samples will also be tested for hydrochloric acid and dioxin. Analysis of over 1,200 gas samples is planned.

General basewide and a site-specific health and safety plans will be adhered to during construction and operation of the pilot plant. These plans are presented in Section 8.

Residual soil waste produced during the pilot study will be characterized before disposal by Toxicity Characteristic Leaching Procedure (TCLP) and Total Threshold Limit Concentration (TTLC) analyses.

In addition to the Work Plan, the following reports will be prepared as a part of the Phase II and III activities of the SVE treatability investigation:

- Data Management Manual
- Operations and Maintenance Plan
- Monthly Operation Reports
- Bioventing Performance Report
- Pilot System Evaluation Final Report

The contents of each of these reports is presented in Section 10 of this Work Plan. A schedule of completion dates and deliverables is included in Section 11 of the Work Plan. Section 12 presents the key CH2M HILL staff members assigned to this project.

During the completion of this project, CH2M HILL will continue to provide support to the ongoing community relations program at McClellan AFB as it applies to the SVE treatability investigation.

Acronyms and Abbreviations

AFB	Air Force Base
BACT	best available control technology
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CO_2	carbon dioxide
DNAB	Standard Operating Procedure for Determining Total Hyphal Length, Numbers of Active Bacteria, and Length of Active Fungi
DOT	Department of Transportation
DQO	data quality objective
EDB	Environmental Data Base
EPA	United States Environmental Protection Agency
GC/MS	gas chromatography/mass spectroscopy
GC	gas chromatograph
GWTP	groundwater treatment plant
H_2O	water
HCl	hydrochloric acid
HDPE	high-density polyethylene
Hg	mercury
HPLC	high pressure liquid chromatography
IP	ionization potential
IRP	installation restoration program
IRPIMS	Installation Restoration Program Information Management System
IWTP	industrial wastewater treatment plant
LEL	lower explosive limit
MDL	method detection limit
MOSA	Methods of Soil Analysis
NMOC	Method TO-12, Total Nonmethane Hydrocarbons
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NO_x	nitrous oxides
NWWA	National Water Well Association
OU	Operable Unit
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
ppbv	parts per billion—volume basis
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act

RI/FS	Remedial Investigation/Feasibility Study
RMSF	Rocky Mountain spotted fever
SARA	Superfund Amendments and Reauthorization Act of 1986
scfm	standard cubic feet per minute
SSC	site safety coordinator
SSP	site safety plan
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TCLP	toxicity characteristic leaching procedure
TIC	tentatively identified compound
TLD	thermal luminescent dosimetry
TO-12	Test method for determination of nonmethane organic compounds in ambient air
TO-14	Test method for determination of volatile organic compounds in ambient air using summa passivated canister sampling and gas chromatography analysis
TPH	total petroleum hydrocarbons
TTLC	total threshold limit concentration
VOC	volatile organic compound
UHP	ultra high purity
SRM	standard reference material

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TABLES

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FIGURES

Section 1
Introduction

This work plan has been developed for Phases II and III of the pilot-scale treatability investigation of soil vapor extraction (SVE) at Site S in Operable Unit (OU) D at McClellan Air Force Base (McClellan AFB) near Sacramento, California. The purpose of the treatability investigation is to develop sufficient field and operational data to assess the applicability of SVE technology in removing site-specific contaminants at the base. The information gathered during Phases II and III will be summarized in a report and used in the ongoing Remedial Investigation/Feasibility Study (RI/FS) efforts to aid in selection of cost-effective remediation procedures for specific types and locations of contaminants. The information developed in this treatability investigation will also be used for the design of full-scale SVE systems if SVE is selected as an appropriate remedial action.

Previous investigations at Site S in OU D indicate contaminants were derived from disposal of spent solvents and fuels. Contaminants at Site S are typical of those at many locations across the base. The SVE technology has been successful in removing similar contaminants in similar soil matrices at sites other than McClellan AFB. The treatability investigation at Site S will allow assessment of the effectiveness of SVE in removing volatile contaminants and less-mobile compounds from the waste pit and from the native soils below the pit. The result will also be useful in assessing SVE applications to other similar on-base sites.

Background Information

The SVE treatability investigation will be carried out in Site S of OU D at McClellan AFB, located near Sacramento, California. An area map showing the general location of McClellan AFB is presented as Figure 1-1.

Operable Unit D consists of approximately 140 acres located in the northwest portion of McClellan AFB. The area was first used for waste disposal in the 1940s and was most recently used in 1981. Past disposal practices in OU D included landfills, disposal pits, open burning, incineration, sludge drying beds, and landfarms. Materials disposed within OU D include industrial sludge, waste solvents, fuel, and oil. Approximately 38,000 cubic yards of waste sludge are known to be present in OU D. There are varying levels of volatile organics, organic acids, base/neutral compounds, trace metals, and cyanides present in both the sludge and the surrounding soil. Some of these contaminants have also been detected in the groundwater beneath OU D.

Site S is one of 12 waste disposal sites identified in OU D and encompasses approximately 9,200 square feet. The waste disposal zone extends from about 4 to 25 feet below the ground surface.

In 1985, two soil borings were completed in Site S. The contaminants found in the soil were primarily volatile organic compounds, including ethylbenzene, toluene, xylene, dichlorobenzene, acetone, and 4-methyl-2-pentanone. Some semivolatile compounds were also detected. The data collected during the 1985 investigation were used to select Site S within OU D as the site for the SVE treatability investigation. The data collected during the 1985 investigation confirmed that the pit was used mainly for disposal of spent solvents and fuels, rather than for burn materials or industrial solids.

In 1985, as part of the McClellan AFB Installation Restoration Program (IRP), a multilayer cap was installed over a portion of OU D, then referred to as Area D. Site S is within the capped area. The purpose of the low-permeability cap was to prevent rainwater infiltration and soil gas migration. Thirty-two vent risers were installed in the cap to allow for venting or collection of soil gas that might accumulate under the cap. The majority of invasive actions taken as part of the SVE treatability investigation will require penetrating the cap. Details of the cap penetration are discussed in Section 4.

The SVE treatability investigation will be undertaken in three phases:

- Phase I site characterization was to assess the nature and extent of contaminants within the vadose zone, evaluate the permeability of the vadose zone soils, and obtain site-specific data for design of the pilot-scale SVE system. Phase I work was completed in June 1992.
- Phase II includes additional pre-operation site characterization and installation of the pilot-scale SVE process equipment.
- Phase III includes operation of the pilot plant and evaluation of the SVE technology.

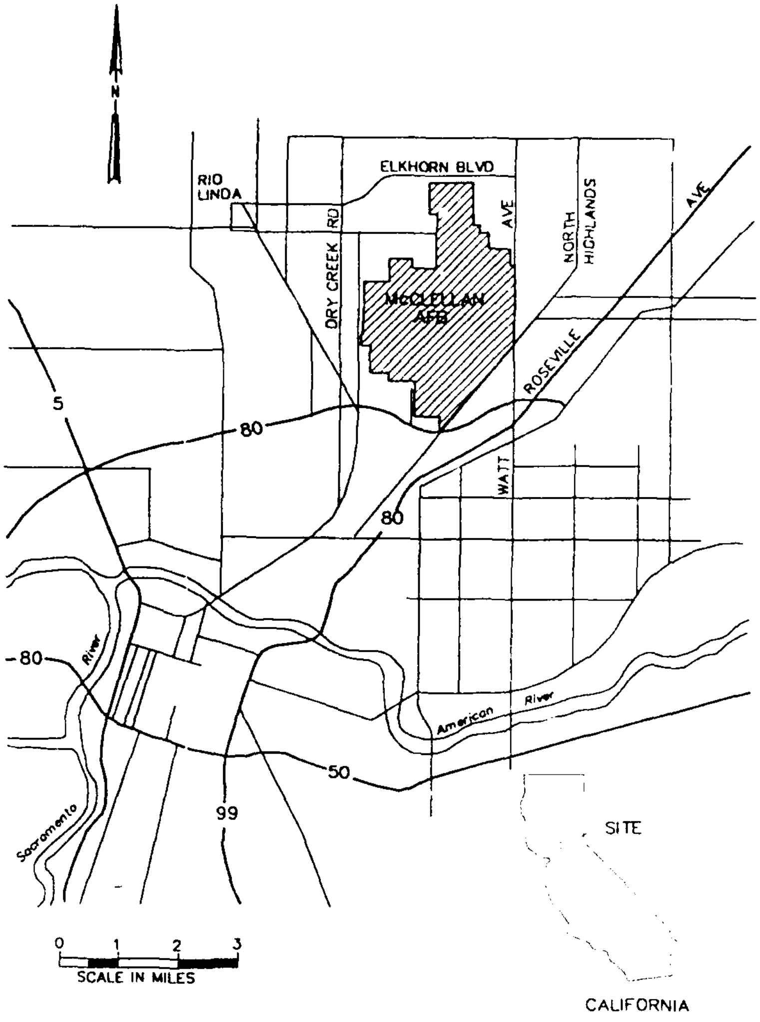
Findings of the Phase I site characterization are presented below.

Phase I Findings

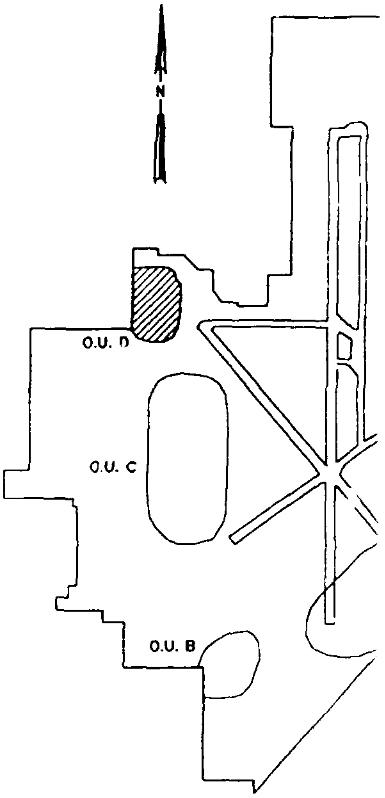
The surface area designated for the SVE pilot test is approximately 4,000 square feet. Five extraction/injection wells and 14 piezometers were installed in this area as part of the site characterization effort. Figure 1-2 presents the locations of these wells and piezometers. Screen locations for the various installations were selected to allow testing and analysis of representative zones of contaminated materials encountered at the site. Five in situ permeability tests were performed using the extraction wells and piezometers. Canister samples of soil gas were collected during the air permeability tests.

Zones of Contamination

Based on the lithologic and contaminant data collected during the Phase I investigation, the following zones of contamination were identified at Site S:



VICINITY MAP



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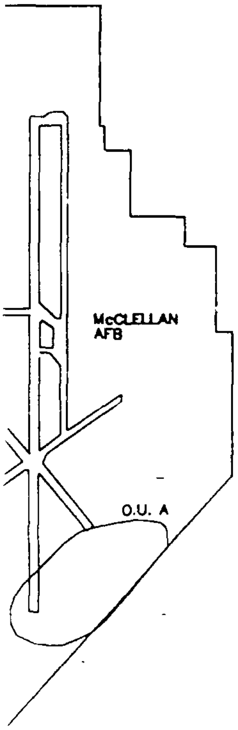

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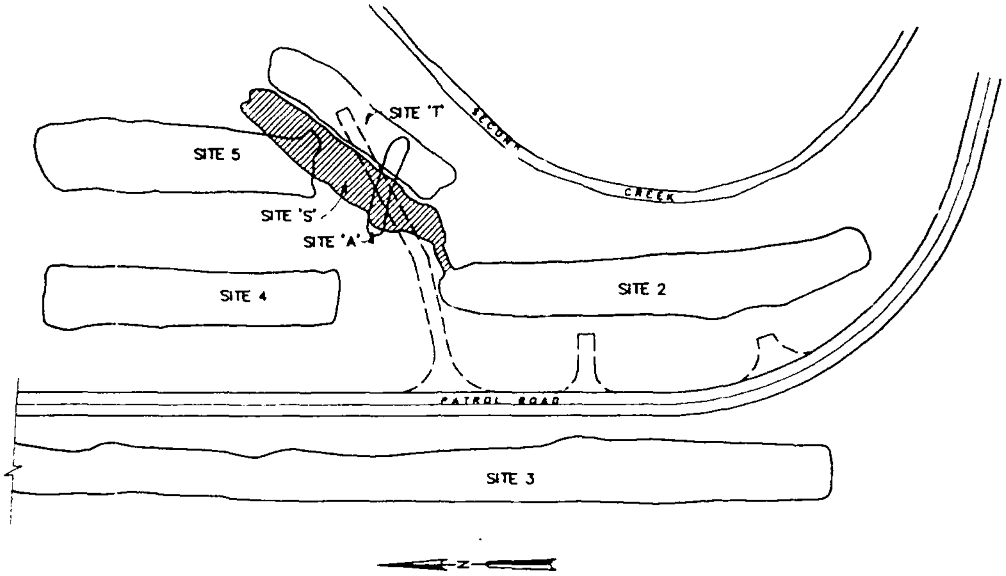

LOCATION OF SITE S IN O.U. D

NTS

FIGURE 1-1
LOCATION PLAN
SITE S, OU D
McCLELLAN AFB

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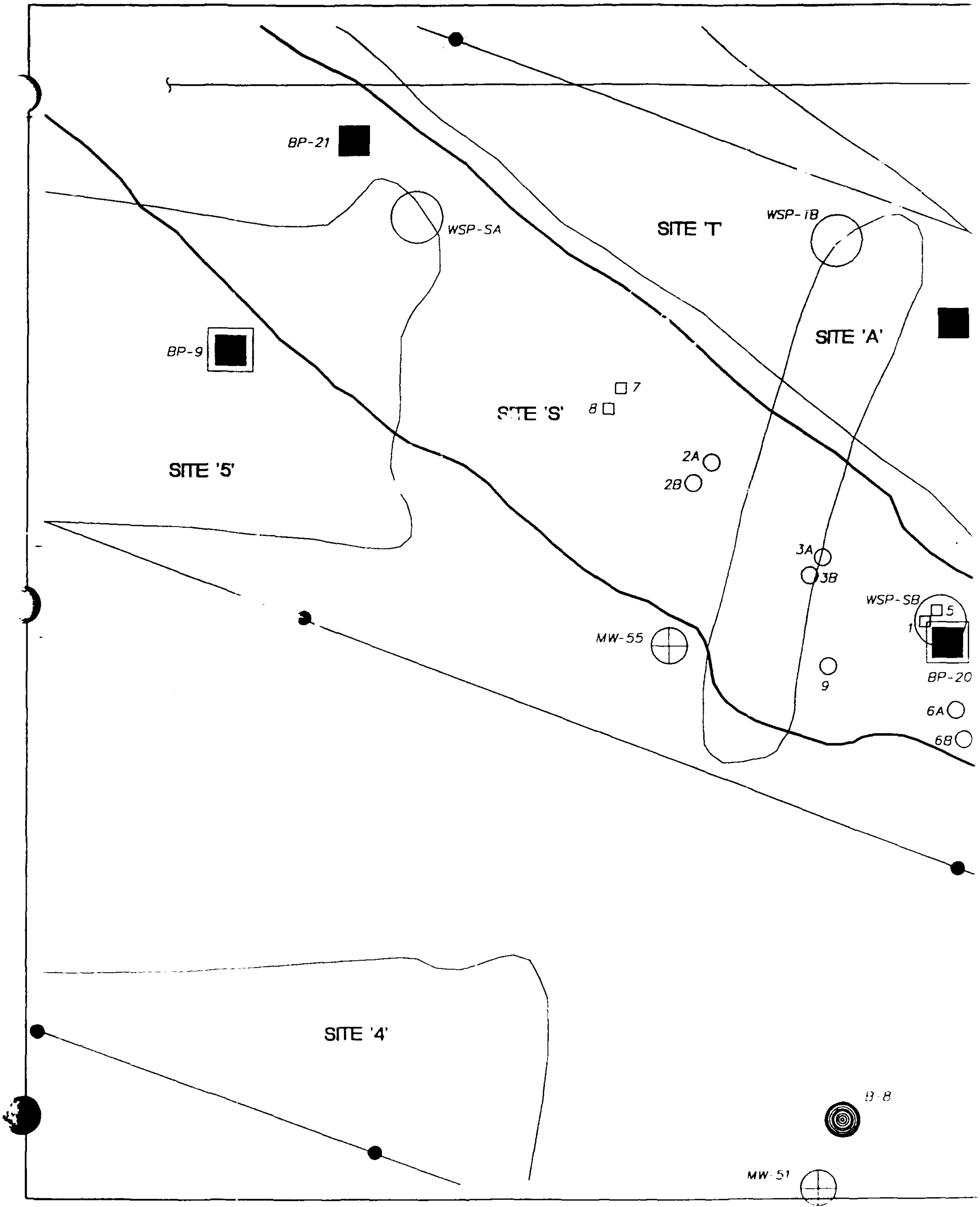
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WSP-SA
SITE 'T'
WSP-1B
SITE 'A'
BP-9
7
8
SITE 'S'
SITE '5'
2A
2B
3A
3B
WSP-SB
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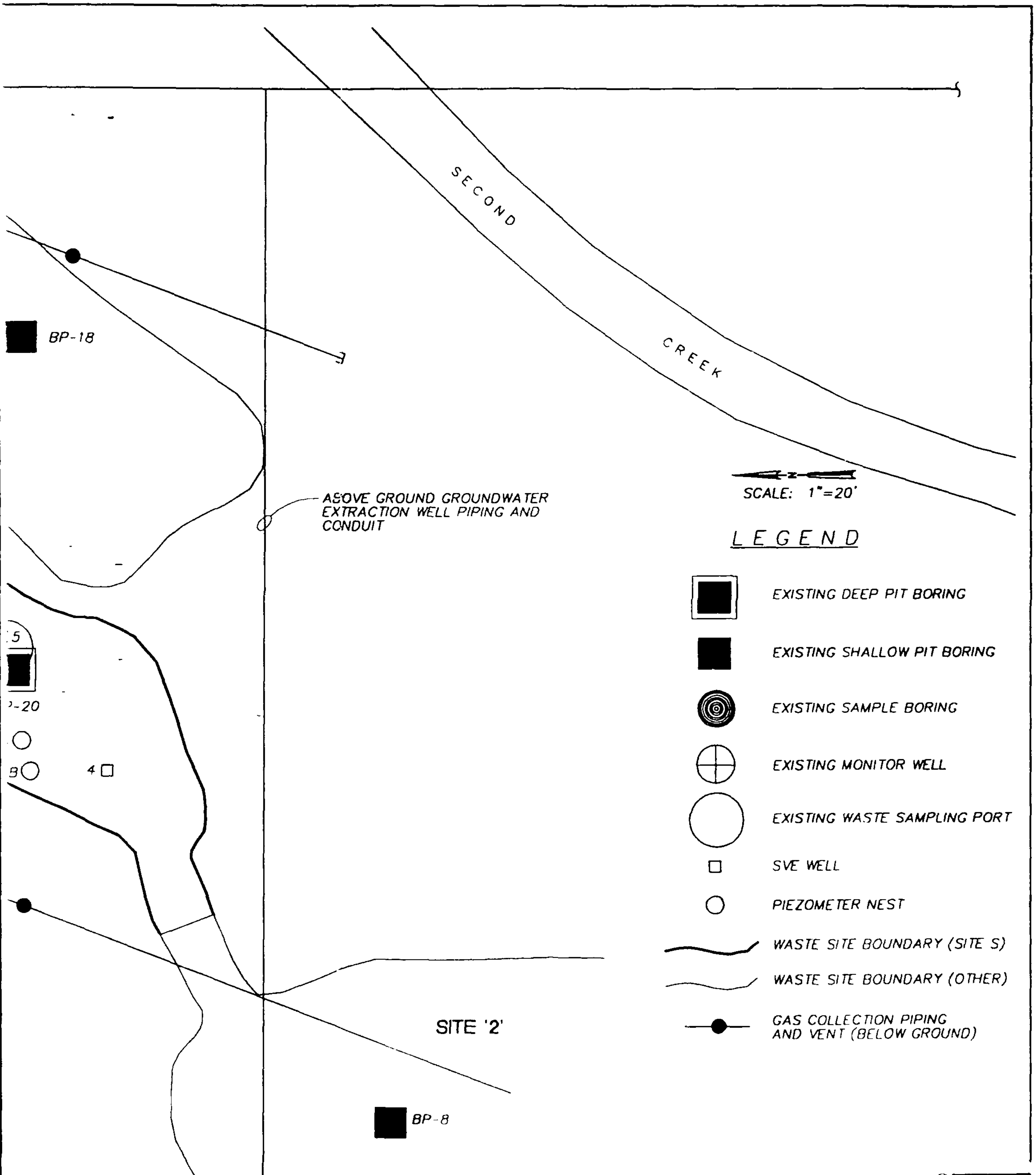

FIGURE 1-2
SITE S WELL AND PIEZOMETER LOCATIONS

Waste Pit (P). Site S (and all of OU D) is capped with a multilayer liner at a depth of approximately 3 feet below ground surface (bgs). The waste pit lies immediately beneath the cap and is characterized by heavy concentrations of contaminants in a matrix of landfilled soils. The average waste pit thickness is approximately 20 feet and extends from the multilayer cap to approximately 25 feet bgs.

Intermediate Alluvium (I). The intermediate alluvial zone is characterized by high concentrations of contaminants in an alluvial soil matrix. The zone consists of the native soil directly below the waste pit. The intermediate alluvial zone has an average thickness of approximately 15 feet, between the depths of 25 feet bgs (bottom of the waste pit) and 40 feet bgs.

Deep Alluvium (D). This zone is characterized by lower concentrations of contaminants in an alluvial soil matrix. The deep alluvial zone consists of the native soil located below the intermediate zone. The deep alluvial zone has an average thickness of approximately 60 feet, between the bottom of the intermediate zone (approximately 40 feet bgs) and the groundwater (approximately 100 feet bgs.)

Physical and Chemical Characteristics

Soil samples were collected during installation of each well or piezometer. Selected samples were tested at offsite laboratories to determine the physical and chemical properties of the materials. Physical properties included horizontal and vertical air permeability; total porosity; bulk density; bulk volume; grain density; sieve analysis; total percent saturation; percent saturation by water; and percent saturation by hydrocarbons. Chemical properties included purgeable hydrocarbons; total petroleum hydrocarbons; purgeable aromatics; volatile organics; pesticides and polychlorinated biphenyls (PCBs); semivolatile organics; dioxins and dibenzofurans; cyanide; total organic carbon; and heavy metals.

Twelve soil vapor samples from the air permeability testing were analyzed for volatile organic compounds and total petroleum hydrocarbons in accordance with United States Environmental Protection Agency (EPA) Method TO-14.

Results of the laboratory permeability tests indicate intrinsic permeabilities varying from about 10^{-3} to 10^{-1} darcies in the silt materials, and from about 10^{-2} to 1 darcies in the silty sand materials.

The analytical results from the soil samples indicate widespread horizontal and vertical organic contamination throughout Site S. The contamination appears to be most prevalent in the zone of the former waste pit, with general trends indicating decreased contamination concentration with depth. The most prevalent compounds at the site appear to be petroleum-based, which is consistent with the past usage of the site. Chlorinated hydrocarbons were also detected throughout the site. Semivolatile organics, PCBs, and dioxins were generally only detected in the waste pit materials. Simple calculations indicate approximately 5,800 pounds of volatile organic contaminants exist within the vadose zone of

Site S, based on the soil sample results. This is probably a low estimate, because of VOC losses during sample collection and analysis.

The contaminants detected in the soil vapor samples from the air permeability tests were predominantly chlorinated hydrocarbons, benzene, toluene, ethylbenzene, and xylenes (BTEX), and petroleum hydrocarbons. The compounds detected at the greatest concentrations in most of the extraction wells were 1,1-dichloroethene and 1,1,1-trichloroethane. The air samples also indicated higher concentrations of vinyl chloride and freons than were determined in the soil samples.

In addition to direct laboratory determinations, soil air permeability was estimated by correlation with grain-size distribution and by analysis of the in situ pressure drawdown test data. Soil air permeability values calculated using the grain-size distribution data compared fairly closely with the laboratory-determined values. Permeability values for similar materials determined from the in situ pressure drawdown tests were generally 10 to 100 times higher than those determined by laboratory or grain-size correlation methods.

The maximum radius of influence of the SVE wells was estimated based on the results of the pressure drawdown tests. A radius of influence of greater than 60 feet was determined for well VES-01, which was screened over its full depth in the vadose zone. A radius of influence of 40 feet was estimated for well VES-04, which was screened in predominantly low permeability material (silty and clayey sand). A radius of influence varying from less than 15 feet to more than 60 feet was estimated for well VES-05, which was screened in the waste pit materials. The variability in radius of influence is indicative of the wide range of material types in the waste pit and the likelihood of encountering zones of relatively impermeable materials. Consequently, SVE wells in the waste pit may be too closely spaced to achieve adequate cleanup.

Section 2
SVE Technology Description

SVE is a relatively new technology that has demonstrated effective removal of VOCs from a variety of soil conditions within the vadose zone. To a lesser extent, SVE has also shown promise in removing some VOCs from heavier hydrocarbons. The technology consists of a series of soil gas extraction wells screened within the zone of contamination. The wells are connected by header pipes to one or more high-capacity blowers. The blowers create a vacuum within the soil and transfer the contaminant-laden soil gas to an emission control system for destruction of the contaminants. Based on an analysis of best available control technology (BACT), a catalytic oxidation system has been selected for the emission control system. The catalytic oxidation system was selected over other technologies because of its ability to destroy vinyl chlorides and methylene chloride, its relatively low nitrous oxides (NO_x) emissions, and its high contaminant destruction efficiency.

The vacuum extraction rate of the SVE system will be reduced to the minimum to sustain aerobic biological degradation of contaminants within the vadose zone after a short period of SVE operation. This bioventing period will allow evaluation of the impact of biodegradation on contaminant removal.

Following bioventing, the conventional SVE system will be enhanced with hot air injection within the waste pit and intermediate alluvial zones. A blower will be used to heat and pressurize injection air to approximately 250°F. The increase in soil gas temperature should enhance volatilization of the VOCs and increase naturally occurring biodegradation.

Soil vapor extraction pilot-scale treatability investigations typically consist of an initial testing stage to establish baseline conditions, a startup period, an operational period, and final testing. The operational period will comprise standard SVE operations, bioventing, and enhanced SVE operations. Section 3 contains the objectives of the Site S pilot-scale treatability investigation and outlines the duration necessary for each stage of the investigation.

Section 3
Pilot Treatability Investigation Objectives

Data previously collected during Phase I and those to be collected during Phases II and III will be used to evaluate the effectiveness of treatment by SVE at Site S, OU D. More specifically, the following are the objectives of the SVE treatability investigation:

1. Quantify the mass of contaminants removed during operation of the pilot-scale system.
2. Evaluate the reduction of specific contaminants in the waste pit and alluvial deposits.
3. Evaluate the benefits of hot air injection as an enhancement to SVE in the waste pit.
4. Evaluate vadose zone transport processes to identify major mechanisms controlling contaminant migration and document the reasons for discounting other migration mechanisms.
5. Evaluate the degree of biodegradation.
6. Identify strata from which contaminants are difficult to remove by SVE.
7. Evaluate performance of the SVE offgas emission control system.
8. Evaluate the applicability of SVE to OU D and collect sufficient operational data to support the detailed analysis of SVE as a remedial action alternative in the feasibility study for OU D.
9. Assess general applicability of SVE at other McClellan AFB sites.

The frequency of sampling to achieve each of the above objectives is based primarily on professional judgement and experience by CH2M HILL. However, collection of these data does not guarantee evaluation of these objectives is possible.

Data Collection Matrices

Following is a summary of the matrices from which data will be collected to evaluate the SVE treatability investigation objectives. Table 3-1, presents the SVE treatability investigation objectives versus the matrices from which samples will be collected.

Table 3-1
Sample Matrices

Goals and Objectives	Soil			Soil Gas	SVE Offgas			Emissions Control (Stack)
	Waste Pit	Intermediate Alluvium	Deep Alluvium		Extraction Wells	Extraction Well Manifolds	Transfer Piping	
1. Quantify mass of contaminants removed					X	X	X	
2. Evaluate the reduction of specific contaminants in the waste pit and alluvial deposits	X	X	X	X	X	X		
3. Evaluate the benefits of hot air injection as an enhancement to SVE in the waste pit	X	X		X	X	X		
4. Evaluate vadose zone transport processes to identify major mechanisms controlling contaminant migration	X	X	X	X				
5. Evaluate the degree of biodegradation	X	X		X		X		
6. Assess whether preferential removal of contaminants from different strata is occurring	X	X	X	X				
7. Evaluate performance of the SVE offgas emission control system							X	X
8. Evaluate applicability of SVE at OU D and as a remedial action alternative for the OU D FS	X	X	X	X	X	X	X	X
9. Assess general applicability of SVE at other McClellan AFB sites	X	X	X	X	X	X	X	X

Soil

Soil borings will be installed and samples collected from various locations in the waste pit, and intermediate and deep alluvial soils.

Soil Gas

The 14 piezometers at Site S have been installed throughout the vadose zone from 13 feet bgs to 96 feet bgs. Each piezometer contains a narrow screened zone (2-1/2 to 3 feet) and will therefore provide soil gas concentrations from a narrow band of the vadose zone. Five piezometers are screened in the waste pit, three in the intermediate alluvium, and six in the deep alluvium. A cross section of the piezometers is presented in Section 5, Figure 5-3. Soil gas samples will be collected at the riser stems of each of the 14 piezometers.

SVE Offgas Extraction Wells

Soil vapor samples will be collected from 17 soil vapor extraction wells at Site S. Seven of these extraction wells are screened in the waste pit (PSP-1 through PSP-7), five in the intermediate alluvial zone beneath the waste pit (PSI-1 through PSI-5), and five in the deep alluvial zone (PSD-1 through PSD-5).

SVE Offgas (Extraction Well Manifolds and Transfer Piping)

Soil vapor samples will be collected from the manifold piping from each of the three contaminant zones. One manifold will comprise soil vapor from all deep extraction wells. A second manifold will comprise soil vapor from all intermediate depth extraction wells. The third manifold will comprise soil vapor from the waste pit extraction wells.

The combined soil vapor from all extraction wells will be sampled at the transfer piping before entering the emissions control system.

Figure 3-1 presents a schematic of the SVE offgas sample locations.

Emissions Control

Samples will be collected from the stack gases prior to discharge to the atmosphere.

Data Collection Periods

Sampling of the various matrices will occur throughout the SVE treatability investigation. To simplify the sampling and evaluation of the SVE treatability investigation objectives, data collection has been separated into discreet sampling periods. Table 3-2 presents the SVE treatability investigation objectives versus the sampling periods during which samples will be collected.

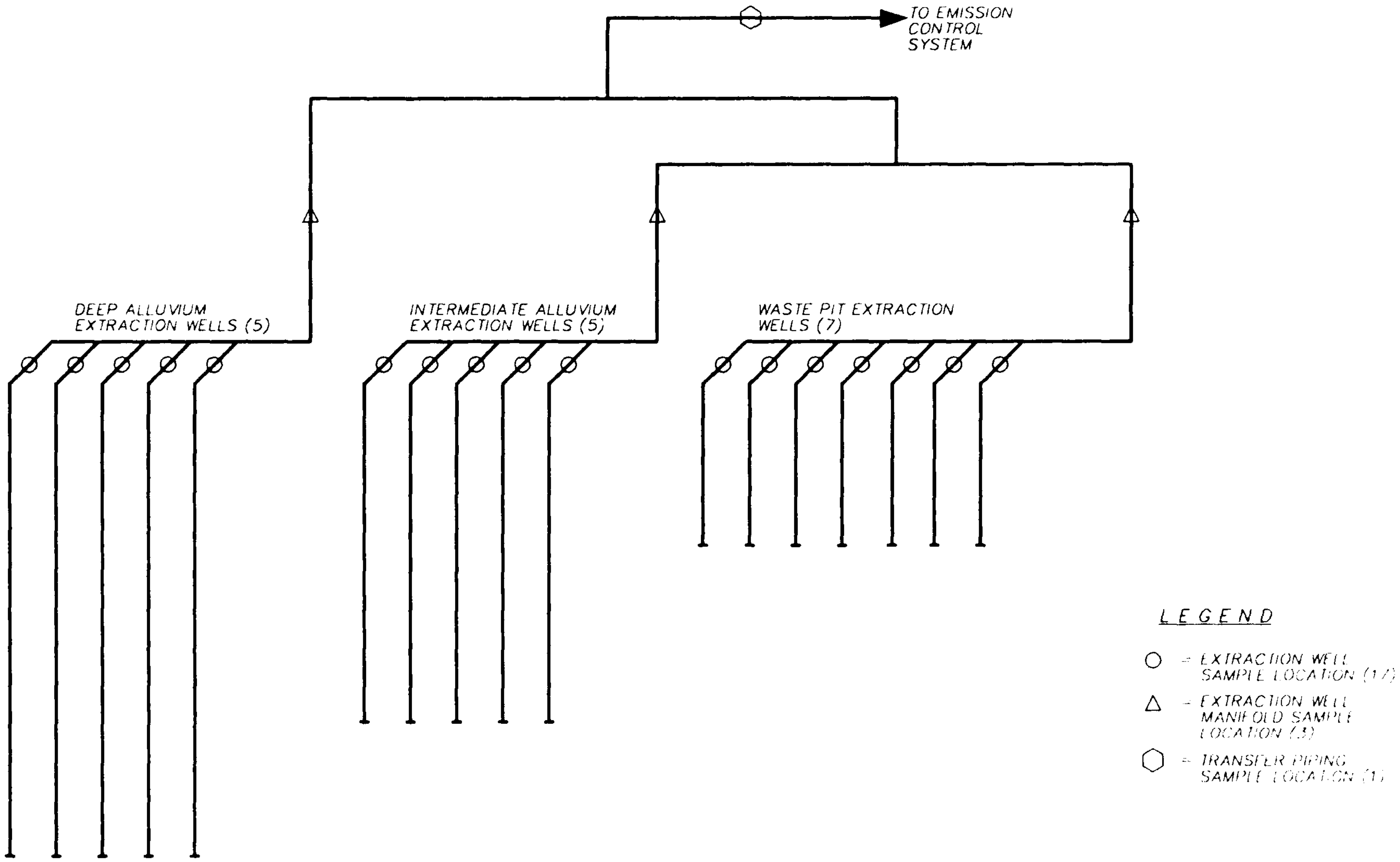

FIGURE 3-1
SVE OFFGAS SAMPLE LOCATION SCHEMATIC

Table 3-2
Sample Periods

	Soil			Soil Gas, SVE Offgas, Emission Control				
	Phase II	Phase III		Phase III				
Goals and Objectives	Pre-Operation	Mid-Operation	Post-Operation	Pre-Operation[a]	Initial Testing	Startup	Continued Operation	Post-Operation[a]
1. Quantify mass of contaminants removed					X	X	X	
2. Evaluate the reduction of specific contaminants in the waste pit and alluvial deposits	X		X	X	X	X	X	X
3. Evaluate the benefits of hot air injection as an enhancement to SVE in the waste pit	X	X	X	X	X	X	X	X
4. Evaluate vadose zone transport processes to identify major mechanisms controlling contaminant migration	X		X	X				X
5. Evaluate the degree of biodegradation	X	X	X	X	X	X	X	X
6. Assess whether preferential removal of contaminants from different strata is occurring	X		X	X	X	X	X	X
7. Evaluate performance of the SVE offgas emission control system					X	X	X	
8. Evaluate applicability of SVE at OU D and as a remedial action alternative for the OU D FS	X	X	X	X	X	X	X	X
9. Assess general applicability of SVE at other McClellan AFB sites	X	X	X	X	X	X	X	X

[a] Soil gas sampling only.

Soil

Soil sampling will be performed at three times during the SVE treatability investigation.

Pre-Operation. Pre-operation soil sampling will supplement data collected during the Phase I site characterization and establish baseline conditions existing in the soil before operation of the SVE pilot plant.

Mid-Operation. Midway through the SVE treatability investigation, but following the bioventing period (see below), the soil will be sampled again to help establish rates of contaminant removal for certain parameters. Furthermore, the mid-operation sampling will help establish baseline conditions existing before implementation of the SVE enhancements.

Post-Operation. Following termination of the SVE pilot plant operation, post-operation soil samples will be collected for comparison to pre-operation and mid-operation samples.

Soil Gas, SVE Offgas, and Emissions Control

The SVE pilot plant operation will last approximately six months, excluding system monitoring before startup and after shutdown. For the purpose of soil gas, SVE offgas and emissions control sampling, the treatability investigation will be separated into five components or sampling periods.

Pre-Operation. The pre-operation period will be used to establish baseline conditions prior to startup of the SVE pilot plant. Pre-operation sampling will last less than 4 weeks.

Initial Testing. After the SVE pilot system has been fully installed the SVE system will be checked for safety and operational effectiveness. Initial testing will last approximately 1 week.

Startup. The system startup period will be used to optimize and fine tune each of the SVE pilot plant components. System startup will last approximately 5 weeks.

Continued Operation. The continued operation period of the SVE treatability investigation comprises the remainder of the pilot plant test. Adjustments to the SVE pilot system components will continue to be made during continued operation to optimize system performance and minimize the occurrence of dead zones in the vadose zone. Six to 8 weeks into the continued operation period, the SVE system will be turned down to provide a low vapor extraction rate (bioventing). The low flows will be maintained for a period of 4 to 6 weeks and biodegradation will be investigated. For the remainder of the continued operation period, the SVE enhancements will be implemented with the SVE flow rate turned back up. The continued operation period will last approximately 20 weeks.

Post-Operation. Post-operation sampling will be conducted to establish site conditions following completion of the SVE pilot system operation. Post-operation sampling will last less than 4 weeks.

Sample Analyses

Certain analyses will be performed on samples from the sample matrices discussed previously. Following is a brief summary of the analyses to be performed in support of the SVE treatability investigation objectives. Table 3-3 presents the SVE treatability investigation objectives versus the analytical methods to be performed.

Soil

Physical Properties. Certain soil samples will be analyzed for physical properties to confirm lithology and identify physical characteristics of specific soil types found at Site S. Twelve samples were analyzed for physical properties during the Phase I site characterization. It is assumed the physical properties of the soil in the vadose zone, with the exception of moisture content, will not change during the SVE treatability investigation, so no mid-operation nor post-operation samples will be analyzed for physical properties other than moisture content.

Total Petroleum Hydrocarbons (Modified Method 8015). Certain TPH compounds may be removed from the soil by the SVE technology and extraction of VOCs may encourage partitioning of TPH. Those TPH compounds remaining will be measured in the soil by the TPH method.

Chemical Oxygen Demand (MOSA 29-3.5.3). Chemical oxygen demand (COD) in soil is primarily a measure of the organic component of the TPH present and is an indication of biodegradation potential. Some aromatic hydrocarbons, however, are not oxidized in the COD test.

Moisture Content (MOSA 21-2.2). Moisture content will be measured to monitor the suitability of the soil environment for microbial activity, and to determine if SVE induces drying.

pH (MOSA 12-2.6). Soil pH will be measured to determine if the in situ pH is within the optimal range for microbial activity.

Ammonia-Nitrogen (MOSA 33-3.2, EPA 350.3), Nitrate-Nitrogen (MOSA 33-3.2, EPA 300.0), and Orthophosphate-Phosphorus (MOSA 24-5.3, EPA 300.0). The inorganic nutrients nitrogen and phosphorous are required for microbial growth. Consequently, these nutrients will be measured in soils to determine if they are available in sufficient supply to

Table 3-3
Schedule of Analyses

Page 1 of 3

Goals and Objectives	Soil Analysis (Method)							
	Physical Properties	Moisture Content (MOSA 21-2.2)	pH (MOSA 12-2.6)	TPH (Modified 8015)	Chemical Oxygen Demand (MOSA 29-3.5.3)	Total Organic Carbon (EPA 415.1)	Microbiological Assay (DNAB)	Nutrients[a]
1. Quantify mass of contaminants removed								
2. Evaluate the reduction of specific contaminants in the waste pit and alluvial deposits	X			X				
3. Evaluate the benefits of hot air injection as an enhancement to SVE in the waste pit		X	X	X	X		X	X
4. Evaluate vadose zone transport processes to identify major mechanisms controlling contaminant migration	X			X		X		
5. Evaluate the degree of biodegradation		X	X	X	X		X	X
6. Assess whether preferential removal of contaminants from different strata is occurring	X			X				
7. Evaluate performance of the SVE offgas emission control system								
8. Evaluate applicability of SVE at OU D and as a remedial action alternative for the OU D feasibility study	X			X		X		
9. Assess general applicability of SVE at other McClellan AFB sites	X			X		X		

[a] NH_3-N (MOSA 33-3.2, EPA 350.3); NO_3-N (MOSA 33-3.2, EPA 300.0); orthophosphate-phosphorus (MOSA 24-5.3; EPA 300.0).

Table 3-3
Schedule of Analyses

Page 2 of 3

Goals and Objectives	Soil Gas Analysis (Method)					SVE Offgas Analysis (Method)							
						Vapor Extraction Wells			Extraction Well Manifolds				
	VOCs (onsite GC)	VOCs (TO-14)	Total Nonmethane Hydro-carbons (TO-12)	Oxygen Uptake Rate Temperature, Relative Humidity, CO_2/O_2	Methane (meter)	VOCs (onsite GC)	VOCs (TO-14)	Total Nonmethane Hydro-carbons (TO-12)	VOCs (Onsite GC)	VOCs (TO-14)	Total Nonmethane Hydro-carbons (TO-12)	CO_2 (meter)	O_2 (meter)
1. Quantify mass of contaminants removed						X	X	X	X	X	X		
2. Evaluate the reduction of specific contaminants in the waste pit and alluvial deposits	X	X	X			X	X	X	X	X	X		
3. Evaluate the benefits of hot air injection as an enhancement to SVE in the waste pit	X	X	X	X		X	X	X	X	X	X	X	X
4. Evaluate vadose zone transport processes to identify major mechanisms controlling contaminant migration	X	X											
5. Evaluate the degree of biodegradation				X	X							X	X
6. Assess whether preferential removal of contaminants from different strata is occurring	X	X	X										
7. Evaluate performance of the SVE offgas emission control system													
8. Evaluate applicability of SVE at OU D and as a remedial action alternative for the OU D feasibility study	X	X	X			X	X	X	X	X	X		
9. Assess general applicability of SVE at other McClellan AFB sites	X	X	X			X	X	X	X	X	X		

Table 3-3
Schedule of Analyses

Page 3 of 3

Goals and Objectives	SVE Offgas—Transfer Piping					Emission Controls Analyses (Method)				
	VOCs (onsite GC)	VOCs (TO-14)	Total Nonmethane Hydrocarbons (TO-12)	CO_2*	O_2*	HCL (M26)	Dioxins (M23)	VOCs (onsite GC)	VOCs (TO-14)	Total Nonmethane Hydrocarbons (TO-12)
1. Quantify mass of contaminants removed	X	X	X							
2. Evaluate the reduction of specific contaminants in the waste pit and alluvial deposits										
3. Evaluate the benefits of hot air injection as an enhancement to SVE in the waste pit										
4. Evaluate vadose zone transport processes to identify major mechanisms controlling contaminant migration										
5. Evaluate the degree of biodegradation										
6. Assess whether *preferential* removal of contaminants from different strata is occurring										
7. Evaluate performance of the SVE offgas emission control system	X	X	X	X	X	X	X	X	X	X
8. Evaluate applicability of SVE at OU D and as a remedial action alternative for the OU D feasibility study	X	X	X	X	X	X	X	X	X	X
9. Assess general applicability of SVE at other McClellan AFB sites	X	X	X	X	X	X	X	X	X	X

*Process Monitoring—real time results.

support biodegradation, and to monitor changes in nutrient levels over time. The MOSA methods are used to extract soil samples, and the EPA methods are used for extract analysis.

Total Organic Carbon (EPA 415.1). Total organic carbon (TOC) data provide information regarding how strongly contaminants adsorb to the soil particles. Eight samples were analyzed for TOC during the Phase I site characterization investigation. No further TOC analyses will be performed.

Microbiological Assay (DNAB). The population of microorganisms in the soil is impacted by the quantity of organic matter in the soil, oxygen in the soil pores, temperature, and various other factors. A microbiological assay in the soil provides a direct measure of biological activity.

Soil Gas and SVE Offgas

Volatile Organic Compounds (Onsite GC). The onsite GC will provide a rapid and inexpensive means to quantify 17 targeted VOCs.

Volatile Organic Compounds (TO-14). Method TO-14 provides quantification of 41 VOCs compared to 17 VOCs with the onsite GC. Furthermore, Method TO-14 uses mass spectroscopy and therefore provides a more positive identification of contaminants. It will be used to provide supplementary information and as a quality control check of the onsite GC results. Each TO-14 sample will be collected as a duplicate to an onsite GC sample at a frequency of one TO-14 for every 20 onsite GC analyses performed per matrix for duration of the project.

Total Nonmethane Hydrocarbons (TO-12). The onsite GC method uses PID and ECD detectors to speciate 17 VOCs. These detectors cannot reliably quantify total nonmethane hydrocarbons; therefore, an offsite analysis method to quantify total nonmethane hydrocarbons is required.

Oxygen, Carbon Dioxide, and Methane (O_2/CO_2 Meter, CH_4 Meter). These gases will be measured in soil gas samples collected from piezometers to determine aeration status and measure O_2 uptake and CO_2 production rates. A number of the commercially available meters will be evaluated to select the appropriate models to meet project needs.

Relative Humidity (RH Meter). The relative humidity of soil gas samples collected from piezometers will be measured to evaluate moisture levels and drying during the treatability investigation.

Emissions Control

Emissions control samples will be analyzed for VOCs by onsite GC and Method TO-14, and for total nonmethane hydrocarbons by Method TO-12. These analyses have been summarized previously. Emissions control samples will also be analyzed for hydrochloric acid and dioxins. For control of the emission control system, transfer piping offgas will be monitored for oxygen and carbon dioxide.

Carbon Dioxide and Oxygen (In-Line Probe). Monitoring oxygen and carbon dioxide concentrations in the offgas transfer piping will provide information to aid in control of the emission control process.

Hydrochloric Acid (Method 26). Chlorinated hydrocarbons will be converted to carbon dioxide, water vapor, and hydrochloric acid (HCL) gas in the emission controls system. Measurement of HCL is required to ensure compliance with discharge standards.

Dioxins (Method 23). Trace levels of dioxin congeners have been reported from thermal incinerators in the past. Although the emission controls system operates at a much lower temperature than thermal incinerators, the possibility still exists dioxin congeners could be generated at low levels during oxidation.

Objective (1): Quantify the Mass of Contaminants Removed During Operation of the Pilot-Scale System

1.1 Data Needs

To quantify the mass of volatile organic contaminants removed during the operation of the pilot-scale system, the following data are needed:

- Flow rate of extracted soil vapor
- Contaminant concentrations in the extracted soil vapor
- Time of operation and time between sampling events

1.2 Data Acquisition

It is expected the SVE pilot system will continue to withdraw contaminants from the vadose zone throughout the SVE treatability investigation. The mass of volatile contaminants removed can best be determined by monitoring the VOC and total nonmethane hydrocarbon concentrations in the SVE offgas and recording the vapor extraction rates. SVE offgas samples will be monitored throughout the initial testing, startup, and continued operation periods of the treatability investigation. Samples will be collected at the extraction wells to estimate removal rates from various depths and locations around the site.

Samples will also be collected from the three extraction well manifolds to determine contaminant removal rates from the waste pit, intermediate, and deep alluvial zones. Samples of the combined offgas from the transfer piping will provide an overall quantification of contaminant removal.

Flow rates of the SVE offgas will be measured during sampling events at the individual well heads, the manifold system, and the transfer piping.

1.2.1 SVE Offgas (Vapor Extraction Wells)

The extraction wells will be sampled for VOCs and total nonmethane hydrocarbons during the initial testing, startup, and continued operation periods.

1.2.1.1 Targeted VOCs (Onsite GC). Each of the 17 vapor extraction wells will be sampled once a week during the initial testing and startup periods. After 6 weeks of operation it is estimated that the SVE wells will be analyzed once every 2 weeks and after 14 weeks the frequency is assumed to drop to once every 3 weeks. The rational for reducing the sampling frequency is based on the assumption that SVE offgas concentrations will decrease sharply over the first 3 to 4 months. This assumes that less samples will be required to estimate the reduction of contaminants from each extraction well. If contaminant concentrations do not decrease as expected, samples will continue to be analyzed once every 2 weeks.

1.2.1.2 Offsite VOCs (TO-14). To provide QC checks, TO-14 analyses will be performed at a rate of 1 for every 20 onsite GC analyses performed over the duration of the investigation. Each TO-14 sample will be collected in duplicate with an onsite GC targeted VOC sample.

Samples will be analyzed during initial testing when the VOC concentrations are expected to be highest, during startup, and several times during continued operations to confirm the expected decline in contaminant concentrations. Samples representative of the waste pit and intermediate and deep alluvial deposits should be collected to provide information concerning contaminant levels at various depths. However, in general, more samples will be analyzed in the waste pit zone and intermediate zone than the deep zone because of the heavy concentration of contaminants there.

1.2.1.3 Total Nonmethane Hydrocarbons (TO-12). It is estimated one sample from each extraction well during initial testing and one sample from each extraction well every 4 weeks thereafter will be sufficient to quantify the mass of contaminants removed from each extraction well.

1.2.2 SVE Offgas (Extraction Well Manifolds and Transfer Piping)

The extraction well manifolds and transfer piping will be sampled for VOCs and total nonmethane hydrocarbons during the initial testing period, startup period, and continued operation.

1.2.2.1 Targeted VOCs (Onsite GC). Each of the three vapor extraction well manifolds and the transfer piping will be sampled more frequently during the first 3 to 4 months. Over the duration of the project, the total number of samples is planned to average one sample per week from each manifold and the transfer piping.

1.2.2.2 Offsite VOCs (TO-14). Data acquisition for VOCs is the same as presented in Part 1.2.1.2.

1.2.2.3 Total Nonmethane Hydrocarbons (TO-12). An average of one sample from each manifold and the transfer piping every 2 weeks will be sufficient to quantify the total nonmethane hydrocarbons removed from each contaminant zone.

1.3 Data Analysis and Interpretation

Following is a brief summary of the methods to be used for data analysis and interpretation of the SVE offgas.

Contaminant removal rates will be determined by multiplying the measured concentrations of each contaminant by the volumetric flow rate. The removal rates (pounds/hour) will be plotted with respect to operational time of the pilot system. The removed mass of selected VOCs will be calculated from the area under the respective curve.

As with the individual VOC analyses, total nonmethane hydrocarbon removal rate will be plotted with respect to operation time, and the mass removed calculated from the area under the curve.

Measuring the vapor concentrations in the extracted vapors gives an idea of the effectiveness of the system; however, a decrease in vapor concentrations is not necessarily strong evidence that soil concentrations have decreased. Decreases in vapor concentrations can also be attributed to other phenomena, such as water table upwelling, increased mass transfer resistance due to drying, diffusion-limited mass transfer flow from dead zones, or leaks in the extraction system ("short-circuiting") (Johnson et al., 1989). Monitoring of the extraction well vapor composition as well as the concentration gives more insight into the effectiveness of the system. If the total vapor concentration decreases without a change in composition, then it is most likely due to one of the phenomena listed above. If the decrease in concentration is accompanied by a shift in composition to less volatile compounds, then it is most likely due to a change in the residual contaminant concentration. DePaoli et al., (1989) has shown how the composition of the extracted soil gas changed over the course of system operation. As the total volume of gas extracted increased, the fraction of lighter-end components decreased while the fraction of heavier components increased markedly. Lighter, more volatile constituents (such as butane and propane) are removed first. As more vapor is removed, the heavier, less volatile constituents predominate due to the absence of the light fraction.

The SVE offgas from the transfer piping will be sampled at a higher frequency during the first 3 to 4 months in order to provide an accurate estimate of the total VOC extraction rate. Several researchers have shown that the rate of VOC extraction is high initially, but decreases with time. This decrease may signal the transfer to a diffusion limited system. In other words, the saturated vapors present in the soil at system startup are quickly removed. Removal of contaminants thereafter may be diffusion-limited. Since diffusion rates are slower than advection, removal rates drop with time of continuous operation.

There is a possibility, however, that air entering Site S will not decrease sharply in concentration if there is a significant mass of contamination in the surrounding waste sites. Air flowing to Site S will pass through these sites before reaching Site S. Some contaminants will be transferred from these other sites to the vapor stream extracted by the Site S SVE system. Air entering Site S could remain at concentrations greater than approximately 1,250 ppm and volatilization of contaminants from Site S could plateau. This could result in residual concentrations in excess of preliminary remediation goals after the proposed operating period. If residual concentrations remain high, then the effect and success of the SVE treatability investigation will be measured more in terms of total mass of VOCs removed during the test. Contingency measures will be developed to further reduce zones of high residual contamination. These measures could include extending the period of operation, or installing additional extraction and injection wells in other sites surrounding Site S.

Objective (2): Evaluate the Reduction of Specific Contaminants in the Waste Pit and Alluvial Deposits

2.1 Data Needs

To evaluate the reduction of specific contaminants, the following data are needed:

- Physical properties for the vadose zone and pit materials
- Contaminant concentrations in the extracted soil vapor
- TPH concentrations in the soil samples

2.2 Data Acquisition

To evaluate the reduction of specific contaminants in the waste pit and alluvial deposits, soil gas, SVE offgas at the extraction wells and extraction well manifolds, and the soil will be sampled.

Soil gas samples will be collected and analyzed throughout the five periods of the SVE treatability investigation. SVE offgas samples will be monitored throughout the initial testing, startup, and continued operation periods of the treatability investigation. Samples will be collected at the extraction wells to estimate the reduction of contaminants at various depths and locations around the site. Samples will also be collected from the three extraction well manifolds to determine the reduction of contaminants in the waste pit, intermediate, and deep alluvial zones.

Soil samples will be collected from various locations within the vadose zone during the pre-operation, and post-operation sampling periods.

2.2.1 Soil Gas

Soil gas samples will be analyzed for VOCs and total nonmethane hydrocarbons.

2.2.1.1 Targeted VOCs (Onsite GC). Each of the 14 piezometers will be sampled once prior to initial testing of the SVE system. This will provide baseline data of initial soil gas concentrations from each of the targeted zones in the waste pit, intermediate alluvial, and deep alluvial zones. During initial testing and startup (6 weeks total), one sample will be collected from each piezometer every 2 weeks. During continued SVE operation, piezometers will be sampled approximately once every 3 weeks to provide data on percent reduction of contaminants and to modify SVE system flows and vacuums to minimize the occurrence of "dead zones." After SVE operation has been discontinued, the piezometers will be sampled approximately twice to estimate the overall percent reduction of contaminants in the soil gas from each piezometer.

2.2.1.2 Offsite VOCs (TO-14). Data acquisition for VOCs is the same as presented in Part 1.2.1.2. In addition, samples will be analyzed during pre-operation to assess baseline contaminant concentrations.

2.2.1.3 Total Nonmethane Hydrocarbons (TO-12). It is estimated that one sample from each piezometer prior to startup and one sample every 4 weeks thereafter will be sufficient to evaluate the percent reduction of total nonmethane hydrocarbons in the soil gas.

2.2.2 SVE Offgas (Vapor Extraction Wells)

Extraction well offgas will be analyzed for VOCs and total nonmethane hydrocarbons.

2.2.2.1 Targeted VOCs (Onsite GC). Data acquisition for VOCs is the same as presented in Part 1.2.1.1.

2.2.2.2 Offsite VOCs (TO-14). Data acquisition for VOCs is the same as presented in Part 1.2.1.2.

2.2.2.3 Total Nonmethane Hydrocarbons (TO-12). Data acquisition for total nonmethane hydrocarbons is the same as presented in Part 1.2.1.3.

2.2.3 SVE Offgas (Extraction Well Manifolds)

Extraction well manifolds will be monitored for VOCs and total nonmethane hydrocarbons.

2.2.3.1 Targeted VOCs (Onsite GC). Data acquisition for VOCs is the same as presented in Part 1.2.2.1.

2.2.3.2 Offsite VOCs (TO-14). Data acquisition for VOCs is the same as presented in Part 1.2.1.2.

2.2.3.3 Total Nonmethane Hydrocarbons (TO-12). Data acquisition for nonmethane hydrocarbons is the same as presented in Part 1.2.2.3.

2.2.4 Soil

The soil at Site S will be sampled for physical properties and TPH in the waste pit and intermediate alluvium during the pre-operation period. Sufficient deep alluvium data have been collected during the Phase I site characterization. Samples from all three zones will be analyzed for TPH during the post-operation soil investigation.

2.2.4.1 Physical Properties. Ten pre-operation soil samples will be analyzed for physical properties in the waste pit and intermediate alluvium. Half the samples will be collected in the waste pit and half in the intermediate alluvial zone.

2.2.4.2 Total Petroleum Hydrocarbons (Modified Method 8015). Twenty samples will be analyzed for TPH during the pre-operation and 31 samples during the post-operation soil investigation.

2.3 Data Analysis and Interpretation

Following is a brief summary of the methods to be used for data analysis and interpretation of the soil gas, SVE offgas and soil analytical data.

2.3.1 Soil Gas

The percent reduction for various target analytes will be calculated in a manner similar to that for the SVE offgas samples as presented below. In addition to calculating overall percent reduction in contaminants, the soil gas data will be used to assess the operational aspects of the pilot study (i.e., identification of "dead" zones) as discussed in Section 5.

2.3.2 SVE Offgas

The reduction of the target analytes in each subsurface zone will be determined by comparing the measured concentrations at various times during the project such as initial system startup, startup of hot air injection, and completion of SVE operation.

2.3.3 Soil

Soil samples will be collected from pre-operation and post-operation soil borings and analyzed for TPH. Average contaminant masses will be determined for each period by multiplying the average measured concentration by the volume of contaminated soil and the average density of the soil. The product of these quantities equals the mass of contaminants present at each sampling period. The difference between the calculated masses gives an indication of the mass of TPH removed.

Alternatively, consideration will be given to determining contaminant mass by dividing the site test area into subareas corresponding to the spatial locations of the soil borings. Similarly, the vertical influence distance for each sample would be determined by adding half the distance to the overlying sample and half the distance to the underlying sample. The "contributing" soil volume for each sample is determined by multiplying this distance by the corresponding surface subarea for each boring. Multiplying this volume by the soil density and the measured contaminant concentration results in a more detailed estimate of the contaminant mass. Comparison of the calculated masses for each sampling event gives a measure of mass of TPH removed.

Because of the inherent heterogeneity of the subsurface materials and the previously demonstrated variability in contaminant concentrations measured in the Phase I soil borings, it is possible that meaningful comparisons based on soil analyses may not be achievable. However, an attempt will be made to correlate the data.

Objective (3): Evaluate the Benefits of Hot Air Injection As an Enhancement to SVE in the Waste Pit

SVE systems physically remove contaminants from the vadose zone. Enhancement of SVE by hot air injection should increase the physical removal of organic contaminants by increasing their vapor pressures. The effects of hot air injection on contaminant biodegradation may initially include increased biodegradation rates due to elevated temperatures. However, in the long run, this positive effect on biodegradation will likely be offset by negative impacts resulting from die-off of microorganisms in the immediate vicinity of the injection wells because of extremely high temperatures, microbial species shifts as temperatures increase farther from the injection wells, and depletion of soil moisture levels because of increased evaporation rates. SVE enhancements will be performed only in the waste pit because this area contains the greatest amount of contamination. Some consequential removal of contaminants from the upper intermediate alluvial zone may occur as a result of the hot air injection system.

3.1 Data Needs

To quantify the benefits of hot air injection as an enhancement to SVE in the waste pit, the following data are needed:

- In situ oxygen uptake and carbon dioxide production
- Contaminant concentrations in the soil gas and SVE offgas
- Soil gas oxygen and carbon dioxide concentrations
- Soil gas temperature and relative humidity
- SVE offgas oxygen and carbon dioxide concentrations
- Soil TPH and COD
- Soil nutrients (nitrogen and phosphorus), moisture content, pH, and temperature
- Microbiological counts in the soil

3.2 Data Acquisition

The effectiveness of SVE enhancements by physical means can be determined by monitoring the contaminant concentrations in the soil gas and SVE offgas in conjunction with the temperature changes in the soil mass. The impact of the SVE enhancements on biological degradation rates can be evaluated by monitoring the soil gas and SVE offgas for oxygen and carbon dioxide concentrations and assessing biological respiration rates, and by performing biological assays on soil samples. Also, to determine whether other factors are limiting the biological degradation of contaminants, nutrient, moisture, and pH analyses will be conducted on soil samples.

Soil gas samples will be collected during the pre-operation, continued operation, and post-operation periods. SVE offgas samples will be collected throughout the pilot plant operation. These data will provide a means of comparing SVE performance (physical removal) with and without SVE enhancements. The oxygen, carbon dioxide, and OUR data will provide a means of comparing biological degradation with and without SVE enhancements.

Soil samples will be collected during the pre-operation, mid-operation, and post-operation sampling periods. Samples will be analyzed for TPH, COD, nutrients, moisture, and pH. Microbiological assays will also be performed. Soil temperature changes will be determined by thermocouples placed at various locations and depths in the waste pit and intermediate alluvial zone.

3.2.1 Soil Gas

Soil gas will be analyzed for VOCs, total nonmethane hydrocarbons, oxygen, and carbon dioxide.

3.2.1.1 Targeted VOCs (Onsite GC). The eight waste pit or intermediate zone piezometers will be sampled approximately once during pre-operation and once every 3 weeks during initial testing, startup, and continued operation to provide data on SVE enhancements and biodegradation. After the hot air injection system is started up, the soil gas samples will also provide data on changes in VOC concentrations in the waste pit and the intermediate zone to evaluate the benefits of the hot air injection system. After the hot air injection system has been shut down, the 8 pit and intermediate piezometers will be sampled twice to allow evaluation of the impact of the hot air injection system on enhanced VOC removal.

3.2.1.2 Offsite VOCs (TO-14). Data acquisition for VOCs is the same as presented in Part 1.2.1.2 with the exception that samples will also be analyzed during pre-operation to assess baseline conditions. Samples will only be collected from the waste pit and intermediate alluvium piezometers.

3.2.1.3 Total Nonmethane Hydrocarbons (TO-12). Prior to startup of the hot air injection system and during the continued operation period, total nonmethane hydrocarbon samples will be collected from each of the eight waste pit or intermediate alluvial zone piezometers. This will provide a baseline concentration of total nonmethane hydrocarbons. During pre-operation, one round of sampling will be conducted. During operation of the hot air injection system, total nonmethane hydrocarbon samples will be obtained approximately every 4 weeks to evaluate the effectiveness of the hot air injection system for enhanced hydrocarbon removal and to assist in evaluating the degree of biodegradation.

3.2.1.4 Carbon Dioxide and Oxygen (Meter). CO_2 and O_2 analyses and OUR tests will be conducted once every 3 weeks during operation of SVE with enhancements.

3.2.1.5 Temperature and Relative Humidity (Meters). Temperature and relative humidity will be monitored once for each OUR test conducted.

3.2.2 SVE Offgas (Vapor Extraction Wells)

Extraction wells will be sampled for VOCs and total nonmethane hydrocarbons.

3.2.2.1 Targeted VOCs (Onsite GC). The 12 waste pit and intermediate zone SVE wells will be sampled approximately once a week during the initial testing and startup phase of operation. After 6 weeks of operation it is planned that the SVE wells will be analyzed every 2 weeks and after 14 weeks the frequency is assumed to drop to once every 3 weeks. During the first two weeks of operation of the hot air injection system, waste pit SVE wells will be sampled twice per week. After 2 weeks of operation it is planned that the frequency will be reduced to once per week and after 6 weeks the frequency will drop back to once every 2 weeks. This sampling frequency is estimated to be adequate to evaluate the benefits of the hot air injection system on enhanced removal of VOCs from the waste pit.

3.2.2.2 Offsite VOCs (TO-14). Data acquisition for VOCs is the same as presented in Part 1.2.1.2. However, samples will be collected predominately from the waste pit since the intermediate alluvial zone will be marginally impacted, and the alluvial zone will not be impacted by hot air injection.

3.2.2.3 Total Nonmethane Hydrocarbons (TO-12). Data acquisition for total nonmethane hydrocarbons is the same as presented in Part 1.2.1.3. However, only the waste pit and intermediate alluvium wells will be sampled.

3.2.3 SVE Offgas (Extraction Well Manifolds)

Extraction well manifolds will be sampled for VOCs, total nonmethane hydrocarbons, carbon dioxide, and oxygen.

3.2.3.1 Targeted VOCs (Onsite GC). The combined offgas from each of the waste pit and intermediate alluvial zone manifolds will be sampled an average of approximately three times every 2 weeks. Sampling will increase to twice per week for the first 4 to 6 weeks of operation of the hot air injection system.

3.2.3.2 Offsite VOCs (TO-14). Data acquisition for VOCs is the same as presented in Part 3.2.2.2.

3.2.3.3 Total Hydrocarbons (TO-12). Prior to startup of the hot air injection system, total nonmethane hydrocarbon samples will be collected twice from the waste pit and intermediate alluvium manifolds. This will provide a baseline concentration of total nonmethane hydrocarbons. During operation of the hot air injection system, total nonmethane hydrocarbon samples will be obtained approximately once every 2 weeks to evaluate the effectiveness of the hot air injection system for enhanced hydrocarbon removal and to assist in evaluating the degree of biodegradation.

3.2.3.4 Oxygen and Carbon Dioxide (Meter). O_2 and CO_2 will be monitored once every 2 weeks in the waste pit and intermediate alluvium extraction well manifolds.

3.2.4 Soil

Soil samples will be collected in the waste pit and intermediate alluvium during the pre-operation, mid-operation, and post-operation soil investigations. Soil samples will be analyzed for TPH, COD, moisture, pH, and nutrients. Microbiological assays will also be performed in support of this objective.

3.2.4.1 Moisture Content (MOSA 21-2.2). Approximately 20 samples will be collected and analyzed during each of the three soil investigation periods. Most samples will be collected from the waste pit because this area contains the heaviest contamination and is likely to support the greatest biological activity. Furthermore, this is the area targeted by hot air injection.

3.2.4.2 Microbiological Assay (DNAB). Twenty samples will be collected during each of the three soil investigations (12 in the pit, 8 in the intermediate zone) to provide a cross-section of biological populations in the waste pit and intermediate alluvium.

3.2.4.3 pH (MOSA 12-2.6). Data acquisition for pH is the same as presented in Part 3.2.4.1.

3.2.4.4 Ammonia Nitrogen (MOSA 33-3.2, EPA 350.3), Nitrate Nitrogen (MOSA 33-3.2, EPA 300.0), Ortho-Phosphorus (MOSA 24-5.3, EPA 300.0). Data acquisition is the same as presented in Part 3.2.4.1.

3.2.4.5 Total Petroleum Hydrocarbons (Modified Method 8015). Data acquisition is the same as presented in Part 3.2.4.1.

3.2.4.6 Chemical Oxygen Demand (MOSA 29-3.5.3). Data acquisition is the same as presented in Part 3.2.4.1.

3.3 Data Analysis and Interpretation

Following is a brief summary of the methods to be used for data analysis and interpretation of soil gas, SVE offgas, and soil analytical data.

3.3.1 Soil Gas

Contaminant concentrations will be determined and analyzed in a manner similar to that discussed in Part 3.3.2. Oxygen uptake rates will be determined as presented in Part 5.3.1.

3.3.2 SVE Offgas

Contaminant concentrations and removal rates during hot air injection will be compared with those determined just prior to initiation of hot air injection. The change in concentrations and removal rate (if any) will be indicative of the increased volatilization caused by hot air injection.

Interpretation of SVE offgas data for O_2 and CO_2 in the manifolds is the same as that presented in Part 5.3.2.

3.3.3 Soil

Interpretation of COD, TPH, nutrient, moisture, and pH data is the same as that presented in Part 5.3.3.

The microbiological assays will be performed to determine if significant changes in microbial numbers/biomass occur during the study. During hot air enhancement of SVE, the viable biomass may increase, decrease, or remain unchanged, as a result of spatial variations in temperature increases. Nevertheless, because of the imprecision associated with quantification of soil microorganisms, statistically significant changes between sampling events may not be discernible.

Objective (4): Evaluate Vadose Zone Transport Processes to Identify Major Mechanisms Controlling Contaminant Migration and Document The Reasons for Discounting Other Migration Mechanisms

4.1 Data Needs

To evaluate the vadose zone transport processes, the following data are needed:

- Physical properties of vadose zone soils
- Contaminant types and concentrations

4.2 Data Acquisition

Soil and soil gas sampling in support of the vadose zone transport evaluation will be conducted only before and after operation of the SVE pilot plant.

VOCs in the soil gas (piezometers) will be measured before and after operation of the SVE pilot investigation to approximate the degree of diffusion of contaminants radially and vertically from Site S.

4.2.1 Soil Gas

The soil gas from each of the 14 piezometers will be monitored for VOCs.

4.2.1.1 Targeted VOCs (Onsite GC). Data acquisition for VOCs is the same as presented in Part 2.2.1.1. However, only samples taken during pre-operation and post-operation will be used to evaluate this objective.

4.2.1.2 Offsite VOCs (TO-14). TO-14 analyses will be performed at a rate of 1 for every 20 onsite GC analyses performed over the duration of the investigation. Each TO-14 sample will be collected in duplicate with an onsite GC sample. Samples will be collected during pre-operation as a baseline measure of contamination. No post-operation samples will be analyzed for VOCs by TO-14.

4.2.2 Soil

Samples will be collected and analyzed for physical properties only during installation of pre-operation borings. Samples will be analyzed for TPH both before and after operation of the SVE pilot system. Total organic carbon samples will only be collected from the post-operation borings. Physical properties, TOC, and TPH data from the Phase I investigation will also be used in the evaluation.

4.2.2.1 Physical Properties. Data acquisition for physical properties is the same as presented in Part 2.2.4.1.

4.2.2.2 Total Petroleum Hydrocarbons (Modified Method 8015). Data acquisition for total petroleum hydrocarbons is the same as presented in Part 2.2.4.2. Several of the deep post-operation samples will be collected close to the water table to provide information regarding partitioning of contaminants into an aqueous phase.

4.2.2.3 Total Organic Carbon (EPA 415.1). A total of 22 TOC analyses will be conducted during the post-operation soil investigation. No further pre-operation TOC analyses will be conducted, since those collected during the Phase I site characterization will be adequate to evaluate this objective.

4.3 Data Analysis and Interpretation

Four processes have been identified that could result in significant transport of contaminants to the groundwater. The initial step in the evaluation will be to determine appropriate equations and simplified models to describe the individual transport processes. A discussion of the anticipated approach to analyzing each of the processes is presented below.

- Rise of the regional groundwater levels and the resultant mobilization of contaminants. This process could cause migration of contaminants from the vadose zone to the aquifer if the current groundwater extraction system is inoperative. The analysis will be performed using typical approaches of saturated-zone solute transport affected by dispersion and retardation. Appropriate assumptions regarding the groundwater levels at Operable Unit (OU) D will be made, such as the groundwater level rising to the level prior to implementation of the groundwater extraction system.

- Radial diffusion of gas-phase contaminants beyond the capped area followed by volatilization to the atmosphere and/or downward leaching and advection to the water table in uncapped areas. This analysis will be based on typical diffusion coefficients that control the movement of contaminants. Typically, transport by gas diffusion is nearly independent of the properties of the porous media assuming that there is a continuous pathway for gas in the vadose zone. In other words, there are no areas or zones where the pore spaces are completely filled with water so the gas diffusion pathway is blocked. The process of downward advection in areas beyond the cap will be evaluated using VLEACH or a similar program that includes the processes of steady unsaturated flow of soil water, downward gas diffusion, three-phase partitioning and retardation.

- Density movement of gas phase contaminants. At high gas concentrations, some contaminants can move in response to density variations. The gas concentrations measured in the vadose zone will be evaluated in order to determine if density driven gas flow is a significant process at OU D. If so, then appropriate equations (e.g., Mendoza and Frind, 1990) will be employed to estimate the flow of gas.

- Unsaturated advection and gaseous diffusion downward to the groundwater in areas beneath the cap. These processes are typically dominant in an uncapped area but because OU D is now capped, it is assumed that advection by water moving downward in the vadose zone is negligible. However, downward diffusion of gases could cause some transport of contaminants. Although it is believed that the mass transport by this mechanism will be small, the impact of this process will be evaluated using VLEACH or a similar program.

Objective (5): Evaluate the Degree of Biodegradation

SVE systems physically remove volatile contaminants from the vadose zone. However, in situ biodegradation of contaminants is recognized as an important secondary removal mechanism in SVE systems, especially for less volatile contaminants. Recent innovations with SVE technology have focused on enhancing the in situ biodegradation of contaminants (particularly hydrocarbons) while minimizing their physical removal. Potential advantages of this modification include reduced equipment size, soil vapor extraction rates, energy, and offgas treatment costs. Most hydrocarbons can be biodegraded by indigenous microorganisms. However, microbial growth is often limited by oxygen availability. Thus, to maximize in situ biodegradation of hydrocarbons and minimize their physical removal, extraction flow rates are reduced to the minimum required to maintain aerobic conditions throughout the vadose zone. SVE systems operating in this mode are called bioventing systems.

The contaminant mass at Site S consists of both chlorinated and nonchlorinated hydrocarbons. Very little biodegradation of chlorinated hydrocarbons is expected to occur. Most chlorinated hydrocarbons are relatively volatile and will be removed with the offgas. The biodegradation evaluation will focus primarily on nonchlorinated hydrocarbons.

5.1 Data Needs

The following data will be collected to evaluate biodegradation and environmental conditions:

- In situ oxygen uptake and carbon dioxide production rates
- Soil gas oxygen, carbon dioxide, and methane concentrations
- Soil gas temperature and relative humidity
- SVE offgas oxygen and carbon dioxide concentrations
- Soil Total Petroleum Hydrocarbons (TPH) and Chemical Oxygen Demand (COD)
- Soil nutrients (nitrogen and phosphorus), moisture content, and pH
- Soil microbiological assays

Sampling and analysis will focus on the waste pit and intermediate alluvial zones because they contain the heaviest contamination.

5.2 Data Acquisition

Quantifying the mass of contaminants physically removed with an SVE system is readily accomplished through sampling the offgas. Quantifying the mass of contaminants biodegraded in situ is more difficult and is done indirectly. This subsection lists the data required to estimate biodegradation rates as well as monitor the environmental conditions that may limit microbial growth.

5.2.1 Soil Gas

The soil gas will be monitored only in the five waste pit and three intermediate alluvium piezometers in support of this objective.

5.2.1.1 Carbon Dioxide and Oxygen (Meter). During the pre-operation period in situ concentrations of oxygen and carbon dioxide will be measured in the waste pit and intermediate alluvium piezometers. Prior studies have suggested that the waste pit and intermediate alluvium are anoxic; these measurements will confirm whether anoxic conditions prevail.

Measuring oxygen uptake and carbon dioxide production is a common method of assessing the rate of biodegradation. Oxygen uptake rates (OURs, also called in situ soil respiration rates) will be measured in each piezometer in both the waste pit and intermediate alluvial zones. The OUR measurement procedure is presented in Section 5.

After approximately 12 to 14 weeks of SVE operation, the soil vapor pumping rates are planned to be reduced to levels more compatible with bioventing operation for a period of 4 to 6 weeks. During this period, oxygen and carbon dioxide concentrations will be monitored weekly and OURs will be measured every other week.

OUR measurements for each pit and intermediate piezometer will be conducted once during initial testing (week 1), three times during startup (weeks 2, 4, and 6), twice during operation of SVE before bioventing (weeks 8 and 11), and approximately three times during bioventing (weeks 14, 16, and 18). In addition, oxygen and carbon dioxide tests will be conducted on odd weeks during bioventing.

5.2.1.2 Methane (Meter). During the pre-operation period, data acquisition for methane will be the same as presented in Part 5.2.1.1.

5.2.1.3 Temperature and Relative Humidity (Meters). Data acquisition is the same as presented in Part 3.2.1.5.

5.2.2 SVE Offgas (Extraction Well Manifolds)

Offgas will be measured for oxygen and carbon dioxide every other week in the waste pit and intermediate alluvial zone SVE manifolds. If the first several samples do not reveal any discernable difference from atmospheric oxygen and/or carbon dioxide concentrations, these analyses will be discontinued. Even if SVE offgas O_2/CO_2 analysis is discontinued during the SVE phase, it will be resumed, on a weekly basis, after reducing pumping rates to bioventing levels. Flow rates in each manifold will be measured each time an SVE offgas manifold sample is measured or another sample taken.

5.2.3 Soil

Soil samples will be collected in the waste pit and intermediate alluvium during the pre-operation, mid-operation, and post-operation soil investigations. Each sample collected will be analyzed using the methods presented below.

5.2.3.1 Total Petroleum Hydrocarbons (Modified Method 8015). Data acquisition is the same as presented in Part 3.2.4.1.

5.2.3.2 Chemical Oxygen Demand (MOSA 29-3.5.3). Data acquisition for COD is the same as presented in Part 3.2.4.1.

5.2.3.3 Moisture Content (MOSA 21-2.2). Data acquisition is the same as presented in Part 3.2.4.1.

5.2.3.4 pH (MOSA 12-2.6). Data acquisition is the same as presented in Part 3.2.4.1.

5.2.3.5 Ammonia Nitrogen (MOSA 33-3.2, EPA 350.2), Nitrate Nitrogen (MOSA 33-3.2, EPA 300.0), Ortho-Phosphorus (MOSA 24-5.3, EPA 300.0). Data acquisition is the same as presented in Part 3.2.4.1.

5.2.3.6 Microbiological Assay (DNAB). Data acquisition for the microbiological assay is the same as presented in Part 3.2.4.2.

5.3 Data Analysis and Interpretation

This section describes how the data will be used to assess the amount of contaminant mass biologically degraded and the suitability of environmental conditions for microbial activity.

5.3.1 Soil Gas

The purpose of conducting in situ soil gas measurements of oxygen, carbon dioxide, and methane prior to starting SVE is to verify that low oxygen or anoxic conditions exist in the vadose zone. Such a situation would suggest that microbial growth and contaminant biodegradation are constrained by low oxygen availability, and that provision of oxygen to the subsurface environment might stimulate biodegradation of hydrocarbons.

Oxygen uptake with corresponding carbon dioxide production is an indirect indication of aerobic respiration (biodegradation) of organic compounds by heterotrophic microorganisms. Thus, oxygen uptake/carbon dioxide production rates are directly related to biodegradation rates. Elevated OURs indicate biodegradation of organic contaminants.

Oxygen uptake can be related to contaminant biodegradation theoretically using the stoichiometry of oxidation of a representative contaminant compound, or empirically using a measured ratio of contaminants to oxygen demand. In the first case, a theoretical oxygen demand (TOD) is used to estimate the mass of oxygen used in biodegrading a unit mass of contaminant, such as is shown for hexane below:

$$C_6H_{14} + 9.5\ O_2 \text{ -----> } 6\ CO_2 + 7\ H_2O$$

According to this equation, 3.5 grams of oxygen are required for each gram of hexane biodegraded. (A similar relationship can be developed between carbon dioxide production and hydrocarbon degradation.) The mass of hydrocarbon biodegraded can be estimated from the measured OURs using this relationship as illustrated below:

Example Calculation Oxygen Uptake Rate Data Conversion

Assume 1 liter of soil (2.65 kgs) with a 50 percent porosity and 50 percent saturation. Also assume the oxygen concentration in the soil has decreased from 20 percent to 5 percent during a 24-hour OUR study.

- Volume of air = 1 x 0.5 x 0.5 = 0.25 liters
- Volume of oxygen = 0.25 x (20% - 5%) = 0.0375 L oxygen/day
- Mass of 0.0375 liters of oxygen = 53 mg
- (53 mg of oxygen uptake/day) x (0.283 mg hydrocarbon/mg oxygen) = 15 mg/day of hydrocarbon biodegraded
- (15 mg/day of hydrocarbon)/2.65 kg of soil = 5.7 mg/kg/day of hydrocarbon biodegraded

Typical values of hydrocarbon degradation in the field range from 5 to 30 mg of hydrocarbon per kg of soil per day.

The empirical approach to estimating biodegradation is exactly the same except that the average TPH/COD ratio measured in soil samples from the appropriate area is used in lieu of the stoichiometry-based hydrocarbon/TOD relationship. These types of calculations will be used to estimate the mass of contaminants removed via biodegradation. Plots of OUR versus time will be developed for each piezometer tested to evaluate changes in biodegradation rates over the course of the study.

Data obtained by CH2M HILL and by others indicate that oxygen utilization rates typically range form 0.0001 to 0.01 percent oxygen utilized per minute in contaminated soils. At 0.01 percent oxygen per minute, most of the available oxygen would be utilized in one day. The purpose of measuring OURs after 1 week of SVE is to ensure that the oxygen is being utilized by the soil microbial community. If the oxygen were not depleted after a few days, it could suggest some other limitation to microbial growth.

The initial oxygen concentrations measured at the beginning of each OUR study will be examined to verify that aerobic conditions are being maintained throughout the treatment zone. This should not be a problem during the period employing SVE pumping rates (the first 3 months of the piloting program). After reducing pumping to bioventing rates, however, the oxygen levels in soil gas may decrease. The goal of bioventing is to minimize the extraction of soil vapor while enhancing biodegradation. Thus flow rates are adjusted to the minimum level which aerates the soil. Ideally, the oxygen concentration in each piezometer will be between 15 percent and 19 percent.

Biodegradation rates are strongly dependent on temperature and moisture content. Soil gas temperature will be monitored and compared to OURs. Relative humidity will be monitored to determine if vapor extraction causes significant drying of the vadose zone.

5.3.2 SVE Offgas

The oxygen and carbon dioxide concentrations measured at the offgas manifolds will be used, if possible, to estimate contaminant biodegradation in a manner analogous to the OUR data. During steady state extraction conditions, a reduction in oxygen concentration compared to the atmospheric concentration (21 percent) would be interpreted to indicate microbial respiration/biodegradation. A corresponding increase in carbon dioxide concentration relative to the atmospheric level (0.5 percent) would support this interpretation. If variations from atmospheric levels are detectable, the mass of oxygen utilized will be calculated and used to estimate the mass of hydrocarbon biodegraded. Because the treatment area is capped, pumping will likely pull gas in from surrounding soils; consequently, it will be impossible to discern the location that any measured biodegradation takes place from this analysis—only that it has occurred. The high rates of pumping used during the SVE investigation may mask any changes in O_2/CO_2 beyond the discrimination capacity of the analytical method. However, changes may be distinguishable during the period of reduced pumping rates (bioventing).

5.3.3 Soil

The TPH analyses will yield information on the change in hydrocarbon concentrations over time due to both physical and biological removal mechanisms. Moreover, the soil TPH and COD data will be used to develop empirical relationships between hydrocarbon mass and oxygen demand, which will be applied in the evaluation of O_2/CO_2 data in soil gas and SVE offgas, as described above.

Nitrogen and phosphorous are required nutrients for microbial growth, and biological degradation of organics can be limited by the availability of either nutrient. Nitrogen and phosphorous are the nutrients which are most often limiting, although other inorganic nutrients can be limiting in certain situations. However, in many natural soil systems, required nutrients are available in sufficient supply to support microbial metabolism, and the terminal electron acceptor (oxygen, in the case of aerobic respiration) is usually the rate-limiting requirement. Furthermore, nutrient addition can be costly compared to supplying oxygen. The soil nutrient data will be examined to determine the likelihood of nutrient limitation and to determine if nutrient depletion occurs during the study.

Moisture is essential to any microbial community. Currently, the soil is very moist. Because of the cap, little infiltration is expected into the soil, and SVE tends to dry the soil. However, air will tend to be humidified as it is pulled through soil adjacent to the treatment zone (because of the cap), and significant drying may not occur over the duration of the pilot program. The soil moisture data will be evaluated to determine if drying occurs and to assess whether long-term SVE/bioventing would be likely to cause sufficient moisture loss to inhibit microbial growth.

The microbial assays will be performed to determine if significant changes in microbial numbers/biomass occur during the study. It can be logically assumed that if contaminant biodegradation is stimulated in the treatment zone by the SVE/bioventing process that the biomass of microorganisms capable of degrading those contaminants will increase. Unfortunately, precise quantification of the biomass of a specific group of microorganisms in a soil matrix is difficult at best. Because of the imprecision associated with soil microbial quantification techniques, statistically significant increases may not be observed.

Objective (6): Assess Whether Preferential Removal of Contaminants From Different Strata is Occurring During SVE

6.1 Data Needs

Assessment of whether preferential removal of contaminants is occurring by SVE at Site S, OU D, will allow comparison of lithology to other sites basewide and determination of whether SVE may be an effective remedial technology for application at those sites. To assess whether preferential removal of contaminants is occurring from different strata, the following data are needed:

- Physical properties and location and extent of the vadose zone and pit materials
- Concentration of contaminants in the various strata
- Concentrations of contaminants in the soil vapor

6.2 Data Acquisition

The reduction of contaminants in different strata will be evaluated by monitoring the soil gas for VOCs and total nonmethane hydrocarbons. In most cases the piezometer screens are not located within homogeneous soil strata. Instead, it is typical that variable thin material stratifications occur throughout the screened interval. This may preclude complete assessment of Objective (6). Soil gas samples will be collected and analyzed throughout the SVE treatability investigation.

Comparison of TPH concentrations before and after the SVE treatability investigation may provide information regarding which strata have a tendency to exhibit preferential removal of TPH. Consequently, soil samples will be collected from various strata within the vadose zone and analyzed for TPH before, during, and after the SVE pilot plant operation.

Several pre-operation soil samples will be analyzed for physical characteristics in the waste pit and intermediate alluvial deposits to confirm lithology. These data along with those collected during Phase I should provide sufficient lithologic data to be used throughout the project.

6.2.1 Soil Gas

The soil gas in the piezometers will be sampled for VOCs and total nonmethane hydrocarbons throughout the SVE treatability investigation.

6.2.1.1 Targeted VOCs (Onsite GC). Data acquisition for VOCs is the same as presented in Part 2.2.1.1.

6.2.1.2 Offsite VOCs (TO-14). Data acquisition for VOCs is the same as presented in Part 1.2.1.2.

6.2.1.3 Total Nonmethane Hydrocarbons (TO-12). Data acquisition for total nonmethane hydrocarbons is the same as presented in Part 2.2.1.3.

6.2.2 Soil

The soil at Site S will be sampled for physical properties and TPH as a part of the SVE investigation. Samples will be collected and analyzed for TPH and physical properties in the waste pit and intermediate alluvium during the pre-operation investigation. Sufficient deep alluvium data have been collected during the Phase I site characterization. Samples from all three zones will be analyzed for TPH during the post-operation soil investigation.

6.2.2.1 Physical Properties. Data acquisition for physical properties is the same as presented in Part 2.2.4.1.

Total Petroleum Hydrocarbons (Modified Method 8015). Data acquisition for total petroleum hydrocarbons is the same as presented in Part 2.2.4.2.

6.3 Data Analysis and Interpretation

Following is a summary of the methods to be used for data analysis and interpretation for soil gas and soil analytical data.

It is likely that preferential removal of VOCs will not occur due to the heterogeneous nature of the subsurface materials and the nonuniform distribution of contaminants. The Phase I soil borings indicated that the waste pit is comprised of miscellaneous fill, debris, and various contaminants. The air permeability tests in the waste pit indicated the presence of zones of very low permeability material adjacent to medium to high permeability materials. Likewise, the native materials below the pit are comprised of heterogeneous mixtures of fine sand, silt, and clay. Considerable variation in material types was observed within individual split-spoon samples during the field investigation.

6.3.1 Soil Gas

The ability to evaluate preferential removal of contaminants is dependent on the nature of the subsurface materials that the piezometers are screened in. If reasonable uniformity can be assumed in several piezometers with different materials, then those installations may be useable to evaluate preferential removal of VOCs from the various soil zones. However, the variability of material adjacent to piezometers will affect contaminant removal rate. For example, a piezometer screened in a large silt zone may show much less contaminant removal than a similar installation located in a thin silt zone surrounded by a sand layer. The difference in removal mass and rate will be influenced more by the overall stratigraphy than the particular material in which the screen is located. During the pilot study it will be impossible to accurately quantify adjacent contributing stratigraphic factors.

Analysis and interpretation for soil gas data is the same as presented in Part 2.3.1.

6.3.2 Soil

Analysis and interpretation for soil data is the same as presented in Part 2.3.3.

Objective (7): Evaluate Performance of the SVE Offgas Emissions Control System

7.1 Data Needs

To evaluate the performance of the SVE offgas emission control system, the following data are needed:

- Type and concentration of contaminants entering the emission control system.
- Type and concentration of contaminants exiting the emission control system.
- Flow rate through the emission control system.
- Operating temperature and pressure of the emission control system.
- Sufficient data to assure compliance of the SVE offgas emission control system with air emission ARARs. A list of applicable ARARs is presented in Appendix P.

7.2 Data Acquisition

Analytical data for emission control system process monitoring will be collected from the SVE offgas transfer piping before to the incinerator and from the emission control system stack during the initial testing, startup, and continued operations periods.

7.2.1 SVE Offgas (Transfer Piping) and Emissions Control

7.2.1.1 Targeted VOCs (Onsite GC). The combined SVE offgas entering the emission controls system and discharge from the stack will be monitored daily during initial testing, once a week during startup, and once every 2 weeks during the continued operation phase. This sampling strategy will provide sufficient data to verify compliance with discharge limits and to calculate the destruction removal efficiency for specific VOCs of concern.

7.2.1.2 Offsite VOCs (TO-14). TO-14 analyses will be performed at a rate of 1 for every 20 onsite GC analyses performed over the duration of the treatability investigation. Each TO-14 sample will be collected in duplicate with an onsite GC sample. One emissions control sample and one transfer piping sample will be collected during the startup period. This period will correspond with the period when the maximum mass removal is occurring.

7.2.1.3 Total Hydrocarbons (TO-12). The combined SVE offgas entering the emission controls system and the discharge from the stack will be sampled for total nonmethane hydrocarbons approximately three times during initial testing, once per week during startup, and approximately once every 2 weeks during the continued operation phase. The total nonmethane hydrocarbon data at this frequency will provide sufficient data to calculate destruction removal efficiency of total nonmethane hydrocarbons and quantify the total discharge of nonmethane hydrocarbons from the system.

7.2.1.4 Hydrochloric Acid (HCL—Method 26). Chlorinated hydrocarbons will be converted to carbon dioxide, water vapor, and hydrochloric acid (HCL) gas in the emission controls system. Measurement of HCL is required to ensure compliance with discharge standards. Discharge from the stack will be sampled once during initial testing, once every 3 weeks during startup, and approximately once a month during the continued operation phase. As VOC concentrations decrease, HCL concentrations will also decline; therefore, if limits are met during the startup phase, they should be met during continued operation, and sampling intervals will be adjusted accordingly.

7.2.1.5 Dioxins (Method 23). Trace levels of dioxin congeners have been reported from thermal incinerators in the past. Although the catalytic oxidation emission controls system operates at a much lower temperature than thermal incinerators, the possibility still exists that dioxin congeners could be generated at low levels during oxidation. Therefore, the stack will be sampled for dioxin congeners once during initial testing, once every 3 weeks during startup, and approximately once a month during the continued operation phase.

7.2.1.6 Carbon Dioxide and Oxygen (Meters). The SVE offgas (transfer piping) will be monitored in conjunction with other soil gas, SVE offgas, or emission control sampling to aid in process control of the emission control system.

7.3 Data Analysis and Interpretation

Following is a brief summary of the methods to be used for data analysis and interpretation of SVE offgas (transfer piping) and emissions control analytical data.

7.3.1 SVE Offgas (Transfer Piping) and Emissions Control

Comparison of contaminant concentrations for samples taken from the transfer piping and the stack will yield information for assessment of contaminant destruction efficiencies and achievement of air emissions ARARs.

Concentrations of VOCs, total nonmethane hydrocarbons, HCl, and dioxin measured in the stack samples will be monitored to ensure compliance with the regulatory discharge standards. Process flow rates and/or combustion temperature will be varied as necessary to conform with the regulatory discharge requirements.

Objective (8): Evaluate the Applicability of SVE to OU D and Collect Sufficient Operational Data to Support the Detailed Analysis of SVE as A Remedial Action Alternative in the Feasibility Study for OU D

8.1 Data Needs

Evaluation of the above objective requires completion of the SVE treatability investigation and overall assessment of how well the SVE technology performed at Site S, OU D. The data needs are similar to those previously discussed for Objectives (1) through (7).

8.2 Data Acquisition

Data will be collected from soil, soil gas, SVE offgas, and emission control system over the duration of Phases II and III of the SVE treatability investigation as discussed for the previous objectives.

Summaries of the sampling required to support all objectives of the SVE treatability investigation are presented in Tables 5-6 (soil), 5-10 (soil gas), and 5-11 (SVE offgas and emissions control).

8.3 Data Analysis and Interpretation

The applicability of SVE to remove VOCs at OU D will be determined by evaluating the degree to which the other goals and objectives were achieved. SVE will be judged to be applicable to the remediation of OU D and qualify as a remedial action alternative in the feasibility study (FS), provided that:

- A large mass of contaminants is removed and successfully treated or a significant reduction in the target contaminants is achieved
- Soil gas movement represents a major mechanism contributing to areal contamination
- Emission control system (stack) discharge limits and ARARs are achieved
- The SVE technology is accepted by the community and regulatory agencies as a feasible remedial technology

The effect of hot air enhancement and the amount of biodegradation will be considered as important but "secondary" factors in evaluating the applicability of SVE at OU D and the assessment of SVE as a FS alternative. Lack of significant contaminant removal directly attributable to hot air injection or biodegradation will not be considered as fatal flaws in the assessment of the overall performance of SVE.

Further criteria for evaluating the applicability of SVE to OU D are those set forth in the *Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction*, Interim Guidance, EPA, September 1991. These are similar criteria that will be considered during the OU D Feasibility Study. The evaluation criteria are:

- Overall protection of human health and environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Objective (9): Assess General Applicability of SVE at Other McClellan AFB Sites

9.1 Data Needs

The data needs to achieve this objective are the same as presented in Part 8.1.

9.2 Data Acquisition

The data acquisition required to achieve this objective is presented in Part 8.2.

9.3 Data Analysis and Interpretation

The applicability of SVE to other McClellan AFB sites will be based on analysis of the performance at Site S and comparison of the nature and extent of contamination. The nature and extent of contamination must be determined at each proposed site and compared to that at Site S. The presence of VOCs as contaminants of concern at a site combined with the reduction of target analytes at Site S will be useful in determining the potential effectiveness of SVE at other McClellan AFB sites. This objective will be evaluated in considerably more detail during the feasibility studies being conducted for the respective OUs at McClellan AFB.

Section 4
Experimental Design and Procedures

The work items covered under this work plan are divided into two phases. Phase II includes installation and soil sampling of additional vapor extraction wells to be used as a part of the SVE treatability investigation, and installation of other SVE process equipment. Phase III comprises the operation and sampling of the SVE system and includes installation of mid- and post-operation soil borings for evaluation of the effectiveness of the SVE technology.

Cap Penetration

All soil borings will be located within the area of the existing multilayer cap. The cap consists of 24 inches of silty sand/sandy silt cover material overlying a 40-mil high-density polyethylene (HDPE) synthetic membrane. The membrane is underlain by 18 inches of low-permeability soil (clay), which in turn is underlain by 6 inches of granular drain material and a variable thickness of site grading material. Waste sampling ports consisting of 5-foot-long segments of 5-foot-diameter reinforced concrete pipe were installed through the cap during the original cap construction to facilitate future sampling of the contaminated materials. One new soil boring will be installed through existing sampling port WSP-SB. *Other borings will require new penetrations* directly through the multilayer cap. Cap penetration and sealing procedures are discussed below. These procedures are the same for all wells.

At the conclusion of the Phase II and III investigation, the wells will be left intact for use during site remediation, assuming that soil vapor extraction is selected for such remediation. If soil vapor extraction is not implemented at Site S after the pilot-scale testing is complete, then the wells and piezometers should be abandoned in accordance with applicable regulatory requirements. Such procedures typically require that the well or piezometer be fully grouted in place.

Penetrations Through Existing Sampling Ports

During Phase I, the sampling port was filled with compacted, noncontaminated, low-permeability material similar to that placed in the original multilayer cap. One well will be constructed through the backfilled sampling port. Figure 4-1 depicts a sampling port after well construction.

Penetration Through Multilayer Cap

Figure 4-2 depicts a cross-section through the existing multilayer cap and schematically illustrates the procedure for penetrating and resealing the multilayer cap at locations other than the existing waste sampling ports.

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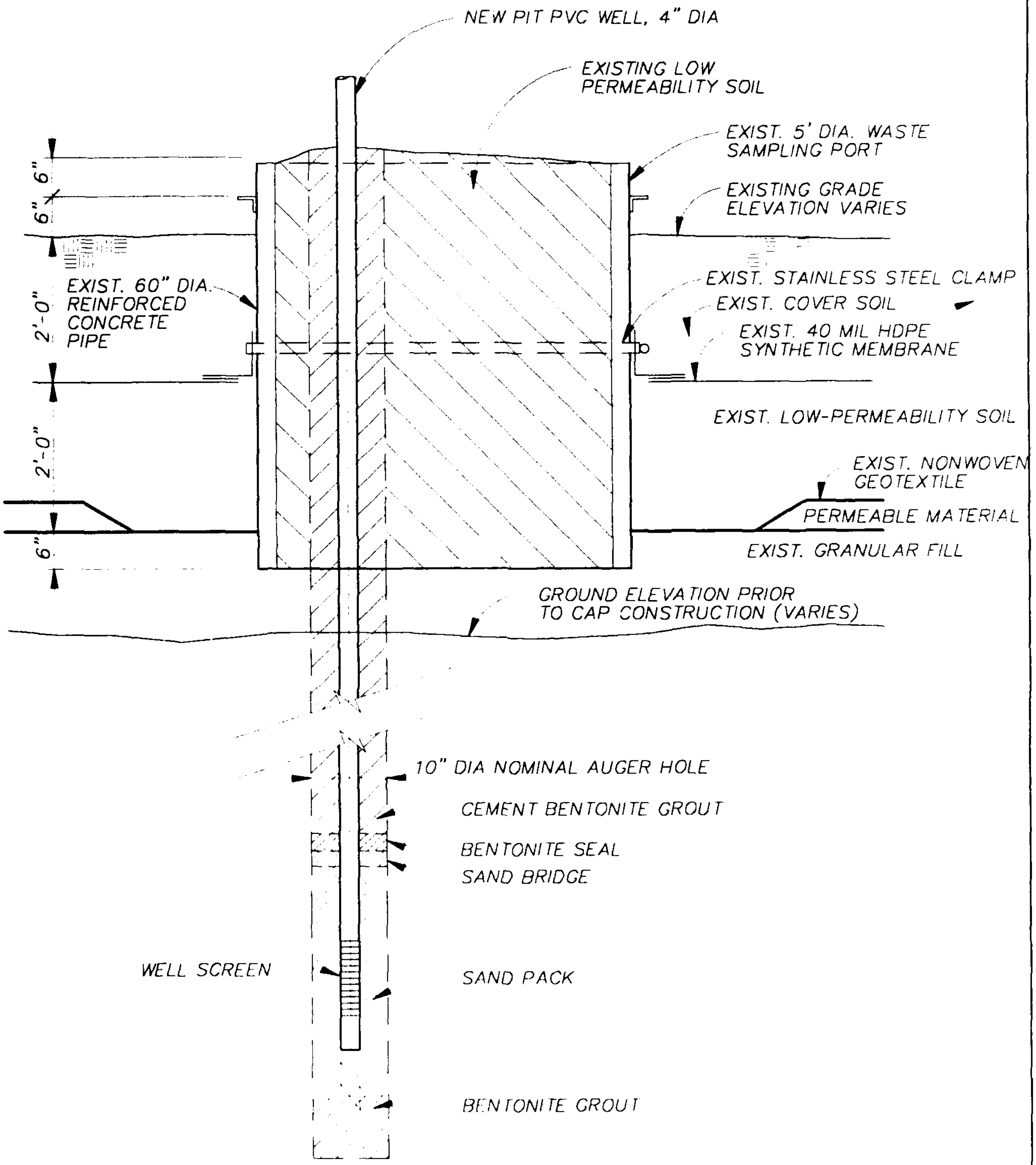


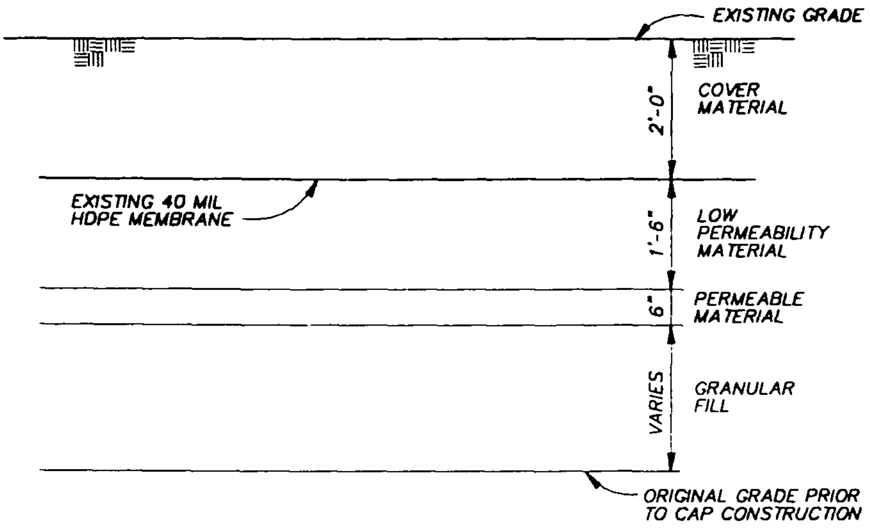
SECTION
NTS

NOTE: DETAILS OF EXISTING WASTE SAMPLING PORT TAKEN FROM "MTN GROUNDWATER CLEANUP AREA D CAP INSTALLATION" DWG NO. SMBE-S-6316, SHT 12 OF 13 APRIL, 1986

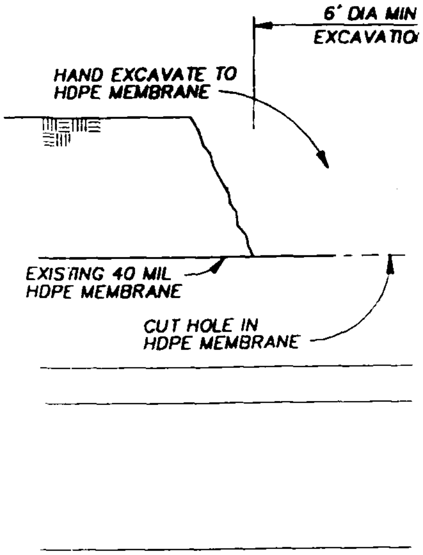
FIGURE 4-1
WELL INSTALLED THROUGH EXISTING WASTE SAMPLING PORT

CH2M HILL

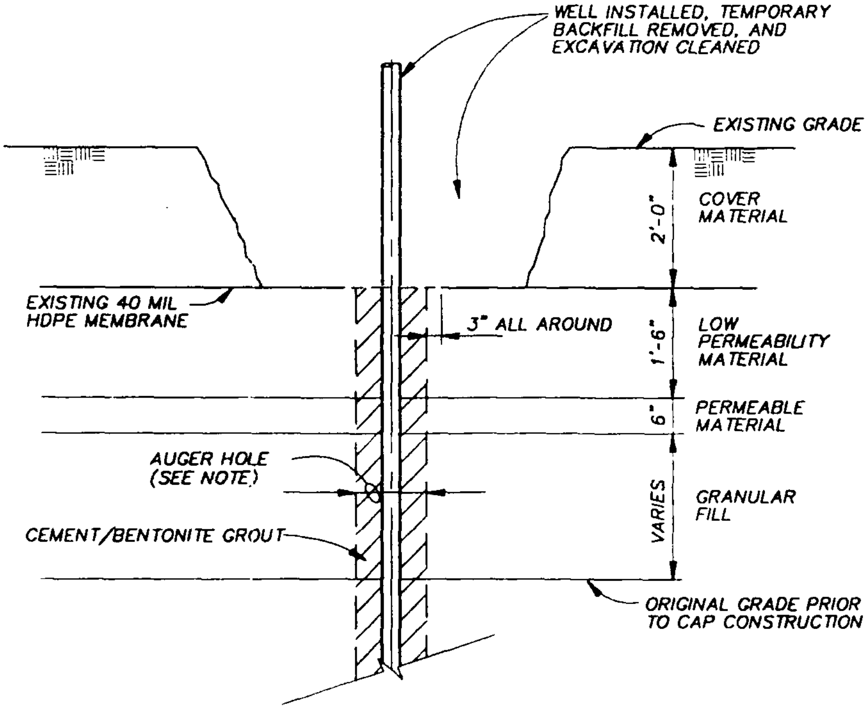
04-09-92



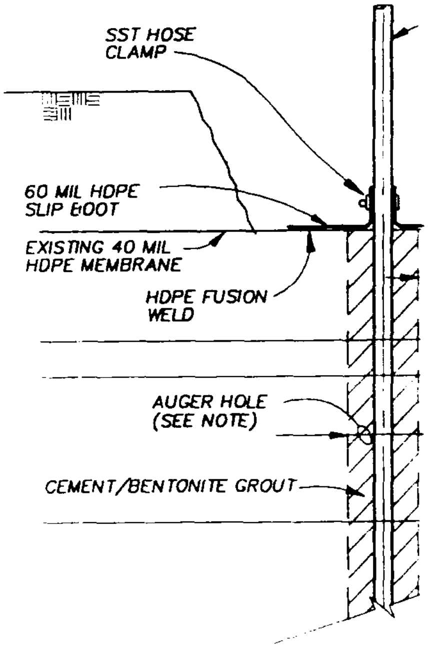
TYPICAL SECTION THROUGH EXISTING CAP



STEP 1: EXPOSE HDPE ME
HOLE FOR AUGER



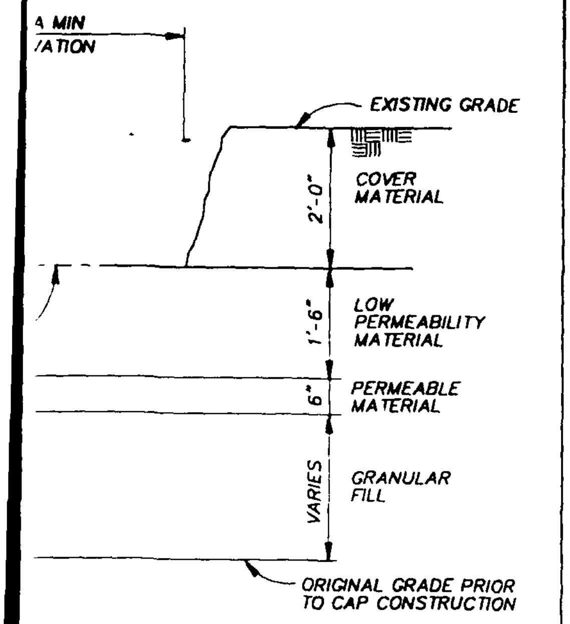
STEP 3: INSTALL WELL OR CASING STEM AND THERMOCOUPLE LEADS, THEN REMOVE TEMPORARY FILL AND CLEAN THE HDPE MEMBRANE SURFACE



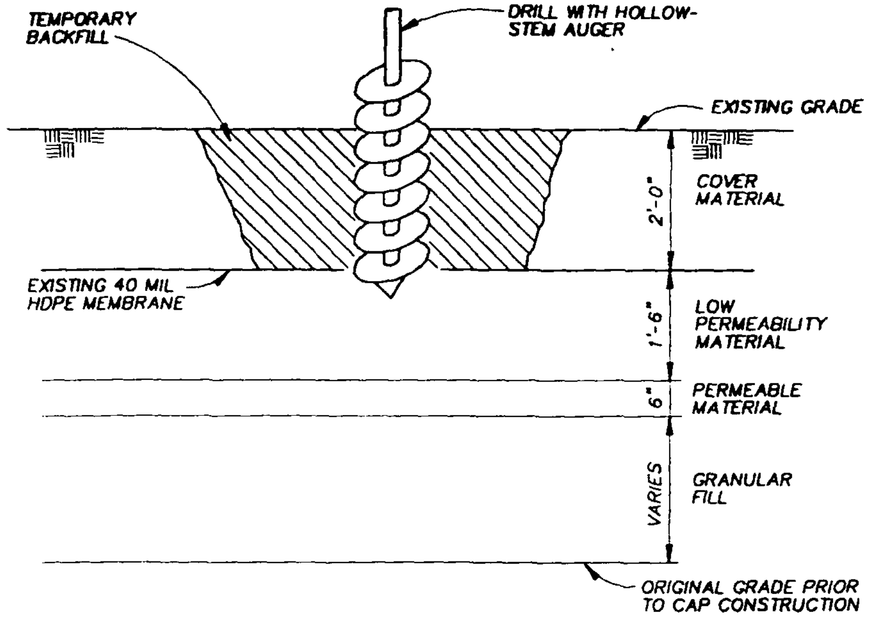
STEP 4: FUSION WELD HD
AND CLAMP BOOT

NOTE: EXTRACTION WELLS USE 10" DIA NOMINAL AUGER HOLE AND 4" DIA PVC CASING.
HOT AIR INJECTION WELLS USE 8" DIA NOMINAL AUGER HOLE AND 2" DIA CARBON STEEL CASING.
HOT AIR TEMPERATURE WELLS USE 8" DIA NOMINAL AUGER HOLE WITH 2" DIA PVC CASING STEM INS

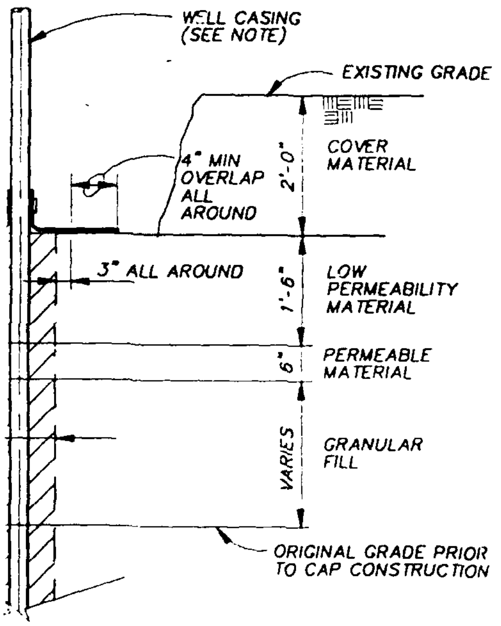
J:\DIS\INDUST\SAC28722\S8722F3.1 DWG



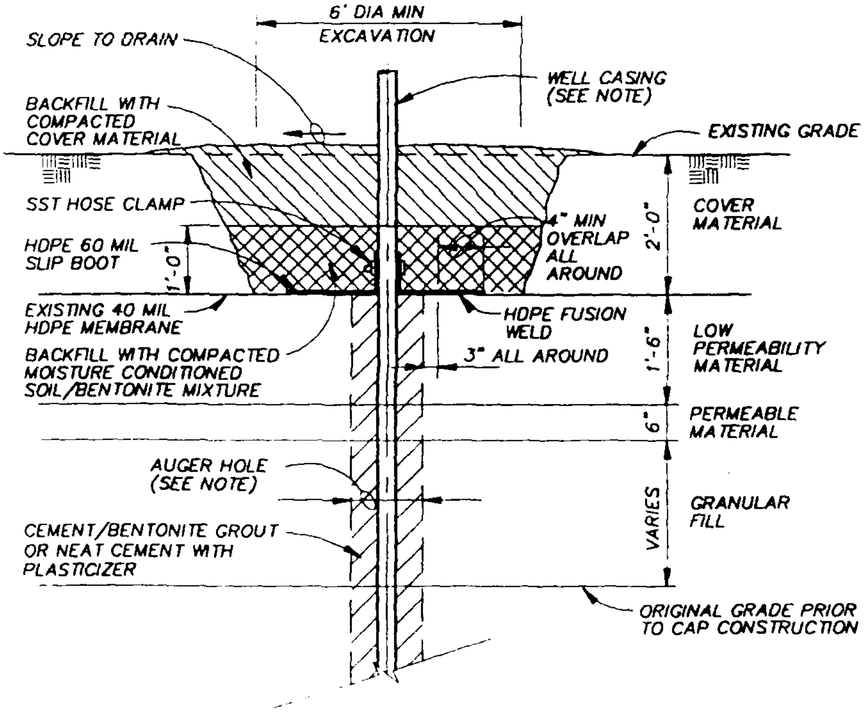
MEMBRANE AND CUT
GER PENETRATION



STEP 2: PLACE TEMPORARY BACKFILL AND
BEGIN DRILLING



HDPE MEMBRANE
BOOT TO WELL CASING



STEP 5: PLACE COMPACTED SOIL/BENTONITE MIXTURE
AND COVER MATERIAL OVER THE PVC BOOT

NG.
M INSTALLED TO 2 FT BELOW EXISTING HDPE LINER.

FIGURE 4-2
CAP PENETRATION DETAILS

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04-09-92

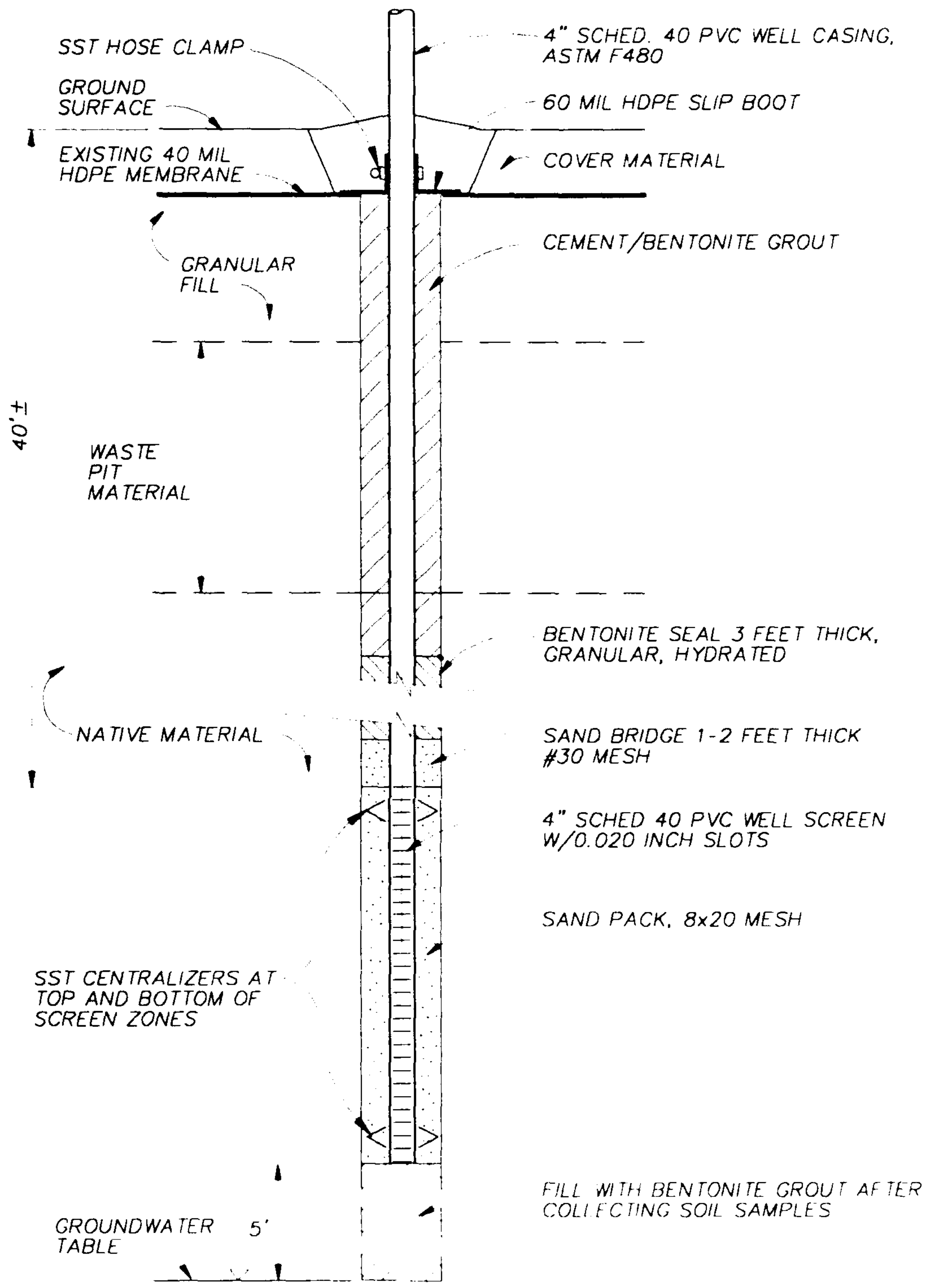


FIGURE 4-4

DEEP EXTRACTION WELL
SVE PHASE II
SITE S, OU D

McCLELLAN AFB

04-09-92

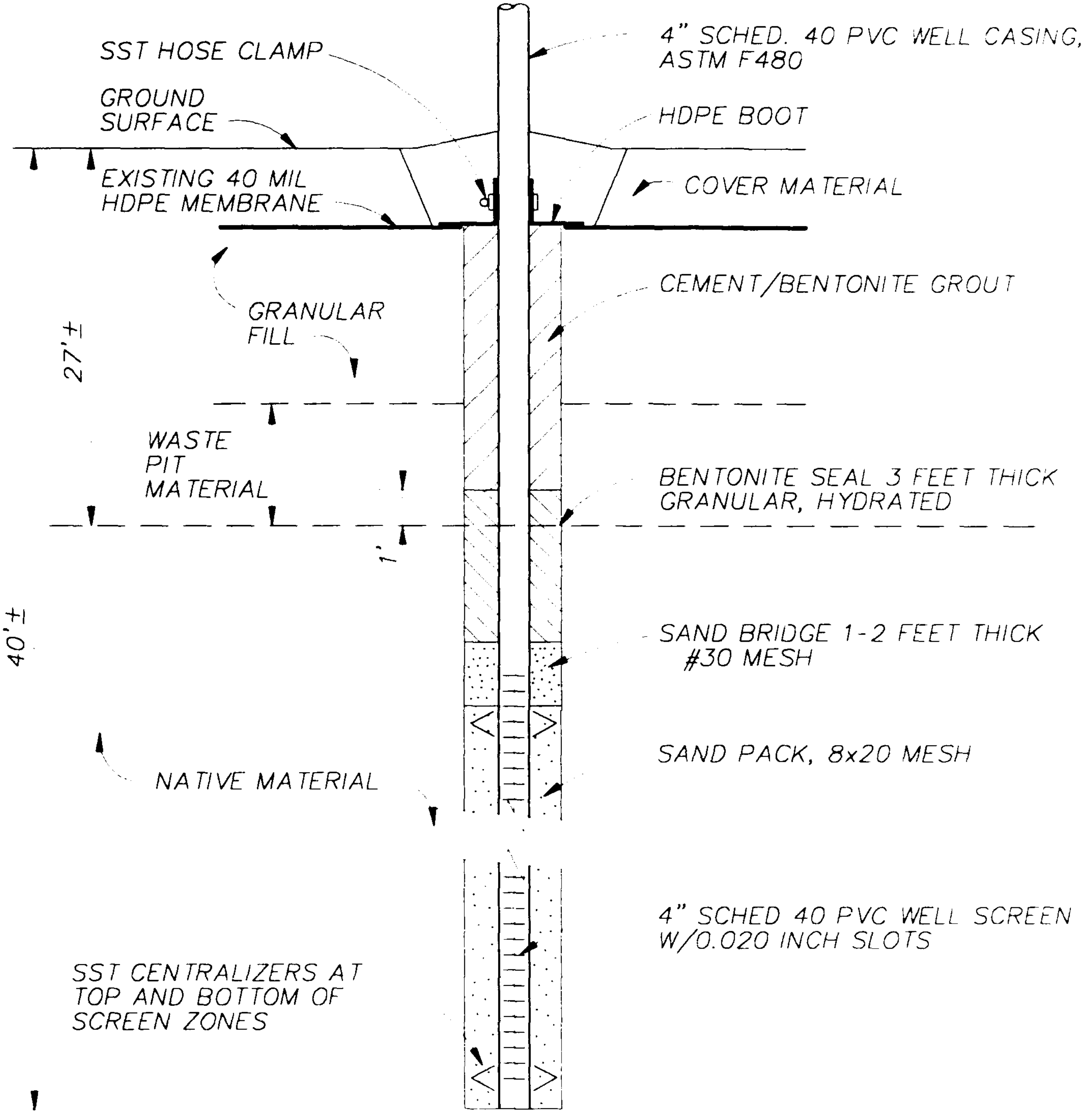
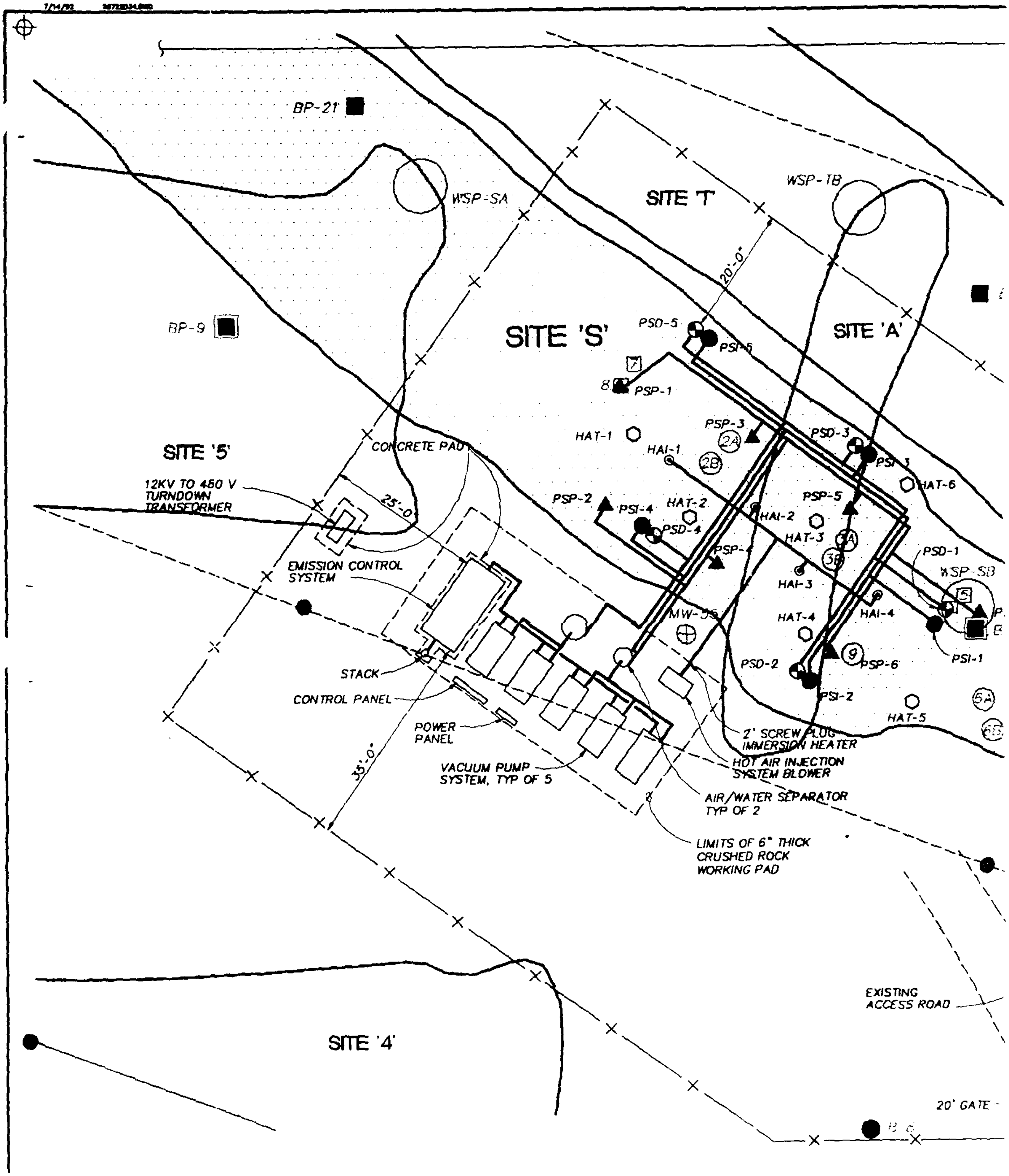


FIGURE 4-5

INTERMEDIATE EXTRACTION WELL
SVE PHASE II
SITE S, OU D
McCLELLAN AFB

CH2M HILL



CH2M HILL

		NO.	DATE	REVISION	BY	APVD
DSGN	C. NOUNG					
DR	D KING					
CHK	J. DANKO					
APVD	C NOUNG					

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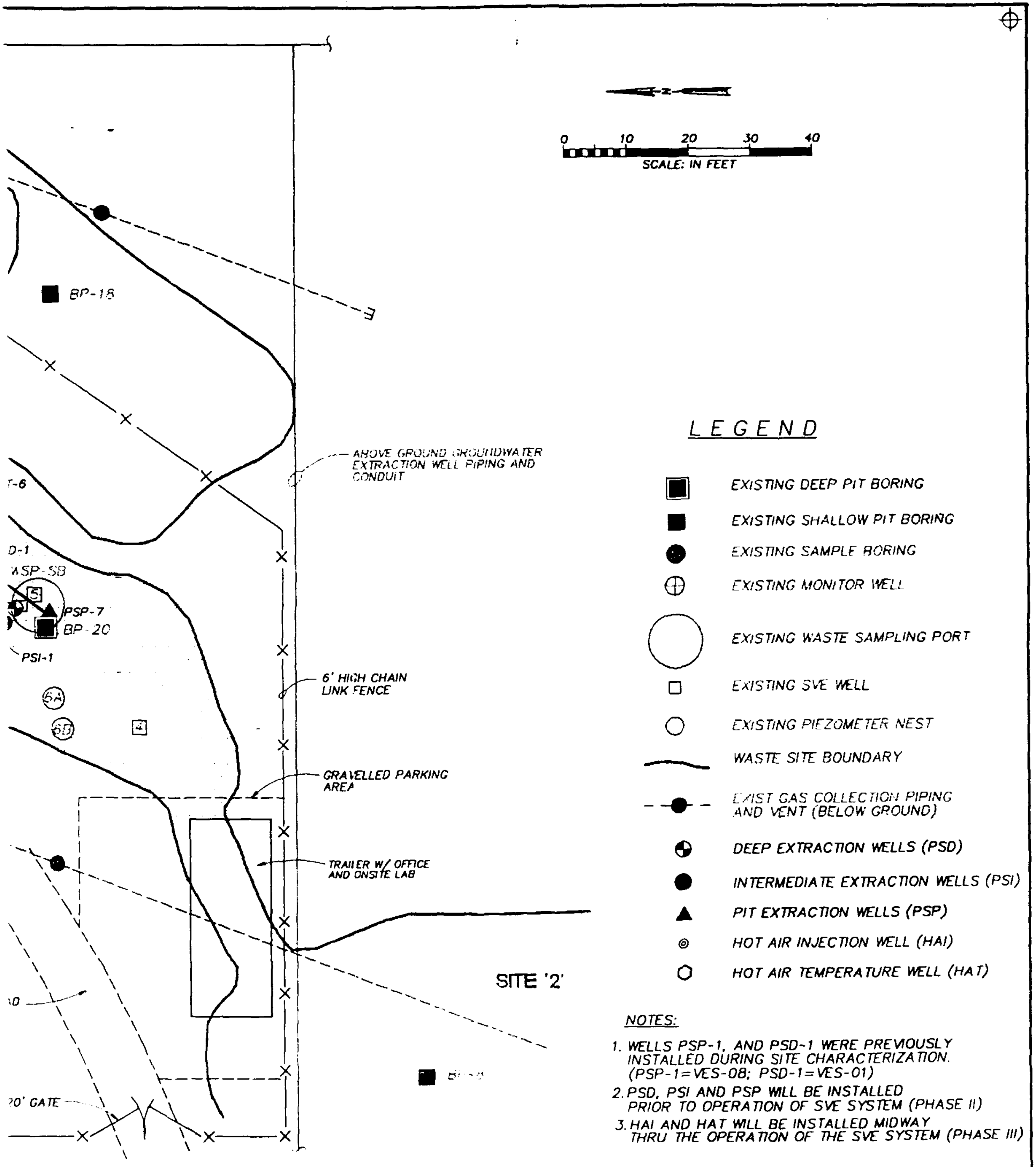

NOTES:

1. WELLS PSP-1, AND PSD-1 WERE PREVIOUSLY INSTALLED DURING SITE CHARACTERIZATION. (PSP-1=VES-08; PSD-1=VES-01)
2. PSD, PSI AND PSP WILL BE INSTALLED PRIOR TO OPERATION OF SVE SYSTEM (PHASE II)
3. HAI AND HAT WILL BE INSTALLED MIDWAY THRU THE OPERATION OF THE SVE SYSTEM (PHASE III)

McCLELLAN AFB
SVE PILOT-SCALE SYSTEM
SITE S IN O.U. D

FIGURE 4-3
PILOT SYSTEM LAYOUT

SHEET
DWG NO.
DATE JUNE 1992
PROJ NO SAC28722 38

The existing cover material will be carefully hand excavated down to the HDPE liner at each new boring location. The excavation will be large enough to cut a circular hole in the liner 6 inches larger than the outside diameter of the largest drill to be used. After the initial section of drill auger is positioned within the hole in the liner, the remainder of the hole will be temporarily backfilled to allow the drill cuttings to be deposited at the ground surface for removal. The boring will then be advanced to the desired depth and the well constructed.

After installation of the well screen, the remainder of the boring will be filled with a bentonite seal and cement/bentonite grout up to the HDPE liner. For hot air injection wells the remainder of the boring will be filled with a neat cement with plasticizer. Prior to placing a slip boot, the exposed surface of the HDPE liner will be brushed clean of soil. Once the grout has cured, the cover material will be re-excavated to expose the HDPE liner. A 60-mil-thick HDPE slip boot will be placed over the well casing. The slip boot will be sized such that the collar of the slip boot will overlap the circular cut in the HDPE liner by at least 4 inches all around. The slip boot will be bonded to the liner using the extrusion welding process. The slip boot collar will be clamped to the well casing with a stainless steel hose clamp.

Once the slip boot has been satisfactorily prepared, a soil/bentonite mixture will be moisture conditioned and placed in the excavation in maximum 6-inch-thick lifts and compacted with at least six passes of the manually operated pneumatic compactor, taking care not to damage the neck of the slip boot that is attached to the casing pipe. Compaction will be to 90 percent relative compaction as defined in ASTM Method D1557. The material will consist of a mixture of silty sand/sandy silt and bentonite. This mixture will be proportioned as one part bentonite to four parts soil prior to placement. At least 12 inches of the compacted soil/bentonite mixture will be placed over the slip boot. The remaining portion of the hand excavation will be backfilled with compacted cover material from the initial excavation. The cover material will be compacted similar to the soil/bentonite mixture. The finish surface of the compacted cover material will be sloped away from the well or piezometer casing to minimize the potential for rainwater to infiltrate around the piezometer or well installation.

Pilot Plant Installation

Installation of the SVE pilot plant includes installation of vapor extraction wells, hot air injection system, and other SVE process equipment.

The pilot-scale SVE system is planned to include up to 15 new wells. The field program will include six new wells in the waste pit, four new deep wells, and five new intermediate depth wells. Two of the existing Phase I wells will be incorporated into the pilot system. The hot air injection system will include four injection wells and six temperature wells to be installed part way through the pilot treatability investigation.

Figure 4-3 presents the locations of the wells to be installed for the SVE treatability investigation.

SVE System

New wells will be installed in drilled borings using hollow stem augers, and construction will be similar to that used for the Phase I site characterization wells with the following changes:

- Well centralizers will be used.
- A fine sand bridging zone will be placed between the sand pack and the "holeplug" or bentonite seal.
- Penetrations through the existing HDPE liner will be repaired by fusion-welding a HDPE boot to the existing liner. The top of the boot will be sealed to the well casing with a stainless steel hose clamp.

Deep Wells

Borings for the deep wells will be drilled to groundwater. Well VES-01 was installed during the site characterization study and will be used as a deep well in the pilot test. It is identified as Well PSD-1 on Figure 4-3.

All deep wells will be constructed with 4-inch-diameter Schedule 40 polyvinyl chloride (PVC) and screened from approximately 40 feet in depth below grade level to 5 feet above the groundwater table (approximately at 100-foot depth). Details of the deep well installation are shown on Figure 4-4.

Intermediate Wells

The intermediate wells will target the low permeability, low flow, and high concentration zone beneath the pit with selective well screens to enhance the probability of significant VOC reduction. The intermediate wells will be located within 5 feet of the deep wells. The intermediate borings will not be logged in detail because of their proximity to the deep wells.

The intermediate depth wells will be constructed with 4-inch-diameter Schedule 40 PVC and screened in the lower permeability material between 27 and 40 feet below grade. Details of the intermediate well installation are shown on Figure 4-5.

Waste Pit Wells

The pit borings will be drilled through the pit materials to native soil to verify the depth of the bottom of the pit. The borehole will then be backfilled with bentonite to 1 foot above the bottom of the pit before the well is constructed. The pit wells will be 4-inch-diameter Schedule 40 PVC and screened within the pit from about 3 feet below the fill to about 1 foot above the bottom of the pit (approximately 15 to 26 feet below grade). Details of the waste pit well installation are shown on Figure 4-6.

Existing Well VES-08 was installed during the site characterization study and will be used as a pit well during the pilot test.

Manifold Piping and Blowers

Three manifold systems will be provided to draw contaminated vapor from the soil; one system will transmit flow from the deep wells, another from the intermediate wells, and a third from the waste pit wells. The pit and intermediate zone manifolds will join together prior to entering the pit/intermediate zone air/water separator. The manifolds have been sized to accommodate a flow of 300 standard cubic feet per minute (scfm) from each deep extraction well, 120 scfm from each pit extraction well, and 30 scfm from each intermediate extraction well. This provides approximately 50 percent additional flow capacity over the anticipated design flows from each well.

Two skid-mounted 40-horsepower (hp) vacuum pumps rated at 900 scfm each at 2 inches of mercury (Hg) (measured at the extraction wells) will be installed for the deep extraction well system. Three 50-hp, 500-scfm skid-mounted pumps operating at approximately 14 inches of Hg at the wells will be required for the combined pit and intermediate extraction well systems. For the majority of the time, only one pump will be required for the deep system and two pumps for the pit and intermediate system. The additional pumps will be available for high flow periods and to provide adequate system redundancy.

Air/Water Separators

A 3-foot-diameter, 6-inch tangential entry, 1,000-scfm air/water separator with a demister and high level shutdown will be installed in-line prior to the blowers on the combined pit and intermediate extraction well manifold. A 4-foot-diameter, 8-inch tangential entry, 2,000-scfm unit will be installed on the deep extraction well system. The air/water separators will remove entrained moisture from the SVE offgas. Water level will be measured with a sight glass. Water will be removed from the separator as required and transported to the Groundwater Treatment Plant (GWTP) for treatment. The high level shutdown switch will activate the controller to shut down all process equipment with the exception of the catalytic oxidation system if water levels exceed a preset level.

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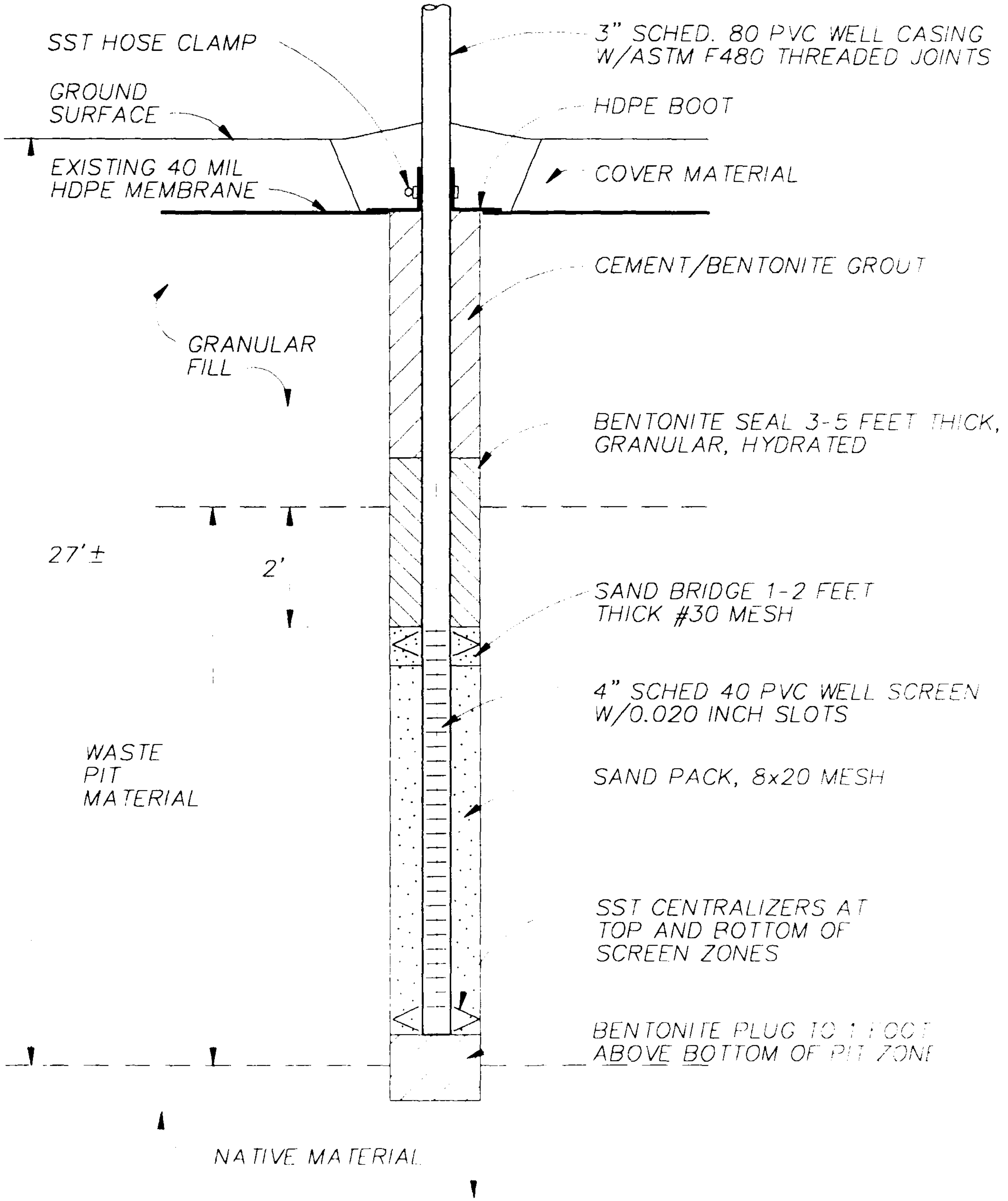

FIGURE 4-6
WASTE PIT EXTRACTION WELL
SVE PHASE II
SITE S, OU D
McCLELLAN AFB

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Hot Air Injection System Construction

A hot air injection system will be installed midway through the SVE treatability investigation to evaluate the impact of this enhancement on the SVE technology. The system will include a 50-hp, 300 scfm, rotary vane, positive displacement blower to heat and pressurize the injection air. The heat of compression of the blower in conjunction with a supplementary 15-kW immersion heater is capable of heating the air to approximately 300°F at 12 psi. The blower will be equipped with an inlet air filter/silencer. Discharge from the blower will be transferred through an above ground insulated carbon steel piping manifold and distributed to four carbon steel injection wells screened in the waste pit.

The temperature of the soil will be monitored through a network of thermocouples installed in six temperature wells around the site. Temperature wells are described below.

Injection Wells

The locations of the four hot air injection wells are shown on Figure 4-3. The locations were selected along the axis of waste pit and are enveloped by the waste pit extraction wells to prevent offsite migration of contaminants. A schematic of a hot air injection well is shown on Figure 4-7. The injection wells will be drilled into the intermediate alluvial zone to allow soil sampling as a part of the mid-operation soil investigation. Borings will be grouted with cement/bentonite grout to approximately 1 foot above the bottom of the waste pit.

After the grout has set, the 2-inch-diameter carbon steel well will be installed. The well will be screened in the pit between approximately 2 feet below the top of the pit and 1 foot above the bottom of the pit. A 1- to 2-foot-thick sand bridge will be installed at the top of the screen. The well casing will be grouted between the sand bridge and the HDPE liner using neat cement containing a plasticizer. This will reduce the impact of the high temperature on the integrity of the grout and casing seal.

Temperature Wells

The temperature distribution in the soil will be monitored through a network of thermocouples installed within the waste pit and upper intermediate alluvial zones of Site S. Six temperature wells will be installed in various locations between the hot air injection wells and waste pit extraction wells. The locations of the temperature wells were selected so as to monitor the movement of the temperature front between the injection and extraction points. Two temperature wells will be placed outside the pit extraction wells to monitor for divergence of the hot air front. The locations of the temperature wells are shown on Figure 4-3.

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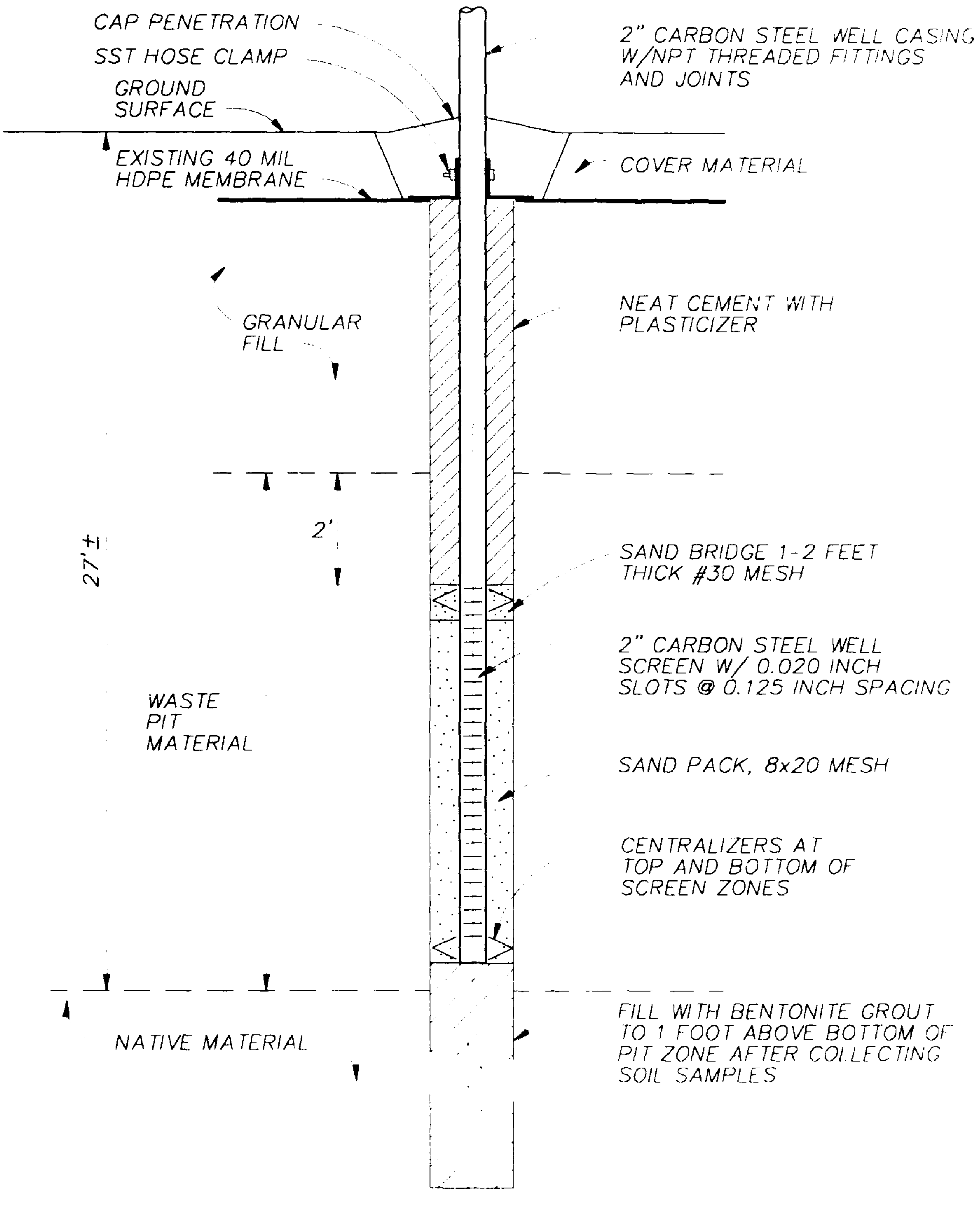

FIGURE 4-7
HOT AIR INJECTION WELL
SVE PHASE III
SITE S, OU D
McCLELLAN AFB

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Six thermocouples will be installed in each temperature well as shown in Figure 4-8. Two thermocouples will be installed in the upper half of the intermediate alluvial zone and the remainder in the waste pit. The shallowest probe will be placed just inside the waste pit at the interface of the pit and fill materials below the liner.

The thermocouples will be immobilized by taping them to a 1-inch-diameter PVC pipe and grouting the pipe into the boring. Plasticizer will be added to the grout to control shrinkage when the grout mix is heated. A section of 2-inch-diameter PVC pipe will be installed over the 1-inch pipe and thermocouple leads to 2 feet below the HDPE liner. A HDPE slip boot will be fusion welded to the 2-inch pipe and existing HDPE liner. The thermocouple lead wires will be threaded through the 2-inch PVC pipe and completed at the surface.

Care should be taken to identify the individual leads as to the depth of the attached thermocouple.

Emission Control System

In the oxidation system, halogenated and nonhalogenated VOCs exiting the air/water separator will be catalytically oxidized to complete products of combustion, namely carbon dioxide, water, and hydrochloric acid. The SVE air stream flows from the positive displacement blower to a preheater chamber, where it is mixed with natural gas and dilution air and preheated to approximately 750°F. The preheated gas then enters the combustion chamber, where the SVE gases are oxidized at approximately 1,200°F. Total residence time in the combustion chamber is approximately 1 second.

The combustion chamber contains a stainless steel catalyst support plate and distribution grid. This support provides proper distribution of the process stream, assuring uniform flow and complete contact of the stream with the catalyst. The catalyst initiates, promotes, and accelerates VOC oxidation. The catalyst, without itself being altered, significantly reduces the oxidation activation energy, thus allowing the oxidation reaction to occur at much lower temperatures than would be required with conventional oxidation.

Since oxidation is an exothermic reaction, it heats up the exiting gases as well as the catalyst bed. The exhaust gas stream temperature from the catalytic oxidation chamber will be up to 1,200°F. Natural gas and dilution air flow rates will be controlled to limit catalyst bed temperatures to approximately 1,200°F to protect the catalyst from being sintered. The hot exhaust gas stream is vented to the atmosphere through a 12-inch-diameter stack at approximately 1,200°F. The destruction removal efficiency for the halogenated and nonhalogenated hydrocarbons is estimated to be over 99 percent based on past performance history for similar streams.

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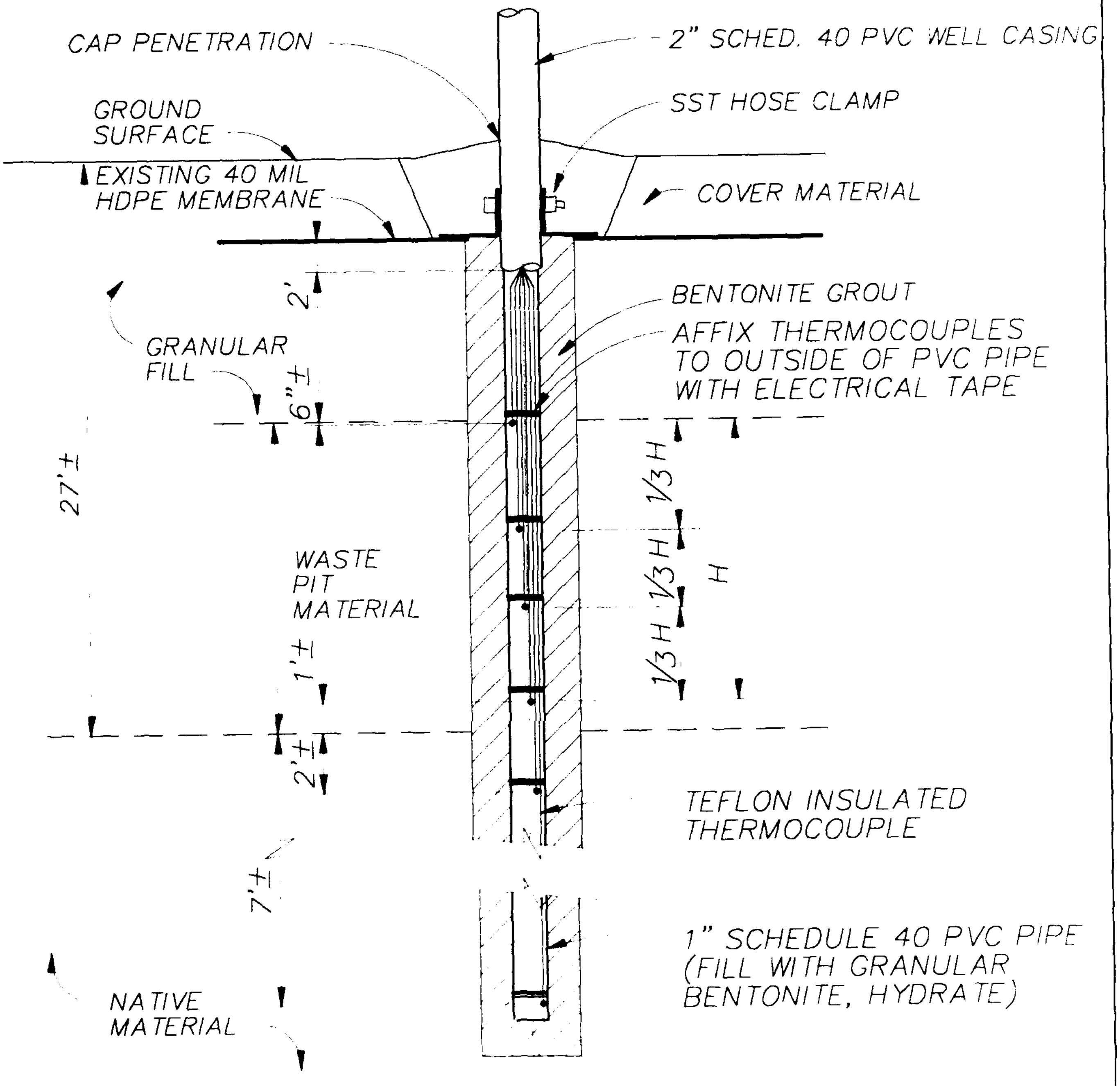

FIGURE 4-8

HOT AIR TEMPERATURE WELL
SVE PHASE III
SITES, OU D

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Utility Requirements

Natural gas will be used to provide supplemental fuel for the catalytic oxidation system. Process equipment will operate using electrical power. Automatic shutdown alarms will activate an autodialer system, which, in turn, will communicate the fault via phone to the SVE operator.

Natural Gas

Natural gas for the catalytic oxidation system will be supplied from existing on-base sources. The closest natural gas line is located approximately 500 feet east of Site S. The existing line is a buried 4-inch polyurethane pipe at a pressure of 15 psig. The catalytic oxidation system will require a maximum natural gas flow rate of 2,400 ft^3/hr at 5 psig. A new 1-1/2-inch polyurethane line will be installed to Site S to supply the catalytic oxidation system with natural gas.

Electrical Power

Electrical power for the SVE process equipment and the onsite laboratory will be supplied from existing on-base sources. The most convenient tie-in location for electrical power is located approximately 350 feet east of Site S. The 12-kV powerlines are suspended by a series of power poles.

A 12-kV electric line will be buried between an existing pole and Site S. Two turndown transformers will be supplied by the contractor to transform the 12-kV power to 480 V (for process equipment) and 120 V (for use by the onsite laboratory, the alarm dialer, control panels, and lighting).

Telephone Service

No telephone lines are located in the vicinity of Site S. Therefore, a cellular or hardwired phone system will be used for offsite communications while the site is manned. The phone will be equipped with an autodialer for remote communication of system shutdown alarms when the site is not manned.

Other Aspects of Pilot Plant Installation

Other aspects of the pilot treatability investigation installation include:

- Construction of gravel treatment pad
- Equipment mobilization
- Mobilization of onsite trailer and field sampling equipment

- Installation of above grade PVC piping manifold to transport extracted soil vapors to process equipment

- Installation of steel manifold to connect blowers to catalytic oxidizer system

- Installation of above grade carbon steel piping for the hot air injection system

- Installation of hot air thermocouple sensors

- Installation of security fence

- Utility connection and equipment wiring

Equipment will be supplied in accordance with the design documents developed in Phase I. An onsite trailer will be provided to serve as field office and laboratory. A gas chromatograph (GC) will be provided to analyze a portion of sample data generated during site operations (Figure 4-3 presents the pilot system layout).

Pilot Plant Operation

The pilot plant operation will include three tasks:

- Operation and monitoring of the pilot system
- Performance of mid-operation soil sampling and analytical testing
- Performance of post-operation soil sampling and analytical testing

Operation and Monitoring of the Pilot System

Operation and monitoring of the pilot system will entail five components:

- Pre-operation
- Initial system testing and shakedown
- System startup
- Continued operations
- Operation of hot air injection system
- Post-operation

The pilot system is planned to be in operation for approximately 6 months.

Pre-Operation

The 14 piezometers at Site S have been installed throughout the vadose zone from 13 feet bgs to 96 feet bgs. Each piezometer contains a narrow screened zone (2-1/2 to 3 feet) and will therefore provide soil gas concentrations from a narrow band of the vadose zone. Each of the piezometers will be sampled prior to startup of the SVE system. This will provide baseline data of initial soil gas concentrations from each of the targeted zones in the waste pit, intermediate alluvial zone, and deep alluvial zone. Pre-operation testing will last less than 4 weeks.

Initial System Testing and Shakedown

After all equipment and piping manifolds are installed, the system will be checked for safety and operational effectiveness. Terra Vac personnel (technician and chemist) will be onsite to test shutdown controls and catalytic oxidizer efficiency. Initial testing is estimated to last 1 week.

System Startup

Terra Vac will provide operating staff to monitor system performance on a daily basis (5 days per week) during startup. It is estimated that startup will take approximately 5 weeks.

The goal during this period is to optimize the extraction system. The flow rates from the individual wells will be balanced to maximize the mass rate of contaminant removal. This is also the period when the system is changing rapidly and adjustments are needed on a frequent basis. A sample operating log sheet and gas chromatograph log sheet are included as Figures 4-9 and 4-10.

Intense monitoring during startup includes vapor sampling at the inlet and outlet of the vapor treatment system, close monitoring of wellhead concentrations, and measurement of the subsurface extent of vacuum influence.

Each well will be monitored for temperature, vacuum, and flow. In addition, each wellhead will contain a sample port for onsite GC analysis. Flow measurements from the shallow, intermediate, and deep zones will be recorded separately before flows enter the vacuum pumps.

Routine process monitoring will be conducted daily until concentrations of the SVE offgas (prior to treatment) have stabilized. Process monitoring will include documentation of flows, pressures, and sampling results at several key locations in the process. Additionally, the system will be monitored for destruction removal efficiency and other physical parameters to maintain trouble-free and safe operations.

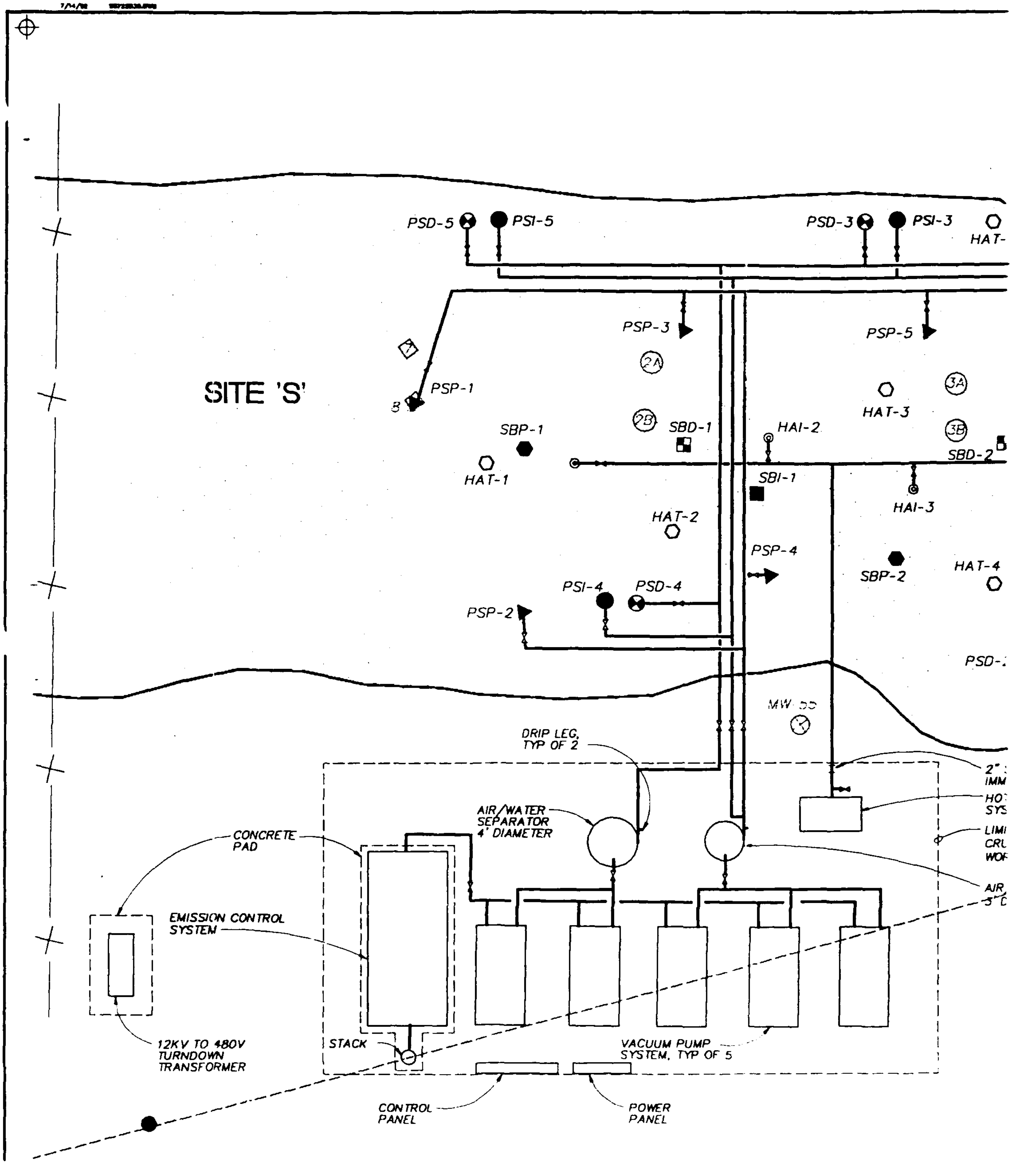
Figure 4-9

TERRA VAC

OPERATING LOG

PROJECT ____________

DATE/ TIME	SAMPLE NUMBER	LOCATION	VACUUM ("HG)	FLOW ("H2O)	PUMP VAC ("HG)	TEMP	INIT	NOTES



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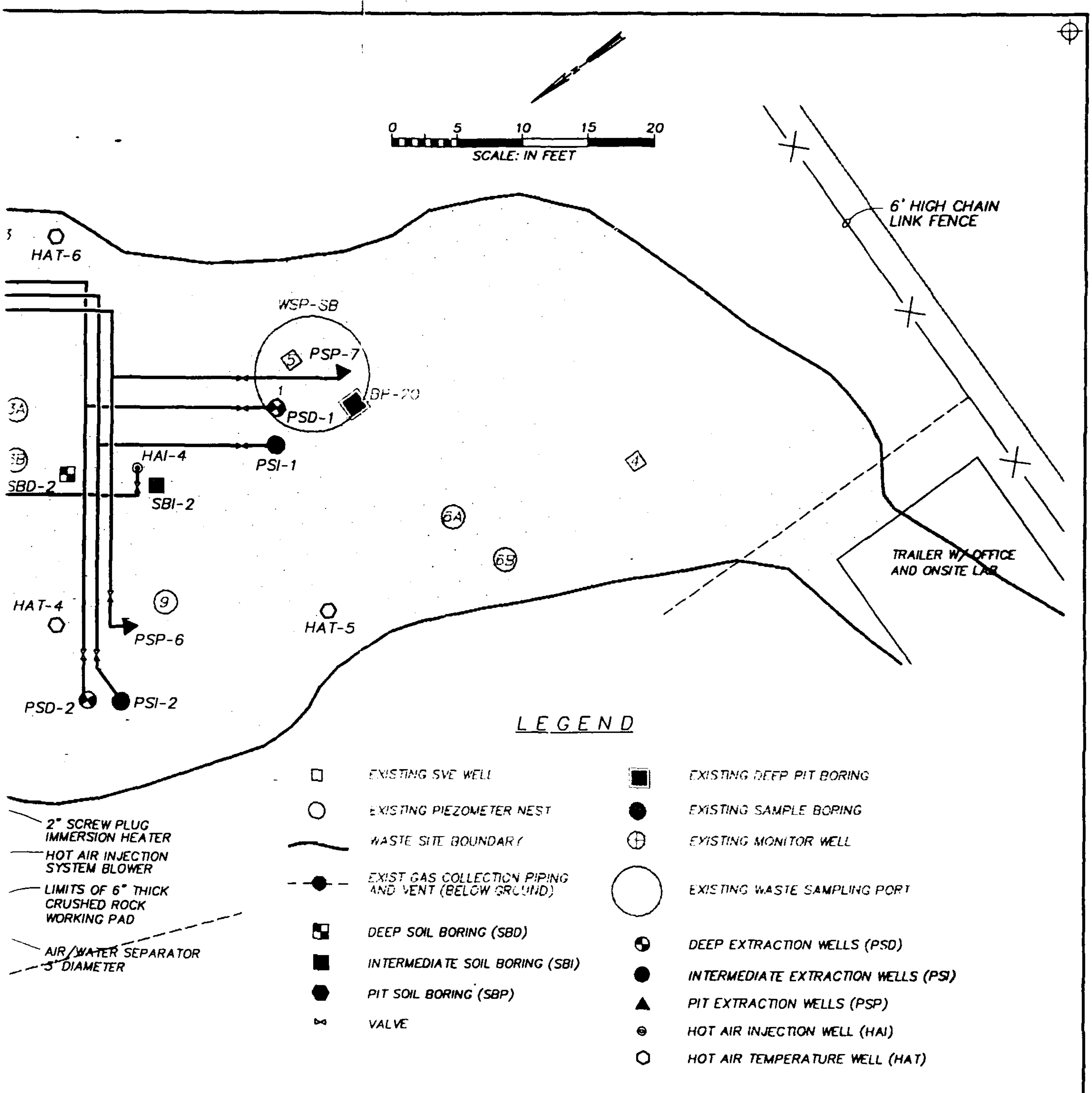

NOTE:

WELLS PSP-1, AND PSD-1 WERE PREVIOUSLY INSTALLED DURING SITE CHARACTERIZATION. (PSP-1=VES-08; PSD-1=VES-01)

SAMPLE THE FOLLOWING BORINGS:

PHASE II	(PSP2, PSP4, PSP7, PSD3, PSD2, PSD5
PHASE III-MID	(HAI1, HAI2, HAI3, HAI4)
PHASE III-POST	(SBP1, SBP2, SBI5, SBI6, SBD1, SBD2)

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McCLELLAN AFB
SVE PILOT-SCALE SYSTEM
SITE S O.U. D

FIGURE 4-11

PRELIMINARY SITE SOIL BORING PLAN

SHEET
DWG NO.
DATE JUNE 1992
PROJ NO. SAC28722.38

Figure 4-10

TERRA VAC

Project ____________

GC LOG

Cal = Calibrate

Dupe = Duplicate

Date	Sample	Sample			Volume	Sample	Chemical	Results			Notes	Analyst
	Time	Number	Syr	Bag	Injected	Location		Area	RF	mg/l		

Continued Operations

During the remainder of the pilot test, monitoring of system operations and efficiency will continue with field personnel and the onsite laboratory. Adjustments in extraction well operation will continue to provide optimized remediation parameters.

After the extraction rates stabilize, vapor monitoring with onsite GC will continue at the inlet and outlet of the vapor treatment system, but individual wellhead monitoring will be reduced. As remediation proceeds, the source of the contamination will be removed and extraction rates will decline. Variations in the subsurface conditions cause the cleanup to proceed at different rates in various locations of the site, requiring adjustment in vacuum and flow to optimize the extraction and treatment system.

Soil lithology, well depth, length of screening interval, flow rate, mass extraction, vacuum at the wellhead, radius of influence, and various other parameters are evaluated before the system is adjusted. Optimization of mass flow rate and cumulative removal of VOCs is the primary objective, and can be accomplished by isolating various sectors of the site or distributing vacuum proportionally among the wells. Adjustments are based on empirical data and are site-specific.

If startup data collected indicate weekly averages are as representative as daily sampling, then weekly sampling is sufficient to track mass removal rates, and a reduced monitoring pattern is proposed. Once the initial operating period is complete the concentrations will continue to decline at a decelerated rate, making reduced monitoring a practical alternative. It is estimated that continued operations will last 20 weeks.

Operation of Hot Air Injection System

Midway through the treatability investigation, additional borings will be installed and completed for use as hot air injection or temperature wells. After the baseline concentrations for the initial SVE system are recorded, the hot air injection system will be turned on. The injection air flow, temperature, and pressure will be recorded as required to quantify heat loading to the vadose zone. In conjunction with recording the hot air injection system parameters, measurable extraction well variables will be documented to assess their effects on SVE removal rates. Vapor concentration monitoring at wellheads and for mass extraction calculations will continue with no modification to procedure. Additional samples will be collected early in system operations to document increase, decrease, or no change in extraction. Hot air injection will occur during continued operations.

Post-Operation

Following the completion of the pilot system operation, the wellheads will be sampled to estimate the contaminant concentrations in the soil gas.

Once the goals of Phase III have been met, Terra Vac will demobilize equipment from the site and file the necessary final reports, compiling data and evaluating the effectiveness of the system in removing volatile organic compounds from Site S.

Mid-Operation Soil Sampling

After the pilot system has been in operation for approximately 3 months, it is planned that soil borings will be installed to gather soil samples for analytical testing. Tentative locations for mid-operation soil borings are shown on Figure 4-11. Actual locations will be established following a thorough field reconnaissance.

Drilling, Sampling, and Well Installation

Some of the mid-operation borings will extend to the water table, and some of the borings will terminate at a depth of approximately 40 feet. After the sampling is complete, hot air injection wells will be constructed within the pit interval in each of the borings. Well installation will confonn to the details shown on the Phase I design drawings.

The test data developed from these samples will indicate the interim effectiveness of the SVE system as well as provide baseline data for measuring the effectiveness of hot air injection in further enhancing contaminant removal and degradation of pollutants through bacterial activity.

Post-Operation Soil Sampling

Following completion of the pilot system operation, borings will be installed to obtain samples for post-operation testing. Analytical data will be collected for comparison to the Phase I, II, and III mid-operation data. Tentative locations for the post-operation borings are also shown on Figure 4-11. Actual soil boring locations will be determined following a thorough field reconnaissance. In addition, the 14 piezometers will be sampled to estimate the overall percent reduction of contaminants in the soil gas.

Drilling and Sampling

Some of the post-operation borings will extend to the water table, and some of the borings will terminate at a depth of approximately 40 feet. Samples will be collected for analysis and comparison to pre- and mid-operation soil samples. After the sampling is complete, the borings will be grouted and abandoned in accordance with the design requirements.

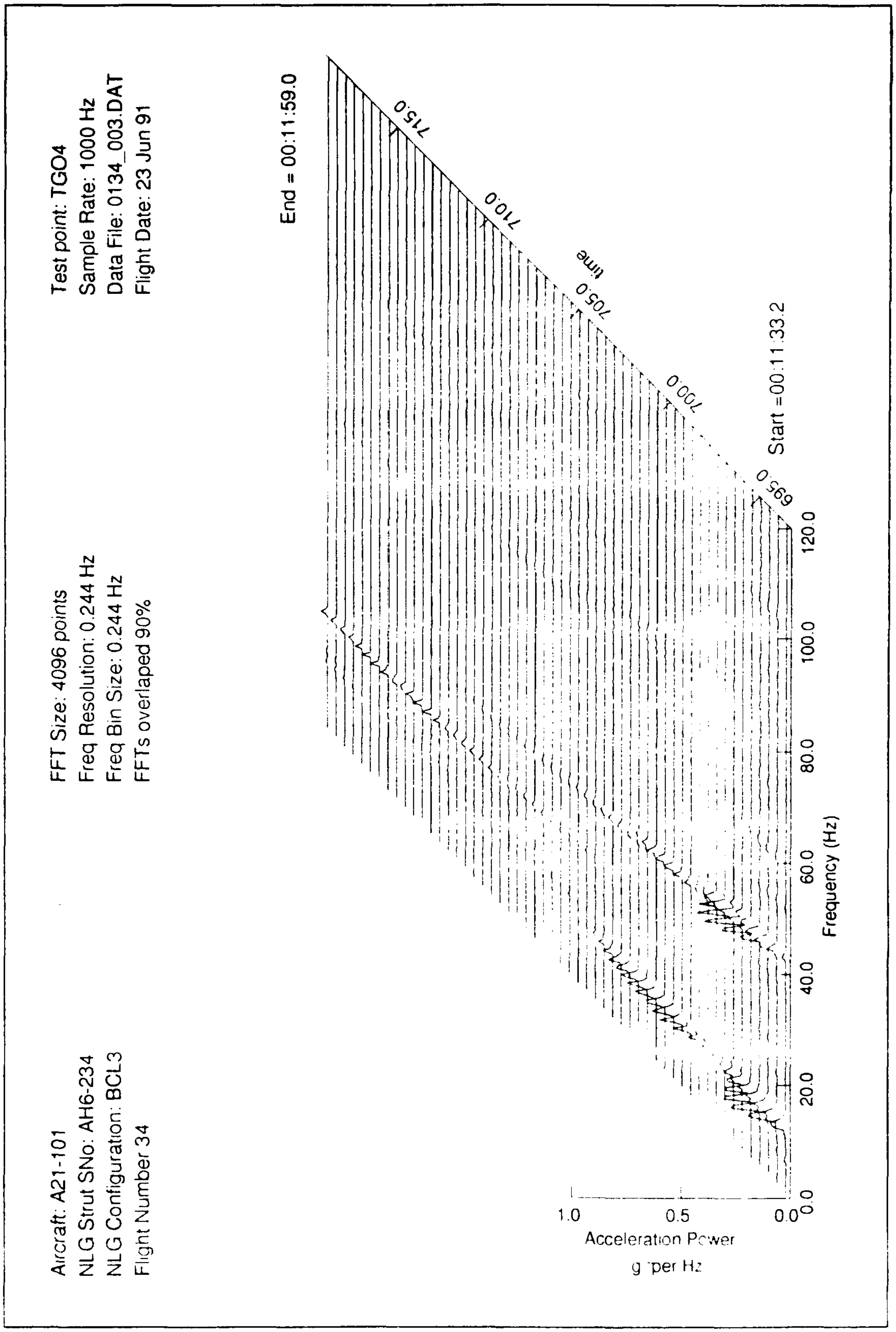


Figure P-5: Configuration BCL_s - Median Sequential Power Spectral Densities for Strut Lateral(y) Accelerometer Spanning the Duration of the Test

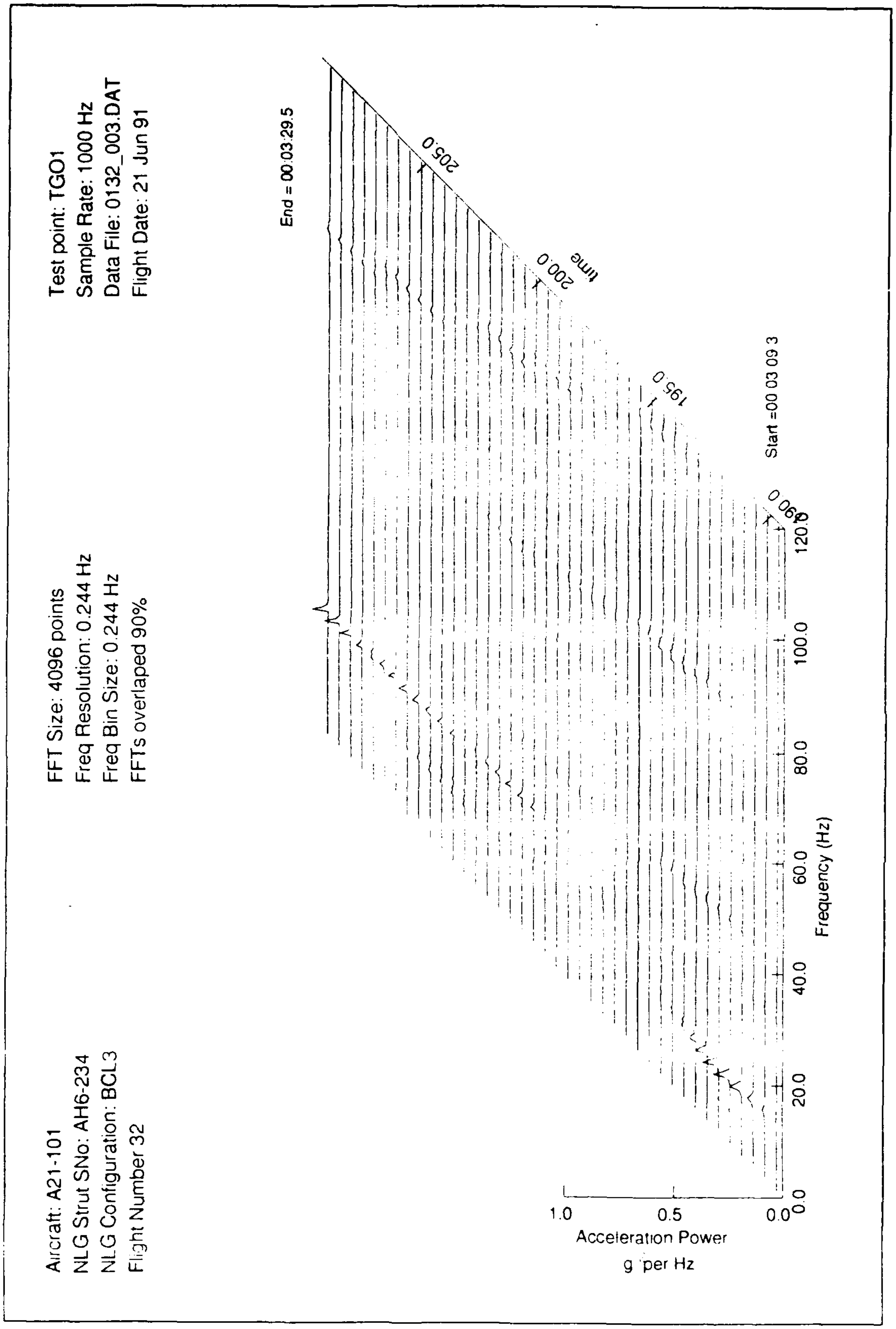


Figure P-6: Configuration BCL_s - Low Tail
Sequential Power Spectral Densities for Strut Lateral(y) Accelerometer
Spanning the Duration of the Test

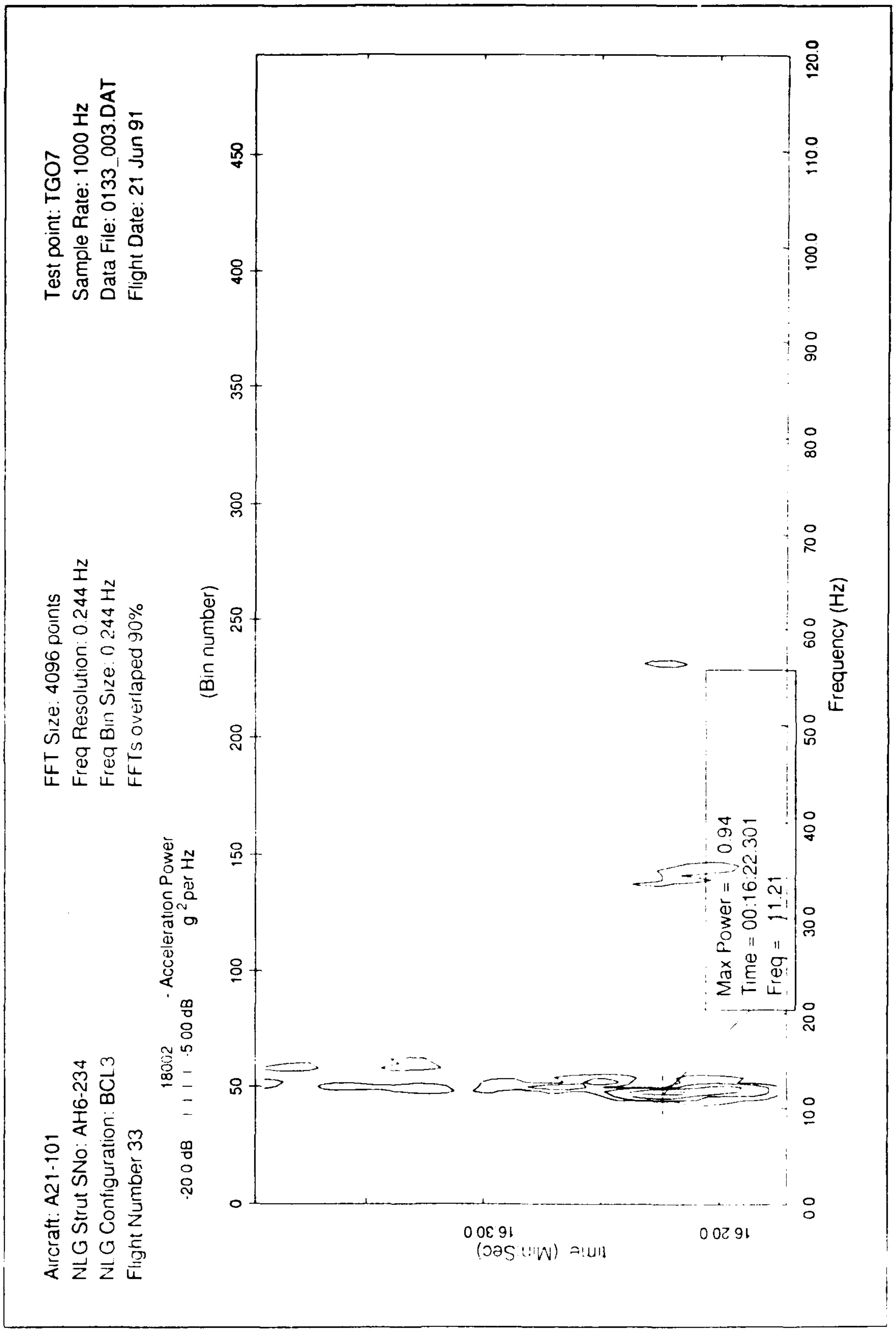


**Figure P-7: Configuration BCL_s - High Tail
Sequential Power Spectral Densities for Strut Lateral(y) Accelerometer
Spanning the Duration of the Test - Contour Plot**

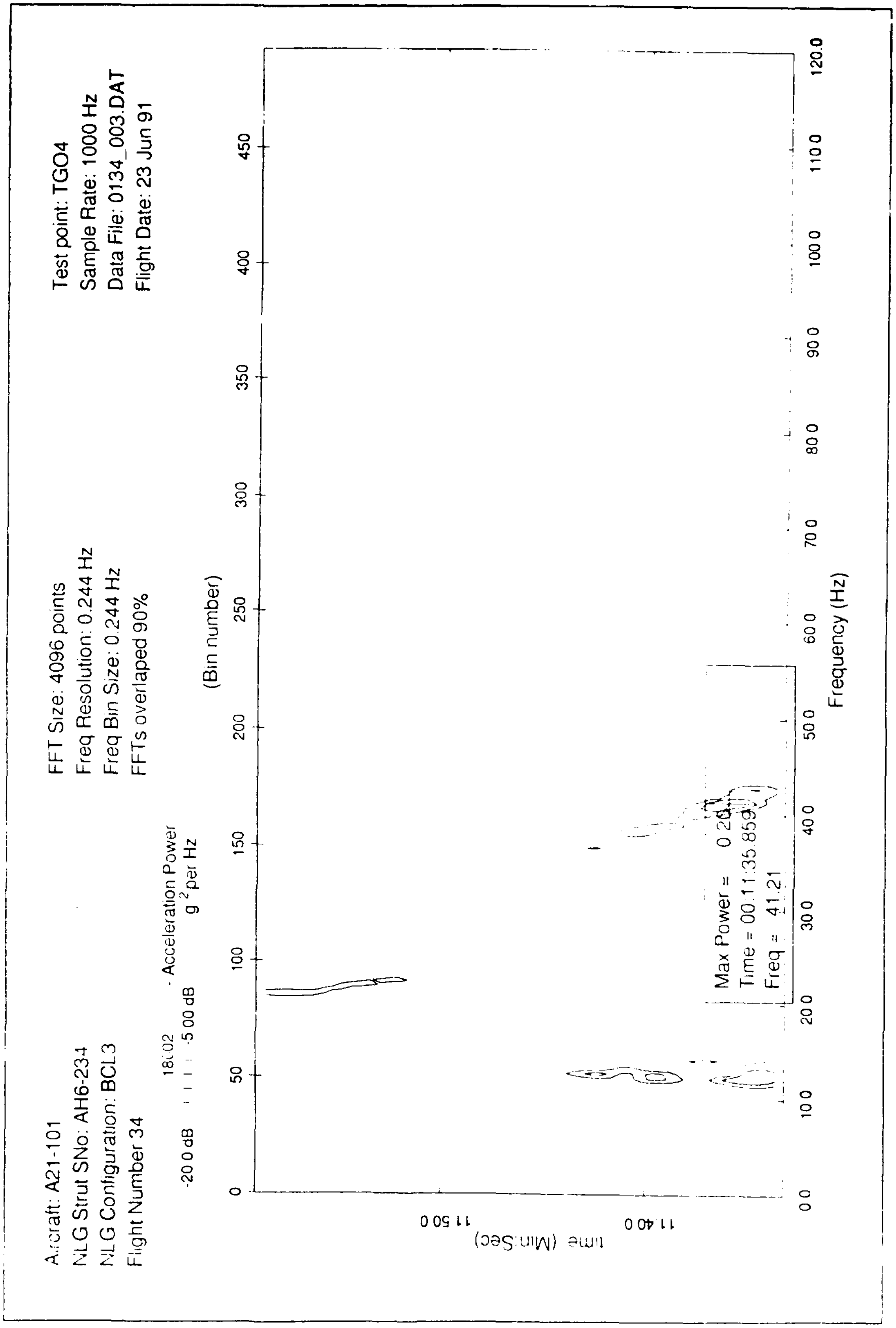


Figure P-8: Configuration BCL_s - Median
Sequential Power Spectral Densities for Strut Lateral(y) Accelerometer
Spanning the Duration of the Test - Contour Plot

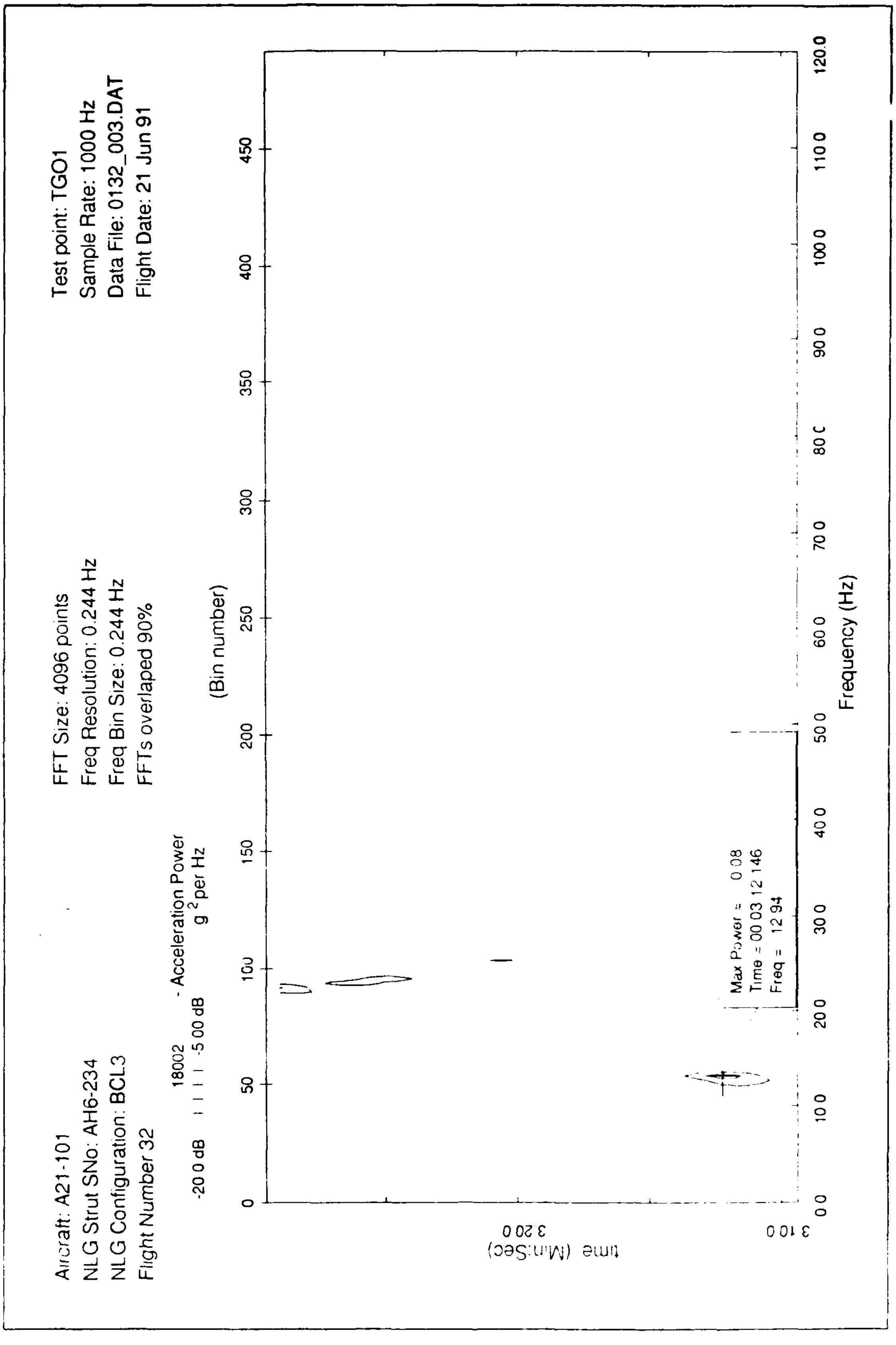


Figure P-9: Configuration BCL_s - Low Tail
Sequential Power Spectral Densities for Strut Lateral(y) Accelerometer
Spanning the Duration of the Test - Contour Plot

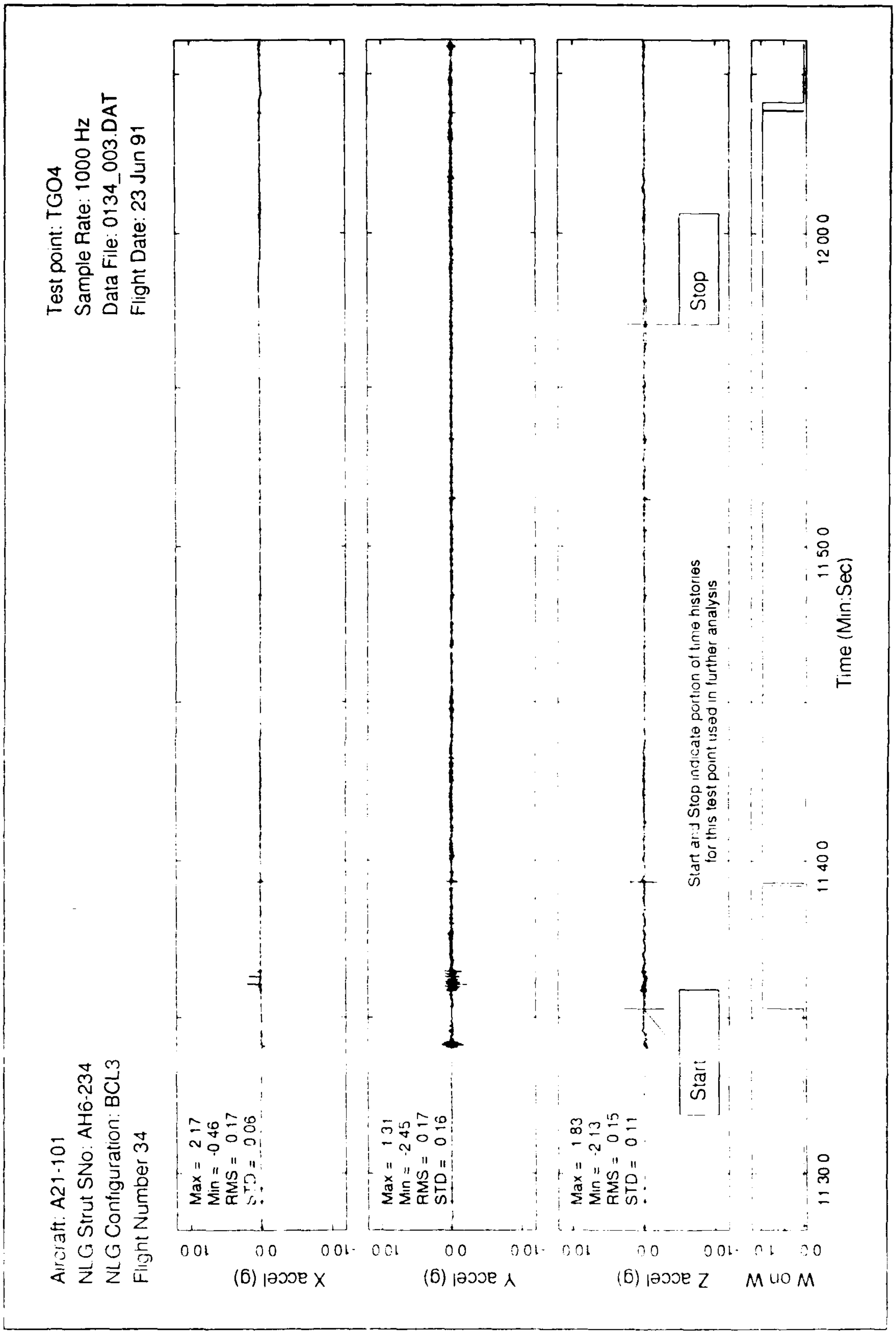


Figure P-10: Configuration BCL_s - Median Time History Plot of Fuselage X,Y,Z Accelerometer Channels

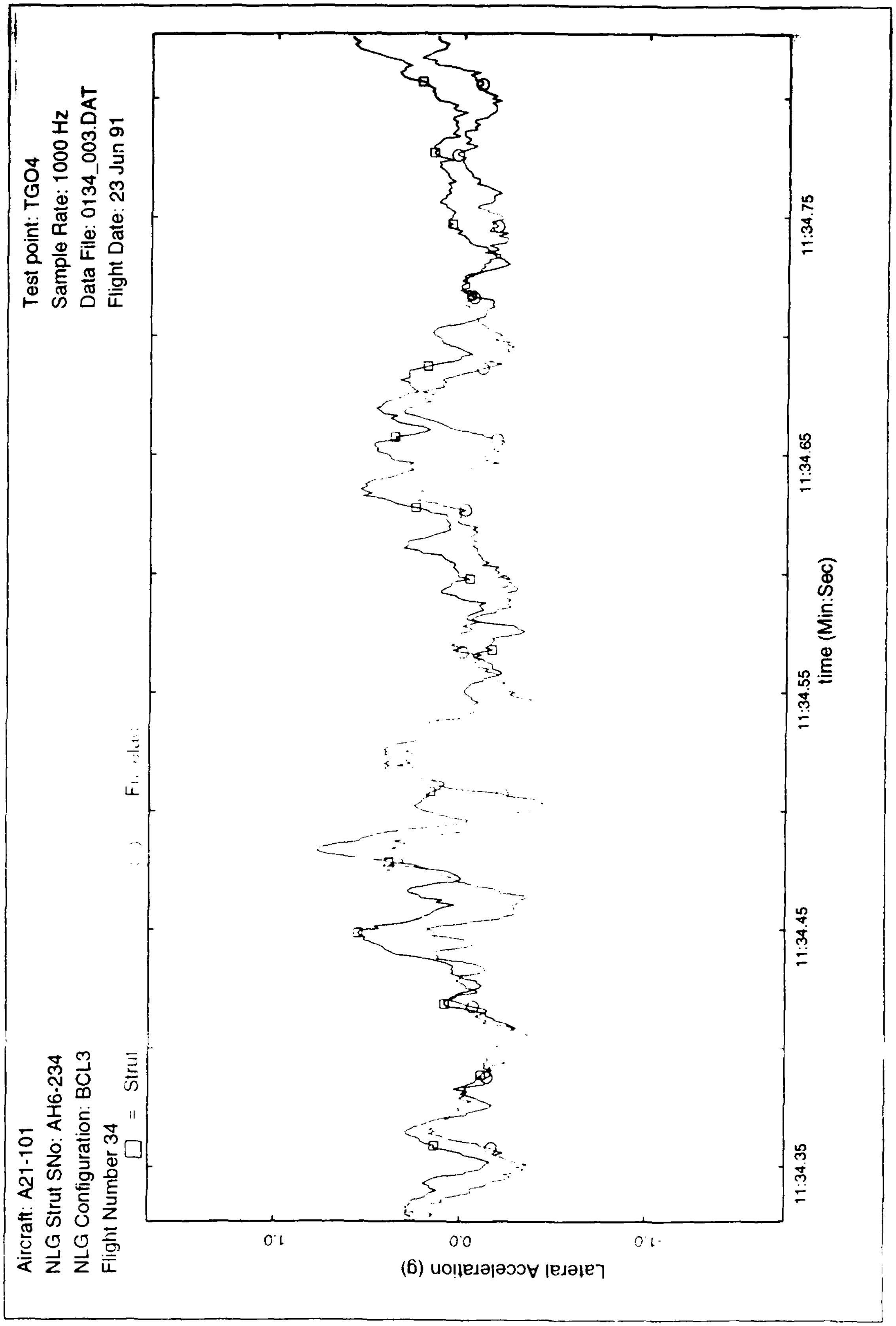


**Figure P-11: Configuration BCL_s - Median
Time History Plot of Strut and Fuselage Y Accelerometer Channels
Expanded Scales at Time of Maximum Y Vibration Power**

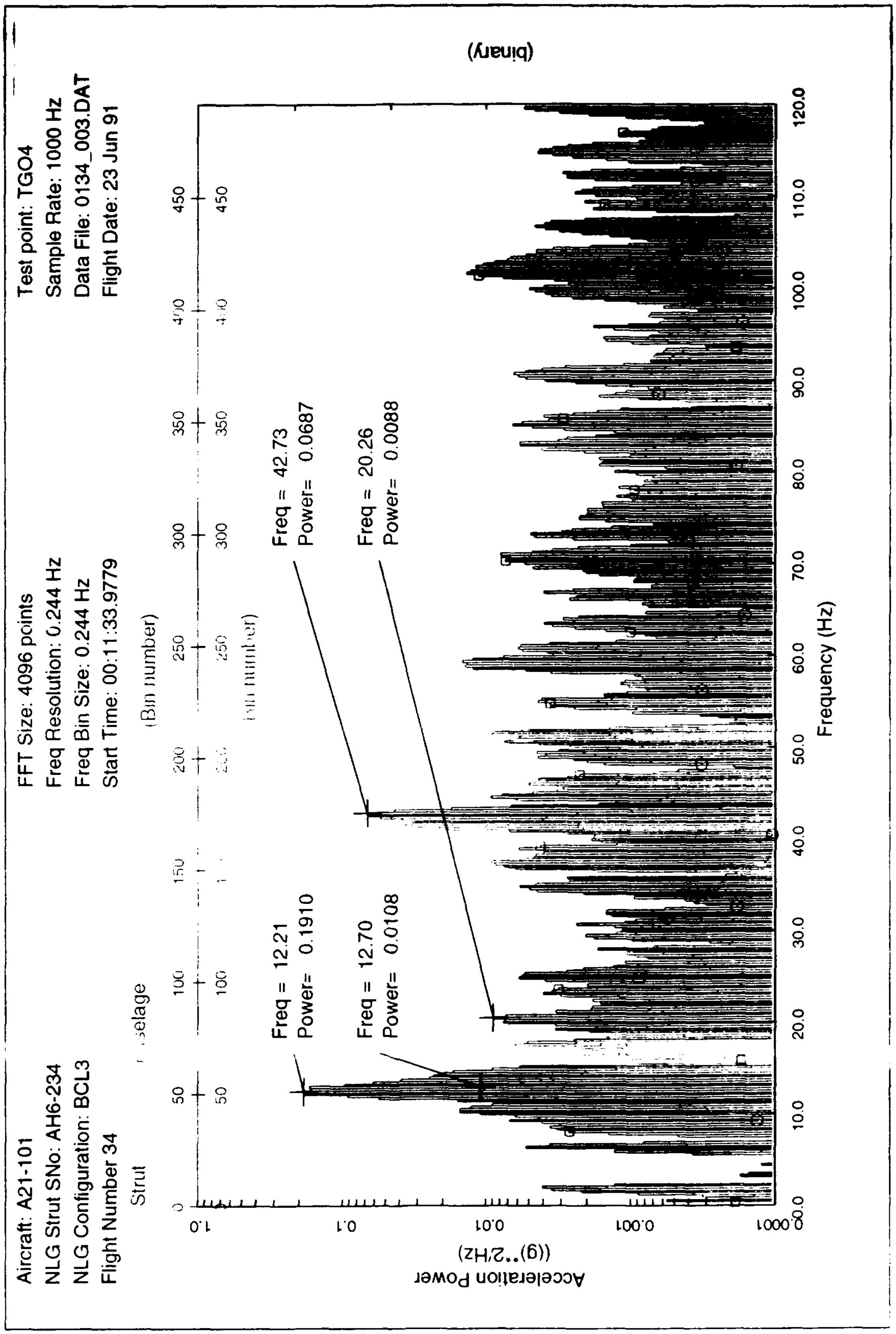
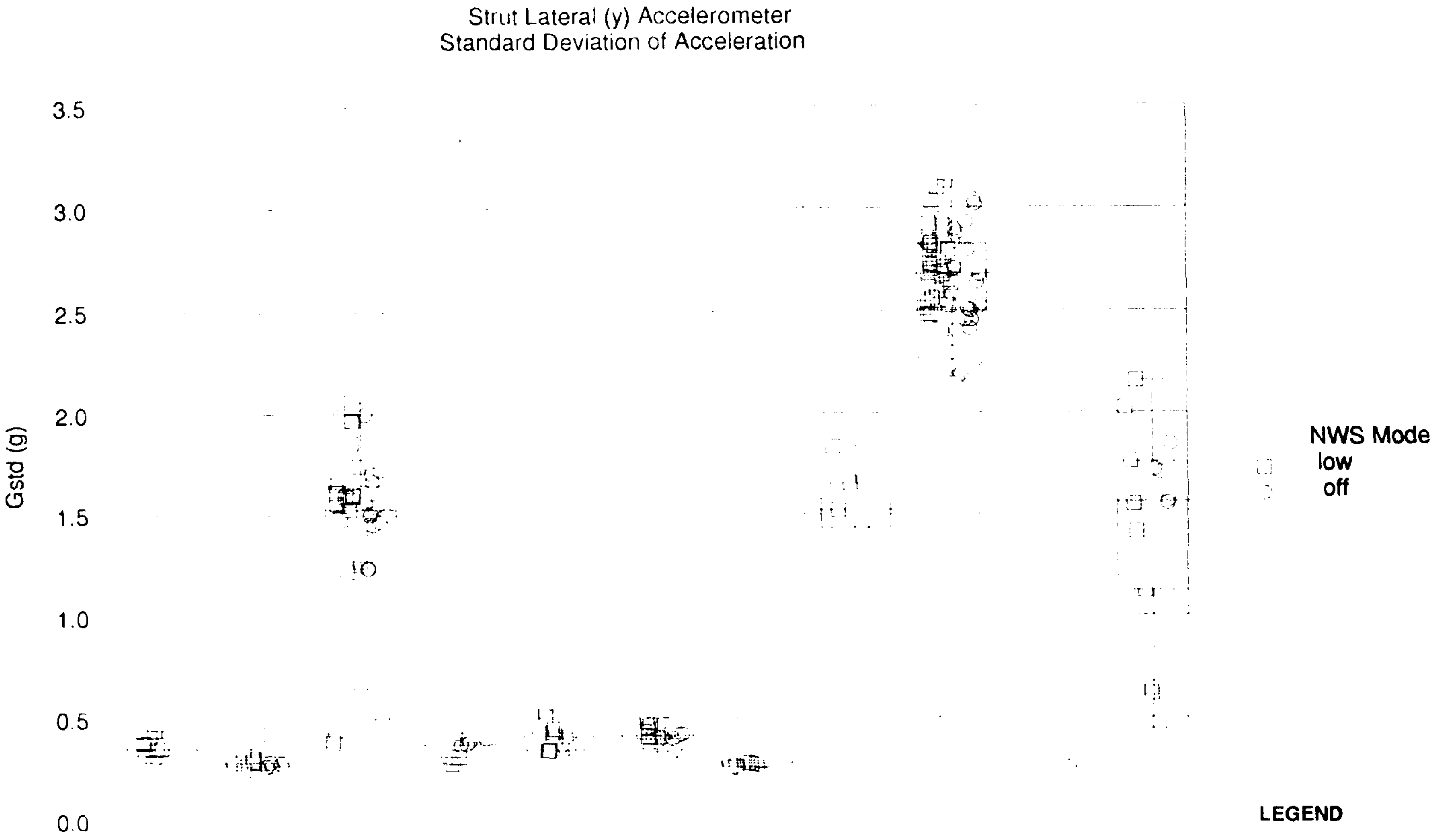


Figure P-12: Configuration BCL_s - Median
Comparison of Power Spectral Densities for Strut and Fuselage Accelerometers
at Time of Maximum Strut Lateral(y) Vibrational Power

ANNEX Q TO
ARDU FORMAL REPORT
TASK 0067

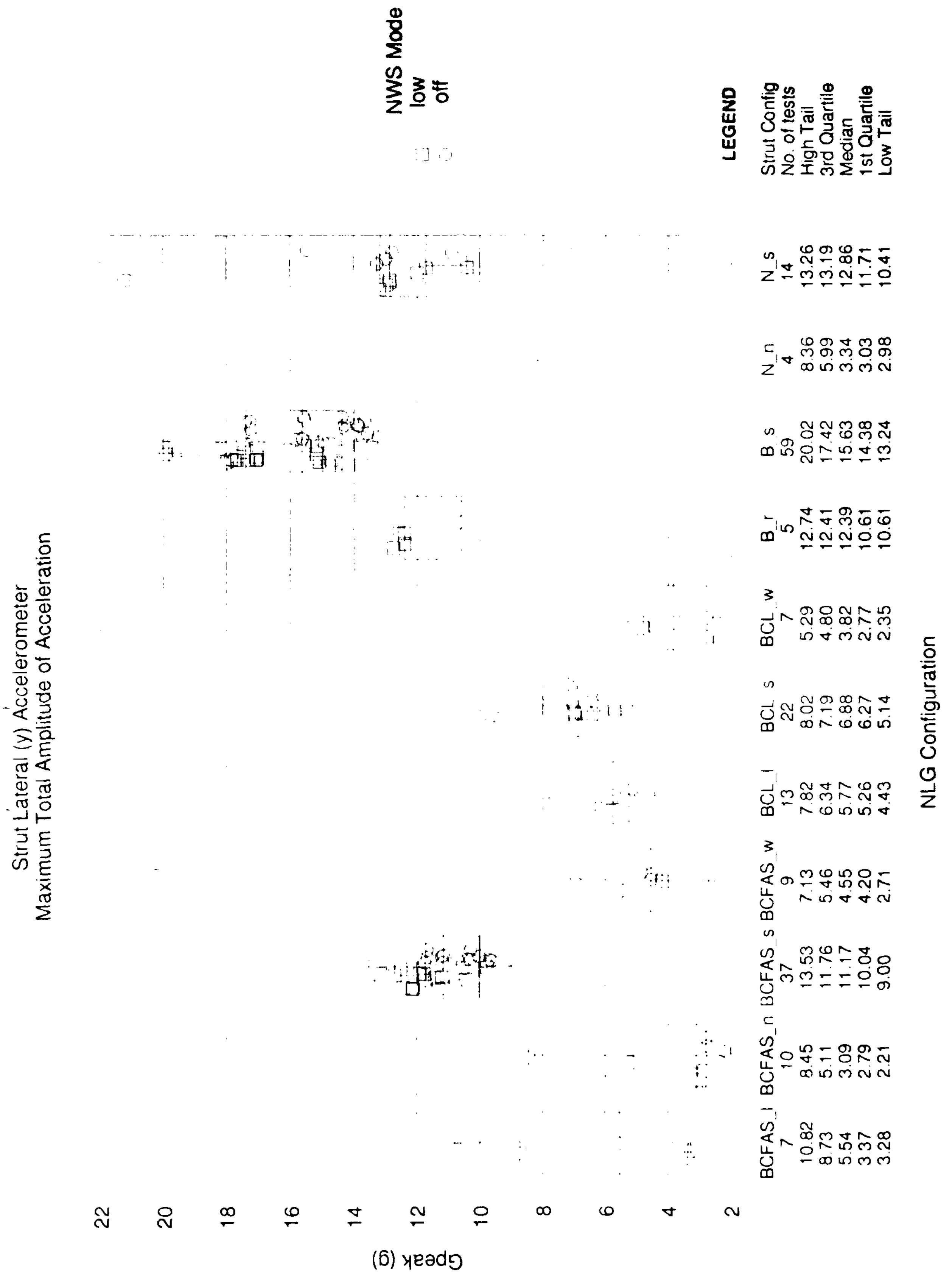
STATISTICAL COMPARISONS - STRUT



BCFAS l	BCFAS n	BCFAS s	BCFAS w	BCL l	BCL s	BCL w	B r	B s	N n	N_s	Strut Config
7	10	37	9	13	22	7	5	59	4	14	No. of tests
0.446	0.340	2.059	0.429	0.541	0.503	0.291	1.835	3.129	0.386	2.158	High Tail
0.412	0.321	1.648	0.387	0.431	0.453	0.291	1.654	2.828	0.337	1.760	3rd Quartile
0.353	0.286	1.526	0.372	0.410	0.413	0.278	1.521	2.680	0.288	1.557	Median
0.325	0.270	1.272	0.313	0.343	0.398	0.262	1.434	2.510	0.272	1.121	1st Quartile
0.285	0.254	1.222	0.276	0.321	0.337	0.256	1.434	2.176	0.256	0.442	Low Tail

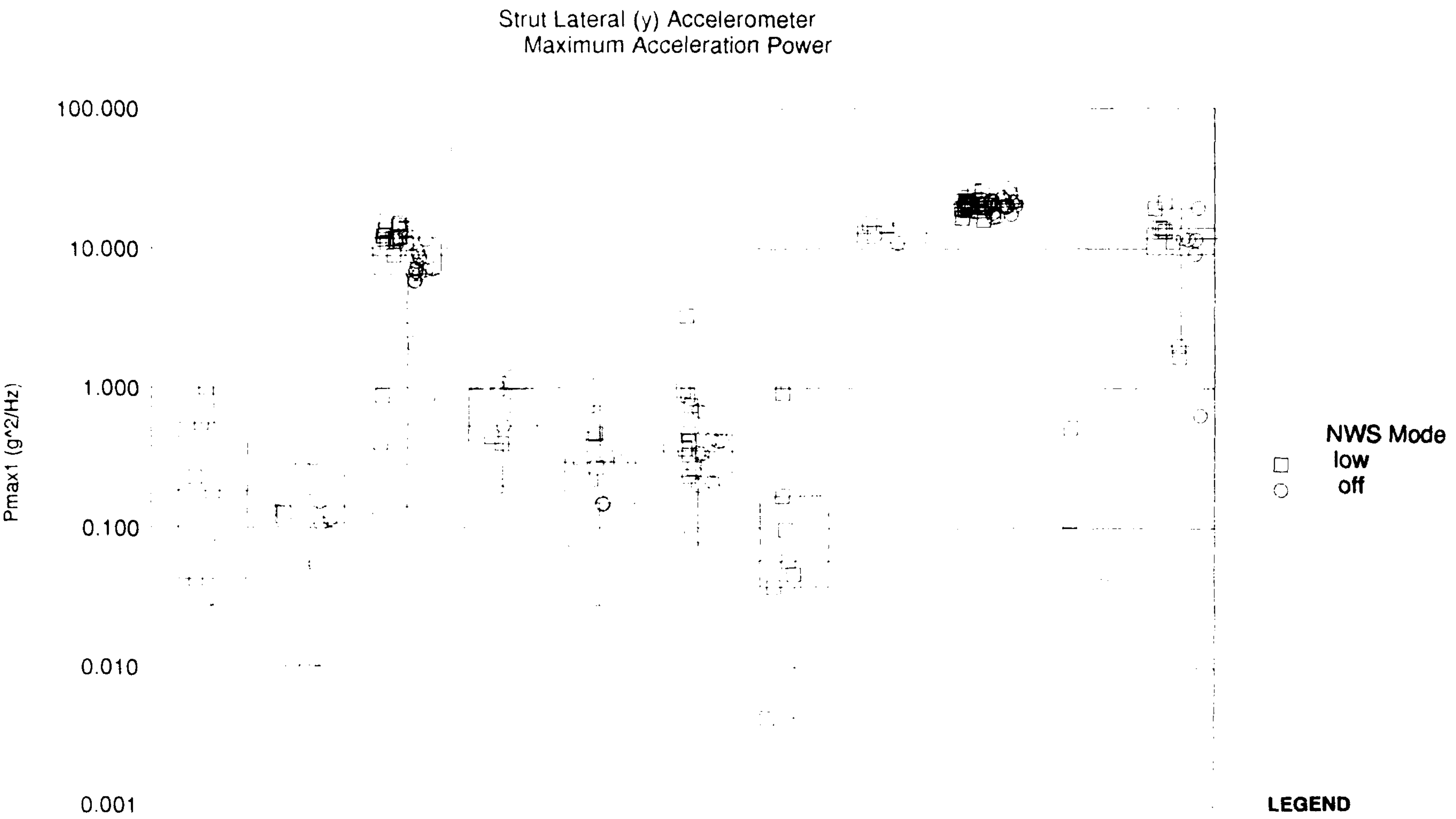
NLG Configuration

Figure Q-1: Strut Lateral (y) Accelerometer Standard Deviation of Acceleration



Strut Config	BCFAS_l	BCFAS_n	BCFAS_s	BCFAS_w	BCL_l	BCL_s	BCL_w	B_r	B_s	N_n	N_s
No. of tests	7	10	37	9	13	22	7	5	59	4	14
High Tail	10.82	8.45	13.53	7.13	7.82	8.02	5.29	12.74	20.02	8.36	13.26
3rd Quartile	8.73	5.11	11.76	5.46	6.34	7.19	4.80	12.41	17.42	5.99	13.19
Median	5.54	3.09	11.17	4.55	5.77	6.88	3.82	12.39	15.63	3.34	12.86
1st Quartile	3.37	2.79	10.04	4.20	5.26	6.27	2.77	10.61	14.38	3.03	11.71
Low Tail	3.28	2.21	9.00	2.71	4.43	5.14	2.35	10.61	13.24	2.98	10.41

Figure Q-2: Strut Lateral (y) Accelerometer Maximum Total Amplitude of Acceleration



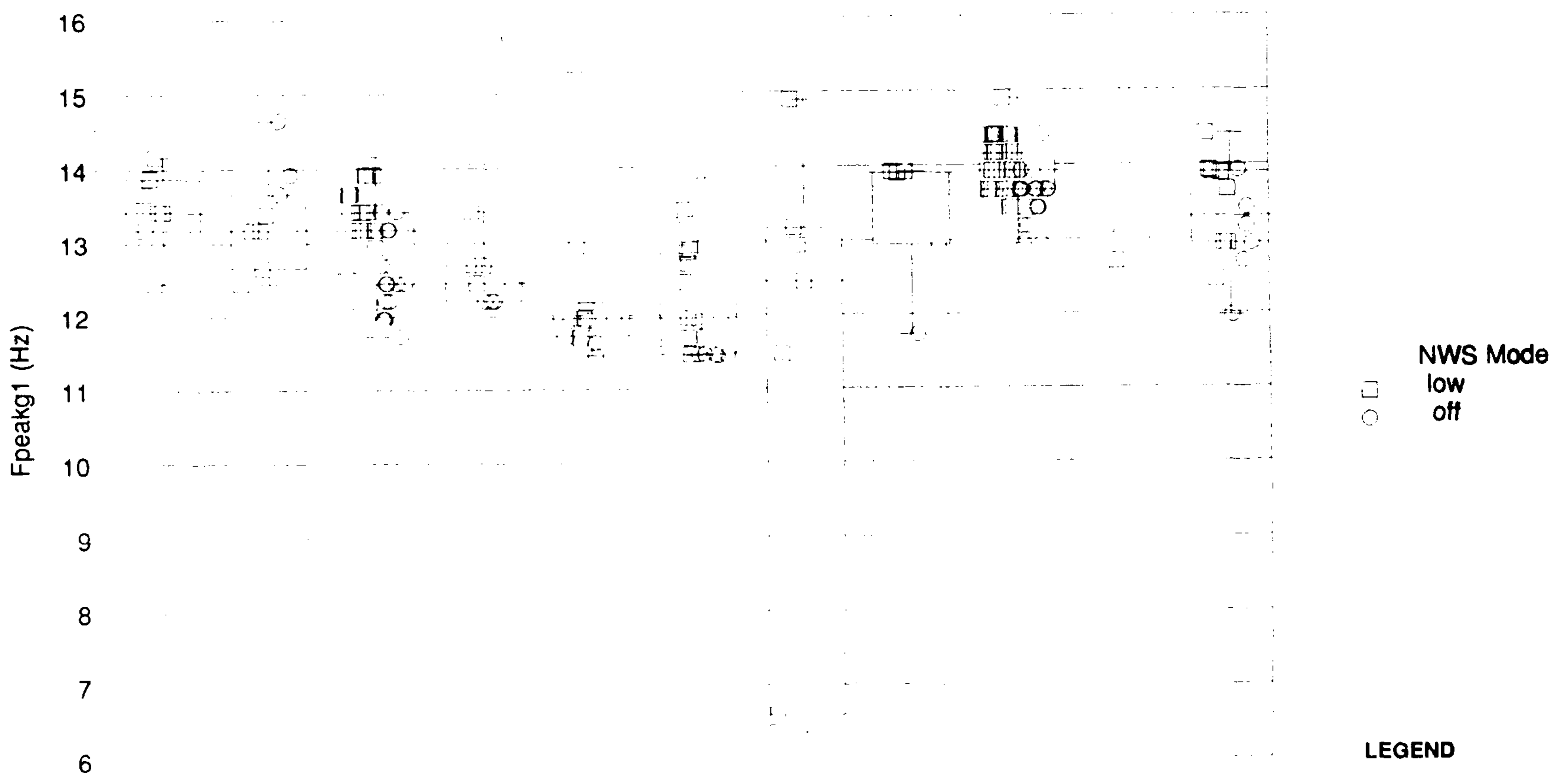
Strut Config	BCFAS_l	BCFAS_n	BCFAS_s	BCFAS_w	BCL_l	BCL_s	BCL_w	B_r	B_s	N_n	N_s
No. of tests	7	10	37	9	13	22	7	5	59	4	14
High Tail	0.993	0.283	15.661	1.199	0.737	0.741	0.170	15.243	24.674	0.517	19.495
3rd Quartile	0.557	0.283	11.946	0.976	0.430	0.468	0.170	14.702	21.879	0.316	14.089
Median	0.180	0.141	8.927	0.532	0.293	0.352	0.059	12.930	20.882	0.081	11.791
1st Quartile	0.043	0.107	6.516	0.396	0.150	0.230	0.038	10.964	19.749	0.026	9.133
Low Tail	0.027	0.010	0.140	0.197	0.027	0.078	0.004	10.964	16.651	0.005	2.020

LEGEND

NLG Configuration

Figure Q-3: Strut Lateral (y) Accelerometer Maximum Acceleration Power

Strut Lateral (y) Accelerometer
Primary Shimmy Frequency (5 - 17 hz range)
at Time of Maximum Strut Lateral Acceleration



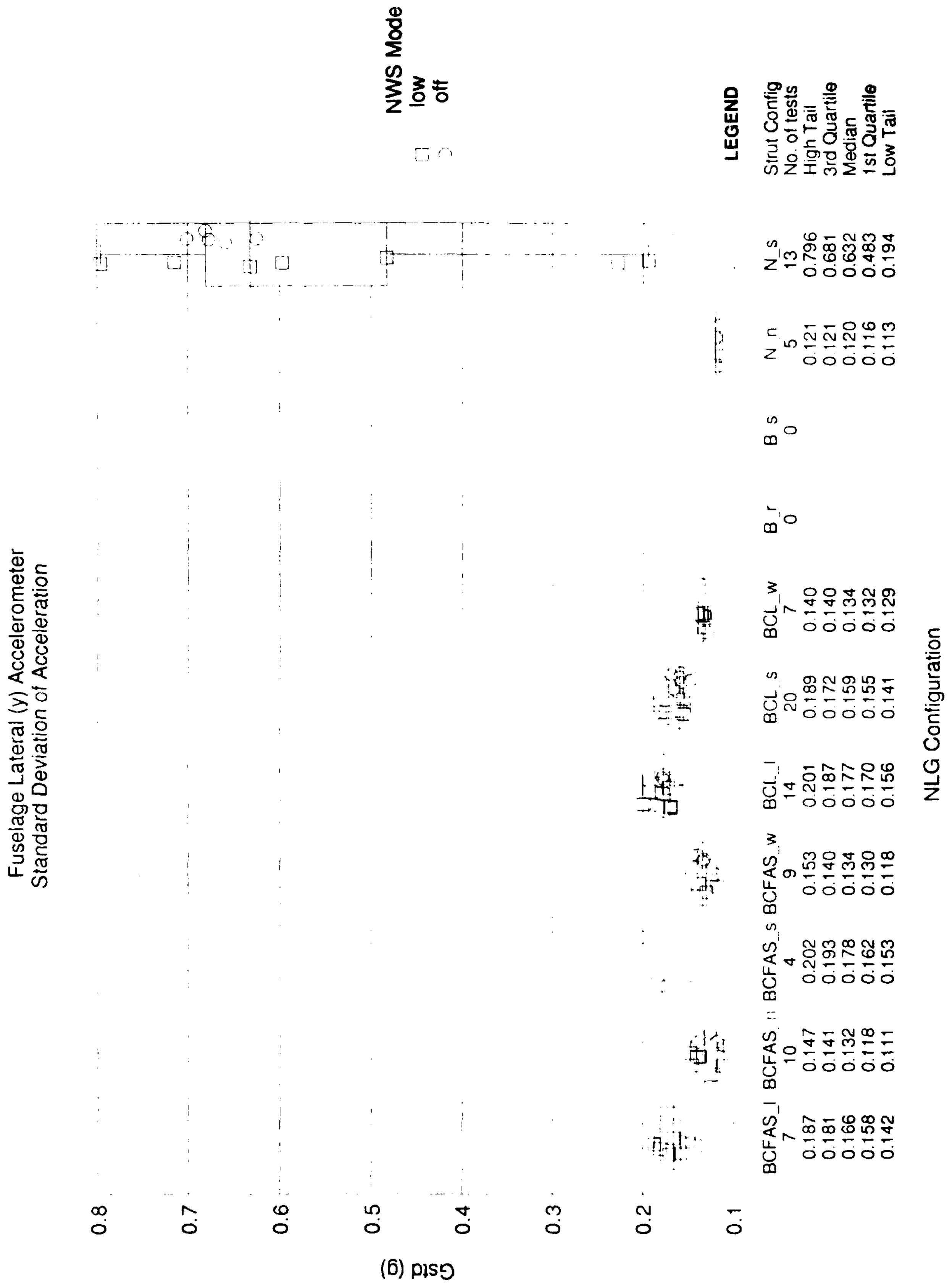
Strut Config	BCFAS_l	BCFAS_n	BCFAS_s	BCFAS_w	BCL_l	BCL_s	BCL_w	B_r	B_s	N_n	N_s
No. of tests	7	10	37	9	13	21	7	5	59	3	14
High Tail	14.16	14.65	14.16	13.43	12.18	13.85	14.89	13.92	14.89	13.18	14.41
3rd Quartile	13.88	13.67	13.43	12.70	12.18	12.85	13.18	13.92	14.16	13.18	13.90
Median	13.43	13.18	13.18	12.45	11.96	11.96	12.45	13.91	13.92	12.70	13.31
1st Quartile	13.18	12.66	12.45	12.21	11.72	11.47	6.59	12.94	13.67	11.72	12.94
Low Tail	12.45	12.45	11.72	12.21	11.45	11.45	6.35	11.72	12.94	11.72	11.96

LEGEND

NLG Configuration

Figure Q-4: Strut Lateral (y) Accelerometer
Primary Shimmy Frequency (5 - 17 hz range)
at Time of Maximum Strut Lateral Acceleration

STATISTICAL COMPARISONS - FUSELAGE



Strut Config	BCFAS_l	BCFAS_n	BCFAS_s	BCFAS_w	BCL_l	BCL_s	BCL_w	B_r	B_s	N_n	N_s
No. of tests	7	10	4	9	14	20	7	0	0	5	13
High Tail	0.187	0.147	0.202	0.153	0.201	0.189	0.140			0.121	0.796
3rd Quartile	0.181	0.141	0.193	0.140	0.187	0.172	0.140			0.121	0.681
Median	0.166	0.132	0.178	0.134	0.177	0.159	0.134			0.120	0.632
1st Quartile	0.158	0.118	0.162	0.130	0.170	0.155	0.132			0.116	0.483
Low Tail	0.142	0.111	0.153	0.118	0.156	0.141	0.129			0.113	0.194

Figure R-1: Fuselage Lateral (y) Accelerometer Standard Deviation of Acceleration

Fuselage Lateral (y) Accelerometer
Maximum Total Amplitude of Acceleration

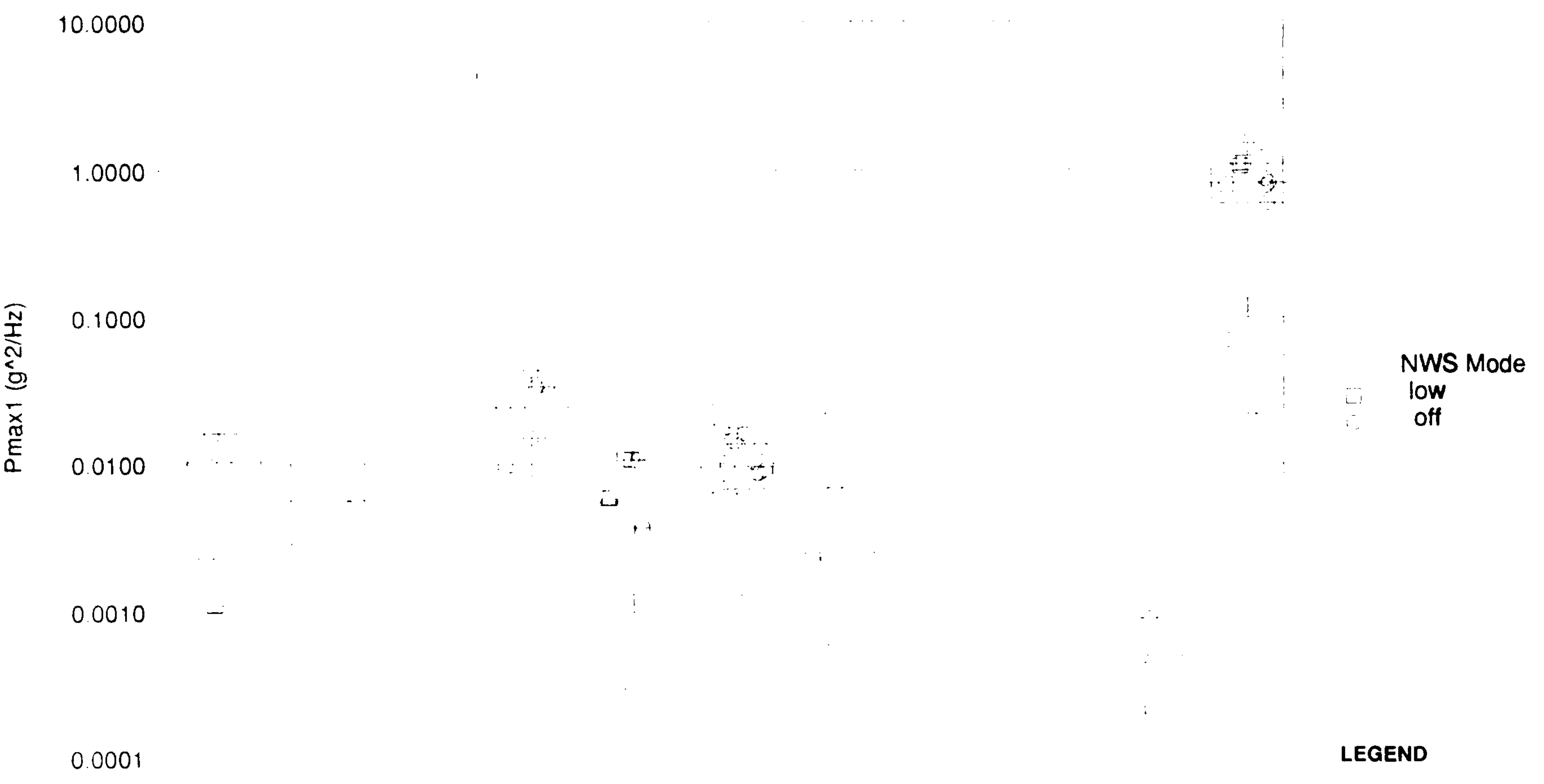
LEGEND

Strut Config	BCFAS l	BCFAS	BCFAS s	BCFAS w	BCL l	BCL s	BCL_w	B r	B s	N n	N s
No. of tests	7	10	4	9	14	20	7	0	0	5	13
High Tail	4.06	2.85	2.27	1.71	3.17	3.76	1.89			1.85	6.16
3rd Quartile	3.36	2.01	2.23	1.71	2.73	2.99	1.66			1.85	5.77
Median	2.46	1.39	2.13	1.51	2.40	2.67	1.46			1.38	5.41
1st Quartile	1.52	1.11	1.81	1.46	2.05	2.16	1.24			1.14	5.30
Low Tail	1.36	1.04	1.56	1.27	1.45	1.57	1.22			0.96	5.30

NLG Configuration

Figure R-2: Fuselage Lateral (y) Accelerometer
Maximum Total Amplitude of Accelertion

Fuselage Lateral (y) Accelerometer
Acceleration Power at time of Strut Maximum Power

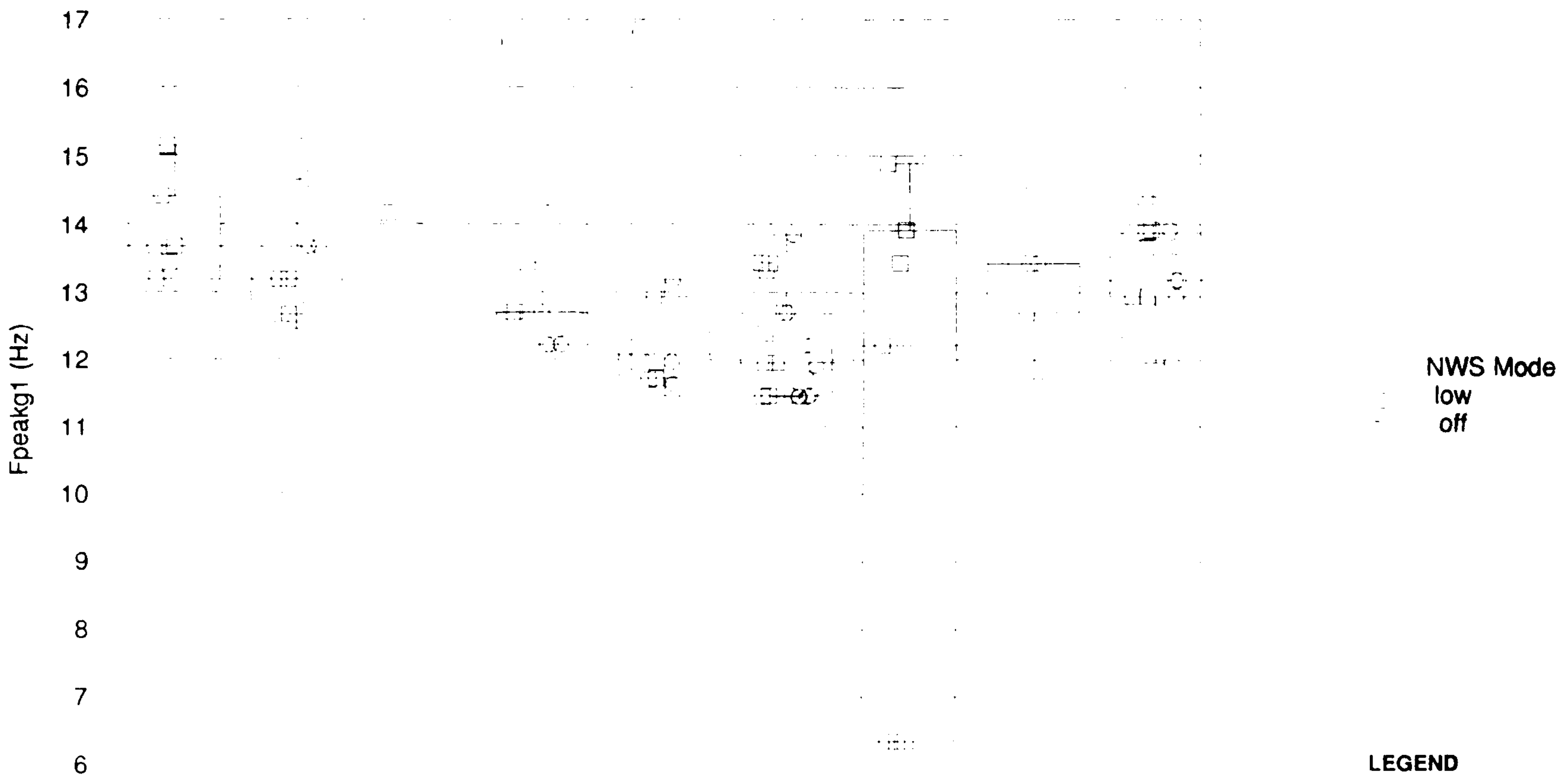


Strut Config	BCFAS l	BCFAS n	BCFAS s	BCFAS w	BCL l	BCL s	BCL w	B r	B s	N n	N s
No. of tests	7	[illegible]	1	9	14	20	7	0	0	5	13
High Tail	0.016	0.015		0.044	0.012	0.018	0.007			0.001	1.492
3rd Quartile	0.016	0.015		0.034	0.011	0.014	0.007			0.001	1.091
Median	0.010	0.006		0.025	0.006	0.010	0.003			0.001	0.810
1st Quartile	0.002	0.003		0.015	0.004	0.007	0.001			0.001	0.589
Low Tail	0.001	0.001		0.008	0.000	0.001	0.000			0.000	0.022

NLG Configuration

Figure R-3: Fuselage Lateral (y) Accelerometer Acceleration Power at time of Strut Maximum Power

Fuselage Lateral (y) Accelerometer
Primary Frequency (5 - 17 hz range)
at Time of Maximum Strut Lateral Acceleration



Strut Config	BCFAS_l	BCFAS_[illegible]	BCFAS_s	BCFAS_w	BCL_l	BCL_s	BCL_w	N_n	N_s
No. of tests	7	10	1	9	14	20	7	5	13
High Tail	15.14	14.65		13.43	13.18	13.85	14.89	13.43	14.41
3rd Quartile	14.41	13.67		12.70	12.94	12.70	13.92	13.43	13.88
Median	13.67	13.18		12.70	12.07	11.96	12.21	13.43	13.18
1st Quartile	13.18	12.66		12.21	11.72	11.47	6.35	12.70	12.94
Low Tail	13.18	12.45		12.21	11.45	11.45	6.35	11.72	11.96

LEGEND

NLG Configuration

Figure R-4: Fuselage Lateral (y) Accelerometer
Primary Frequency (5-17 hz range)
at Time of Maximum Strut Lateral Acceleration

ANNEX S TO
ARDU FORMAL REPORT
TASK 0067

COMPARISON OF PRIMARY CONFIGURATIONS

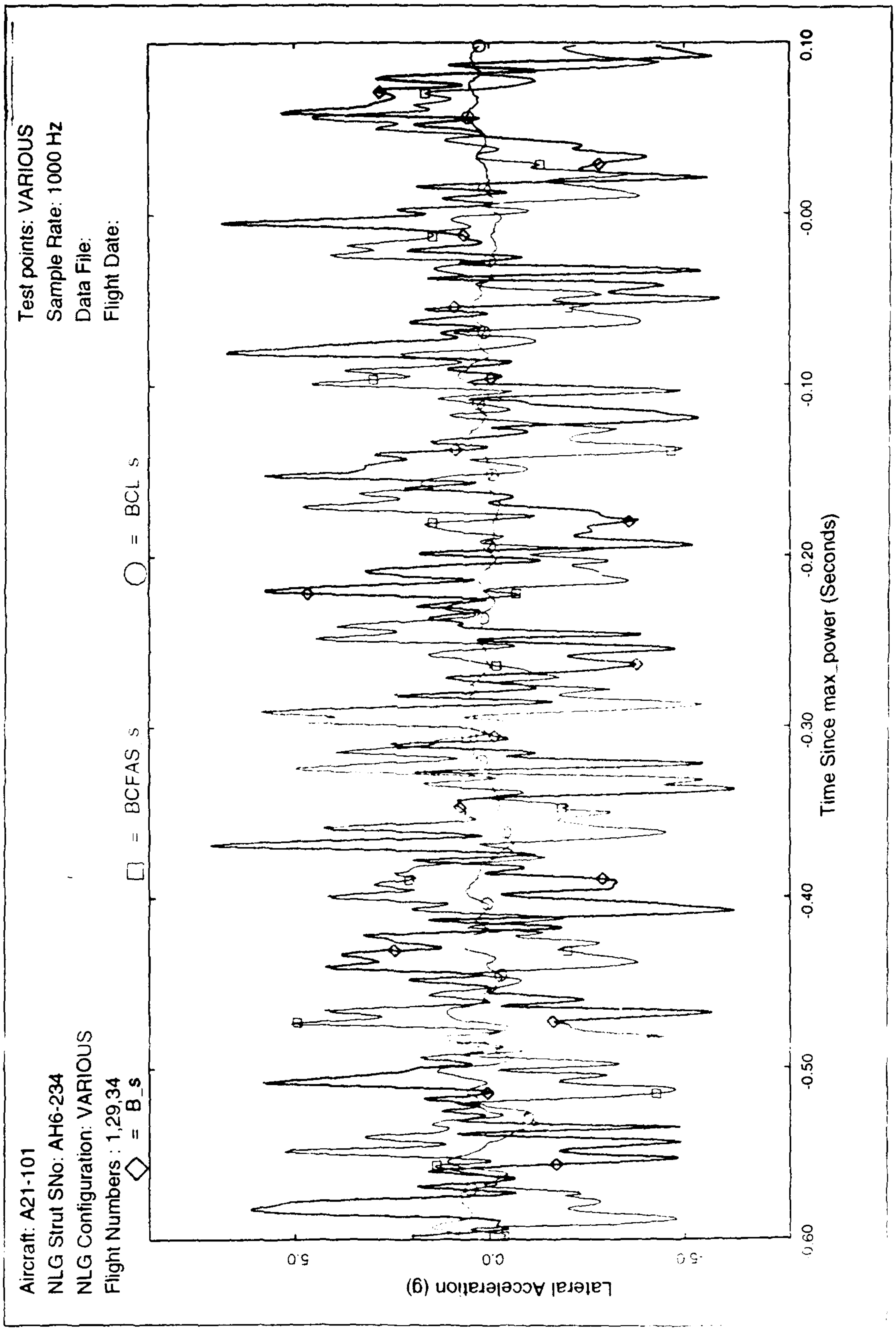


Figure S-1: Comparison of Time Histories of Strut Y Accelerometer Channels for Primary Configs - Expanded Scales at Time of Maximum Y Vibration Power

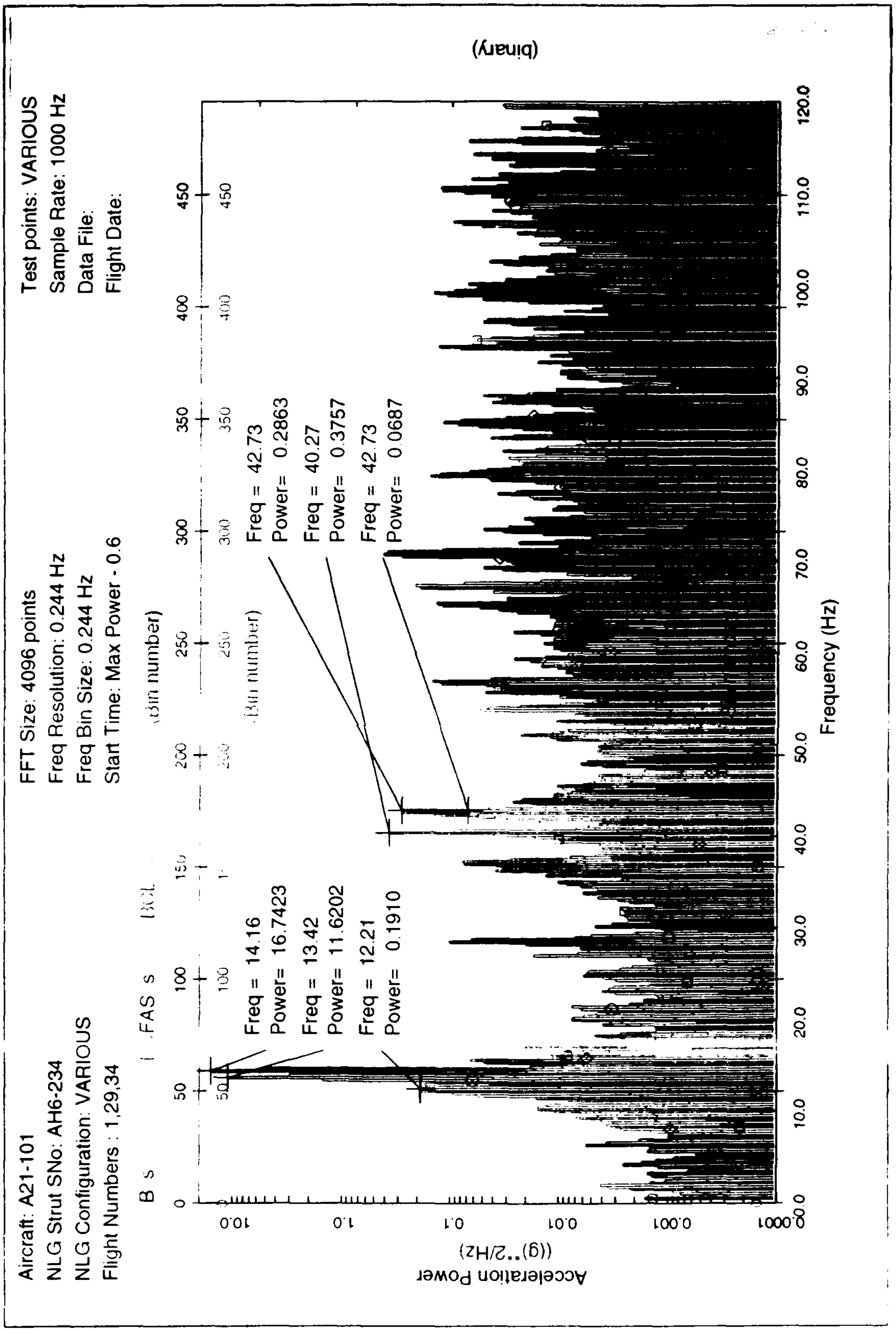


Figure S-2: Comparison of PSD for Strut Y Accelerometer Channels for Typical Test Runs at Time of Maximum Y Vibration Power

ANNEX T TO
ARDU FORMAL REPORT
TASK 0067

SHIMMY DISTRIBUTION DATA

1. The data in Table T-1 show the distribution of measured shimmy levels for each of the primary strut configurations tested.

Table T-1: Distribution of Shimmy Levels for Primary Configurations

STRUT CONFIGURATION	No OF TESTS	% LIGHT SHIMMY	% MODERATE SHIMMY	% SEVERE SHIMMY
N_s	14	43	57	0
N_n	5	0	0	0
B_s	59	2	42	56
B_r	5	40	40	0
BCL_w	7	14	0	0
BCL_s	22	77	0	0
BCL_l	13	54	0	0
BCFAS_w	9	22	0	0
BCFAS_s	37	49	46	0
BCFAS_l	7	29	0	0
BCFAS_n	10	10	0	0

ANNEX U TO
ARDU FORMAL REPORT
TASK 0067

STATISTICAL COMPARISON - ALL CONFIGS

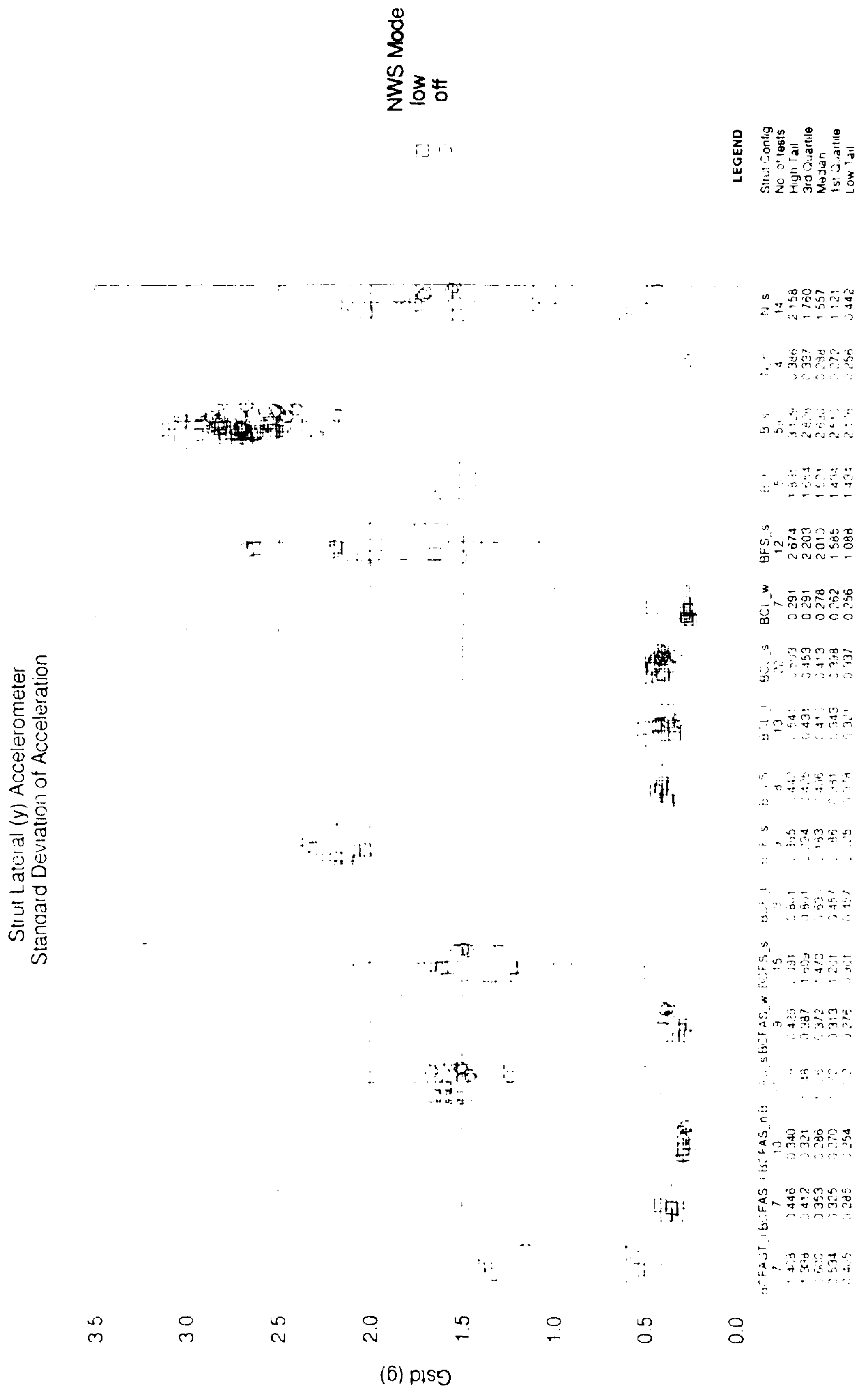


Figure U-1: Strut Lateral (y) Accelerometer Standard Deviation of Acceleration

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Non-Thesaurus Terms	Shimmy, FFT, PSD, NLG
DRDA CAT	010303

ABSTRACT

In April 1991 Officer Commanding ARDU was tasked to develop a quantitative measurement system for Hornet NLG shimmy and conduct flight trails to define the physical characteristics of the NLG Shimmy in the current RAAF configuration and quantitatively determine the reduction of NLG Shimmy provided by the MCAIR proposed modification, the launch bar, and a number of other factors.

ARDU instrumented the NLG of Hornet A21-101 (which was a known shimmy aircraft) with two tri-axial accelerometers and installed the programmable data acquisition system to record the output of these accelerometers and various other flight parameters.

This Report documents the results of this task.

Section 5

Sampling Plan

The SVE treatability investigation will include field sampling separated into two phases. Phase II will include the collection of soil samples. Phase III will include the collection of soil, and gas samples. Gases include soil gas, SVE off gas, and emissions control.

Soil Samples

Soil sampling during the installation of soil borings will result in the collection of a minimum of approximately 70 split-spoon soil samples from approximately 16 borings. The following provides the rationale for selecting the number of soil borings in each contaminant zone during each phase.

Selection of Soil Borings

During Phase I of the SVE treatability study, data were collected from all three depth zones. Following are some considerations applicable to selection of boring locations for data collection for the Phase II and Phase III segments of the SVE treatability investigation.

- Deep zone borings installed through the waste pit will yield samples from all three contaminant zones and provide lithologic data at one location.
- Intermediate zone borings installed through the waste pit will yield soil samples from the intermediate zone and the waste pit.
- Waste pit borings will be valuable for collection of waste pit soil samples only.

Phase II

During Phase II, approximately 15 wells (6 in the waste pit, 5 in the intermediate alluvial zone, and 4 in the deep alluvial zone) will be installed at Site S for installation of the process equipment and operation of the pilot system. During the installation of these wells, six borings will be sampled to collect additional data to be used in the evaluation of the objectives outlined in Section 3. The remaining wells will be visually logged prior to installation.

During Phase II, three of the waste pit borings and three deep alluvial zone borings will be sampled. The reasons for selecting these borings for sample collection include the following:

- Most soil samples collected during Phase I were from the waste pit (37 percent) and deep alluvial zone (40 percent.) Intermediate depth alluvium samples account for only 23 percent of samples collected. Therefore, more data are needed from the intermediate alluvial zone.

- These six borings in conjunction with samples collected during Phase I will provide a reasonable areal distribution of borings given the size of Site S. Furthermore, six additional borings provide a boring spacing of approximately 30 feet, as was originally used during the Phase I site characterization.

- Wells will be installed through the waste pit during Phase II. The wells will be placed to target suspected or previously identified hot spots in the pit.

- Intermediate depth borings will be located within 5 feet of deep borings. Because of the close proximity to the deep borings, intermediate depth borings will not be lithologically logged or sampled.

Phase III Mid-Operation

Four hot air injection wells will be installed in the waste pit and upper intermediate alluvial zones during the mid-operation sampling period. To take advantage of the soil borings performed during the installation of these wells, soil samples will be collected from each hot air injection boring.

Phase III Post-Operation

Based on the maximum number of soil samples proposed for Phase III post-operation, two waste pit borings, two intermediate alluvial borings, and two deep borings will be necessary. This number of borings will provide an adequate areal and vertical distribution of samples in each zone to evaluate the SVE treatability investigation objectives.

Table 5-1 summarizes the number of soil borings to be sampled during Phases II and III of the SVE treatability investigation. Figure 4-11 presents a preliminary plan for locations of the soil borings to be installed during the SVE project.

Table 5-1
Number of Soil Borings to be Sampled, Phases II and III

Phase	Waste Pit	Intermediate Alluvium	Deep Alluvium	Total
II Pre-operation	--	5	3	8
III Mid-operation	--	4	--	4
III Post-operation	2	2	2	6
Total	2	11	5	18

This provides an adequate areal distribution of sampling locations to evaluate the SVE treatability investigation objectives. Table 5-2 summarizes the number of borings from which samples can be collected in each contaminant zone.

Table 5-2
Number of Boring Locations Sampled in Each Contaminant Zone

Phase	Waste Pit	Intermediate Alluvium	Deep Alluvium
II Pre-operation	8	8	3
III Mid-operation	4	4	--
III Post-operation	6	4	2
Total	18	16	5

Selection of Soil Samples

Guidelines for collecting soil samples for analysis during Phase II are presented in Table 5-3. Guidelines for sample collection during Phase III are presented in Tables 5-4 and 5-5.

Analytical Testing of Soil Samples

Table 5-6 summarizes the soil analyses to be performed as a part of the SVE treatability investigation.

Table 5-3
Location of Soil Samples for Chemical Analysis
Phase II Pre-Operation

Soil Analysis/Sample Zone	Boring								Samples Per Zone
	Waste Pit					Deep Alluvium			
	PSI-1	PSI-2	PSI-3	PSI-4	PSI-5	PSD-3	PSD-2	PSD-5	
Physical Properties									
Waste Pit	1	1	0	1	0	2	1	0	6
Int. Alluvium	0	0	0	0	0	0	2	2	4
TPH (Modified 8015)									
Waste Pit	2	2	0	1	1	3	2	2	13
Int. Alluvium	0	0	0	0	0	2	3	2	7
Microbiological Assay (DNAB)									
Waste Pit	2	2	0	2	3	0	0	0	9
Int. Alluvium	2	2	0	2	2	0	0	0	8
COD (MOSA 29-3.5.3)									
Waste Pit	0	0	0	0	0	3	2	2	7
Int. Alluvium	0	0	0	0	0	2	3	2	7
Moisture Content (MOSA 21-2.2)									
Waste Pit	0	0	0	0	0	3	2	2	7
Int. Alluvium	0	0	0	0	0	2	3	2	7
pH (MOSA 12-2.6)									
Waste Pit	0	0	0	0	0	3	2	2	7
Int. Alluvium	0	0	0	0	0	2	3	2	7
NH_3-N (MOSA 33-3.2, EPA 350.2)									
Waste Pit	0	0	0	0	0	3	2	2	7
Int. Alluvium	0	0	0	0	0	2	3	2	7
NO_3-N (MOSA 33-3.2, EPA 300.0)									
Waste Pit	0	0	0	0	0	3	2	2	7
Int. Alluvium	0	0	0	0	0	2	3	2	7
ortho PO_4-P (MOSA 24-5.3, EPA 300.0)									
Waste Pit	0	0	0	0	0	3	2	2	7
Int. Alluvium	0	0	0	0	0	2	3	2	7

Note: All analyses but physical properties must be conducted on the same samples.

Table 5-4
Location of Soil Samples for Chemical Analysis
Phase III—Mid-Operation

Soil Analysis/Sample Zone	**Intermediate Zone Boring**				**Samples Per Zone**
	HAI-1	**HAI-2**	**HAI-3**	**HAI-4**	
TPH (Modified 8015)					
Waste Pit	x	x	x	x	12
Int. Alluvium	x	x	x	x	8
Microbiological Assay[a] (DNAB)					
Waste Pit	x	x	x	x	12
Int. Alluvium	x	x	x	x	8
COD[a] (MOSA 29-3.5.3)					
Waste Pit	x	x	x	x	12
Int. Alluvium	x	x	x	x	8
Moisture Content[a]					
Waste Pit	x	x	x	x	12
Int. Alluvium	x	x	x	x	8
pH[a] (MOSA 12-2.6)					
Waste Pit	x	x	x	x	12
Int. Alluvium	x	x	x	x	8
NH_3-N[a] (MOSA 33-3.2, EPA 350.3)					
Waste Pit	x	x	x	x	12
Int. Alluvium	x	x	x	x	8
$N0_3$-N[a] (MOSA 33-3.2, EPA 300.0)					
Waste Pit	x	x	x	x	12
Int. Alluvium	x	x	x	x	8
ortho PO_4-P[a] (MOSA 24-5.3, EPA 300.0)					
Waste Pit	x	x	x	x	12
Int. Alluvium	x	x	x	x	8

[a] *Analyses must be conducted on the same sample.*

Table 5-5
Location of Soil Samples for Chemical Analysis
Phase III—Post-Operation

Soil Analysis/Sample Zone	Boring						Samples Per Zone
	Waste Pit		Intermediate Alluvium		Deep Alluvium		
	SBP-1	SBP-2	SBI-5	SBI-6	SBD-1	SBD-2	
TPH (Modified 8015)							
Waste Pit	x	x	x	x	x	x	12
Int. Alluvium	-	-	x	x	x	x	9
Deep Alluvium	-	-	-	-	x	x	10
Total Organic Carbon (EPA415.1)							
Waste Pit	x	x	x	x	x	x	7
Int. Alluvium	-	-	x	x	x	x	7
Deep Alluvium	-	-	-	-	x	x	8
Microbiological Assay (DNAB)							
Waste Pit	x	x	x	x	x	x	12
Int. Alluvium	-	-	x	x	x	x	8
Deep Alluvium	-	-	-	-	-	-	0
COD* (MOSA 29-3.5.3)							
Waste Pit	x	x	x	x	x	x	12
Int. Alluvium	-	-	x	x	x	x	8
Deep Alluvium	-	-	-	-	-	-	0
Moisture Content (MOSA 21-2.2)							
Waste Pit	x	x	x	x	x	x	12
Int. Alluvium	-	-	x	x	x	x	8
Deep Alluvium	-	-	-	-	-	-	0
pH (MOSA 12-2.6)							
Waste Pit	x	x	x	x	x	x	12
Int. Alluvium	-	-	x	x	x	x	8
Deep Alluvium	-	-	-	-	-	-	0
NH_3-N (MOSA 33-3.2, EPA 350.3)							
Waste Pit	x	x	x	x	x	x	12
Int. Alluvium	-	-	x	x	x	x	8
Deep Alluvium	-	-	-	-	-	-	0
NO_3-N (MOSA 33-3.2, EPA 300.0)							
Waste Pit	x	x	x	x	x	x	12
Int. Alluvium	-	-	x	x	x	x	8
Deep Alluvium	-	-	-	-	-	-	0
ortho PO_4-P (MOSA 24-5.3, EPA 300.0)							
Waste Pit	x	x	x	x	x	x	12
Int. Alluvium	-	-	x	x	x	x	8
Deep Alluvium	-	-	-	-	-	-	0

*All samples analyzed for COD must also be analyzed for TPH, moisture content, DNAB, pH, Nitrogen, Phosphorus.

Soil Sample Collection

Soil borings will be drilled with hollow stem augers. The waste pit borings will be drilled to depths suitable to verify the bottom of the pit, estimated to be approximately 25 feet below ground surface. The intermediate borings will be drilled to the approximate base of the low permeability, high concentration zone between the bottom of the pit and a depth of about 40 feet below ground surface. The deep borings will be drilled to groundwater or approximately 100 feet below ground surface. Representative formation samples will be collected by driving split spoons ahead of the augers in accordance with ASTM D-1586 procedures for standard penetration resistance test in soils. Field logging will be completed by the onsite staff under the direction of a registered civil engineer or geologist.

Samples will be obtained at 5-foot intervals from grade to total depth in some borings. The remaining borings will be visually logged during drilling. The samples will be collected using a modified 2-inch-diameter split-spoon sampler fitted with four 6-inch-long brass sleeves (Figure 5-1). Sampling procedures include:

- Prior to sample collection for chemical analysis, the split-spoon and brass sleeves will be thoroughly decontaminated as outlined in the decontamination section.

- The sampler will be driven 18 inches into the undisturbed soil, or until refusal, and blow counts will be recorded (ASTM D-1586).

- Upon opening the sampler, the second liner from the bottom will immediately be trimmed and removed from the spoon and capped with teflon tape and PVC slip caps. The liner will be numbered and labeled for offsite analysis.

- Immediately upon capping and labeling, the two center liners will be placed in an iced cooler. The samples designated for offsite analysis will later be shipped under chain of custody to the analytical laboratory.

- The remaining soil in the liner will be used for soil logging per CH2M HILL Soil Boring Log Guidelines (Appendix B) and Air Force data management requirements.

To obtain valid microbial population counts representative of the soil environment being sampled, the brass liner should be clean and free of any debris. If there is any indication of contamination, it should be flame-sterilized using a propane torch immediately prior to use.

Table 5-6
Soil Sampling Frequency

Analysis	Method	Soil Zone			Pre-Operation Phase II	Mid-Operation Phase III	Post-Operation Phase III	Total
		P	I	D				
Physical Properties	--	P			6			6
			I		4			4
				D				
Total Petroleum Hydrocarbons	Modified 8015	P			13	12	12	37
			I		7	8	9	24
				D			10	10
Total Organic Carbon	EPA 415.1	P					7	7
			I				7	7
				D			8	8
Microbiological Assay	DNAB	P			9	12	12	33
			I		8	8	8	24
				D				
Chemical Oxygen Demand	MOSA 29-3.5.3	P			7	12	12	31
			I		7	8	8	23
				D				
Moisture Content	MOSA 21-2.2	P			7	12	12	31
			I		7	8	8	23
				D				
pH	MOSA 12-2.6	P			7	12	12	31
			I		7	8	8	23
				D				
Ammonia Nitrogen	MOSA 33-3.2, EPA 350.2	P			7	12	12	31
			I		7	8	8	23
				D				
Nitrate Nitrogen	MOSA 33-3.2, EPA 300.0	P			7	12	12	31
			I		7	8	8	23
				D				
ortho-Phosphate Phosphorus	MOSA 24-5.3, EPA 300.0	P			7	12	12	31
			I		7	8	8	23
				D				

P = Waste Pit I = Intermediate Alluvium D = Deep Alluvium

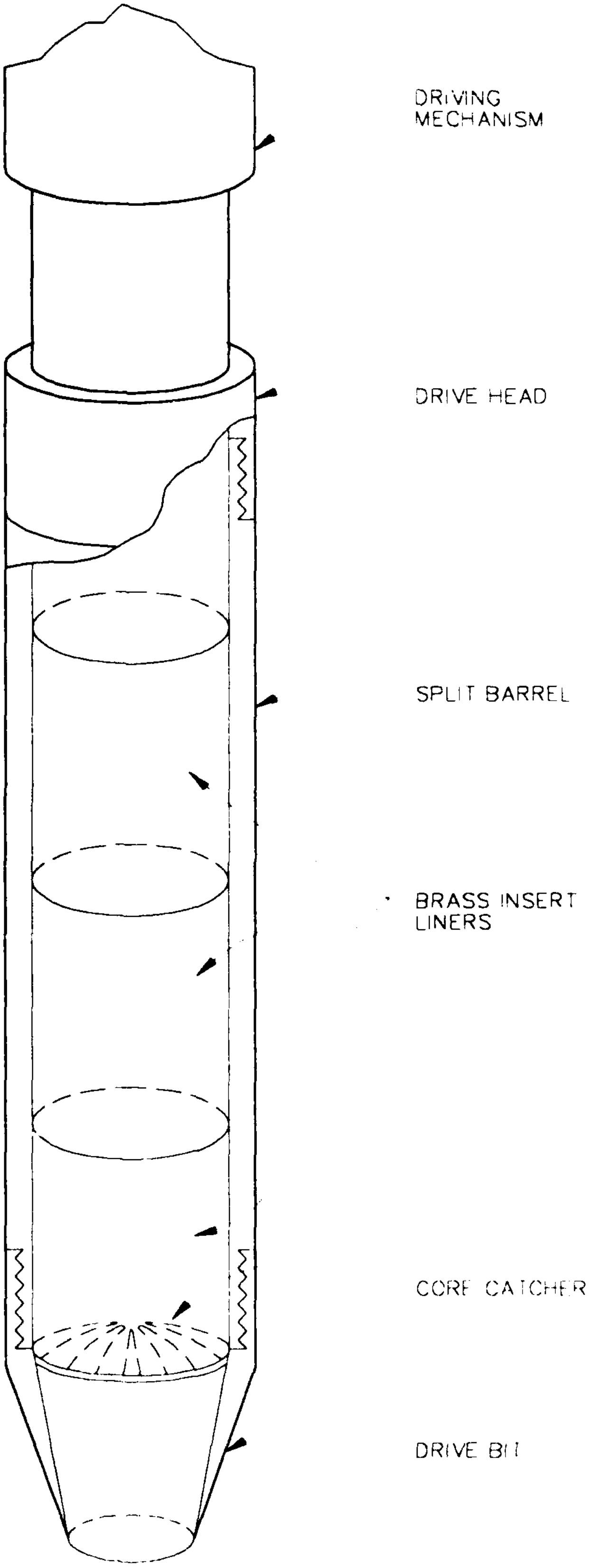


FIGURE 5-1
SPLIT-SPOON SAMPLER

CH2M HILL

Gas Samples

Soil gas (piezometer samples), SVE offgas, and emissions control sampling will occur throughout Phase III of the SVE treatability investigation. SVE offgas can be further divided into three components: 1) extraction wells, 2) extraction well manifolds, and 3) transfer piping. A schematic presentation of the SVE offgas sample locations is shown in Figure 3-1.

Analytical Testing of Gas Samples

Table 5-7 summarizes the soil gas, SVE offgas, and emissions control analyses to be performed as a part of the SVE treatability investigation.

Preoperation

Soil gas samples collected at the piezometers will be analyzed for VOCs, total nonmethane hydrocarbons, carbon dioxide, oxygen, and methane during the preoperation period.

Initial Testing, Startup, and Continued Operation

During the 1-week initial testing, 5-week startup, and 20-week continued operation periods, soil gas, SVE offgas, and emissions control samples will be collected. Soil gas samples will be analyzed for VOCs and total nonmethane hydrocarbons. In addition, soil gas will be monitored for carbon dioxide and oxygen content and OURs performed. SVE offgas samples collected with canisters will be analyzed for VOCs and total nonmethane hydrocarbons. Gas samples collected with syringes will be analyzed for VOCs. In addition, carbon dioxide and oxygen content will be monitored in certain extraction well manifolds and the transfer piping.

Emissions control samples will be analyzed for hydrochloric acid, dioxins, VOCs, and total nonmethane hydrocarbons.

Post-Operation

Post-operation sampling will be limited to VOCs in the soil gas since the SVE system will have been shut down.

Table 5-7
Preliminary Gas Sampling Schedule

Matrix, Analysis, Zone	Pre-Operation	Initial Testing	Start-up 5 weeks					Continued Operations																				Post-Operation	Total
								SVE (with OURs) 7 weeks							Bioventing 5 weeks					SVE (with enhancements) 8 weeks									
Week No.	<4 weeks	1 week	1	2	3	4	5	1	2	3	4	5	6	7	1	2	3	4	5	1	2	3	4	5	6	7	8	<4 weeks	Total
Soil Gas																													
Volatile Organic Compounds (Onsite GC)																													
P	5	5		5		5		5			5			5				5				5			5		5	5	60
I	3	3		3		3		3			3			3				3				3			3		3	3	36
D	6	6		6		6		6			6			6				6				6			6		6	6	72
Total	14	14		14		14		14			14			14				14				14			14		14	14	168
Volatile Organic Compounds (TO-14)																													
P	1	1				1					1							1											5
I	1					1																							2
D	1																					1							2
Total	3	1				2					1							1				1							9
Total Nonmethane Hydrocarbons (TO-12)																													
P	5			5			5				5			5				5				5					5		40
I	3			3			3				3			3				3				3					3		24
D	6			6			6				6			6				6				6					6		48
Total	14			14			14				14			14				14				14					14		112
Methane (Meter)																													
P	5																												5
I	3																												3
D																													0
Total	8																												8
Carbon Dioxide and Oxygen (Meters) w/out OUR																													
P	5															5		5		5									20
I	3															3		3		3									12
D																													0
Total	8															8		8		8									32
Oxygen Uptake Rate (Carbon Dioxide / Oxygen / Relative Humidity / Temperature)																													
P		5	5		5		5		5			5			5		5		5		5			5			5		60
I		3	3		3		3		3			3			3		3		3		3			3			3		36
D																													0
Total		8	8		8		8		8			8			8		8		8		8			8			8		96

Table 5-7
Preliminary Gas Sampling Schedule

Matrix, Analysis, Zone	Pre-Operation	Initial Testing	Start-up 5 weeks					Continued Operations																				Post-Operation	Total
								SVE (with OURs) 7 weeks							Bioventing 5 weeks					SVE (with enhancements) 8 weeks									
Week No.	<4 weeks	1 week	1	2	3	4	5	1	2	3	4	5	6	7	1	2	3	4	5	1	2	3	4	5	6	7	8	<4 weeks	Total
SVE Offgas - Extraction Wells																													
Volatile Organic Compounds (Onsite GC)																													
P		7	7	7	7	7	7		7		7		7		7			7		14	14	7	7	7	7		7		140
I		5	5	5	5	5	5		5		5		5		5			5			5			5			5		70
D		5	5	5	5	5	5		5		5		5		5			5			5			5			5		70
Total		17	17	17	17	17	17		17		17		17		17			17		14	24	7	7	17	7		17		280
Volatile Organic Compounds (TO-14)																													
P		2				1					1							1				1							6
I		1				1					1							1				1							5
D		1				1					1																		3
Total		4				3					3							2				2							14
Total Nonmethane Hydrocarbons (TO-12)																													
P		7			7			7				7				7				7					7				49
I		5			5			5				5				5				5					5				35
D		5			5			5				5				5				5					5				35
Total		17			17			17				17				17				17					17				119
SVE Offgas - Extraction Well Manifolds																													
Volatile Organic Compounds (Onsite GC)																													
P		3	2	2	1	2	1	2	1	2	1	1		1		1		1		2	2	2	2	2	2		1		34
I		3	2	2	1	2	1	2	1	2	1	1		1		1		1		2	2	2	2	2	2		1		34
D		3	2	2	1	2	1	2	1	2	1	1		1		1		1		2		2		2			1		28
Total		9	6	6	3	6	3	6	3	6	3	3		3		3		3		6	4	6	4	6	4		3		96
Volatile Organic Compounds (TO-14)																													
P		1																1				1							3
I											1																		1
D						1																							1
Total		1				1					1							1				1							5
Total Nonmethane Hydrocarbons (TO-12)																													
P		1	1	1	1		1		1		1			1				1		1		1		1			1		13
I		1	1	1	1		1		1		1			1				1		1		1		1			1		13
D		1	1	1	1		1		1		1			1				1		1		1		1			1		13
Total		3	3	3	3		3		3		3			3				3		3		3		3			3		39

Table 5-7
Preliminary Gas Sampling Schedule

Matrix, Analysis, Zone	Pre-Operation	Initial Testing	Start-up 5 weeks					Continued Operations																				Post-Operation	Total
								SVE (with OURs) 7 weeks							Bioventing 5 weeks					SVE (with enhancements) 8 weeks									
Week No.	<4 weeks	1 week	1	2	3	4	5	1	2	3	4	5	6	7	1	2	3	4	5	1	2	3	4	5	6	7	8	<4 weeks	Total
Carbon Dioxide and Oxygen (Meters)																													
P		1		1		1		1		1		1		1	1	1	1	1	1	1		1		1		1	1		17
I		1		1		1		1		1		1		1	1	1	1	1	1	1		1		1		1	1		17
D																													0
Total		2		2		2		2		2		2		2	2	2	2	2	2	2		2		2		2	2		34
SVE Offgas - Transfer Piping																													
Volatile Organic Compounds (Onsite GC)																													
Total		5	1	1	1	1	1	1		1		1		1		1		1		1		1		1			1		20
Volatile Organic Compounds (TO-14)																													
Total						1																							1
Total Nonmethane Hydrocarbons (TO-12)																													
Total		3	1	1	1	1	1	1		1		1		1		1		1		1		1		1			1		18
Carbon Dioxide and Oxygen (Meters)																													
Total		5	1	1	1	1	1	1	1		1		1		1		1		1		1		1		1	1			21
Emissions Control																													
Volatile Organic Compounds (Onsite GC)																													
Total		5	1	1	1	1	1	1		1		1		1		1		1		1		1		1			1		20
Volatile Organic Compounds (TO-14)																													
Total						1																							1
Total Nonmethane Hydrocarbons (TO-12)																													
Total		3	1	1	1	1	1	1		1		1		1		1		1		1		1		1			1		18
Hydrochloric Acid (Method 26)																													
Total		1			1			1				1				1				1				1					7
Dioxins (Method 23)																													
Total		1			1			1				1				1				1				1					7

P = Waste Pit I = Intermediate Alluvium D = Deep Alluvium

Gas Sample Collection

Soil gas samples will be collected from the piezometer well heads; there are 14 piezometers installed at Site S. SVE offgas extraction well samples will be collected from the conveyance piping from each of the 17 vapor extraction wells to be installed at the site. There are three SVE offgas extraction well manifolds; one corresponding to each contaminant zone. Transfer piping and emissions control samples will be collected from either side of the emissions control system. Figure 5-2 presents the sample collection points for the SVE offgas extraction well manifolds, SVE offgas transfer piping, and emissions control system. Figure 5-3 presents a cross-section of the piezometer screen locations.

Canister sampling will be used to collect TO-14 and some TO-12 samples. Tedlar bag sampling will be used to collect certain TO-12 samples when the gas concentration is in excess of 10 ppmv as measured with an OVA meter. Syringe sampling will be used to collect onsite GC samples.

Following the startup period of SVE operation, the target analyte list for a matrix may be reduced to include only those analytes determined to be characteristic of that matrix. Periodically, but no less frequent than once every 2 weeks, a full scan TO-14 analysis will be performed for each matrix. This will ensure the target analytes selected to be included on the reduced analyte list remain those characteristic of the matrix.

Canister Samples

Soil gas, SVE offgas, and emissions control samples for the SVE pilot test will be collected. Canister samples will be collected following the guidance offered in EPA's "*Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air,*" EPA 4-84-041-April 1984. The specific methods to be used are:

- TO-14, "Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using SUMMA Passivated Canister Sampling and Gas Chromatography Analysis."
- TO-12, "Determination of Non-Methane Organic Compounds (NMOC) in Ambient Air Using Cryogenic Preconcentration and Direct Flame Ionization Detection (PDFID)."

Evacuated, SUMMA polished canisters will be used to collect soil gas samples from the vacuum extraction system and piezometers at approximately -10 inches Hg and at 55°F. The exact location for sample collection will be determined in the field by the field team leader, but in principal a sample port/tap will be placed in the gas exhaust line after the gas has exited the soil vapor extraction well and prior to the vacuum pump or at the piezometer well head. After passing the sample tap the gas enters the carbon canister exhaust gas treatment system. The line at the sample tap is expected to maintain a vacuum of approximately -10 inches Hg.

The canisters will be used and samples collected in the vacuum mode. That is to say, the vacuum in the clean canister (near 30 inches Hg) will be used to pull the sample out of the SVE duct or piezometer casing and deliver it to the canister. A flow regulator will be used to control the sample rate and maintain it near constant over the prescribed course of the sample collection period. The desired sample rate, determined by the size of the canister and the length of sample period, will be preset using a Mini-Buck calibrator or calibrated rotometer by the laboratory prior to shipment to the field. The preset rate will be confirmed during sample collection at various time intervals by checking the canister pressure gauge and comparing that value to the elapsed time. The appropriate integration period and flow rate will be determined for each type of sample being collected.

The final canister pressure will always be less than that of the pressure in the SVE line to maintain canister integrity. For example, if the line pressure is -10 inches Hg, the sample will be stopped with the canister at approximately -12 inches Hg. This procedure allows monitoring of the canister for leaks after sampling and during shipment and also preserves/stabilizes the sample in the gas phase prior to analysis.

Prior to sample collection, each canister will be cleaned in the lab as follows:

- Using exponential dilution, each canister will be rinsed several times with ultra high purity nitrogen.
- Each canister will be subsequently placed in an oven (125°C) and connected to a high vac. pump. Heat and vac. will be applied until the canister pressure is <5mTorr (EPA spec: 50mTorr).
- Certification will be done using GC/MS with surrogate spikes. At least 10 percent of the canisters will be certified.

Following cleaning, the canisters will be evaluated and evacuated in the laboratory. Additionally, those containers to be used for spike sample preparation and blanks will be humidified. All canisters used on the project will be prescreened and 10 percent of the canisters verified clean to a level of <0.2 ppbv of any target organic species or 20 ppbv total chromatographical organics. After analysis, the canisters will be evacuated to a level of at least -27 inches Hg and the absolute pressure recorded. A stainless steel 2-micron filter will be attached to each flow controller prior to shipment to remove particulate material in the gas stream prior to entering the canister.

Soil Gas. To collect a SVE canister soil gas sample and equipment blank, the following procedure shall be followed:

1. All sample manifold components will be removed from shipping containers and inspected for damage. The canister vacuum will be verified with a pressure/vacuum gauge (acceptable range 27-inch Hg or greater vacuum).

2. Flow controllers, filters, and manifold fittings will be tagged as dedicated inlet sample stream components and the reference number on the flow controller noted on the sample location log shown in Figure 5-4.

3. The sample manifold will be assembled as shown in Figure 5-5 with the well head connection and sample lines temporarily capped and all in-line valves opened.

4. An ultra high purity (UHP) N_2 or UHP air supply cylinder will be connected to the purge pump side of the manifold (outlet) and pressure regulated to approximately 5 psig.

5. Leak detection fluid will be applied to each manifold connection in turn and leaking fittings tightened to a leak-free condition as evidenced by an absence of bubbling in the leak detection fluid.

6. Leak detection fluid will be flushed from the connection with high purity water and then each connection wrapped tightly with 1/2-inch teflon tape. Prior to closing off the UHP gas supply, equipment blank samples may be collected by temporarily removing the carbon canister, replacing the UHP gas supply in its place, closing one of the sample line valves, removing the cap from the end of the sample line, and connecting the canister. Sample line and canister valves will then be opened and the UHP equipment blank collected.

7. Sample line valves will be closed and end caps removed.

8. The UHP gas supply will be removed and the carbon canister and purge pump attached to the outlet of the manifold.

9. A suitable volume (at least five well volumes) will be purged from the piezometer casing through the carbon canister.

Figure 5-4

Sample Location Log

Soil Vapor Extraction-Pilot Test Sampling

Sampling Location

Project Number____________________
Date______________________________
____

Names and Company of Personnel Present
1______________________________
2______________________________
3______________________________
4______________________________
5______________________________
6______________________________
7______________________________
8______________________________

Canister Data

Lab ID No.	CH2M HILL	Initial Vacuum

Probe Data

CH2M HILL Sample ID	Initial Vacuum	5 Minute Vacuum

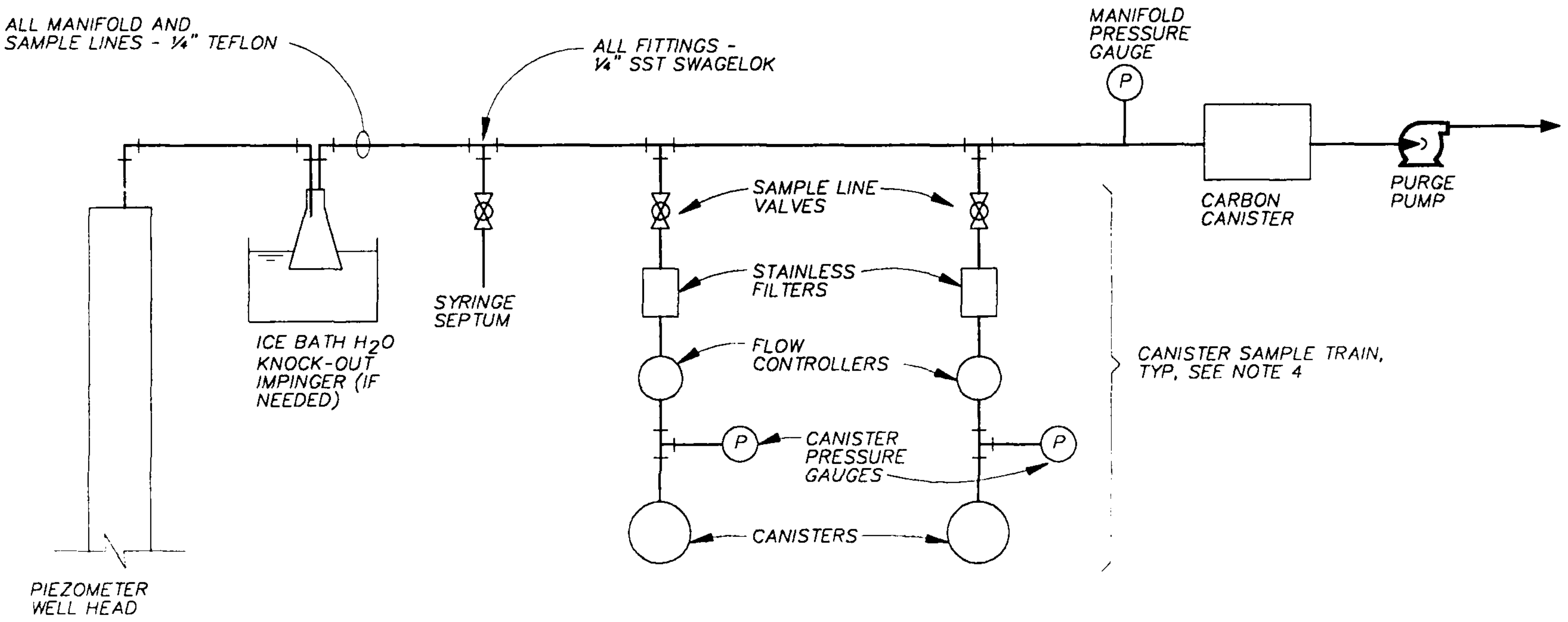
Syringe Data

ID No.
____
____
____

Sampling Data

Time								
Duct Temp								
Duct Vacuum								
ID No.	Canister Vacuum Readings - in Hg							
ID No.	Duct Vacuum Reading - in Water							

04-09-92



NOTES:

1. TEFLON DISCARDED AFTER EACH WELL HEAD.
2. FITTINGS DECONTAMINATED AFTER EACH USE.
3. 1 ADDITIONAL PURGE PUMP AND CHARCOAL TUBE NECESSARY FOR FLUSHING SAMPLE LINES.
4. CANISTER SAMPLE APPARATUS MAY BE REPLACED BY TEDLAR BAG SAMPLE APPARATUS FOR TO-12 SAMPLE COLLECTION. TEDLAR BAG APPARATUS SHOWN ON FIGURE 5-8.

FIGURE 5-5
SOIL GAS SAMPLE
TRAIN

CH2M HILL

=1.0

10. With the purge pump in operation, each sample line will be connected to an auxiliary pump (with carbon tube in-line) to flush the line with sample gas.

    Sample line valves will be opened and the auxiliary pump allowed to purge enough sample gas through the line to flush any air remaining (two to three sample line volumes). The sample valve will be closed, and the sample container connected to the sample line immediately upon removing the auxiliary purge pump from each line. This final connection will be wrapped with teflon tape.

11. All sample line valves will be opened fully and sampling start times noted on the sample location log. Periodically throughout the selected sampling period, the time and sample container pressure will be recorded on the sample location log to confirm appropriate sample integration.

12. Sample container valves and then, any in-line valves will be closed when the desired vacuum (measured by the canister vacuum gauge) is reached in the canisters. The vacuum should be no less than 2 inch Hg greater than the vacuum measured in the sample manifold. Sample end-times are recorded on the sample location log.

13. The main purge pump may be shut down, the manifold disconnected from the quick connect, and the well head capped.

14. The canisters are removed, capped, labelled, and prepared for shipment to the laboratory.

15. The manifold is disassembled and fittings stored in a clearly marked storage container to be prepared for reuse. Teflon sample line is discarded. Filters and flow controllers are prepared for return to the laboratory.

SVE Offgas and Emissions Control. To collect a SVE offgas sample, the following procedure will be followed:

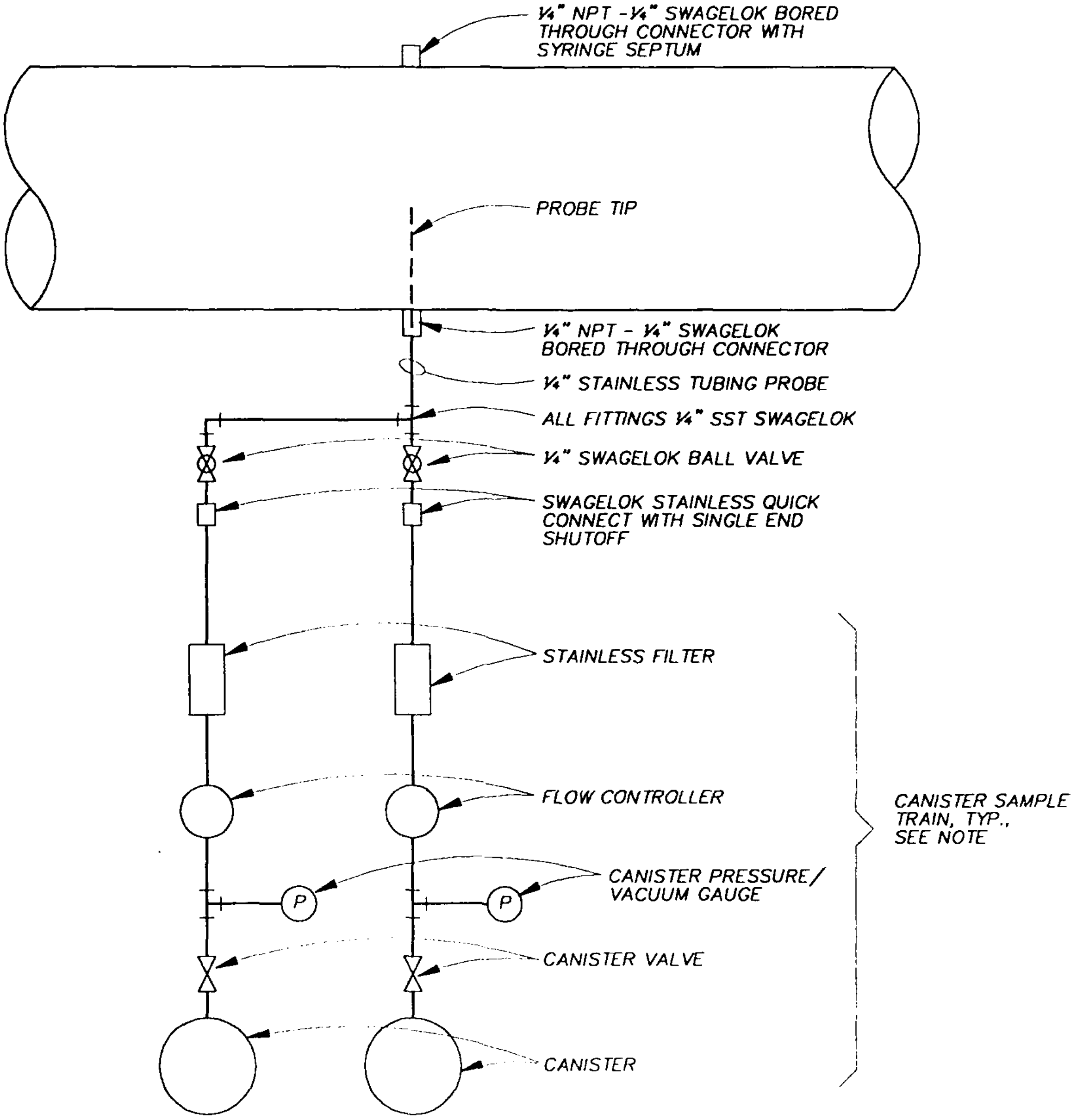
1. All sample probe components will be removed from shipping containers and inspected for damage. The canister vacuum will be verified with a pressure/vacuum gauge (acceptable range greater than 27-inch Hg vacuum).

2. Flow controller, filter, and manifold fittings will be tagged as dedicated inlet sample stream components and the reference number on the flow controller noted on the sample location log shown in Figure 5-4.

3. The assembled sample probe will be connected to the quick connect as shown in Figure 5-6 with the probe tip capped and canister removed. For emissions control samples the assembly will be as shown in Figure 5-7.

4. A UHP N_2 or UHP air supply cylinder will be connected to the outlet end and pressure regulated to approximately 5 psig.

04-09-92

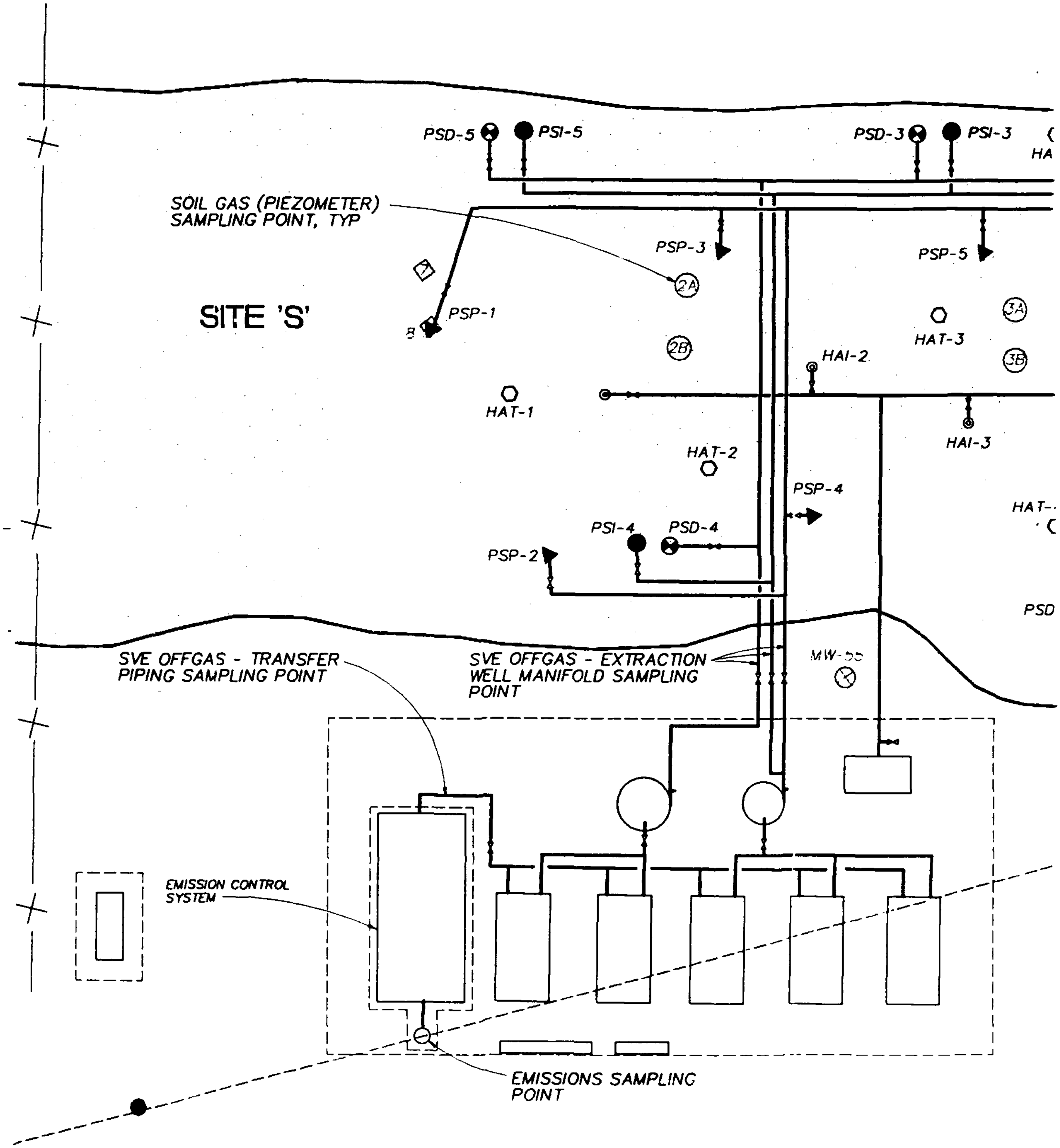


NOTE: CANISTER SAMPLE TRAIN MAY BE REPLACED BY TEDLAR BAG SAMPLE APPARATUS FOR TO-12 SAMPLE COLLECTION. TEDLAR BAG APPARATUS SHOWN ON FIGURE 5-8.

FIGURE 5-6

SVE OFFGAS SAMPLE TRAIN

CH2MHILL



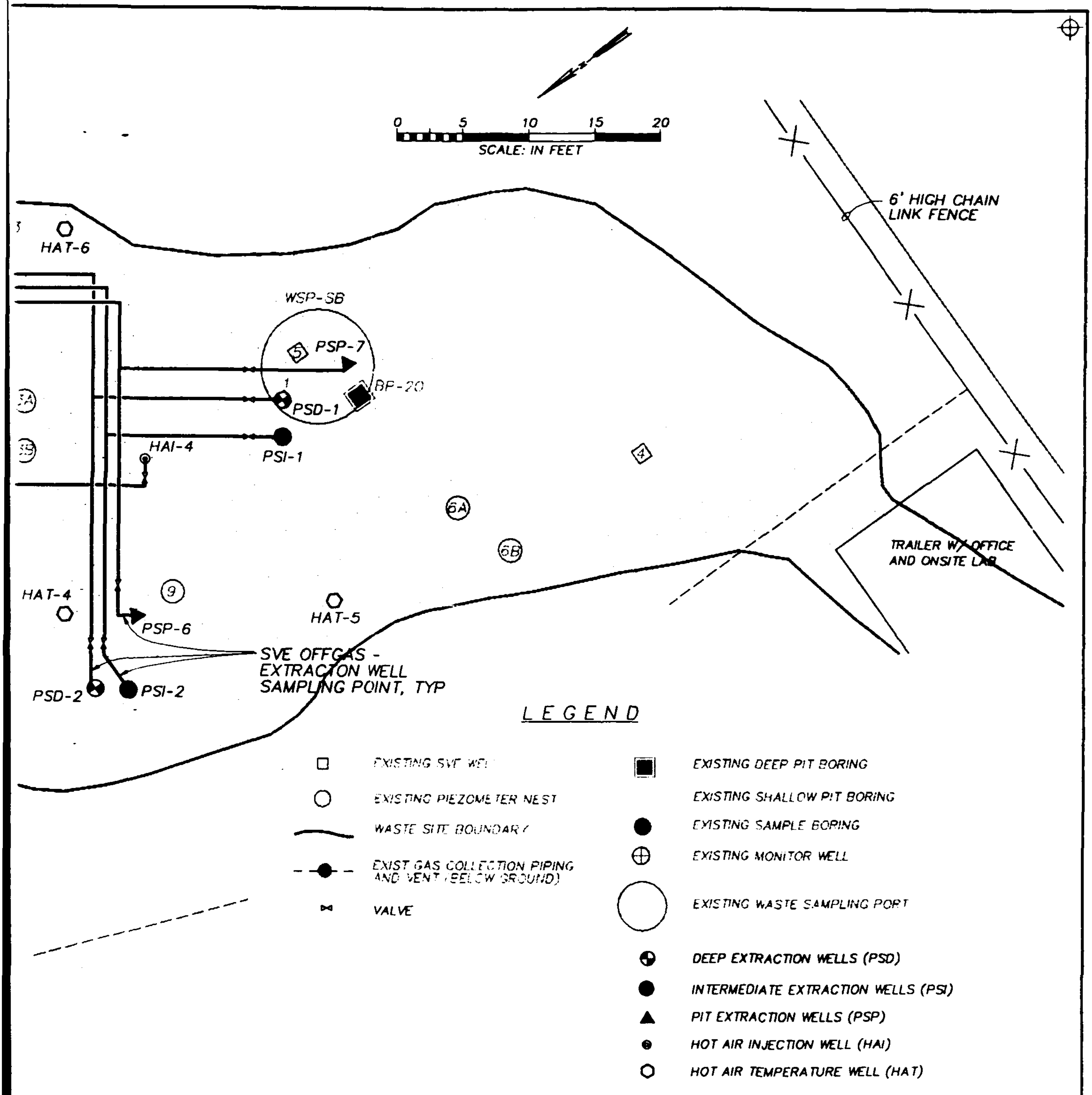
CH2M HILL

DSGN	C NOLING
DR	D KING
CHK	J TRACY
APVD	C NOLING

NO.	DATE	REVISION	BY	APVD

REUSE OF DO

THIS DOCUMENT, AND THE IDEA
PORATED HEREIN, AS AN INSTRU
SERVICE, IS THE PROPERTY OF CH2
USED, IN WHOLE OR IN PART, FO
WITHOUT THE WRITTEN AUTHOR



NOTE:

WELLS PSP-1, AND PSD-1 WERE PREVIOUSLY INSTALLED DURING SITE CHARACTERIZATION. (PSP-1=VES-08; PSD-1=VES-01)

OF DOCUMENTS

THE IDEAS AND DESIGNS INCOR-
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RTY OF CH2M HILL AND IS NOT TO BE
PART, FOR ANY OTHER PROJECT
AUTHORIZATION OF CH2M HILL.

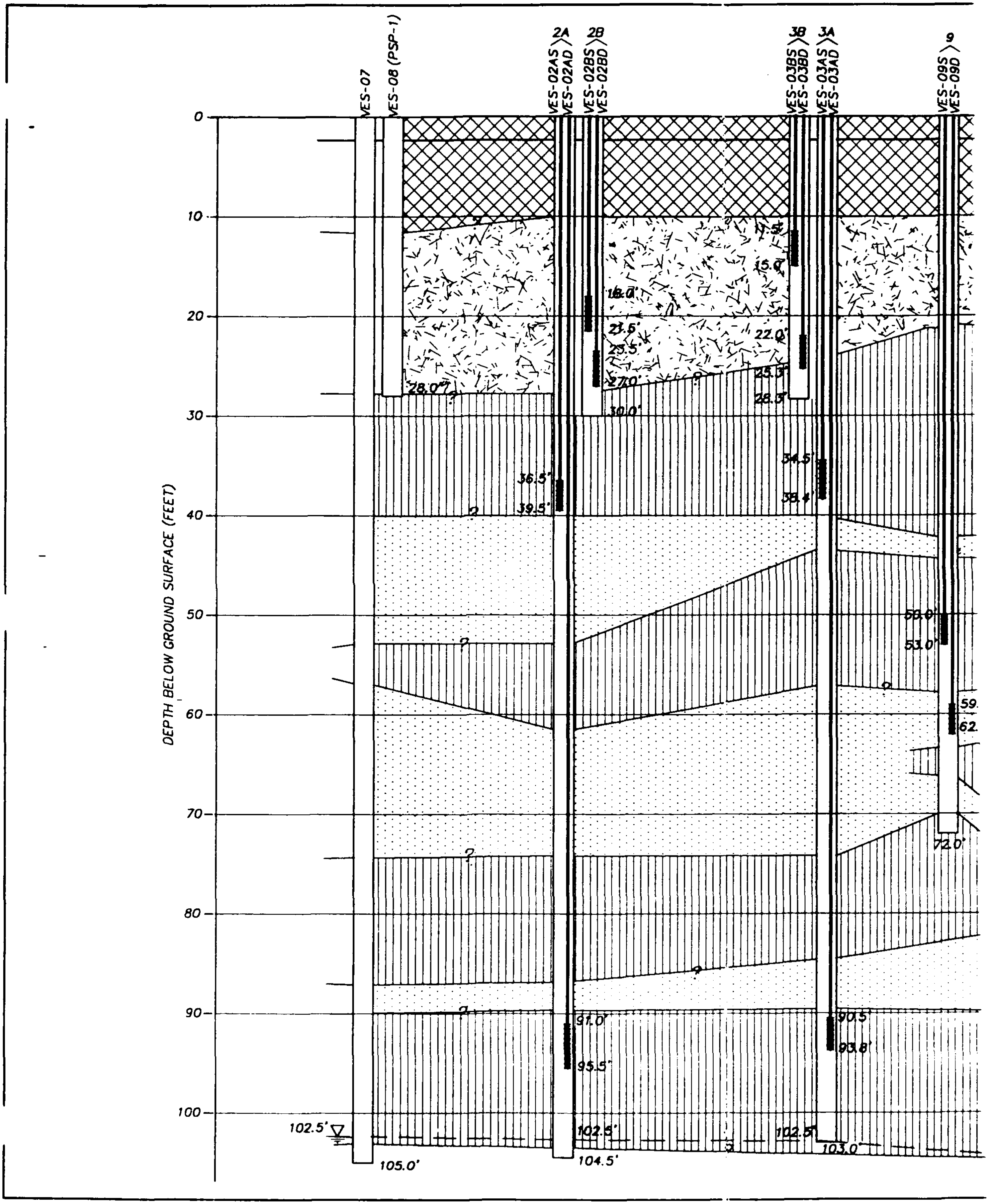
McCLELLAN AFB
SVE PILOT-SCALE SYSTEM
SITE S O.U. D

FIGURE 5-2
GAS SAMPLE COLLECTION POINTS

SHEET
DWG NO.
DATE JUNE 1992
PROJ NO. SAC28722.38

L WOODWARD S28722W03

10-24-91



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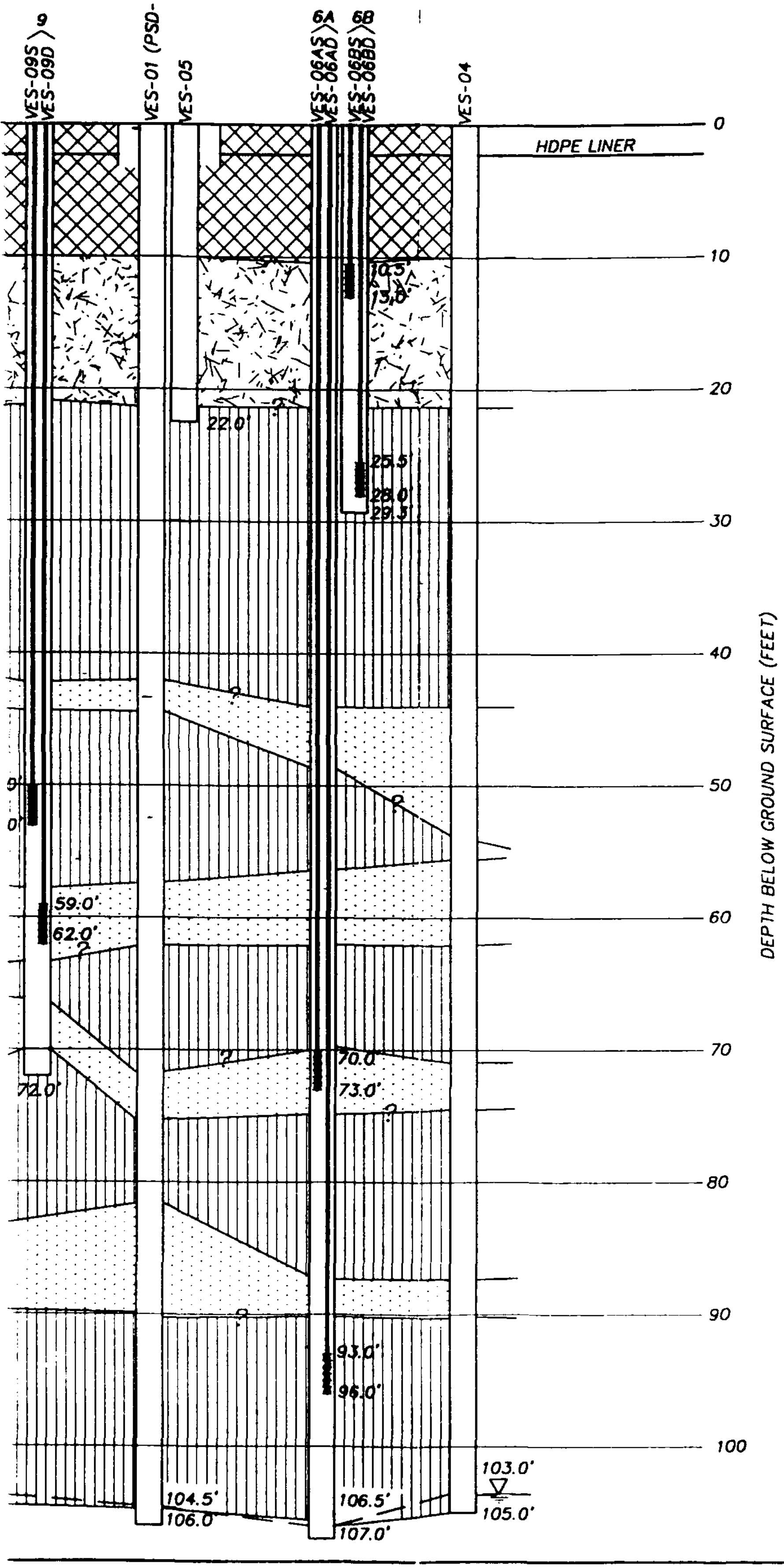


LEGEND

— ▽ — WATER LEVEL ENCOUNTERED DURING DRILLING

▨ FILL - COMBINATION OF GRAVEL, SAND, AND SILT WITH CLAY UNDERLYING THE HDPE LINER

▨ PIT - SILTY SANDS AND SANDY SILTS WITH OILY MATERIAL, WIRE, WOOD, DEBRIS, ETC; DESIGNATION BASED ON PRESENCE OF WASTE MATERIAL LISTED ABOVE, AS WELL AS ODOR, PID MEASUREMENTS OVER 200ppm

▨ FINE SAND (INCLUDES SAND W/ SILT)

▥ COMBINATION OF SILTY/CLAYEY SAND, SANDY SILT/CLAY, WITH LENSES OF SILT AND CLAY

▮ SCREENED SECTION OF 1" DIA PIEZOMETER (SOIL GAS SAMPLING)

NOTES:

1. THIS GEOLOGIC CROSS SECTION IS A SIMPLIFIED AND GENERALIZED INTERPRETATION OF THE MATERIAL ENCOUNTERED DURING THE DRILLING. REFER TO THE BORING LOGS IN APPENDIX A FOR DETAILED DESCRIPTIONS OF MATERIALS ACTUALLY ENCOUNTERED IN EACH BORING.
2. WASTE PIT PIEZOMETERS (5)
   VES-02BS, VES-02BD, VES-03BS, VES-03BD, VES-06BS
3. INTERMEDIATE ALLUVIUM PIEZOMETERS (3)
   VES-02AS, VES-03AS, VES-06BD
4. DEEP ALLUVIUM PIEZOMETERS (6)
   VES-02AD, VES-03AD, VES-09S
   VES-09D, VES-06AS, VES-06AD

0 5 10 15 20 25

SCALE IN FEET
(HORIZ AND VERT)

FIGURE 5-3
PIEZOMETER SCREEN LOCATIONS

McCLELLAN AFB
SVE TREATABILITY INVESTIGATION
SITE S, OU D

07-15-92

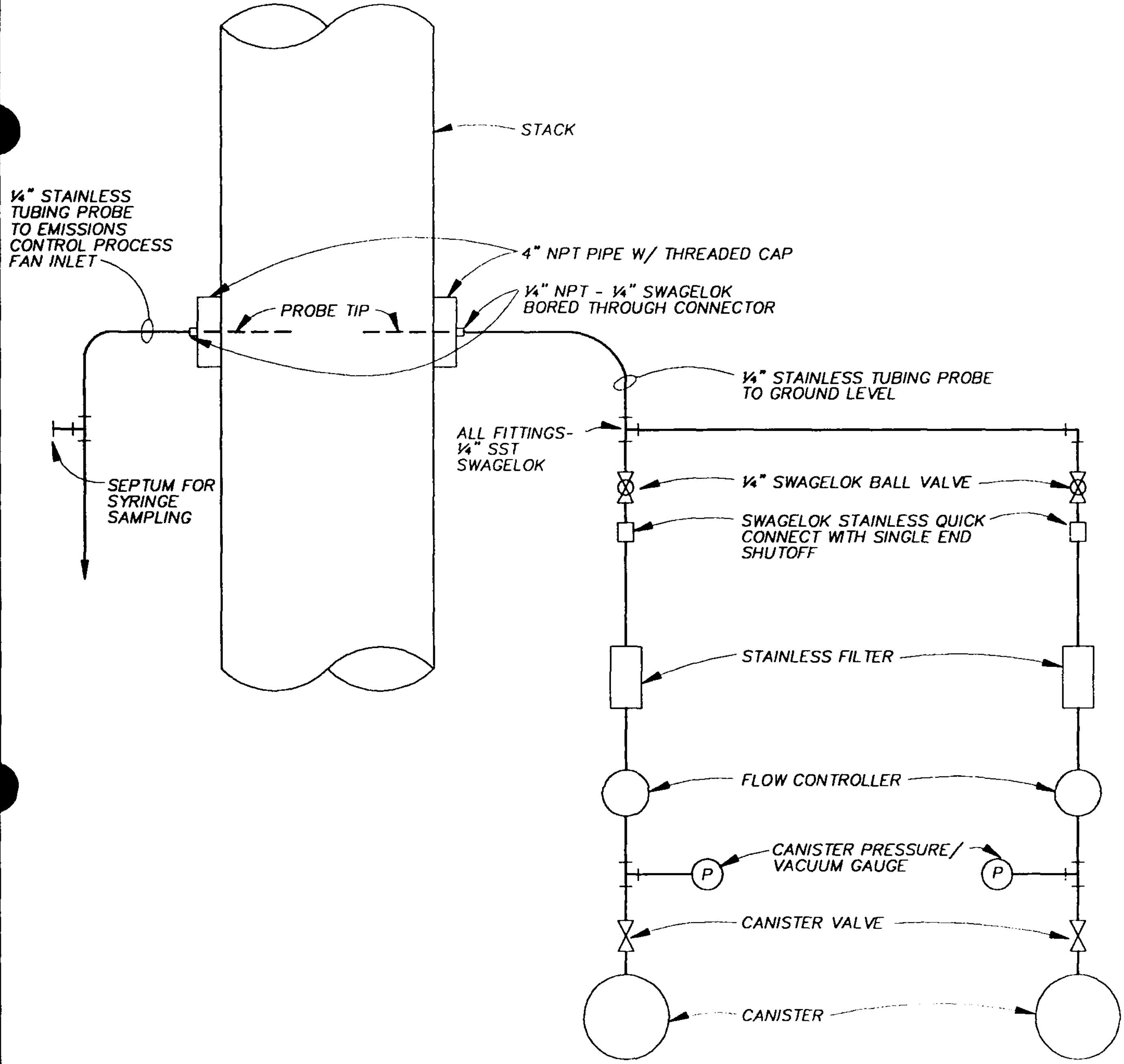


FIGURE 5-7

EMISSIONS CONTROL SAMPLE TRAIN

J:\MCCLELLAN\SAC28722\58722W05.DWG

5. Apply leak detection fluid to each probe connection in turn and tighten leaking fittings to a leak-free condition as evidenced by an absence of bubbling in the leak detection fluid.

6. Flush the leak detection fluid from the connection with high purity water and then wrap each connection tightly with 1/2-inch teflon tape.

7. Attach "dummy" evacuated canister securely to the outlet fitting and open its valve. Record the initial vacuum once the canister has evacuated the probe.

8. Record the vacuum again after 5 minutes. There should have been negligible change (<2-inch Hg). If the vacuum decreased measurably, repeat Steps 1 through 6.

9. After the probe is determined to be leak-free, remove the inlet end cap and fitting and attach the probe to the swagelok stainless steel quick connect manifold at the selected sampling location.

10. Prior to attaching the sample canister, the probe line will be flushed with sample gas using the auxiliary purge pump and carbon filter. Firmly attach the sample canister to the outlet side of the probe assembly and tightly wrap this connection with 1/2-inch teflon tape.

11. Initiate sampling by completely opening the canister valve and record the time and initial vacuum on the sample location log.

12. Periodically throughout the selected sampling period, record the time and sample container pressure on the sample location log to confirm appropriate sample integration.

13. Close the canister valve and any in-line valves when the desired vacuum (measured by the canister vacuum gauge) is reached in the canister. The vacuum should be no less than 2 inch Hg greater than the vacuum measured in the sample manifold.

14. Disconnect the probe from the quick connector. Then record sample end-time on the sample location log.

15. Remove, cap, label, and prepare the canister for shipment to the laboratory.

16. Disassemble and store pieces of the probe in a clearly marked storage container to be returned to the laboratory.

Tedlar Bag Samples

The following matrices may be sampled for analysis by EPA Method TO-12 using Tedlar bags:

- Soil gas
- SVE off gas
    - Extraction wells
    - Extraction well manifolds
    - Transfer piping

Only medium to high concentration samples will be collected using this technique (>10 ppm using an OVA as a screening test), because of concerns with analyte adsorption to the walls of the Tedlar bags, and other low concentration interferences.

The samples will be collected by attaching the Tedlar bag sampling apparatus, presented in Figure 5-8, to the sampling manifold in place of one or more canisters.

The sampling system consists of Teflon tubing, a pump, and a rigid-wall container that holds a sample bag. The sample bag is constructed of 5-mil tedlar with a stainless steel entry port and valve. The principal advantages of the sampler are that the sample gas contacts only noncontaminating Teflon tubing and stainless steel swagelock connectors before it enters the sample bag, and that the Tedlar, Teflon and stainless components can be decontaminated for reuse.

For collection of gas samples, the sample line is purged and connected to the rigid-wall sample container, and the sample gas is extracted at a rate of approximately 1 liter per minute until the sample bag is full, usually 4 to 5 minutes later.

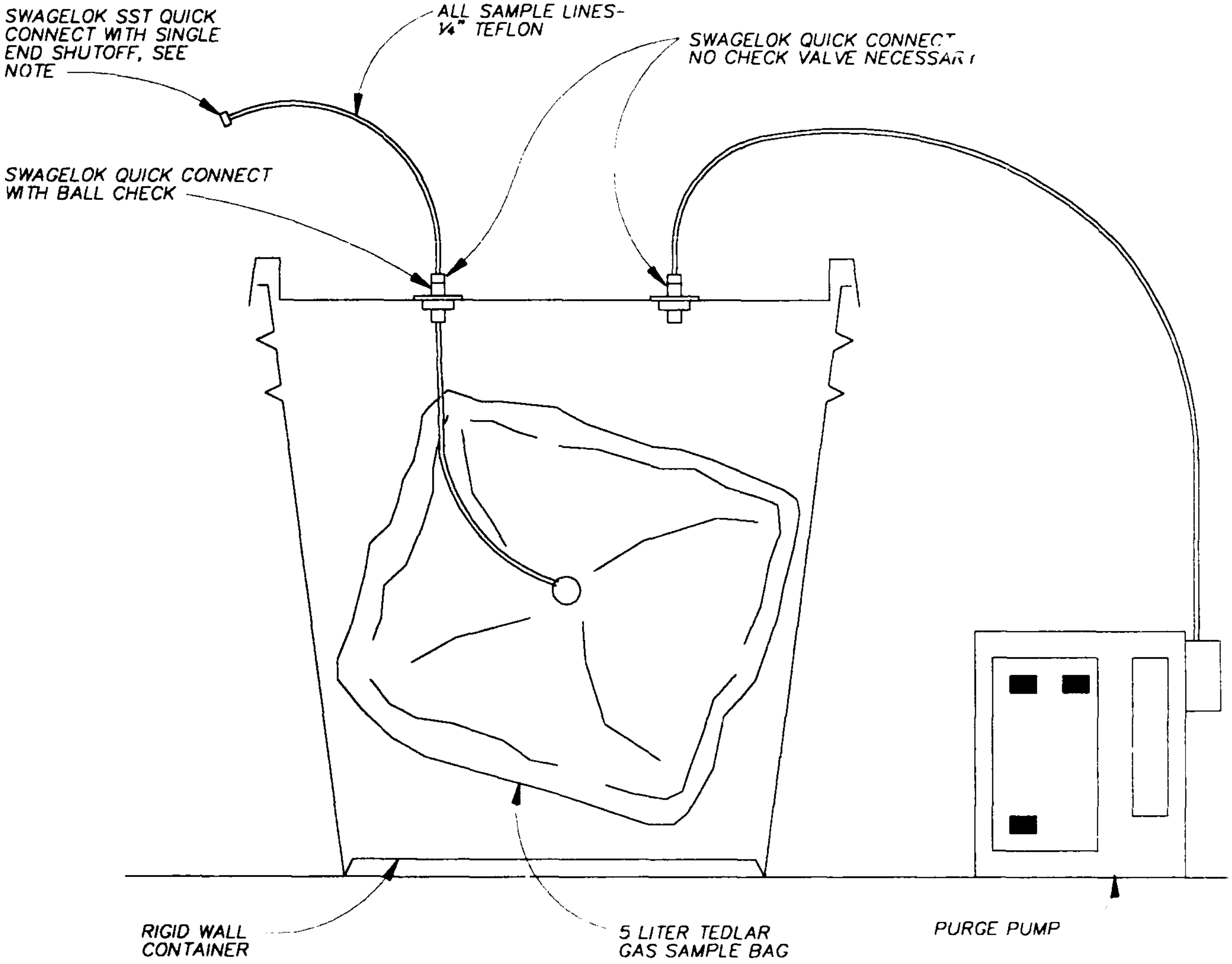
After collection, the sample gas bags are delivered to the laboratory for testing.

To prevent contamination between low and higher concentration samples, two precautions will be taken. First, sampling apparatus that are dedicated to high or low concentration samples will be used. Second, before each use, the Teflon tubing, stainless fittings, and valves will be decontaminated by rinsing with deionized water and drying with zero-grade air.

The Tedlar bag samples will be collected using the following procedure:

1. Clean the sampling apparatus tubing and fittings by flushing with zero-grade air. The Tedlar bag sampling apparatus will be connected into the canister sampling system.

07-16-92



NOTE: *USE SWAGELOK QUICK CONNECT FITTING FOR APPLICATION IN THE SVE OFFGAS SAMPLE TRAIN. CONNECT TEFLON TUBING DIRECTLY TO STAINLESS STEEL TEE FOR APPLICATION IN THE SOIL GAS (PIEZOMETER) SAMPLE TRAIN.*

FIGURE 5-8
TEDLAR BAG GAS SAMPLE APPARATUS

CH2M HILL

\MC [illegible] AN\SAC28722\58722W06.DWG

2. Flush each Tedlar bag three times with zero air.

3. A purge pump with charcoal tube in line will be connected to the inlet line. The sample lines will then be flushed with sample gas.

4. Open the sample valve on the Tedlar bag and insert it into the vacuum vessel, connecting it to the tubing on the sample inlet line. Replace the vessel lid, making sure it is sealed.

5. Perform a system leak check by plugging the sample inlet line and applying a vacuum to the system. Observe the sample bag for several minutes to insure it is not inflating from a leak in the system.

6. Connect the sample inlet line and begin collecting the sample at a rate of approximately 1 liter/minute until the sample bag is full.

7. After the bag is full, close the bag valve and disconnect from the sample line.

8. Label the bag, place in a container impervious to lights, and send to the laboratory by next-day delivery service. Do not send full bags using air freight to prevent rupture of the bag in-flight.

Syringe Samples

VOCs are regulated toxic chemicals and should be treated with care to avoid personal and environmental contamination. When sampling vapors from the vacuum system, it will be considered that the air stream is contaminated with VOCs. Care should be taken so that no contaminated air is discharged to the atmosphere.

Following is a list of equipment needed for sampling using the onsite GC method:

- Clean and well-lighted work area
- Hamilton Gastight Syringes, 500-ul size

To collect a sample of soil vapor for onsite GC analysis, the following procedure will be used:

1. Install a syringe septum fitting into the sampling location on the SVE duct or on the piezometer manifold.

2. Purge syringe with clean air and test syringe for leaking plunger and tight needle.

3. Insert the clean syringe through the septum to reach the midpoint in the duct or to be well into the sample line for soil gas.

4. Close the syringe valve and withdraw the plunger.

5. Open the syringe valve and push the plunger into the syringe to flush the syringe with sample gas.

6. Close the syringe valve and withdraw the plunger to collect the sample.

7. Stopper the syringe.

8. Log time, location, well head vacuum, flow, and return sample to GC.

Oxygen Uptake Rate Samples

Oxygen Uptake Rates (OUR) will be performed in the soil gas. The OUR measurement procedure is as follows:

1. Turn off the vapor extraction pumps.

2. Using a small vacuum pump (less than 1 scfm of flow), purge three volumes of gas from the piezometer, and then collect a soil gas sample from the screened level.

3. Analyze the soil gas sample for oxygen and carbon dioxide using an 02/C02 meter. The temperature and relative humidity will be measured once during each OUR test in conjunction with the initial O_2 and CO_2 sample. The soil gas temperature and relative humidity will be measured by lowering a hand-held thermometer and humidity gauge into each piezometer to the screened level. Cap the piezometer after sampling.

4. Repeat sampling at each piezometer at 3-hour intervals (initially) to develop a plot of oxygen uptake and carbon dioxide production over time. The sampling intervals can be lengthened for slow oxygen uptake rates. A target oxygen content decrease of 2 to 4 percent between measurements should be used to determine appropriately spaced sampling intervals. The initial oxygen concentration should be near 20 percent. Terminate the study when the oxygen concentration decreases to 5 percent in each piezometer.

5. The OUR is equal to the slope of the linear portion of the oxygen uptake versus time plot. The carbon dioxide production rate should mirror the oxygen uptake rate an is equal to the slope of the linear portion of the carbon dioxide versus time plot.

Other Samples

Both canister and onsite GC samples will be collected for the emissions control system operation. In addition, stack emissions will be monitored for hydrochloric acid and dioxins.

Hydrochloric Acid. To collect a sample of emission control system exhaust gas for analysis for HCl, the procedures outlined in Method 26—Determination of Hydrogen Chloride Emissions from Stationary Sources will be followed. This method is presented in Appendix H.

Dioxins. To collect samples of emission control system exhaust gases for analysis of dioxins, the procedures outlined in Method 23—Determination of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans from Stationary Sources will be followed. This method is presented in Appendix I.

Quality Control Samples

The purpose of the field quality control program is to provide a measure of data quality. Field duplicates indicate the precision of the overall sampling and analysis event, and matrix spike/matrix spike duplicates indicate the precision and accuracy of the laboratory analyses. The following duplicate samples will be collected during the SVE Demonstration Project.

- **Field Duplicates.** For air samples, field duplicates will be collected at a frequency of one per twenty samples. Field duplicates will not be collected for soil samples. All field duplicates will be identified in the field and on the sample chain-of-custody.

- **Matrix Spike/Matrix Spike Duplicates.** For soil samples, MS/MSD will be performed at a frequency of one per twenty. All MS/MSD will be identified in the field and on the sample chain-of-custody.

- **Laboratory Duplicates.** For gas samples laboratory duplicates will be analyzed at a frequency of 5 percent.

- **Audit Cylinder.** For air VOC analyses, a performance evaluation sample will be submitted to the onsite and offsite laboratories by CH2M HILL. The audit cylinder will be analyzed at a frequency of once per week for each week samples will be submitted for analysis. The performance evaluation sample will be prepared by delivering a mixture of standard gas from the audit cylinder to a premoistened canister for offsite analyses. For onsite analyses, the performance evaluation sample will be prepared by delivering a mixture of standard gas from the audit cylinder to a sample syringe. The gas will be prepared by the EPA and preanalyzed to a tolerance of ± 5 percent for each compound. The compounds range in concentration by one order-of-magnitude above each method's detection limit.

An independent QC check sample will also be analyzed by the offsite laboratory using standard reference material (SRM) and is certifiable to National Institute of Standards and Technology (NIST).

The audit cylinder will be used to deliver gas to a six-liter canister previously requested for field use. The canister audit sample will be prepared to a final pressure similar to the actual samples collected in the SVE treatability investigation (i.e., 6 to 10 inches Hg). The syringe audit sample will be prepared onsite and drawn into the syringe in the same manner as field samples are collected.

- **Chloride Audit Samples.** For the analysis of HCL in air, two EPA audit samples will be analyzed concurrently with a set of field samples to evaluate the technique of the analyst and the standards preparation. The audit samples should be analyzed once during each operating period of the SVE pilot project.

- **Dioxin Audit Samples.** For analysis of dioxin in air, an EPA audit sample will be analyzed concurrently with a set of field samples to evaluate the technique of the analyst and the standards preparation. The audit sample will be analyzed once during each period of the SVE pilot project.

- **Sampling Train Collection Efficiency Check.** For analysis of dioxins in air, surrogate standards will be added to the absorbent cartridge of each train before collecting each field sample. The surrogate compounds are a measure of collection efficiency only and should achieve recoveries between 70 and 130 percent.

A number of blank samples will be collected and analyzed for each analytical method. Equipment and field blanks monitor contaminants that may be contributed by the sampling equipment. The following blank samples will be collected during the SVE treatability investigation.

- **Equipment Blanks.** For soil samples, two equipment blanks will be collected, the first midway through sampling and the second at the end of the procedure. After decontamination procedures have been performed on the sampling equipment, High Pressure Liquid Chromatography (HPLC) water will be poured over the sampling equipment and collected in the proper sampling bottles and sent in for analysis. See Section 6 for a list of sample bottles and preservatives needed.

- **Ambient Condition Blanks.** For gas samples, ambient condition blanks will be collected at a frequency of one per twenty samples for onsite analyses only. This blank will allow determination of ambient concentrations of target compounds onsite. These concentrations will help determine target detection limits. For onsite analysis, the field blank will be collected into a premoistened sample syringe.

- **Hexane Train Blank.** For the analysis of dioxins in air, a train blank will be collected for each day of analysis. The sampling train will be flushed with hexane provided by the laboratory to monitor contaminants that may be contributed by the sampling train.

Soil Samples

Table 5-8 summarizes the QC samples to be performed for soil sampling.

Gas Samples

Table 5-9 presents a summary of the quality control samples to be collected as a part of the SVE treatability investigation gas sampling program.

Field Duplicate Sample Collection

To collect a field duplicate of a gas sample, the following steps shall be followed.

1. Assemble twin sampling trains (i.e., canister or tedlar bags, flow controllers) as described for sample collection.
2. Fill in appropriate line data on field data collection sheet and start each sampling train simultaneously by fully opening the canister valves or starting purge pump on the tedlar bag apparatus.
3. Record the start time. Record each canister pressure reading (initial pressure) if canister sampling is being performed.
4. Monitor the pressure of each train throughout the desired sample run and record on field data sheet.
5. When the sample time has expired or the trains have reached ending target pressure, stop the runs by simultaneously closing each canister or bag valve.
6. Complete sample recovery and sample chain-of-custody forms.

The probes and flow controllers shall be used only once. All sample assemblies will be dedicated to the sampling location in service and not decontaminated in the field.

Table 5-8
Summary of Quality Assurance Samples for Soil

Analysis	Method	Analysis Level	Number of Treatability Samples	Number of Equipment Blanks	Number of Matrix Spikes	Number of Matrix Spike Duplicates
Total Petroleum Hydrocarbons	Modified 8015	III	71	4	4	4
Microbiological Assay	DNAB	III	57			
Chemical Oxygen Demand	MOSA 29-3.5.3	III	54			
Physical Properties	--	III	10			
Moisture Content	MOSA 21-2.2	III	54			
pH	MOSA 12-2.6	III	54			
Ammonia-Nitrogen	MOSA 33-3.2, EPA 350.2	III	54			
Nitrate-Nitrogen	MOSA 33-3.2, EPA 300.0	III	54			
Phosphate Phosporus	MOSA 24-5.3, EPA 300.0	III	54			

Table 5-9
Summary of Quality Assurance Samples for Gas

Sample Matrix	Analysis	Method	Analysis Level	Primary Samples	Field Duplicates	Ambient Condition Blanks	Collection Efficiency Checks	Hexane Train Blanks	Audit Cylinder[a]	Laboratory Duplicates
SOIL GAS										
	VOCs	Onsite GC	II	168	9	9			7	9
	VOCs	TO-14	III	9	1				2	1
	Total Nonmethane Hydrocarbons	TO-12	III	112	6				7	6
	Methane	Meter	I	8						
	Oxygen and Carbon Dioxide (only)	Meter	I	32						
	Oxygen Uptake Rate	--	I	96						
SVE OFFGAS (Extraction Wells)										
	VOCs	Onsite GC	II	280	16	16			12	16
	VOCs	TO-14	III	14	1				3	1
	Total Nonmethane Hydrocarbons	TO-12	III	119	6				8	6
SVE OFFGAS (Extraction Well Manifolds)										
	VOCs	Onsite GC	II	96	4	4			4	4
	VOCs	TO-14	III	5	1				1	1
	Total Nonmethane Hydrocarbons	TO-12	III	39	2				3	2
	Oxygen and Carbon Dioxide (only)	Meter	I	34						
SVE OFFGAS (Transfer Piping)										
	VOCs	Onsite GC	II	20	2	2			1	2
	VOCs	TO-14	III	1	1				1	1
	Total Nonmethane Hydrocarbons	TO-12	III	18	1				1	1
	Oxygen and Carbon Dioxide (only)	Meter	I	21						
EMISSION CONTROLS										
	VOCs	Onsite GC	II	20	2				2	2
	VOCs	TO-14	III	1	1				1	1
	Total Nonmethane Hydrocarbons	TO-12	III	18	1				1	1
	Hydrochloric Acid	M26	III	7	1	1			3[b]	1
	Dioxins	M23	III	7	1		1	1	3[c]	1

[a] Only during weeks when analysis is being conducted. One sample per week. Distributed among matrixes proportionately to number of primary samples collected.
[b] Chloride audit sample.
[c] Dioxin audit sample.

Sample Designation

A CH2M HILL sample identification system will be used to identify each sample submitted for analysis. A listing of sample identification numbers will be maintained in a field log book and a separate sample record book. The field log book will be used for keeping general field notes, while the sample record book will be used for recording sample numbers and to aid field personnel in tracking sample sequences. Each sample identification number will have two components: station code and sample code. No sample identification number will exceed nine characters in length. Descriptions of the sample identification codes are described below.

Soil Samples

Soil Borings Samples

The station code for samples collected from a soil boring will have three components. The first two characters will be PS for pilot system soil boring. The third character will indicate soil zone (P for waste pit, I for intermediate alluvium, and D for deep alluvium). The fourth character will be a sequential boring number beginning with 1. All soil samples collected from the same soil boring will have the same sequential boring number.

The sample code will consist of a dash (-) followed by the depth from which the sample was collected. The letters A or B may be used following the sample code to indicate adjacent samples from within the same split spoon. C will indicate the top sample. The reference point for a sample depth will be the distance from ground surface to the bottom edge of the brass sample sleeve. If the sample is collected from a depth greater than 99.9 feet, the decimal place will be dropped and the depth will be indicated by the closest integer value. The actual sample depth will be recorded in the log book.

Examples:
SBP2-08.5C (pit boring number 2, depth 8.5 feet, top sample)
SBI2-35.5B (intermediate boring number 2, depth 35.5 feet, middle sample)
SBD1-101A (deep boring number 1, depth approximately 101 feet, bottom sample)

SVE Soil Borings

The station code for samples collected from a soil boring, which will be converted to a SVE well will have two components. The first three characters will indicate the SVE well zone (PSP for wells installed in the waste pit and PSD for wells installed in the deep alluvium.) The fourth character will indicate the sequential number of the SVE well.

The sample code will consist of a dash (-) followed by the depth from which the sample was collected. The reference point for a sample depth will be the distance from ground surface to the bottom edge of the brass sample sleeve. If the sample is collected from a depth greater than 99.9 feet, the decimal place will be dropped and the depth will be indicated by the closest integer value.

Examples:	PSP3-18.0	(SVE soil boring PSP-3, depth 18.0 feet)
	PSD4-74.5	(SVE soil boring PSD-4, depth 74.5 feet)
	PSD4-102	(SVE soil boring PSD-4, depth 102 feet)

Soil Gas Samples

Two types of soil gas samples will be collected, canister samples for offsite analysis and syringe samples for onsite GC analysis. The station code for soil gas samples collected from a SVE piezometer will have two components. The first character will be V for vapor extraction system. The second through fifth characters will indicate the piezometer number. All soil gas samples collected from the same piezometer will have the same piezometer number.

The sample code will consist of a dash (-) followed by two components: S for syringe sample or C for canister sample, and a sequential sample number beginning with 01 particular to an individual piezometer.

Most samples will be collected by syringe for onsite GC analysis. When a canister sample is collected it will be as a duplicate to a syringe sample as a means of checking the onsite GC results. Therefore, the numerical sequence of the sample code will be governed by the syringe samples. A canister sample will be assigned the same sample number as the syringe sample it is duplicating.

Examples:	V03BS-S06	(piezometer VES-03BS, sixth syringe sample collected from this piezometer)
	V03BS-C06	(piezometer VES-03BS, canister sample is duplicate to sample VO3BS-S06)

SVE Offgas Samples

There are three types of SVE offgas samples which will be collected. Vapor extraction well offgas samples will be collected from the individual extraction wells and the extraction well manifolds coming from each of the three contaminant zones (waste pit, intermediate alluvium, and deep alluvium.) Transfer piping offgas samples will be collected from the combined system offgas.

Vapor Extraction Wells

The station code for SVE offgas samples collected from individual extraction wells consists of three components. The first character will be O for offgas. The second character will be W for well. The third and fourth characters will designate the individual well from which the sample was collected. The third character will indicate the waste zone in which the extraction well screen is set (P for waste pit, I for intermediate alluvium, and D for deep alluvium). The fourth character is the well number for that contaminant zone. Samples from waste pit well PSP-1 will be designated by OWP1. Those from intermediate well PSI-3 will be designated by OWI3, etcetera.

The sample code will consist of a dash (-) followed by two components: S for syringe sample or C for canister sample, and a sequential number beginning with 01 particular to an individual extraction well.

Most samples will be collected by syringe for onsite GC analysis. When a canister sample is collected it will be as a duplicate to a syringe sample as a means of checking the onsite GC results. Therefore, the numerical sequence of the sample code will be governed by the syringe samples. A canister sample will be assigned the same sample number as the syringe sample it is duplicating.

Examples:	OWP2-S01	(waste pit extraction well PSP-2, first syringe sample from this extraction well)
	OWI1-C17	(intermediate alluvium extraction well PSI-1, canister sample is duplicate to sample OWI1-S17)
	OWD4-S23	(deep alluvium extraction well PSD-4, twenty-third sample from this extraction well)

Vapor Extraction Well Manifolds

The station code for SVE offgas samples collected from vapor extraction well piping will have three components. The first character will be O for offgas. The second character will be M for manifold. The third character will indicate the extraction well piping type. Samples from the waste pit manifold will be designated by OMP. Samples from the intermediate zone manifold will be designated by OMI. Samples from the deep zone piping will be designated by OMD.

The sample code will consist of a dash (-) followed by two components: S for syringe sample or C for canister sample, and a sequential sample number beginning with 01 particular to an individual extraction well.

Most samples will be collected by syringe for onsite GC analysis. When a canister sample is collected it will be as a duplicate to a syringe sample as a means of checking the onsite GC results. Therefore, the numerical sequence of the sample code will be governed by the syringe samples. A canister sample will be assigned the same sample number as the syringe sample it is duplicating.

Examples:	OMP-S04	(waste pit extraction well manifold, fourth syringe sample from this manifold)
	OMI-C07	(intermediate alluvium extraction well manifold, canister sample is duplicate to sample OMI-S07)
	OMD-S14	(deep alluvium extraction well manifold, fourteenth syringe sample from this manifold)

Transfer Piping

The station code for SVE offgas samples collected from the transfer piping will have two components. The first character will be O for offgas. The second and third characters will be TP for transfer piping.

The sample code will consist of a dash (-) followed by two components: S for syringe sample or C for canister sample, and a sequential sample number beginning with 01 particular to an individual extraction well.

Most samples will be collected by syringe for onsite GC analysis. When a canister sample is collected it will be as a duplicate to a syringe sample as a means of checking the onsite GC results. Therefore, the numerical sequence of the sample code will be governed by the syringe samples. A canister sample will be assigned the same sample number as the syringe sample it is duplicating.

Example:	OTP-S01	(transfer piping offgas, first syringe sample)
	OTP-C19	(transfer piping offgas, canister sample is duplicate to sample OTP-S19)

Emission Control Samples

The station code for emission control samples will have two characters: EC for emissions control. The sample code will consist of a dash (-) followed by three components: S for syringe sample or C for canister sample, a sequential sample number beginning with 001, and a D for duplicate to syringe sample or blank for primary sample.

Many samples will be collected by syringe for onsite GC analysis. Some canister samples will be collected as duplicates to syringe samples (TO-14). Some canister samples will be collected as primary samples. The numerical sequence of the sample code will be governed by the primary samples (syringe plus primary canister samples). A canister sample collected as a duplicate to a syringe sample will be assigned the same sample number as the syringe sample it is duplicating).

Examples:	EC-S001	(emissions control sample, first primary sample, by syringe)
	EC-C004	(emissions control sample, fourth primary sample, by canister)
	EC-C004D	(emissions control sample, canister sample is duplicate to fourth primary sample EC-S004)

Quality Control Samples

Several QA/QC samples will be collected including field duplicates, equipment blanks, trip blanks, ambient condition blanks, collection efficiency blanks and hexane train blanks. Definitions of these QA/QC samples are presented later in this section under "Field Quality Control Samples." Guidelines for naming QA/QC samples are provided below.

Field Duplicates

QA/QC samples for field duplicates will be blind coded on the chain of custody records. However, the true sample identification codes should be recorded in the field log book along with the blind sample codes.

The station code for field duplicate samples will consist of two components. The first two characters will be FD for field duplicate. The third character will be a dash (-). The fourth and fifth characters will designate the source of the field duplicate sample. Soil gas field duplicates will be designated by SG and emissions control duplicates by EC. Offgas duplicates will be designated by OG regardless of whether the sample is from vapor extraction wells, extraction well manifolds or transfer piping. However, the source of this sample will be recorded in the field log book.

The sample code will consist of a dash (-) followed by a sequential sample number beginning with 001.

Examples:	FD-SG-002	(field duplicate, soil gas, second sample)
	FD-OG-001	(field duplicate, SVE offgas, first sample)
	FD-EC-006	(field duplicate, emissions control system, sixth sample)

Equipment Blanks

The station code for equipment blanks will consist of two components. The first two characters will be EB for equipment blank. The third character will be a dash (-). The fourth and fifth characters will designate the purpose of the equipment blank. Blanks conducted on equipment from soil borings will be designated by SB for soil boring. Blanks conducted on equipment from SVE well installations will be designated by PS from well names.)

The sample code will consist of a dash (-) followed by a sequential sample number beginning with 01.

Examples:	EB-SB-02	(equipment blank, soil boring, second sample)
	EB-PS-03	(equipment blank, SVE well boring, third sample)

Trip Blanks

The station code for trip blanks will be TB. The sample code will consist of a dash (-) followed by a sequential number beginning with 01.

Example:	TB-07	(trip blank, seventh sample)

Ambient Condition Blanks

The station code for ambient condition blanks will consist of two components. The first two characters will be AB for ambient blank. The third character will be a dash (-). The fourth and fifth characters will designate the purpose of the ambient condition blank. Ambient condition blanks collected for emissions control background levels will be designated by EC for emissions control.

The sample code will consist of a dash (-) followed by a sequential sample number beginning with 01.

Examples:	AB-EC-02	(ambient condition blank, emissions control, second sample)

Collection Efficiency Check

The station code for collection efficiency checks will consist of two components. The first two characters will be CE for collection efficiency. The third character will be a dash (-). The fourth and fifth characters will be EC since collection efficiency blanks will only be conducted in association with emissions control QA/QC monitoring.

The sample code will consist of a dash (-) followed by a sequential number beginning with 1. It is anticipated only one collection efficiency check will be collected.

Example:	CE-EC-1	(collection efficiency check, emissions control, first sample)

Hexane Train Blank

The station code for hexane train blanks will consist of two components. The first two characters will be HT for hexane train. The third character will be a dash (-). The fourth and fifth characters will be EC since hexane train blanks will only be conducted in association with emissions control QA/QC monitoring.

The sample code will consist of a dash (-) followed by a sequential number beginning with 1. It is anticipated only one hexane train blank will be collected.

Example: HT-EC-1 (hexane train blank, emissions control, first sample)

Sample Handling, Preservation, and Shipment

This section presents the methods to be followed to ensure that samples arrive at the laboratory intact, at the proper temperature, and free from external contamination.

Sample Handling

Soil samples designated for offsite analysis will be submitted to the laboratory in the brass liners used for sample collection. Upon opening a split-spoon sample, the brass liner will be removed from the split spoon and excess soil will be trimmed from the ends of the liner. The ends of the liner will then be covered with teflon tape and PVC slip caps placed over the teflon tape. The liner will then be placed in a labeled ziplock plastic bag, which will in turn be placed in an iced cooler.

Soil vapor (air) samples will be collected in stainless steel canisters supplied by and returned to the laboratory. Dedicated shipping containers will be used to ship the canisters to and from the laboratory.

Sample Preservation

All soil samples collected for offsite analysis will be placed on ice in coolers immediately after collection. Coolers will be kept out of direct sunlight as much as possible and removed to the field office at least every 4 hours. The samples will be repacked with ice prior to shipping them to the laboratory. In the laboratory, samples will be stored at 4°C or less prior to analysis, and stored below 4°C between analysis and sample release for disposal.

In addition to cooling all samples to 4°C, the following equipment blanks and trip blanks collected as part of the soil sampling field analysis will require preservation as indicated:

- TOC (415.1)--H_2SO_4 to $pH<2$

Canister, syringe, and tedlar bag samples for gas do not require preservation but should be kept out of direct sunlight.

Sample Shipment

All samples will be shipped to the laboratory via overnight or next day delivery. All applicable sample packaging and labelling requirements for interstate transport of hazardous materials will be followed as defined in 40 CFR 49, Chapter 1, Part 171. A chain of custody report will accompany each sample shipment.

Sample Documentation

The components of the sample documentation program include the use of sample seals, logbooks, chain of custody form, photographs, and standard handling and shipping procedures. Each component is described briefly below.

Sample Labels

Each sample collected will be labelled with the nine character sample designation number, sample type, date, and sampler's name. The sample labels will be affixed to the sample container and will accompany the samples to the laboratory. Sample descriptions were described previously.

Custody Seals

Custody seals will be placed on the sample coolers anytime a cooler is not in the immediate view of the collection team. The team will sign custody seals and place one on each side of the cooler if they are required to leave the area and cannot maintain visual contact with the samples. Seals will also be affixed to containers shipped offsite for sample analysis.

Field Logbook

The sample team will maintain a field logbook for all sampling events. The field logbook will be a bound notebook with numbered pages. All entries will be made with ink. At the start of each day, the names of sample team members, weather conditions, and reason for sampling will be recorded. The field team leader will keep custody of the field logbook at all times and sign each page.

Data obtained on all of the samples will be entered into the logbook. This includes: the sample identification, location, depth, date and time of sample collection, parameters requested for analysis, field measurement and calibration data, analysis data and methods, sample distribution and transporter, field lot control number, field observations, and crew times.

Any corrections in the logbooks will be made by striking out the incorrect entry with a single line such that the original entry is not obliterated. The person making the correction will also initial and date the crossed out entry. The correct entry will then be made below the crossed out entry.

Sample Record Book

The sample team will maintain a sample record book throughout Phases II and III of the SVE treatability investigation. The sample record book will be a bound notebook with numbered pages. All entries will be made in ink. The sample record book will be divided into 15 sections as shown below or in a manner which allows an organized record of samples collected. Sufficient pages will be left in each section to accommodate a record of all samples collected during Phases II and III of the SVE treatability investigation. Records of onsite GC samples will be included in the sample record book in the appropriate section.

- Soil Boring Samples
- SVE Soil Boring Samples
- Soil Gas Samples (Piezometers)
- SVE Offgas Samples—Extraction Wells
- SVE Offgas Samples—Extraction Well Manifolds
- SVE Offgas Samples—Transfer Piping
- Emissions Control Samples
- Soil Characterization Samples (Disposal)
- QA/QC—Field Duplicates
- QA/QC—Equipment Blanks
- QA/QC—Trip Blanks
- QA/QC—Ambient Condition Blanks
- QA/QC—Collection Efficiency Checks (Emissions Control)
- QA/QC—Hexane Train Blank (Emissions Control)
- Reserved for Notes

The purpose of the sample record book will be to track sample numbers used for each of the sample types collected during the demonstration and to aid field personnel in tracking sample sequences. The date and time each sample was collected, and the recorders initials will be entered in the log book. Any corrections in the logbook will be made by striking out the incorrect entry with a single line such that the original; entry is not obliterated. The person making the correction will also initial and date the crossed out entry. The correct entry will then be made below the crossed out entry.

Chain-of-Custody Forms

Chain-of-custody forms will be used for all samples, which are analyzed offsite. Forms equivalent to the one shown as Figure 5-9 will be delivered with the samples to the laboratory. Each time the sample containers change custody, both the sender and receiver will sign and date the chain-of-custody form accompanying the sample set. When a sample shipment is sent to the laboratory, a copy of the chain-of-custody form will be retained. The laboratory will be instructed to sign its copy of the chain-of-custody sheet included with the samples and return a copy of the signed sheet along with the analytical results. A chain-of-custody record will be completed for each shipping container.

The following information is included on the chain-of-custody form:

- Sample number
- Signature of sampler
- Date and time of collection
- Place of collection

- Type of sample
- Number and type of container
- Inclusive dates of possession
- Signature of receiver
- Cooler identification number (assign a letter A through Z for each cooler for each day)

Laboratory Logbook

Upon receipt of each sample shipment by the laboratory, each cooler will be inspected and any problems reported to the sample coordinator or site manager. Samples will be logged and immediately placed in a refrigerator at a temperature of approximately 4°C. Only upon review and validation of the data at the end of the project will the samples be released by the project manager for return to McClellan AFB.

Following sample receipt in the laboratory, the sample custodian or laboratory personnel will clearly document the processing steps that are applied to the sample. The results of the analysis of all quality control samples will be identified specific to each batch of samples analyzed. The laboratory logbook will include the time, date, and name of the person who performed each processing step.

Decontamination Procedures

This section includes a description of equipment decontamination procedures that will be employed during the SVE treatability investigation. Decontamination procedures for field personnel are described in the site health and safety plan (HASP).

Contamination at the treatability investigation site is principally associated with volatile and semivolatile organic compounds; therefore, pressurized hot water cleaning to remove soil and contaminants will be the primary feature of the equipment decontamination process. Two levels of equipment decontamination will be implemented. The first level (Level 1) of equipment decontamination will be a general decontamination process that applies to all onsite equipment used for soil augering, soil borings, and sampling. The second level (Level 2) of equipment decontamination will be a more specific decontamination process applied to sampling equipment, tools, and utensils or other equipment that will contact soil samples. This decontamination protocol is based on information presented by EPA in *Protocol for Groundwater Evaluation*, OSWER DIR 9080.0-1.

Figure 5-9

CH2M HILL
QUALITY ANALYTICAL LABORATORIES

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M HILL Project # ☐☐☐☐☐☐☐☐.☐☐.☐☐

Purchase Order #

Project Name

Company Name/CH2M HILL Office

Project Manager & Phone #
Mr. [ ]
Ms. [ ]

Report Copy to:

Requested Completion Date:

Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal: Dispose ☐ Return ☐

OF CONTAINERS

LAB TEST CODES

ANALYSES REQUESTED

Sampling		Type		Matrix		CLIENT SAMPLE ID (9 CHARACTERS)	# OF CONTAINERS	ANALYSES REQUESTED
Date	Time	COMP	GRAB	WATER	SOIL			

SHADED AREA -- FOR LAB USE ONLY

Lab 1 #	Lab 2 #
Quote #	Kit Request #
Project #	
No. of Samples	Page ___ of ___
COC Rev	Login
LIMS Ver	Ack Gen

REMARKS	LAB 1 ID	LAB 2 ID

Sampled By & Title (Please sign and print name) Date/Time

Received By (Please sign and print name) Date/Time

Received By (Please sign and print name) Date/Time

Received By (Please sign and print name) Date/Time

Work Authorized By (Please sign and print name)

Relinquished By (Please sign and print name) Date/Time

Relinquished By (Please sign and print name) Date/Time

Relinquished By (Please sign and print name) Date/Time

Shipped Via
UPS BUS Fed-Ex Hand Other____

Shipping #

Remarks

HAZWRAP/NESSA: Y ___ N ___

QC Level: 1 2 3 Other: ___

COC Rec	ICE
Ana Req	TEMP
Cust Seal	Ph

Instructions and Agreement Provisions on Reverse Side

DISTRIBUTION: ORIGINAL - LAB, Yellow - LAB, Pink - Client

Level 1—General Equipment Decontamination

All equipment (including but not limited to drilling equipment, support and ancillary equipment, vehicles, drill rods, auger flights, sampling equipment, split spoons, and tools) will be given the following general decontamination before site entry. Also, sampling equipment (including all downhole and surface sampling gear) must be put in a plastic-lined "dirty-equipment" area for decontamination after each sampling event.

All drilling equipment, including the rig and associated equipment, will be decontaminated by the drilling subcontractor before entering and leaving the site. Drilling equipment will also be decontaminated between the drilling of each borehole.

The decontamination process will include:

- Removal of all loose dirt
- Thorough cleaning with a pressurized hot water spray

All air sampling equipment will be laboratory cleaned prior to mobilization to the field in accordance with TO-14 and TO-12 protocol. Dedicated sampling equipment will be used for each sampling location and therefore no field decontamination will be required.

Dedicated syringes will be used for most sample locations. Syringes will be purged prior to each sampling event using procedures already outlined.

Level 2—Sampling Equipment Decontamination

Sampling equipment, such as split spoons, brass liners, utensils, and other items that will contact with soil samples, will receive a second decontamination as follows:

- Scrub with Alconox and water
- Rinse with distilled water
- Rinse with methanol
- Rinse with deionized/distilled water
- Air dry

Decontamination procedures for air sampling equipment that will contact the air samples will receive a second decontamination as follows:

- Rinse with distilled water
- Rinse with methanol
- Rinse with deionized/distilled water
- Air dry

Section 6
Quality Assurance

Introduction

This section is an addendum to the basewide Quality Assurance Project Plan (QAPP) issued for the McClellan AFB in March 1992. The addendum addresses quality assurance and quality control issues related to the completion of the in situ soil vapor extraction treatability investigation at Site S in OU D, McClellan AFB.

The organization of this section parallels that of the basewide QAPP, and wherever possible and appropriate, the section references the existing basewide QAPP. Specifically, this section includes only those portions of the existing QAPP that require modification in order to complete the following Phases II and III tasks:

- The collection and offsite analysis of soil samples as part of the treatability study site characterization (Phase II) and Phase III mid-operation and post-operation sampling.
- The collection, onsite field analysis, and offsite laboratory analysis of canister and Tedlar bag samples as part of the soil gas, SVE offgas, and emissions control testing.

Quality Assurance Objectives

Quality assurance (QA) refers to the overall program for assuring that data of known quality are collected. Quality control (QC) refers to the specific routine procedures to help ensure that the quality of the measurements meet the specific QC level considered appropriate for the intended use of the data.

The general QA objectives for this project are to develop and implement procedures for obtaining and evaluating data of a known and acceptable quality so that they can be used to:

- Quantify the mass of contaminants removed during operation of the pilot-scale system.
- Evaluate the reduction of specific contaminants in the waste pit and alluvial deposits.
- Evaluate the benefits of hot air injection as an enhancement to SVE.

- Evaluate vadose zone transport processes to identify major mechanisms controlling contaminant migration and document the reasons for discounting other migration mechanisms.
- Evaluate the degree of biodegradation.
- Assess whether preferential removal of contaminants from different strata is occurring during SVE.
- Evaluate performance of the SVE offgas emission control system.
- Evaluate the applicability of SVE to OU D and collect sufficient operational data to support the detailed analysis of SVE as a remedial action alternative in the feasibility study for OU D.
- Assess general applicability of SVE at other McClellan AFB sites.

The data should be of such quality that they can be used as part of the basewide Remedial Investigation/Feasibility Study. Specific procedures to be used for sampling, chain-of-custody, calibration, laboratory analysis, reporting, internal quality control, audits, preventive maintenance, and corrective actions are described in the IRP QAPP and elsewhere in this document.

Specific QA objectives are:

1. Establish sampling and sample preparation techniques in such a manner that the analytical results are representative of the media and conditions being measured.
2. Analyze a sufficient number of laboratory duplicate samples to establish the sampling and sample preparation precision. No soil duplicate samples will be collected because of the difficulty in obtaining a representative sample in the highly heterogeneous soils of Site S.
3. Collect and analyze a sufficient number of trip blank and field blank samples to evaluate the potential for contamination from sampling equipment and techniques.
4. Analyze a sufficient number of ambient condition blank, primary, duplicate, matrix spike, matrix spike duplicate, and check samples internally within the laboratory to effectively evaluate results against numerical QA goals established for precision and accuracy.

Data quality is assessed in terms of representativeness, comparability, precision, accuracy, and completeness of the data. These are discussed in the IRP QAPP, as identified in Section 4, Item—Data Quality Objectives, of the final copy of the QAPP.

Data Quality Objectives

The data collected here will be used primarily for evaluating the SVE technology. The data quality objectives (DQOs) described herein have been developed around the data use specific to the SVE treatability investigation.

Table 6-1 presents the DQOs developed for the treatability investigation. This table correlates data use with the required degree of analytical sophistication. This approach is based on the generalized data quality objectives presented by the United States Environmental Protection Agency (EPA) in *Data Quality Objectives for Remedial Response Activities*, EPA 540/G-87/003A, March 1987. Five levels of data quality are available ranging from Level I, Field Screening, to Level V, Contract Laboratory Program (CLP) Special Analytical Services. For the treatability investigation, three analysis levels will be utilized: Level I, Field Screening; Level II, Field GC/Mobile Laboratory and Level III, Non-CLP Standard Analysis.

The number of samples, analytical methods, and the type and number of QC samples planned for the treatability investigation were presented in Section 5.

Data Usage

Table 6-2 lists the separate sampling phases of the treatability investigation and the planned data usage for each phase.

Quality Control Criteria

Specific procedures for assessing precision, accuracy, completeness, representativeness, and comparability are presented in the IRP QAPP. The actual compounds to be used in evaluating the data precision, accuracy, and representativeness will be selected from the most prevalent compounds detected with each analytical method. This selection will be made during the data validation process.

Table 6-1
Data Quality Objectives

Analytical Description	Data Usage	Soil Borings	SVE Pilot Test
Level I--Field Screening	Evaluate SVE enhancements and degree of biodegradation; monitor emission control performance	None.	O_2 and CO_2 monitoring for process control and oxygen uptake rate (biodegradation). Soil, gas, and SVE offgas manifolds and transfer piping will be monitored.
Level II--Field GC/Mobile Laboratory (speciation of indicator compounds)	Evaluate performance of SVE technology; evaluate SVE enhancements and degree of biodegradation; evaluate preferential removal of VOCs from various strata.	None.	Onsite GC analyses for VOCs performed on soil gas, SVE offgas and emissions control system.
Level III--Non-CLP Laboratory Analysis	Quantify mass of contaminants removed; evaluate reduction of specific contaminants, SVE enhancements, vadose zone transport processes, degree of biodegradation, preferential removal of contaminants from different strata, SVE offgas emission control system; assess applicability of SVE to OU D and other McClellan AFB sites.	TPH (Modified 8015), COD (MOSA 29-3.5.3), physical properties, moisture content (MOSA 21-2.2), pH (MOSA 12-2.6), microbiological assay (DNAB), and nutrients on many samples; total organic carbon (EPA 415.1) in selected post-operation borings.	VOCs (TO-14) and total nonmethane hydrocarbons (TO-12) on selected soil gas, SVE offgas, and emissions control samples; HCl (Method 26) and dioxins (Method 23) analyses on selected emissions control samples.
Level IV--CLP Routine Analytical Services	None.	None.	None.
Level V--CLP Special Analytical Services	None.	None.	None.

Table 6-2
Sampling Program Data Usage

Page 1 of 2

Sampling Phase	Approximate Number of Samples	Planned Data Usage
1. Soil Borings (Phases II and III)	Split-spoon samples will be collected at various depths in six borings during Phase II, four borings during Phase III mid-operation (MO) and six borings during Phase III post-operation (PO). Phase II borings sampled will be PSP-2, PSP-4, PSP-7, PSD-3, PSD-2, and PSD-5 (3 pit, 3 deep). These six and nine other Phase II borings will be converted to SVE extraction wells. Phase III MO borings will be intermediate depth (SBI-1, SBI-2, SBI-3, SBI-4). Phase III PO borings will be SBP-1, SBP-2, SBI-5, SBI-6, SBD-1, SBD-2 (2 pit, 2 intermediate, 2 deep). Samples will be collected and submitted for analysis according to the plan set forth in Section 5. A minimum of approximately 70 samples will be submitted for analysis for physical properties, TPH (SW8015M), total organic carbon (EPA 415.1), microbiological assay (DNAB), COD (MOSA) 29-3.5.3), moisture content (MOSA 21-2.2), pH (MOSA 12-2.6), ammonia nitrogen (MOSA 33-3.2, EPA 350.3), nitrate nitrogen (MOSA 33-3.2, EPA 300.0), and orthophosphate-phosphorus (MOSA 24-5.3, EPA 300.0).	Physical property data will be used to evaluate specific contaminant reduction in the pit versus alluvium and preferential removal of contaminants from various strata, provide data for the vadose zone transport process evaluation, and assess the applicability for use of SVE at other OU D and McClellan AFB sites. TPH data will be used to evaluate reduction of contaminants in the waste pit and alluvial deposits; evaluate SVE enhancements and degree of biodegradation; evaluate preferential removal of contaminants from different strata; and assess applicability of SVE at other OU D and McClellan AFB sites. TPH data will also be used to evaluate vadose zone transport processes. COD, moisture, pH, nutrients, and microbiological data will be used to assess SVE enhancements and the degree of biodegradation. TOC data will be used in conjunction with the vadose zone transport process assessment.

Table 6-2
Sampling Program Data Usage

Page 2 of 2

Sampling Phase	Approximate Number of Samples	Planned Data Usage
2. SVE Pilot Test (Phase III) Soil Gas, SVE Offgas, Emissions Control	Soil gas samples will be collected from each of the 14 piezometers installed at Site S. SVE offgas samples will be collected at the extraction wells, extraction well manifolds (waste pit, intermediate zone, and deep zone piping), and the transfer piping. Emission control samples will be collected at the incinerator stack. For soil gas sampling, approximately 300 Level II or III analyses will be conducted throughout the SVE investigation. Samples will be analyzed for VOCs (onsite GC and TO-14), and total nonmethane hydrocarbons (TO-12). Oxygen uptake will be monitored and will require approximately 100 oxygen and carbon dioxide samples (Level I). Eight piezometers will be monitored once for methane (Level I). For SVE offgas-extraction well sampling, approximately 400 Level II or III analyses will be conducted throughout the pilot investigation. Samples will be analyzed for VOCs (onsite GC and TO-14) and total nonmethane hydrocarbons (TO-12). For SVE offgas-extraction well manifold sampling, approximately 140 Level II or III analyses will be performed throughout the pilot investigation. For SVE offgas-transfer piping, approximately 40 analyses will be conducted throughout the pilot investigation. Samples will be analyzed for VOCs (onsite GC and TO-14) and total nonmethane hydrocarbons (TO-12). Carbon dioxide and oxygen concentrations will be recorded approximately 70 times. For emission control sampling, approximately 50 Level II or III analyses will be conducted. Samples will be analyzed for VOCs (onsite GC, TO-14), total nonmethane hydrocarbons (TO-12), HCl (Method 26), and dioxins (Method 23).	Canister samples will be analyzed for VOCs (TO-14) as a means of confirming the accuracy of GC samples. Total nonmethane hydrocarbons analyses (TO-12) will be used in parallel with VOC analyses and may be collected in a canister or Tedlar bag. Onsite GC data for VOCs will be used as the primary means of assessing SVE performance. Oxygen uptake rates will be used to assess biodegradation potential and the impact of SVE enhancements on biodegradation. CO_2 and O_2 readings from the SVE offgas-transfer piping will aid in process control and help confirm biodegradation. VOCs, total nonmethane hydrocarbons, hydrochloric acid, and dioxin analyses will be conducted on the emissions control system stack to ensure compliance with discharge standards. Analyses for VOCs (TO-14) may be performed using a reduced target analyte list after the first several months of sampling since analytes characteristic of Site S will have been identified. Periodic full scan TO-14 analyses will be performed to provide confirmation of contaminants identified using onsite GC analysis.

Sample Containers, Preservation, and Holding Time Requirements

Tables 6-3 and 6-4 present the sample containers, preservation, and holding time requirements for soil and gas samples.

Table 6-3
Container, Preservative, and Holding Time Requirements
Soil Samples

Parameter	Container	Preservative	Holding Time
Total Petroleum Hydrocarbons (Modified Method 8015)	a	Cool 4°C	28 days
Chemical Oxygen Demand (MOSA 29-3.5.3)	a	Cool 4°C	28 days
Total Organic Carbon (Method 415.1)	a	Cool 4°C	28 days
Microbiological Assay (DNAB)	a	Cool 4°C	30 hours
Physical Properties	a	Cool 4°C	NA
Moisture Content (MOSA 21-2.2)	a	Cool 4°C	NA
pH (MOSA 12-2.6)	a	Cool 4°C	NA
Ammonia Nitrogen (MOSA 33-3.2, EPA 350.3)	a	H_2SO_4, pH<2 Cool 4°C	28 days
Nitrate Nitrogen (MOSA 33-3.2, EPA 300.0)	a	Cool 4°C	NA
Ortho-phosphorus (MOSA 24-5.3, EPA 300.0)	a	Cool 4°C	NA

[a] All soil samples will be collected in 6-inch-long x 2-inch-diameter brass sleeves.

Table 6-4
Method of Collection and Holding Time Requirement
Gas Samples[a]

Parameter	Method of Collection	Holding Time
Volatile Organic Compounds (Onsite GC)	Hamilton Gastight Syringes, 500 µl	24 hours
Volatile Organic Compounds (Method TO-14)	Canister	14 days
Total Hydrocarbons (Method TO-12)	Canister Tedlar bag	14 days 72 hours
Hydrochloric Acid (Method 26)	Impinger	28 days
Dioxins (Method 23)	XAD-Resin	30 days until extraction 45 days after extraction

[a] No sample preservation required.

Method Detection Limits

Volatile Organic Compounds (TO-14)

The target compound list for full scan GC/MS volatile TO-14 analyses is presented in Table 6-5. The listed compounds have a method detection limit (MDL) of approximately 1 part per billion volume (ppbv) basis with the exception of acetone at approximately 10 ppbv.

Following the startup period of SVE operation, the target analyte list for a matrix may be reduced to include only those analytes determined to be characteristic of that matrix. Periodically, but no less frequent than once every 2 weeks, a full scan TO-14 analysis will be performed for each matrix. This will ensure the target analytes selected to be included on the reduced analyte list remain those characteristic of the matrix.

Total Nonmethane Hydrocarbons (TO-12)

The MDL for total nonmethane hydrocarbons is approximately 500 ppbv carbon.

Volatile Organic Compounds (Onsite GC)

The onsite GC is calibrated to detected 17 targeted VOCs. MDLs for each VOC are shown in Table 6-6.

Table 6-5
TO-14 Target Analyte List
(Full Scan GC/MS)

Analyte	Common Name	Analyte	Common Name
Benzene		cis-1,3-Dichloropropene	
Bromomethane	Methyl Bromide	1,2-Dibromoethane	
Trichloromethane	Chloroform	1,2-Dichlorobenzene	
Chloromethane	Methyl Chloride	1,3-Dichlorobenzene	
cis-1,2-Dichloroethylene		1,4-Dichlorobenzene	
1,1-Dichloroethane		Ethylbenzene	
1,2-Dichloroethane		Hexachloro-1,3-butadiene	
1,1-Dichloroethylene	1,1,1-DCE	Styrene	Vinyl Benzene
1,2-Dichloropropane		1,1,2,2-Tetrachloroethane	
Chloroethane	Ethyl Chloride	Tetrachloroethylene	
Trichlorofluoromethane	Freon 11	trans-1,3-Dichloropropene	
Trichlorotrifluoroethane	Freon 113	1,1,1-Trichloroethane	1,1,1-TCA
1,2-Dichloro-1,1,2,2-tetrafluoroethane	Freon 114	Trichloroethylene	
Dichlorodifluoromethane	Freon 12	1,2,4-Trichlorobenzene	
Dichloromethane	Methylene Chloride	1,2,4-Trimethylbenzene	
Methylbenzene	Toluene	1,3,5-Trimethylbenzene	
1,1,2-Trichloroethane		1,3-Dimethylbenzene	m-Xylene
Chloroethylene	Vinyl Chloride	1,2-Dimethylbenzene	o-Xylene
Tetrachloromethane	Carbon Tetrachloride	1,4-Dimethylbenzene	p-Xylene
Chlorobenzene	Phenyl Chloride	Acetone	
a-Chloromethylbenzene	Benzyl Chloride		

Table 6-6 VOCs (Onsite GC) Target Analyte List	
Compound	**Detection Limit (ppbv)**
Freon 12	10
Vinyl Chloride	10
1,1-Dichoroethene	10
Freon 113	10
1,1-Dichloroethane	10
Methylene Chloride	10
cis-1,2-Dichloroethene	10
1,1,1-Trichloroethane	10
Benzene	50
Trichloroethene	10
Toluene	50
m,p-Xylene	50
o-Xylene	50
Ethylbenzene	50
Chlorobenzene	10
1,2,4-Trimethylbenzene	50
1,2-Dichlorobenzene	10

Sample Custody

Sample custody procedures to be implemented during the SVE treatability investigation at Site S, OU D are presented and described in Section 5 and the IRP QAPP (March 1992).

Calibration Procedures and Frequency

The calibration procedures to be used for field and laboratory equipment during the SVE treatability investigation at Site S, OU D are presented in the IRP QAPP (March 1992). All analytical instruments are to be calibrated according to manufacturers' recommendations and method requirements. Laboratory calibration procedures and frequencies are included in analytical standard operating procedures (SOPS) for analytical levels prescribed for this project.

Analytical Procedures

The majority of analytical methodology and calibration procedures that will be used to analyze samples generated during the SVE treatability investigation project are described in the IRP QAPP (March 1992). Methods that are not included in the IRP QAPP are described briefly below. Methods described below include determination of Volatile Organic Compounds (VOCs) from canister air sampling (EPA TO-14), determination of total nonmethane hydrocarbons from canister air sampling (EPA TO-12), determination of total nonmethane hydrocarbons from Tedlar bag gas sampling (EPA TO-12), onsite soil gas analysis of VOCs from syringe sampling (Radian), gas analysis of oxygen (Standard Methods 2720C), measurement of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (Method 23), and hydrogen chloride from stationary sources (Method 26), organic total carbon (EPA 415.1), chemical oxygen demand (MOSA), and microbiological assay (DNAB).

The laboratory methods or SOPs identified here and in the IRP QAPP were published in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846*, EPA, Third Edition, revised November 1986; *Methods for Analysis of Water and Wastes*, EPA-600/4-79-020, 1979; Title 22, Article 11 of the California Administrative Code, "Criteria for Identification of Hazardous and Extremely Hazardous Wastes;" *Compendium of Methods for the Determination of Toxic Compounds in Ambient Air*, EPA-600/4-84-041, April 1984, 40 CFR Part 60, Appendix A, Methods 23 and 26, February 13, 1991; Methods of Soil Analysis, Part 2—Chemical and Microbiological Properties, Second Edition, 1982; and Standard Operating Procedures for Determining Total Hyphal Length, Numbers of Active Bacteria and Length of Active Fungi, Elaine R. Ingham, Oregon State University, March 19, 1992.

TO-14—Determination of VOCs and TPH Using Summa Passivated Canisters and GC Analysis

Upon arrival at the contracted laboratory, the canister sample information is recorded from the Chain Of Custody form and logged into the laboratory sample tracking system. To analyze a canister sample, the container is pressurized to a known pressure and the pressure recorded. This pressure value is again used to calculate the final sample concentration after analysis.

The pressurized canister is then attached to the analytical instrument. The instrument extracts a known volume of air from the canister to be analyzed. The air is then passed through a drier to remove entrained moisture and concentrated by collection in a cryogenically cooled trap. The trap temperature is then raised and the collected compounds are volatilized back into the gas phase and directed to a high resolution gas chromatographic analytical instrument. The individual species are separated on the GC column, identified and quantified using a mass spectrometer (MS-specific detector) operated in the full scan mode.

For the purposes of this study, the standard list of TO-14 compounds plus acetone and MIBK will be evaluated. The GC/MS scan mode evaluations will be reported in their entirety, including any nontarget list compounds detected and up to 10 TICs.

TO-12—Determination of Total Nonmethane Hydrocarbons Using Summa Passivated Canister and GC Analysis

Upon arrival at the contracted laboratory,the canister sample information is recorded from the Chain-of-Custody form and logged into the laboratory sample tracking system. To analyze a canister sample, the container is pressurized to a known pressure and the pressure recorded. This pressure value is again used to calculate the final sample concentration after analysis.

The pressurized canister is attached to the analytical instrument. The instrument extracts a known volume of air from the canister to be analyzed. The analytes are then concentrated by collection in a cryogenically cooled trap. The trap temperature is then raised and the trap is purged with a helium carrier gas, the flow is directed to the flame ionization detector (FID) where total nonmethane hydrocarbons are measured.

The instrument calibration is based on ppbv carbon. The standard is prepared using propane in ultrapure air.

TO-12—Determination of Total Nonmethane Hydrocarbons Using Tedlar Bag and GC Analysis

Upon arrival at the contracted laboratory, the canister sample information is recorded from the Chain-of-Custody form and logged into the laboratory sample tracking system. To analyze a Tedlar bag sample, the container is attached to the analytical instrument and a known volume of air extracted from the bag. The analytes are then concentrated by collection in a cryogenically cooled trap. The trap temperature is then raised and the trap is purged with a helium carrier gas, the flow is directed to the flame ionization detector (FID) where total nonmethane hydrocarbons are measured.

The instrument calibration is based on ppbv carbon. The standard is prepared using propane in ultrapure air.

Onsite GC—Target Volatile Organic Compounds Radian Corporation Standard Operating Procedure

Upon arrival at the onsite laboratory, the syringe sample information is recorded from the Chain-of-Custody and logged into the sample tracking system. To analyze a syringe sample, a known volume aliquot is taken from the syringe and injected into the GC.

The instrument is calibrated using the 17 targeted VOCs. Gas standards are prepared using Scott specialty gases. Targeted VOCs are identified based on retention time and data from the standard calibrations. Detectors for each VOC are shown on Table 6-7.

Table 6-7
VOCs (Onsite GC) Instrument Detectors

Compound	Detector
Freon 12	ELCD
Vinyl Chloride	ELCD/PID
1,1-Dichoroethene	PID
Freon 113	ELCD
1,1-Dichloroethane	ELCD
Methylene Chloride	ELCD
cis-1,2-Dichloroethene	ELCD
1,1,1-Trichloroethane	ELCD
Benzene	PID
Trichloroethene	ELCD
Toluene	PID
m,p-Xylene	PID
o-Xylene	PID
Ethylbenzene	PID
Chlorobenzene	PID
1,2,4-Trimethylbenzene	PID
1,2-Dichlorobenzene	ELCD

Method 23—Measurement of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (40 CFR Part 60)

A sample is withdrawn isokinetically and collected in the sample probe, on a glass fiber filter, and on a packed column of adsorbent material. The PCDDs and PCDFs are extracted from the particulate matter and adsorbent material with a hot organic solvent. The extracted PCDDs and PCDFs are separated by capillary gas chromatography, and then, each isomer is identified and measured with mass spectrometry (GC/MS). The dioxin/furan practical quantitation limit (PQL) range for liquids (based on the hot organic solvent) is 0.008 to 0.050 ppt.

Refer to Appendix I for further discussion of sampling apparatus and analytical procedures required for Method 23.

Method 26—Determination of Hydrogen Chloride Emissions (40 CFR Part 60)

A sample is withdrawn at a constant rate from the source through a probe and impingers filled with dilute sulfuric acid. In the dilute acid, the HCl gas is dissolved and forms chloride ions. The chloride ion is separated by ion chromatography and measured by a conductivity meter.

Refer to Appendix H for a thorough discussion of sampling apparatus and analytical procedures required for Method 26.

Physical Properties

Each soil sample will be subjected to the same series of physical tests, which includes horizontal and vertical air permeability; total porosity; bulk density; bulk volume; grain density; sieve analysis; total percent saturation; percent saturation by water; and percent saturation by hydrocarbons. Table 6-8 describes the parameters and methods to be used in conducting the physical tests.

Table 6-8
Soil Parameters and Test Methods

Parameter	Test Method
Permeability	API RP 40
Sieve Analysis	Sieve Analysis--Wet/Dry Method to Particle Size >10 μ
Total Porosity	Archimedes' Method, API RP 40
Bulk Density	Archimedes' Method, API RP 40
Bulk Volume	Archimedes' Method, API RP 40
Grain Density	Archimedes' Method, API RP 40
Total % Saturation	Dean-Stark Extraction, API RP 40
Water % Saturation	Dean-Stark Extraction, API RP 40
Contaminant % Saturation	Dean-Stark Extraction, API RP 40

EPA 415.1—Total Organic Carbon (TOC)

Determination of TOC by EPA 415.1 involves converting the organics to carbon dioxide (CO_2) by catalytic combustion or wet chemical oxidation. The CO_2 formed can be measured directly by an infrared detector or converted to methane (CH_4) and measured by a flame ionization detector. The amount of CO_2 or CH_4 is directly proportional to the concentration of carbonaceous material in the sample.

Modified Method 8015—Total Petroleum Hydrocarbons (TPH) Extractables by GC-FID

A 30-gram, or other appropriate aliquot of soil, is mixed with 30 grams of washed sodium sulfate. 100 mls of 2+1 methylene chloride/acetone is added to the soil and placed on a mechanical shaker for 1 hour. The solvent is decanted off and the process is repeated with an additional 50 ml of methylene chloride/acetone. The combined solvent extracts are filtered through sodium sulfate and the extract is concentrated to a 3 ml final volume.

An appropriate volume of the sample extract is injected into a gas chromatograph equipped with a flame ionization detector (FID), a split/splitless capillary injector (operated in the splitless mode), and a fused silica capillary column. The TPH fraction is quantitated as No. 2 diesel fuel (and/or different petroleum hydrocarbon fuel types if requested, such as JP-4 jet fuel) based on relative retention times and examination of the elution profile. The TPH fraction quantitation is based on chromatographic peak areas against a multipoint standard curve.

MOSA 29-3.5.3—Chemical Oxygen Demand

Determination of chemical oxygen demand (COD) involves adding a known amount of water to a soil sample to make a slurry. A volume of acid equal to the volume of water is added to the slurry. Dichromate is added to the soil slurry and a heated digestion is performed. This digestate is back titrated to determine the amount of dichromate that was reduced. This method is modified with respect to calculating oxygen demand per gram of soil instead of measuring organic carbon per gram of soil.

Refer to Appendix D for a thorough discussion of apparatus and analytical procedures required for this method.

DNAB—Standard Operating Procedure for Determining Total Hyphal Length, Numbers of Active Bacteria, and Length of Active Fungi

This procedure determines the number of metabolically active bacteria in soil samples and calculates the biomass of these organisms. At the lab, the microbiological samples will be collected first and stored separate from the samples for physical/chemical analysis. To obtain these samples, the core will be partially extruded from the liner, and, using aseptic technique, all exterior surfaces will be pared off (using a flame sterilized metal spatula) and discarded. Then an aliquot of the remaining soil will be aseptically transferred to an autoclaved glass jar and stored under refrigeration until analyzed. A known aliquot of soil is stained with fluorescein diacetate and an aliquot of agar-soil suspension is placed on a slide. Using epi-fluorescent oil-immersion microscopy, numbers and size of fluorescent bacteria are determined.

Refer to Appendix C for a thorough discussion of apparatus and analytical procedures required for this method.

MOSA 21-2.2—Moisture Content

Water content measurements by gravimetric methods involve weighing the wet sample, removing the water, and reweighing the sample to determine the amount of water removed. Water content then is obtained by dividing the difference between wet and dry masses by the mass of the dry sample to obtain the ratio of the mass of water to the mass of the dry soil. When multiplied by 100, this becomes the percentage of water in the sample on a dry-mass (or, as often expressed, on a dry-weight) basis.

Refer to Appendix J for a thorough discussion of apparatus and analytical procedures required for this method.

MOSA 12-2.6—Soil pH

Practically all laboratories use the glass (indicating) electrode paired with a calomel ($Hg-Hg_2\ Cl$) (reference) electrode for measuring soil pH. The electrodes are normally plugged into a regular commercial pH meter. Upon proper standardization with buffers of known pH, the meter indicates the pH of the soil suspension from the millivolts of potential generated when the two electrodes are placed in the soil suspension.

Refer to Appendix K for a thorough discussion of apparatus and analytical procedures required for this method.

MOSA 33-3.2—Extraction of Exchangeable Ammonium

Performance of this extraction method is necessary to convert nitrogen in soil to an aqueous phase. To perform the test, place 10 g of soil in a 250-ml, widemouth bottle, and add 100 ml of 2M KCl. Stopper the bottle, and shake it on a mechanical shaker for 1 hour. Allow the soil-KCl suspension to settle until the supernatant liquid is clear (usually about 30 minutes), and perform the analyses described on aliquots of this liquid.

Refer to Appendix L for a more thorough discussion of apparatus and analytical procedures required for this method.

MOSA 24-5.3--Phosphorus Soluble in Water (Extraction)

This is a method to extract phosphorus in soil to an aqueous phase. To perform the test, add 5 g of air-dry soil and 50 ml of distilled water to a flask suitable for continuous shaking. Shake the contents of the flask continuously for 5 minutes. Centrifuge the mixture until the solution is free of soil mineral particles. This usually occurs in 15 minutes in a high-speed Sorvall centrifuge at a setting of 100. Obtain clear extracts alternatively by repeated filtration through Whatman No. 42 filter paper. Return to the suspension the first portions coming through the filter paper.

Refer to Appendix M for a thorough discussion of apparatus and analytical procedures required for this method.

EPA Method 350.3—Ammonia Nitrogen

The ammonia is determined potentiometrically using an ion selective ammonia electrode and a pH meter having an expanded millivolt scale or a specific ion meter. The ammonia electrode uses a hydrophobic gas-permeable membrane to separate the sample solution from an ammonium chloride internal solution. Ammonia in the sample diffuses through the membrane and alters the pH of the internal solution, which is sensed by a pH electrode. The constant level of chloride in the internal solution is sensed by a chloride selective ion electrode, which acts as the reference electrode.

Refer to Appendix R for a thorough discussion of apparatus and analytical procedures required for this method.

EPA Method 300.0—Determination of Inorganic Anions in Water by Ion Chromatography (Nitrate Nitrogen and Orthophosphate-Phosphorus)

A small volume of sample, typically 2 to 3 ml, is introduced into an ion chromatograph. The anions of interest, nitrate nitrogen and orthophosphate, are separated and measured, using a system comprised of a guard column, separator column, suppressor column, and conductivity detector.

Refer to Appendix O for a thorough discussion of apparatus and analytical procedures required for this method.

Data Reduction, Validation, and Reporting

In a project such as the SVE Treatability Investigation, information flow from the field and laboratory to those persons involved in project decision making is critical. A data management system assists in this process by providing a means of tracking, cataloging, and organizing information. Such a system includes hardware and software for data handling (the data base), data management protocols such as chain-of-custody and QA/QC validation, and trained personnel to keep the system updated and operational. The primary objective of a data management system is to provide the user with data sets that have been verified and are internally consistent. These data can then be used for data analysis, statistics, plotting, etc.

There are two groups of data user's for this project: the Air Force personnel responsible for the Installation Restoration Program Information Management System (IRPIMS) and the CH2M HILL project team. IRPIMS requires that certain data be made available to the Air Force in a format compatible with their data base, while the project team requires that a subset of the IRPIMS data (namely sample and analysis information) be available in a system that can support data queries, reports, and graphics.

To satisfy the data needs of both sets of users, an Environmental Data Base (EDB) will be used for this project. The EDB will be used to prepare ASCII files in the correct format for the Air Force data base. The data delivery schedule and valid values lists in the IRPIMS Data Loading Handbook (Version 2.2) will be followed. The EDB can be restructured to meet the data needs for the demonstration project. This same set base will then be used by the CH2M HILL project team to support data analysis activities.

Reduction

Data reduction will be performed to determine the representativeness of the data and to validate laboratory quality control. The information generated by the data reduction step will be used in the interpretation of the data.

Validation

Data validation involves a review of the laboratory-provided QC data and the raw data in order to identify any qualitative, unreliable, or invalid laboratory measurements. As a result, it will be possible to determine which samples, if any, are related to out-of-control laboratory QC samples. Laboratory data will be screened for inclusion of and frequency of the necessary QC supporting information such as detection limit verification, initial calibration, continuing calibration, duplicates, spikes, and reagent blanks. QC supporting information will be screened to determine whether any data is outside established control limits, and if out-of-control data is discovered, appropriate corrective action will be determined based upon QC criteria for precision, accuracy, and completeness in the IRP QAPP. Any out-of-control data without appropriate corrective action will be cause to qualify the affected measurement data.

Levels of data validation for the Phase II SVE project are defined below.

- Level I. For a Level I data validation, sample and method blanks results are provided by the laboratory. Laboratory contamination can be determined from this information.

- Level II. For a Level II data validation, the laboratory provides CLP Forms 1 through 10 for organics analyses. QA/QC parameters that have been selected for the project can be evaluated using these summary forms.
- Level III. For a Level III data validation, a CLP or CLP-like data package is provided by the laboratory. Sample results are evaluated according to the EPA Functional Guidelines for Organics and Inorganics analyses for selected QA/QC parameters. Ten percent of the analytical raw data results are also reviewed to verify sample identity, instrument calibration, detection limits, numerical computation, accuracy of transcriptions, and calculations.

Data validation Levels II and III have been selected to evaluate the analytical data for this project.

The following special reporting requirements will be incorporated into the Phase II SVE project:

- All Level II analyses will have CLP QA/QC summary forms provided by the laboratory.
- All Level III analyses will have a CLP-like data package provided by the laboratory.
- All soil analyses will be reported by the analytical laboratory on a "dry weight" basis.
- All sample results with concentrations between the instrument detection limit and the method detection limit will be reported. These analytical results will be qualified as estimates and flagged with a "J".

Reporting

Data and information generated during the SVE Demonstration Project will be summarized in a site characterization technical memorandum submitted to the McClellan AFB project manager. The information to be included in the memorandum is identified in the Demonstration Project work plan.

Internal Quality Control

The analysis of internal QC samples helps to monitor and document the performance of sampling and analysis activities. The documentation of QC provides a means for establishing the quality of data produced by the project. Both field-generated and laboratory QC samples will be utilized during the SVE Demonstration Project.

The frequency of QC sample collection and data acceptance criteria are project-specific. Field-generated QC samples that are planned as part of the SVE Demonstration Project at Site S, OU D are described in Section 5.

A description of the laboratory QC samples to be analyzed and additional information on the field-generated QC sample are provided in the IRP QAPP (March 1992). The analytical method SOPs also contain information regarding the frequency and acceptance of QC samples.

Table 6-9 presents the quality control acceptance criteria for EPA Method TO-14 (VOCs), EPA Method TO-12 (total nonmethane hydrocarbons), EPA Method 350.3 (ammonia nitrogen), and MOSA 24-5.3 (soluble phosphorus).

Performance and System Audits

Performance and system audits are independent assessments of sample collection and analysis procedures. Audit results can be used to evaluate a project's ability to meet data quality objectives, satisfy quality control criteria, and identify areas requiring corrective action.

CH2M HILL laboratory personnel regularly undergo standard procedural audits in order to ensure understanding and compliance of specified operating protocol. The audits include checks of proper documentation, chain-of-custody procedures, and QA/QC procedures.

The onsite laboratory will be required to satisfactorily analyze an audit sample prior to project startup. Both laboratories will be required to analyze audit samples at a frequency specified in Section 5. A site visit is planned during the operations of the onsite laboratory.

Preventive Maintenance

Preventive maintenance procedures help to maintain project and laboratory schedules through equipment readiness. Maintenance will be performed on all field and laboratory equipment according to the directions and frequency identified by the instrument manufacturers. Dated and signed instrument logbooks describing and documenting scheduled inspections, routine maintenance, and major repairs will be maintained for all instruments.

Maintenance responsibilities for laboratory instruments are assigned to the respective laboratory managers. Maintenance of field equipment is the responsibility of the project manager and the field team leader. The field team is responsible for checking the equipment prior to use and reporting any problems to the field task leader.

Table 6-9
Quality Control Acceptance Criteria

Analytical Method	Quality Control Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Applicable Parameter
EPA Method TO-14	Check of mass spectral ion intensities using PFTBA[a].	Initially, prior to calibration, again prior to initial calibration verification sample analysis.	The relative abundance should show 69 as the base peak. Relative to that peak mass 219 should be at least 35 percent and mass 502 should be at least 1 percent.	1. Retune instrument. 2. Repeat PFTBA analysis.	Volatile Organic Compounds
	Five-point internal standard calibration (for all analytes).	Initial calibration prior to sample analysis.	1. SPCCs[b] average RF $\geq$ 0.30. 2. RSD < 30 percent for CCC[c] RFs.	1. Repeat after corrective action if either criterion is not met.	
	Demonstrate ability to generate acceptable accuracy and precision using four replicate analyses of a QC check sample.	Once per analyst.	Analyte-specific limits as per EPA Method TO-14.	1. Recalculate results. 2. Locate and fix the source of the problem. 3. Rerun demonstration for those analytes, which did not meet criteria.	
	Mid-level second source laboratory control sample (LCS).	5 percent	Response for any analyte within laboratory established limits.	1. Reinject primary stock standard. 2. Repeat LCS.	
	Ongoing calibration check.	10 percent sample frequency	±30 percent	1. Repeat test only for analytes that failed to meet criteria. 2. After repeated failures, locate and correct source of problem—document actions taken. 3. Repeat test for all compounds of interest.	
	Reagent blank	10 percent	No analytes detected > 3 times the detection limits.	1. Source of contamination investigated. 2. Appropriate corrective action taken and documented. 3. Repeat initial blank analysis. 4. Sample results associated with reagent blank contamination at $\leq$ 3 times the detection limit are to be flagged.	

Table 6-9
Quality Control Acceptance Criteria

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Analytical Method	Quality Control Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Applicable Parameter
EPA Method TO-14	Surrogate standard spike	Every sample, spike, standard, and reagent blank	60 to 140 percent recovery	1. Recalculate result, if still out. 2. Determine if calibration standards bracketing sample met QC acceptance criteria, if out. 3. Reanalyze sample, if still out. 4. Flag result and document that Steps 1 to 3 were performed.	Volatile organic compounds
	Laboratory duplicate	5 percent or one per analytical batch, whichever is more frequent.	±30 relative percent difference (RPD)	1. Recalculate result, if still out. 2. Determine if calibration standards bracketing sample met QC acceptance criteria, if out. 3. Reanalyze sample, if still out. 4. Flag result and document that Step 1 to 3 were performed.	
EPA Method TO-12	Five-point calibration	Initial calibration prior to sample analysis.	1. RSD < 20 percent for RFs or R ≥0.995. 2. For quantitation, use calibration curve.	Repeat after corrective action.	Total nonmethane hydrocarbons
	Calibration factor verification check sample.	Daily, before sample analysis.	Response for any analyte within ±30 percent of predicted response.	1. Reanalyze standard to verify result. 2. Prepare new calibration curve. 3. Reinject any samples analyzed after criteria were exceeded.	
	Reagent blank	One per day	No total nonmethane organic compounds at >20 ppb carbon.	1. Source of contamination investigated. 2. Appropriate corrective action taken and documented. 3. Repeat initial daily blank analysis. 4. Sample results associated with reagent blank contamination at ≤ 3 times the detection limit are to be flagged.	

Table 6-9
Quality Control Acceptance Criteria

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Analytical Method	Quality Control Check	Minimum Frequency	Acceptance Criteria	Corrective Action	Applicable Parameter
EPA Method TO-12	Laboratory duplicates	5 percent or one per analytical batch, whichever is more frequent.	±30 RPD	1. Flag data and report results.	Total nonmethane hydrocarbons
EPA Method 350.3 MOSA-24-5.3	Multipoint calibration curve (one blank and five standards).	Prior to sample analysis.	R ≥ 0.995	Repeat calibration	Ammonia Soluble Phosphorus
	Initial calibration verification check sample.	Daily, prior to sample analysis.	±10 percent	1. Repeat after corrective action.	
	Continuing calibration check sample.	10 percent sample frequency	±10 percent	1. Repeat test, if still out. 2. Locate and correct source of problem—document corrective action. 3. Prepare fresh standard and reanalyze.	
	Mid-level second source laboratory control sample (LCS).	Daily	Laboratory established limits.	Prepare fresh primary calibration standard stock.	
	Matrix spike and laboratory duplicate.	5 percent or one per analytical batch, whichever is more frequent.	80 to 120 percent recovery ±20 RPD	Accuracy—flag data Precision—flag data	
	Reagent blank	One per day or one per analytical batch, whichever is more frequent.	Concentration level should be less than detection limit.	1. Clean instrument/equipment. 2. Sample results associated with reagent blank contamination at ≤ 3 times the detection limit will be flagged.	

[a] Perfluorotributylomine (PFTBA).
[b] System performance check compounds (SPCC).
[c] Calibration check compounds (CCC).

Data Assessment Procedures

The assessment of data quality is necessary to ensure that the QA objectives for the sampling and analysis program are being met. The data assessment procedures for the SVE Demonstration Project will include field procedures and laboratory procedures. They are discussed separately below.

Field Procedures

Since field analyses generally do not involve samples that are retained for reanalysis, the primary QA/QC objective is to obtain reproducible measurements with a degree of precision consistent with the limits of the field instrument.

Quality control procedures for field instruments will be limited to verifying that the reproducibility of measurements are within 10 percent by taking multiple readings and periodically conducting instrument calibration checks (a minimum of twice daily). All field data sheets and notebooks used for calculating results and documenting calibration will be retained.

Laboratory Procedures

Data quality assessment for the analytical laboratory will be based on data precision, accuracy, and completeness. The calculation and application of these parameters is presented in the IRP QAPP (March 1992).

Corrective Action

Corrective action procedures are required as the result of audited or self-identified nonconformance with predetermined QA/QC criteria or procedures established for this project. In the event that quality assurance is not met, action will be taken to correct the problem. Corrective action for laboratory problems (e.g., instrument operating ranges or calibrations) is the responsibility of the laboratory, including the lead analyst and the laboratory manager. Any corrective actions taken during the course of the SVE treatability investigation will be documented.

- In the case that TO-14 analyses do not confirm the onsite GC results, a sampling technique investigation will be conducted. This assumes that both laboratories are satisfactorily analyzing their audit samples and both laboratories are following specified QA/QC procedures. The sampling technique investigation will involve collecting new canisters and pulling samples from the same canister for both laboratories to analyze. The results of this investigation will be compared to evaluate proper sampling techniques.

  Method TO-14 will also be used to identify and confirm interferences that the onsite laboratory may encounter.

- In the case that dioxins are detected in the SVE pilot plant emissions, preparations will be made to shut the SVE pilot plant down and additional engineering controls will be implemented. One possible means to control dioxins is the installation of a dry lime scrubber.

Quality Assurance Reports

No separate QA reports for this project are anticipated. The technical memoranda that present the findings of the site characterization and pilot test phases of the work will contain separate QA sections that summarize data quality information collected during the project.

Section 7
Data Management

Information flow from the field and laboratory to those persons involved in project decisionmaking is critical. The data management system will assist in this process by providing a means of tracking, cataloging, and organizing information. The system will include hardware and software for data handling (the data base), data management protocols such as chain-of-custody and QA/QC validation, and trained personnel to keep the system updated and operational. The objective of a data management system is to provide the user with data sets that have been verified and are internally consistent. These data can then be used for data analysis, statistics plotting, etc. An environmental data base using a Paradox-based system will be used for this project.

There are two groups of data users for the Phase II SVE project: the Air Force personnel responsible for the Installation Restoration Program Information Management System (IRPIMS) and the CH2M HILL project team. IRPIMS requires that certain data be made available to the Air Force in a format compatible with their data base. The project team requires a different manipulation of the data for queries, reports, and graphics. The environmental data base will satisfy the data needs of both sets of users.

An environmental data base will be used to prepare ASCII files in the correct format for the Air Force data base. The data delivery schedule and valid values lists in the *IRPIMS Data Loading Handbook* (Version 2.2 or future updates) will be followed. Once these files are prepared, they can be expanded to be used for environmental investigations and to support data analysis activities.

The data management effort will be comprised of seven tasks:

- Preparation of the data management plan that defines data management requirements and identifies the systems and procedures that will satisfy these requirements.
- Loading and set up of the environmental data base with IRPIMS table structures on a computer.
- Preparation of transfer programs to transfer electronic data into the appropriate tables.
- Entry of field data into the environmental data base, including quality control of the entries.
- Entry of laboratory data into the environmental data base, including quality control of the entries.

- Updates of the environmental data base to reflect appropriate data qualifiers.
- Coding and entering all project documents into the environmental data base.

Three groups and types of project data are required for the IRPIMS submittal. Group 1 includes general site and sampling location information. Group 2 includes specific sample collection information such as sample type, location, lithology, classification, etc. Group 3 includes the results of analytical testing.

Section 8
Health and Safety

The health and safety program for CH2M HILL personnel working at McClellan Air Force Base (McClellan AFB) consists of a base site safety plan (SSP) and task-specific amendments. The base SSP contains general information that applies to all or most areas of the site. The base SSP contains: the project description, personnel responsibilities, site hazards, personal protective equipment (PPE), air monitoring guidelines, site control, decontamination procedures, and an emergency response plan. The task-specific addendums are written to add additional information regarding the specific areas and field activities. The addendums not only define the specific field activities and team members, but they contain changes or clarifications of the potential hazards, air monitoring requirements, PPE, decontamination procedures, and emergency contacts. The amendments can be more or less restrictive than the base SSP, depending on the type of field activities being conducted. **Neither the base SSP or the addendums are stand-alone documents; both documents contain important information and they must be used in conjunction with each other.**

McClellan Air Force Base Site Safety Plan

CH2M HILL Site Safety Plan Addendum No. 1 pertains to SVE activities conducted during the Phase I Site Characterization of Site S in OU D and does not cover Phase II or III activities. However, Addendum No. 1 is included to maintain the comprehensive nature of this health and safety plan.

CH2M HILL Site Safety Plan Addendum No. 2 pertains to SVE activities being conducted during the Phase II and III activities and is directly applicable to the work set forth in this Work Plan.

General Information

CLIENT: McClellan Air Force Base (AFB)
PROGRAM MANAGER: Starr Dehn/SAC
SITE NAME: McClellan Air Force Base
SITE LOCATION: **TO BE IDENTIFIED IN TASK-SPECIFIC AMENDMENTS**
PURPOSE OF FIELD VISIT(S): Source testing, site survey, waste minimization and treatability studies, site inspections.
DATE OF VISIT(S): **TO BE IDENTIFIED IN TASK-SPECIFIC AMENDMENTS**
BACKGROUND INFORMATION: Complete ______ Preliminary X
INFORMATION AVAILABLE FROM: SAC (office)
OVERALL HAZARD SUMMARY: **TO BE IDENTIFIED IN TASK-SPECIFIC AMENDMENTS**

Site Characteristics

Site Description

A location map is shown in Figure 1-1.

- McClellan AFB is located north of Sacramento, California. The base is approximately 3 miles north-south and approximately 2 miles east-west in length.
- The base is in the Central California Valley with excellent city street and interstate highway access. Access by air is also excellent.

Status

Active, inactive, unknown; and nature of any site activity: Active Air Force base.

History

Worker or nonworker injury; complaints from public; previous investigations or remedial action: McClellan AFB is a RCRA facility and a CERCLA site. The site is on the National Priority List (NPL).

The predominant functions at McClellan AFB have been to manage, maintain, and repair aircraft, missiles, space vehicles, electronics, and communication equipment. These operations have required the use of toxic and hazardous materials. Some of the hazardous materials that have been used or generated on the base include industrial solvents and caustic cleaners, electroplating waste heavy metals, oils contaminated with polychlorinated biphenyls (PCBs), contaminated jet fuels, low-level radioactive wastes, unused chemicals, and a variety of oils and lubricants.

McClellan AFB has, in the past, used a variety of disposal facilities ranging from burial pits (refuse, demolition material, excess military equipment, possibly chemicals, etc.), sludge/oil pits, burn pits (refuse, oil, chemicals, etc.), to assorted miscellaneous disposal pits (sodium valves, etc.). Industrial waste sludge was also disposed of on-base at the Class II-I site approved by the Regional Board. This practice has since been eliminated. The industrial waste sludge is known to contain high concentrations of tetrachloroethylene, trichloroethylene, chloroform, and 1,1,2-trichloro-2,2,1-trifluoroethane. These types of materials could also have been disposed of in the sludge/oil pits.

Characterization and remediation of the areas affected by these waste disposal practices are ongoing. Today, these wastes are either placed in drums and hauled to an approved Class I disposal site or discharged into the Industrial Wastewater Treatment Plant (IWTP). Sludge from the IWTP is also hauled to an approved Class I disposal site.

Principal Materials Handling Activities

Type, amount, and location of wastes or hazardous materials disposed of, stored, treated, or handled at the site: Contaminated drill cuttings and purge water will be generated during field activities. The purge water will be disposed of at the IWTP or groundwater treatment plant. The drill cuttings and any contaminated soil will be handled in accordance with the McClellan AFB Soils Management Plan.

Features and Unusual Features

Water supply, telephone, radio, power lines, gas lines, water mains, suspect terrain, etc.: Utility lines, both above ground and below ground, may pose a safety hazard for team members during excavation or boring. If a drill rig is used, the driller must maintain a safe clearance (at least 20 feet) between overhead utility lines and the drill-rig mast at all times during site operations. The location of utility lines must be determined prior to startup, and the utility must be notified 48 hours prior to excavation or drilling by contacting Underground Services Alert at 800/422-4133 and Tom Egan, McClellan AFB Engineering at 916/643-4875.

Waste Characteristics

ALL WASTE TYPES AND CHARACTERISTICS MAY NOT BE PRESENT IN ALL AREAS. THE TASK-SPECIFIC AMENDMENTS WILL IDENTIFY WHICH WASTE TYPES AND CHARACTERISTICS ARE OF CONCERN FOR THAT SPECIFIC AREA AND TASK.

Waste Type(s)

Liquid _X_ Solid _X_ Sludge _X_ Gas _X_

Characteristic(s)

Corrosive _X_ Ignitable _X_ Radioactive _X_ Mixed Waste ___

Volatile _X_ Toxic _X_ Reactive ___ Unknown ___ Other (name) ___

Hazard Evaluation

Overall Hazard Level

THE OVERALL HAZARD LEVEL WILL BE IDENTIFIED IN THE TASK-SPECIFIC AMENDMENT.

Chemical Hazards

The major types of processes in operation on the base are paint removal, painting, plating, and foundry. Each process has particular types of chemicals that are associated with it. For example, paint removers contain volatile organic compounds such as methylene chloride. In the painting operations, toluene- and xylene-based paints are applied to parts. Plating processes use degreasers, acids, rust removers, and cyanide. Finally, foundries may emit metallic fumes.

THE ABOVE PROCESSES ARE NOT INCLUSIVE OF ALL THE BASE OPERATIONS; THEREFORE, FOR EACH TASK AND/OR SITE VISIT, AN AMENDMENT WILL BE ATTACHED TO THE OVERALL SSP TO ADDRESS PARTICULAR HAZARDS AT EACH SITE. THE AMENDMENT WILL CONTAIN MORE DETAILED INFORMATION ON CHEMICAL HAZARDS AND WILL ADDRESS TASK AND/OR SITE-SPECIFIC CHEMICAL HAZARDS.

Physical Hazards

The major potential physical hazards possible at the site are: flammable vapors and explosive conditions; utilities; moving and mobile equipment; trips, slips, and falls; and heat stress. **THESE PHYSICAL HAZARDS MAY NOT BE REPRESENTED AT EVERY SITE. THEREFORE, FOR EACH TASK AND/OR SITE, AN AMENDMENT WILL BE WRITTEN WHICH CONTAINS MORE DETAILED INFORMATION ON TASK AND SITE-SPECIFIC PHYSICAL HAZARDS.**

Explosions of vapor can be fatal, and workers must be attentive to this danger and guard against carelessness at all times. The lower explosive limit (LEL) is compound-specific. Explosive atmospheres can occur during a variety of activities including drilling; however, explosive atmospheres have an extremely high potential of occurring in confined spaces. When the vapors are heavier than air, their explosivity and flammability hazard are increased, since they will tend to concentrate near the ground and in low-lying areas and will not be readily mixed or diluted with ambient air. When monitoring LEL, it is important to take measurements at ground level. To reduce the potential of an explosion, each team member must make sure that no spark sources, such as lighters, matches, unapproved flashlights, etc., are brought into the exclusion zone. The Site Safety Coordinator (SSC) must inspect the exclusion zone for spark sources including wiring, motors, etc., and enforce the requirements for fire prevention, including intrinsically safe electrical equipment, spark arresters on vehicles, and exclusion of unauthorized personnel.

There is potential for exposure to excessive noise. If a conversation has to be shouted at a distance of 3 feet or if noise levels exceed 90 dBA, hearing protection will be worn.

Hazards Posed by Site Activities

Hazards may exist from moving process equipment (such as pumps and conveyors) and heavy equipment (such as forklifts). Personnel must be alert for these hazards, protect clothing and hair from entrapment in equipment, and use common sense in these situations. To protect from slips, trips, and falls, proper precautions and good judgement must be exercised. In extremely muddy areas, pallets or similar devices may be used. Personnel should be especially alert when working near pits and excavations and remain at least 2 feet from the edge of the excavation at all times. Exercising caution, using safe ladder practices, and using the buddy system around emission control system stacks is important.

Heat and Cold Stress Hazards

Heat Stress. Heat stress is a hazard of concern during summer months. Wearing PPE puts a hazardous waste worker at considerable risk of developing heat stress. This can result in health effects ranging from transient heat fatigue to serious illness or death. Heat stress is caused by a number of interacting factors, including environmental conditions, clothing, workload, and the individual characteristics of the worker. Because heat stress is probably one of the most common (and potentially serious) illnesses at hazardous waste sites, regular monitoring and other preventive precautions are vital.

Monitoring Heat Stress. Because the incidence of heat stress depends on a variety of factors, all workers, even those not wearing protective equipment, should be monitored. Workers wearing semipermeable or impermeable protective clothing should be monitored when the temperature in the work area is above 70°F (21°C).

To monitor the worker, measure:

- Heart Rate--Count the radial pulse during a 30-second period as early as possible in the rest period.
    - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.
    - If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third again.
- Oral temperature--Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
    - If oral temperature exceeds 99.6°F (37°C), shorten the next work cycle by one-third without changing the rest period.

  - If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third again.

  - Do not permit a worker to wear a semipermeable or impermeable garment when his/her oral temperature exceeds 100.6°F (38.1°C).

- Body Water Loss (if possible)--Measure weight on a scale accurate to ±0.25 lb at the beginning and end of each work day to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee wears similar clothing or, ideally, is nude. The body water loss should not exceed 1.5 percent total body weight loss in a work day.

Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work (see Table 8-1). The length of the work cycle will be governed by the frequency of the required physiological monitoring.

Table 8-1
Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers[a]

Adjusted Temperature[b]	Normal Work Ensemble[c]	Impermeable Ensemble
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5°-90°F (30.8°-32.2°C)	After each 60 minutes of work	After each 30 minutes of work
82.5°-87.5°F (28.1°-30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5°-82.5°F (25.3°-28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F (22.5°-25.3°C)	After each 150 minutes of work	After each 120 minutes of work

[a] For work levels of 250 kilocalories/hour.

[b] Calculate the adjusted air temperature (ta adj) by using this equation: ta adj °F = ta °F + (13 x % sunshine). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent time the sun is not covered by clouds that are thick enough to produce a shadow. (100 percent sunshine = no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows.)

[c] A normal working ensemble consists of cotton coveralls or other cotton clothing with long sleeves and pants.

Prevention of Heat Stress. Proper training and preventive measures will help avert serious illness and loss of work productivity. Preventing heat stress is particularly important because once someone suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat injuries. To avoid heat stress, management should take the following steps:

- Adjust work schedules:
    - Modify work/rest schedules according to monitoring requirements
    - Mandate work slowdowns as needed
    - Rotate personnel: alternate job functions to minimize overstress or overexertion at one task
    - Add additional personnel to work teams.
    - Perform work during coolers hours of the day if possible or at night if adequate lighting can be provided.
- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.
- Maintain workers' body fluids at normal levels. This is necessary to ensure that the cardiovascular system functions adequately. Daily fluid intake must approximately equal the amount of water lost in sweat, i.e., 8 fluid ounces (0.23 liters) of water must be ingested for approximately every 8 ounces (0.32 kg) of weight lost. When heavy sweating occurs, encourage the worker to drink more. The following strategies may be useful:
    - Maintain water temperature at 50° to 60°F (10° to 15.6°C).
    - Provide small disposable cups that hold about 4 ounces (0.1 liter).
    - Have workers drink 16 ounces (0.5 liters) of fluid (preferably water or dilute drinks) before beginning work.
    - Urge workers to drink a cup or two every 15 to 20 minutes, or at each monitoring break. A total of 1 to 1.6 gallons (4 to 6 liters) of fluid per day are recommended, but more may be necessary to maintain body weight.
    - Weigh workers before and after work to determine if fluid replacement is adequate.
- Encourage workers to maintain an optimal level of physical fitness:
    - Where indicated, acclimatize workers to site work conditions, including temperatures, protective clothing, and workload.
    - Urge workers to maintain normal weight levels.

- Provide cooling devices to aid natural body heat exchange during prolonged work or severe heat exposure. Cooling devices include:
    - Field showers or hose-down areas to reduce body temperature and/or to cool off protective clothing.
    - Cooling jackets, vests, or suits.
- Train workers to recognize and treat heat stress. As part of training, identify the signs and symptoms of heat stress (see Table 8-2).

Cold Stress. Although northern California is not prone to bitter-cold temperatures, cold stress may still be a potential problem. Cold stress is possible when work performed over water is at temperatures of 50°F or less. The ultimate effect of cold stress is hypothermia, which is a decrease in the deep core body temperature. At temperatures of 35°F, workers in water, or whose clothing becomes wet, should be provided with an immediate change of clothing. They may need to be treated for hypothermia. Workers who wear impermeable protective clothing are susceptible to chilling because their cotton underclothing may become wet with perspiration.

Table 8-2
Signs and Symptoms of Heat Stress

- Heat rash may result from continuous exposure to heat or humid air
- Heat cramps are caused by heavy sweating with inadequate electrolyte replacement. Signs and symptoms include:
  - Muscle spasms
  - Pain in the hands, feet, and abdomen
- Heat exhaustion occurs from increased stress on various body organs including inadequate blood circulation due to cardiovascular insufficiency or dehydration. Signs and symptoms include:
  - Pale, cool, moist skin
  - Heavy sweating
  - Dizziness
  - Nausea
  - Fainting
- Heat stroke is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must be taken to cool the body before serious injury and death occur. Competent medical help must be obtained. Signs and symptoms are:
  - Red, hot, usually dry skin
  - Lack of or reduced perspiration
  - Nausea
  - Dizziness and confusion
  - Strong, rapid pulse
  - Coma

Windchill Index. The windchill factor is the cooling effect of any combination of temperature and wind velocity of air movement. The windchill index is shown in Table 8-3. The windchill index does not take into account that part of the body which is exposed to cold, the level of activity and its effect on body heat production, and the amount of clothing being worn.

Table 8-3
Windchill Index

Actual Thermometer Reading (F)										
Wind speed in mph	50	40	30	20	10	0	-10	-20	-30	-40
Equivalent Temperature (F)										
calm	50	40	30	20	10	0	-10	-20	-30	-40
5	48	37	27	16	6	-5	-15	-26	-36	-47
10	40	28	16	4	-9	-21	-33	-46	-58	-70
15	36	22	9	-5	-18	-36	-45	-58	-72	-85
20	32	18	4	-10	-25	-39	-53	-67	-82	-96
25	30	16	0	-15	-29	-44	-59	-74	-88	-104
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109
35	27	11	-4	-20	-35	-49	-67	-82	-98	-113
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116
Over 40 mph (little added effect)	LITTLE DANGER (for properly clothed person)				INCREASING DANGER (danger from freezing of exposed flesh)			GREAT DANGER (Danger from freezing of exposed flesh)		

Note: The human body senses "cold" as a result of both the air temperature and the wind velocity. Cooling of exposed flesh increases rapidly as the wind velocity goes up. Frostbite can occur at relatively mind temperatures if wind penetrates the body insulation. For example, when the actual air temperature of the wind is 40°F (4.4°C) and its velocity is 30 mph (48 km/h), the exposed skin would perceive this situation as an equivalent still air temperature of 13°F (-11°C).

Biological Hazards

There is a possibility of contracting Lyme disease or Rocky Mountain Spotted Fever (RMSF).

Check often for tick bites. If bitten, carefully remove tick with tweezers, making certain to remove pincers and being careful not to crush the tick. After removing the tick, wash your hands. Disinfect area, and dress. If the tick resists or cannot be completely removed, seek medical attention.

Look for symptoms of Lyme disease or RMSF. Lyme: rash that looks like a "bulls-eye," with small welt in center, several days to weeks after tick bite. RMSF: Rash comprising red spots under skin, 3 to 10 days after tick bite. For both: chills, fever, headache, fatigue, stiff neck, bone pain. If symptoms appear, seek medical attention.

Unusual Hazards

None.

Hazards Posed by Chemical Substances Provided by CH2M HILL

In accordance with 20 CFR 1910.1200, Hazard Communication, Material Safety Data Sheets are provided in each project specific addendum to this base plan.

Procedures

Site Organization

Map/Sketch Attached _Yes_ Site Secured _Yes_

Perimeter Identified _Yes_

Zone(s) of Contamination Identified _No_

Site Personnel

Team Organization

Team Member/Office	Responsibility

TEAM MEMBERS AND RESPONSIBILITIES WILL BE IDENTIFIED IN THE TASK-SPECIFIC AMENDMENTS.

Each of the team members will be certified as fit for the anticipated work by the CH2M HILL medical surveillance program, and has completed the training requirements of 29 CFR 1910.120. In addition, at least two members will be currently certified by the American Red Cross, or equivalent, in both first aid and CPR. A SSC with the appropriate level of experience will be present during all field activities.

All medical and training records are housed in CH2M HILL's Reston, Virginia, office. They are maintained in accordance with federal and state regulations.

Onsite Engineering Controls

Onsite engineering controls include covers for waste piles and cuttings and barricades to keep unauthorized people from entering contaminated areas.

Work Practices

In general, work practices shall be designed to decrease time of exposure, increase distance to the source, or shield the exposed individual. Work practices that will be implemented at the site include:

- No spark sources within exclusion or decontamination zones.
- Fuel supplies will be properly stored and grounded.
- Avoid visibly contaminated areas.
- No eating, drinking, or smoking in contaminated areas, or exclusion or decontamination zones.
- SSC to establish areas for eating, drinking, smoking.
- No contact lenses in exclusion or decontamination zones.
- No facial hair that would interfere with respirator fit if Level C or B are anticipated.
- Site work will be performed during daylight hours whenever possible. Any work conducted during hours of darkness will require enough illumination intensity "to read a newspaper without difficulty."
- Working from an upwind position whenever possible.

Personal Protective Equipment (PPE)

BECAUSE THE LEVEL OF PPE AND THE SPECIFIC EQUIPMENT REQUIRED FOR EACH LEVEL OF PROTECTION IS DEPENDENT ON THE CONTAMINANTS AND THE TASKS, THE REQUIRED PPE WILL BE IDENTIFIED IN A TASK-SPECIFIC ADDENDUM.

General Hazardous Waste Site Monitoring Equipment and Procedures

Periodic monitoring of the site is required to determine the effectiveness of engineering controls, to re-evaluate levels of protection, and to determine if site conditions have changed. At a minimum, monitor at the beginning of each shift, periodically (e.g., every 15 minutes) throughout the work, whenever work begins at a new area onsite, or when different contaminants are encountered or a different work activity begins. Specific monitoring locations and frequencies are given below.

Carefully inspect each piece of monitoring equipment prior to work startup. Failure of any of the equipment listed below to work properly must be reported to the Project Manager immediately.

Table 8-4 summarizes the air monitoring equipment and action levels that may be required. **SPECIFIC MONITORING REQUIREMENTS ARE DEPENDENT ON THE FIELD ACTIVITIES AND CHANGES IN THE AIR MONITORING PROGRAM WILL BE IDENTIFIED IN THE TASK-SPECIFIC AMENDMENTS.**

Site Entry Procedures

- Conduct Site Safety briefing before starting field activities. Briefing should include a general discussion of the health and safety plan, site-specific hazards, location of work zones, PPE requirements, equipment, special procedures, and emergencies.

- Determine wind direction, install wind flags, and establish work zones onsite (e.g., exclusion zone, contamination reduction zone, and support zone).
- Post Occupational Safety and Health Administration (OSHA) jobsite poster in a central and conspicuous location at the site.

- Set up decontamination facilities.

- Verify that *Material Safety Data Sheets* are available for onsite chemicals.

- Establish onsite communications. These should consist of:

    - Line of sight/hand signals
    - Air horn
    - Two-way radio or cellular phone, if available

Table 8-4
Required Monitoring Equipment and Action Levels of Upgrading Personal Protective Equipment (PPE)

Page 1 of 3

Equipment	Reading[a]	Action
Explosimeter	< 10% LEL*	Continue with caution.
	10-20% LEL	Continue with caution while implementing control measures such as mechanical ventilation.
	> 20% LEL	Halt operations and evacuate the area until the readings are below 10% LEL.
O_2 Explosimeter	19.5-21% O_2	Continue operations in Level D PPE.
	Needle detects upward and then drops to zero	Halt operations and evacuate the area until the readings are approximately 20% O_2.
	< 15% O_2	Halt operations and evacuate the area until readings are approximately 20% O_2.
	< 19.5% O_2	Level B PPE required.
	> 21% O_2	Halt operations and evacuate the area until readings are approximately 20% O_2.
HNu (with 10.2eV or 11.7 eV lamp) or OVA[b,c]	< 1 ppm	Continue operations in Level D PPE.
	1 - 5 ppm	Continue operations in Level C PPE, if there is no color change on the vinyl chloride detector tubes. Level C cannot be used if there is a color change on vinyl chloride detector tubes; Level B is required if vinyl chloride is present
	5 - 100 ppm	Level B PPE required.
	> 100 ppm	Halt work.

Table 8-4
Required Monitoring Equipment and Action Levels of Upgrading Personal Protective Equipment (PPE)

Page 2 of 3

Equipment	Reading[a]	Action
Mini-Ram	<1 mg/m^3	Continue operation in Level D PPE.
	1-5 mg/m^3	Continue operations in Level D PPE. Implement measures such as covering contaminated soils or wetting soils to control airborne dust.
	5-10 mg/m^3	Continue operations in Level C PPE.
	> 10 mg/m^3	Halt operations.
Sound Level Meter (SLM)	<85 dBA	Continue operations.
	85-120 dBA	Continue operations with hearing protection.
	>120 dBA	Continue operations with hearing protection, audiometric monitoring, and training.
Rad-Mini	< 0.3 mR/hr	Continue operations, monitor continuously, and record readings every 30 minutes.
	0.3 mR/hr - 1 mR/hr	Continue operations, monitor continuously, and record readings every 10 minutes.
	1 mR/hr - 2 mR/hr	Continue operations, monitor continuously, and record readings every 10 minutes. SSC will record approximate daily radiation exposure based on rad-mini readings and exposure time (mR/hr x hr = mR/day). Personnel radiation exposure will be kept below 40 mR/wk. The plan approver will be notified of results greater than 30 mR/wk.

Table 8-4
Required Monitoring Equipment and Action Levels of Upgrading Personal Protective Equipment (PPE)

Page 3 of 3

Equipment	Reading[a]	Action
	> 2 mR/hr	Halt work. Plan must be revised by health physists.
Vinyl Chloride Detector Tube[b]	Any color change	Halt work. Level B is required.

*Lower Explosive Limit

[a] Readings are above background.

[b] If the OVA is used, the action levels are based on nonmethane compounds. The charcoal filter will be used to distinguish methane and nonmethane compounds from each other.

[c] Vinyl chloride colorimetric tubes must be collected whenever HNu or OVA readings are greater than 1 ppm.

- Establish emergency signals. For example:
    - Grasping throat with hand—EMERGENCY—HELP ME
    - Grasping buddy's wrist—LEAVE AREA NOW
    - Thumbs up—OK, UNDERSTOOD
    - Two short blasts on air horn—ALL CLEAR
    - Continuous air horn—EMERGENCY—EVACUATE

- Establish offsite communications.

- Establish "buddy" system.

- Establish procedures for disposal of material generated onsite

- Conduct initial air monitoring to determine appropriate level of protection

- If toilet facilities are not located within a 3-minute walk from the decontamination facilities, either provide a chemical toilet and hand washing facilities or have a vehicle available (not the emergency vehicle) for transport to nearby facilities.

Work Limitations: (time of day, etc.)

- No eating, drinking, or smoking onsite.

- No contact lenses onsite.

- No facial hair that would interfere with respirator fit.

- Buddy system at all times in exclusion zone.

- CH2M HILL employees who have been issued thermal luminescent dosimetry (TLD) badges will wear them at all times when on or near the site.

- Site work will be performed during daylight hours whenever possible. However, some predawn work is anticipated to minimize activities during the hottest part of the day. Any work conducted during hours of darkness will require the following minimum illumination intensity:

General Site Areas	5 foot-candles
First Aid Station/Office/Lab	30 foot-candles
Storerooms, Changehouse, Toilets, Rest Areas	10 foot-candles

- Motors used in the exclusion zone will be nonsparking electrical motors or equipped with spark arresters.

Decontamination Procedures

Set up decontamination area upwind of the exclusion zone. Water and Alconox detergent should be placed in buckets prior to beginning work. The decontamination area should be a sufficient distance from the work in the exclusion zone so that the decontamination area will not become contaminated by splashing water or flying dirt.

Personnel Decontamination Procedures

- Wash boots and outer gloves in detergent and water, rinse, and remove outer gloves.

- Remove and bag coveralls. If cotton coveralls are used, bag in plastic bags and wash prior to rewearing.

- Remove respirator, if worn.

- Remove surgical gloves and dispose in a plastic trash bag.

- Wash hands and face.

- Sanitize respirator nightly, if used.

- Take a shower and wash hair as soon as possible after leaving the site.

Sampling Equipment Decontamination Procedures. Equipment needed will be buckets, detergent, cleaner-sanitizer, brush, garbage bags, hand soap, and paper towels. The decontamination process will include:

- Removal of all loose dirt
- Scrub with Alconox and water
- Rinse with distilled water
- Rinse with methanol
- Rinse with deionized/distilled water
- Air dry

Heavy Equipment Decontamination Procedures. Wash off the bucket of the backhoe or the drilling equipment with detergent and water. Rinse in water. Use an organic vapor monitor to screen the backhoe or drilling equipment. If organic vapor readings are detected from the equipment, steam clean it prior to removing it from the site.

Documentation. It is the responsibility of the SSC to make sure that all equipment coming offsite is properly decontaminated according to the procedures outlined above. At a minimum, visual indication of contamination will be removed, and no organic vapors detectable above background should remain. The equipment and samples will be clean, dry, and free from stains, deposits, encrustations, or discoloration. Documentation of decontamination must be made in the field log notebook, which will become part of the permanent project file. A suitable tag is to be placed on each piece of decontaminated CH2M HILL equipment (or group of equipment, such as a bag of hand tools) stating the date of decontamination and initialed by the SSC.

Spill Containment Procedures

No large-scale spill containment procedures are required because CH2M HILL and its subcontractors are not handling any large amounts of liquid materials. Decontamination procedures will take place over visqueen sheeting. In the event of a spill during decontamination activities, the spilt material will be contained.

Confined Space Entry

No confined space entries are planned during Phase II and III activities. However, if they become necessary, an additional health and safety plan and a permit must be developed prior to conducting such entries. (Refer to CH2M HILL SOP HS-17, contained in the *Waste Management and Industrial Processes Discipline Health and Safety Manual, Volume 1.*)

Material Handling Procedures

The following general material handling procedures apply:

- Drums and containers meeting the appropriate Department of Transportation (DOT), OSHA, and EPA regulations for the waste contents (e.g., decon water) will be used.

- Site operations will be organized to minimize the amount of drum or container movement.

- DOT salvage drums and suitable quantities of absorbent will be available and used on sites where hazardous waste spills could occur.

- Electrically powered material handling equipment used to transfer decontamination solutions will meet the requirements of 29 CFR 1910.307 for the classification of materials being handled.

Disposal of Materials Generated During Fieldwork

- Material generated during fieldwork (decontamination fluids, disposable protective gear or sampling devices, drilling cuttings, well development fluids, etc.) will be considered as contaminated and handled accordingly unless adequate monitoring or analytical data exists to properly classify the materials as nonhazardous.

- Material generated offsite (well drilling fluids, etc.) will be returned to the site unless otherwise specified by the site owner or responsible party.

- Ultimate responsibility for disposal of the material rests with the site owner or responsible party. CH2M HILL may coordinate analysis, packaging, storage, transport and disposal of waste material, but will not assume responsibility for the waste (i.e., sign manifests as generator, etc.). Prior to beginning fieldwork, the waste handling procedures will be agreed to with the client, site owner, and/or responsible party.

- Laboratory samples will be returned to site, client, site owner, or responsible party for disposal following analysis unless otherwise specified.

Description of Planned Activities

This Description of Planned Activities encompasses a broad range of possible tasks to be issued as task orders against contract No. F04699-90-D-0035. This section defines the range of tasks CH2M HILL shall be responsible to perform. **THE TASK-SPECIFIC AMENDMENTS IDENTIFY WHICH ACTIVITIES ARE BEING CONDUCTED DURING THAT FIELD EFFORT.**

- Conduct field sampling of drums, spill sites, tanks (above and underground), monitoring wells, past waste disposal sites, etc., and perform sample characterization studies to include analysis of a wide variety of contaminants in complex matrices, including up to 297 compounds listed as hazardous by EPA.

- Perform laboratory and field tests of environmental monitoring and testing equipment, to include validation of manual/instrumental methods, continuous monitors, analytical support and mathematical models using EPA, ASTM, NR, and/or equivalent procedures specified by the Air Force.

- Perform photogrammetric analyses of environmental and infrared photographs.

- Perform geophysical studies to include, but not be limited to, studies involving magnetometer, metal detection, earth resistivity, terrain conductivity, seismic, gravity, ground penetrating radar and shallow (less than 400 feet, in most cases) borehole logging.

- Perform hydrogeological investigations to determine the magnitude and extent of groundwater contamination.
- Determine the direction and rate of movement of contaminants and estimate the degree of risk associated with contaminant migration.
- Develop methods to mitigate the adverse environmental effects of pollutant migration.
- Develop leachate monitoring and analysis programs to comply with state or EPA regulations required for landfills and other hazardous waste treatment and disposal sites which are currently operated or have been operated in the past by the U.S. Air Force.
- Perform onsite geological/hydrological investigations required to assist the Air Force in selecting proper locations for new solid/hazardous waste treatment, storage, or disposal sites or other facilities.
- Perform sampling of soil and water in the unsaturated (vadose) zone above the water table using techniques recommended by the National Water Well Association (NWWA).
- Perform aquifer tests to determine the porosity, permeability, specific yield, drawdown and extent of cones of depression developed in aquifers in which contamination has been found or is suspected.
- Conduct comprehensive water supply and water distribution studies.
- Perform evaluations of domestic water, industrial wastewater, domestic wastewater, and groundwater treatment plants.
- Perform water and wastewater characterization, to include ambient short-term and continuous water monitoring.
- Conduct inflow/infiltration studies into industrial, reclamation and groundwater extract/treatment systems at McClellan AFB and its satellite locations.
- Perform treatability studies, pilot plant investigations, and toxicity and bioassay determinations.
- Prepare evaluations and analyses providing sufficient detail to allow development of National Pollutant Discharge Elimination Systems (NPDES) permit applications, certifications and discharge monitoring reports.

- Conduct instream biological monitoring and fish-kill investigations.

- Perform laboratory analyses of potable water, groundwater, wastewater, soil, sludges, biologicals, fuels or commercial products and other environmental samples.

- Perform studies to ensure personnel safety, including the use of explosimeters, gas detectors, and survey meters and other equipment necessary to monitor air quality during site operations.

- Prepare evaluations and analyses, providing sufficient details to aid development of state or EPA-mandated permit applications, certifications, discharge monitoring reports and groundwater monitoring reports.

- Perform necessary analysis and reduction of any physical/chemical sample or data acquired under activities outlined herein.

- Provide analytical results in both hard copy and other formats suitable for archiving, including computer format.

- When required and specified in the delivery order, prepare sites for sampling/ monitoring and restore sites upon completion of work.

- Identify, evaluate, design and prototype processes, equipment, and facilities which minimize the generation of hazardous wastes or improve environmental quality.

- Develop permits and various applications as required by the guidance documents.

- Conduct Community Relations Program requirements in accordance with Superfund Amendments and Reauthorization Act (SARA).

- Prepare Site-Specific Spill Plans to be maintained and reviewed annually in accordance with Air Force policy, guidance and directives.

- Develop Base Spill Prevention and Response Plans.

- Conduct quarterly review of regulatory requirements regarding the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Superfund amendments and ongoing RCRA and CERCLA/SARA Programs and other background documents as required.

- Prepare Statements of Work.

- Perform waste minimization assessments and recommend process modifications that eliminate or reduce the use, generation, and disposal of hazardous materials within production process. To do this, project personnel will do the following:

    - Analyze the results of waste audits to identify the most promising areas for waste minimization.

    - Identify, devise, and prototype new approaches to reduce and minimize hazardous wastes through process modification of emission/effluent control.

    - Investigate process technology and develop conceptual system designs to prevent and reduce industrial pollution and hazardous waste generation.

    - Determine the environmental consequences of present and proposed environmental regulations of any recommended process or equipment changes.

    - Recommend control technology for toxics and pollutants to address recovery/recycling and reduction, optimization treatment (chemical and biological), onsite treatment, and substitution with less toxic/hazardous materials.

    - Prepare detailed drawing packages, plans, and designs for waste minimization pilot projects relative to equipment design and modifications including charts, graphs, return on investments, and cost estimates.

    - Document, evaluate, and integrate the results of pilot projects in ongoing industrial processes operations through process modifications or prototype development.

- Conduct and administer the Hazardous Waste Training Program to base employees including requirements under 29 CFR 1910.120.

- Conduct Underground Storage Tank Annual Precision Leak Testing.

- Conduct Environmental Audit Assessment of base facilities and operation in accordance with Air Force and SM-ALC/EM policy, guidance, and directives.

- Perform Inspection Services and Construction Management for Environmental Investigations, Construction Project or Remedial Action Implementation.

- Develop and maintain a computer data base for tracking hazardous waste generator/management data and all delivery order project information.

- Maintain an inventory of McClellan AFB permits. Develop tracking system to monitor environmental compliance. This inventory and tracking system will be maintained in a microcomputer within the Directorate of Environmental Management.

- Provide engineering and services to operate and maintain interim Remedial Measures and Remedial Actions implemented by McClellan AFB in accordance with CERCLA/SARA. This includes the McClellan Groundwater Treatment Plant and existing and future groundwater extractor systems. Operation and maintenance shall be conducted in accordance with existing procedures.

- Prepare Environmental Assessments for proposed Air Force activities in water usage, wastewater discharge, solid waste disposal, hazardous waste cleanup, and contaminated groundwater cleanup.

- Document performance of existing and future McClellan AFB water, wastewater, solid waste, and groundwater treatment facilities (including groundwater extraction systems) to include performance evaluations of individual unit processes within a treatment facility.

- Prepare comprehensive studies to determine potable water supply, storage and distribution requirements for McClellan AFB and its satellite locations.

Emergency Response Plan

Pre-Emergency Planning

The SSC is to perform the following pre-emergency planning tasks before starting field activities and will coordinate emergency response with the operating facility when appropriate:

- Locate telephone nearest to the site and inspect onsite communications (air horns, two-way radios).

- Confirm and post emergency telephone numbers (see Form 311 in Appendix Q) and route to hospital.

- Post site map marked with locations of emergency equipment and supplies.

- Review emergency response plan for applicability to any changed site conditions, alterations in onsite operations, or personnel availability.

- Drive route to hospital.

- Evaluate capabilities of local response teams.

- Where appropriate and acceptable to the client, inform emergency room/ ambulance service and emergency response teams of anticipated types of site emergencies.

- Designate one vehicle as the emergency vehicle and place hospital directions and map inside. Keys should be kept in ignition during field activities.

- Review emergency procedures for personnel injury, exposures, fires, explosions, chemical, and vapor releases with field personnel.

- Inventory and check-out site emergency equipment and supplies.

- Locate onsite emergency equipment and supplies of clean water.

- Verify local emergency contacts, hospital routes, evacuation routes, and assembly points.

- Set up emergency personnel decontamination station(s).

- Rehearse the emergency response plan once prior to site activities.

- Brief new workers on the emergency response plan.

Personnel Roles and Lines of Authority

The SSC takes the lead in emergencies. The SSC has the authority to stop any site activities posing an immediate health and safety hazard to site personnel and must notify the Project Manager or designer as soon as practical of this action. The Project Manager is ultimately responsible for health and safety of the CH2M HILL workers.

Training

At least two personnel currently certified in both first aid and CPR will be present during field activities within the exclusion zone. The site's Emergency Response plan will be reviewed in the initial site safety briefing and will include:

- Emergency procedures for personnel injury or suspected overexposures, fires, explosions, and chemical spills or vapor releases.

- Location of onsite emergency equipment and supplies of clean water.

- Local emergency contacts, hospital routes, evacuation routes, and assembly points.

- Site communication and location of nearest phone to the site.

- Names of onsite personnel trained in first aid and CPR.

- Notification procedures for contacting CH2M HILL's medical consultant and team member's occupational physician.

The emergency response plan will be rehearsed at least once before site activities begin, and periodically afterwards. New workers on the site will be briefed on the emergency response plan before entering the exclusion zone.

Communications

The "buddy system" will be enforced for field activities involving potential exposure to hazardous, toxic, or radioactive materials, and during any work within the exclusion zone. Each person will observe his/her partner for symptoms of chemical overexposures and heat stress and provide emergency assistance when warranted. Personnel working in the exclusion zone will maintain line of sight contact or maintain communications (e.g., two-way radios) with the site support facilities. Offsite communications will consist of either onsite telephone service or use of the nearest telephone to the site.

Emergency Signals

The following emergency signals shall be used:

Grasping throat with hand	Emergency--help me
Thumbs up	OK, understood
Grasping buddy's wrist	Leave site now
2 short blasts or sounds, repeated	All clear
Continual sounding of horn	Emergency--leave site

PPE and Emergency Equipment and Supplies

The following emergency equipment and supplies will be available onsite with the locations marked on the site map and posted in the support zone:

- 20-lb ABC fire extinguisher(s)
- First-aid kit
- Stretcher or blanket
- Supplies of clean water
- Eye wash
- Deluge shower (when required for emergency decontamination)

- PPE (protective clothing, boots, and gloves)
- Air monitoring equipment

Emergency Recognition and Prevention

Prevention of emergencies will be aided by the effective implementation of the health and safety procedures specified in this SSP. The initial site safety briefing will emphasize recognition of the types of emergencies anticipated onsite. Periodic safety briefings will be conducted by the SSC as field activities proceed. Hazards that warrant specific emergency recognition and prevention techniques will be discussed.

Site Security and Control

Access to McClellan AFB is controlled. Visitors must check in with the guard house at the entrance and present their driver's license and car registration. Once inside the base, access to Areas A, B, C, and D is not controlled, though the areas are delineated with a low fence.

Access to specific areas where tasks are being conducted will be controlled by establishing and clearly delineating work zones. The SSC is responsible for prohibiting unauthorized personnel from entering the exclusion and contamination reduction zones.

Emergency Medical Treatment and First-Aid

The SSC will assume charge during a medical emergency. The following procedures should be used:

- Prevent further injury, perform appropriate decontamination, and notify the SSC and the Project Manager.

- Initiate first aid and get medical attention for the injured immediately.

- Depending upon the type and severity of the injury, call the medical consultant and/or occupational physician.

- Notify the Health and Safety Manager.

- Notify the injured person's personnel office.

- Notify the client representative.

- If an injury occurs, it will be reported to the SSC, medical consultant, Health and Safety Manager, and the regional personnel office.

- Prepare an incident report. The SSC is responsible for preparing and submitting the report to the Director of Health and Safety and to the CH2M HILL corporate personnel office within 24 hours.

Emergency Routes and Telephone Numbers

<u>Building 123</u>

Duty Officer: 32751 (on base) 916/643-2751 (off base)
Police: 112 (on base) 916/643-6168 (off base)
Fire: 117 (on base) 916/643-5622 (off base)
Emergency Assistance: 116 (on base)
Ambulance: 116 (on base)
Site Contact: 916/643-1250--Mr. Fran Slavich
Utilities: 34875 (on base) 916/643-4875 (off base)
McClellan Clinic: 35420 (on base) 916/646-8420;
Urgent Care Hours: 0730 to 1900
General Hospital: American River Hospital, 4747 Engle Road,
Carmichael, CA 95608;
916/848-2100
Directions to Hospital: Exit McClellan Air Force Base through the main gate to Watt Avenue. Turn right onto Watt Avenue and travel south to Whitney Avenue. Turn left onto Whitney Avenue and travel east to Mission Avenue. Turn left onto Mission Avenue and travel north to Engle Road. Turn right (east) onto Engle Road. Hospital is at 4747 Engle Road. (See attached map.)
CHEMTREC: 800/424-9300
TOSCA Hotline: 202/554-1404
CDC: 404/452-4100
National Response Center: 800/424-8802
EPA ERT Emergency: 201/321-6660
RCRA Hotline: 800/424-9346

Emergency Decontamination

Personnel will be decontaminated to the extent feasible (usually a "gross decon" or deluge) but life-saving and first aid procedures take priority over personnel decontamination efforts. The personnel decontamination procedures specified in the Procedures section of this SSP, will apply for injuries deemed nonlife-threatening by the SSC.

Evacuation Routes and Procedures

Onsite evacuation routes will be designated. Personnel will exit the site exclusion zone/ contamination reduction zone and assemble at the onsite assembly point in the support zone. The SSC will account for personnel at the onsite assembly point and notify local emergency responders. The SSC will assess the need for site evacuation based on the degree of hazard posed to site personnel remaining in the support zone. Offsite evacuation routes and assembly points will also be designated. A person designated by the SSC will account for personnel at the offsite assembly point. The SSC and an assistant will remain onsite in the event of site evacuation (if feasible) to assist local responders and advise them on the nature and location of the incident.

Onsite and offsite evacuation routes/assembly points will be designated on the site map and posted. They will be based on site topography and layout; anticipated safe distances for places of refuge; prevailing weather conditions; and anticipated location or magnitude of site emergencies. Wind flags will be installed in the exclusion and support zones to assist personnel in determining upwind evacuation routes.

Evacuation Routes (Onsite and Offsite): Evacuation routes will be dependent on the type of accident and wind direction. McClellan AFB has first and second responders to handle evacuations.

Assembly Points (Onsite and Offsite): Assembly points vary by building and areas. Therefore, it will be the responsibility of the SSC to determine the assembly point for each location from the appropriate base representative.

Critique of Response and Followup

The SSC will evaluate the effectiveness of the emergency response and recommend procedures for improving emergency response to the SSP approver. Followup activities include notification of the injured person's personnel office within 24 hours of the injury. Incidents of suspected overexposures will require the notification of CH2M HILL's medical consultant and the injured person's occupational physician so that they may provide assistance and relevant information to the local hospital's emergency room physician.

Emergency Contacts

CH2M HILL Medical Consultant

Name: Dr. Kenneth Chase, Washington Occupational Health Associates, Inc.
Phone: 202/463-6698 (8-5 eastern standard time)
202/463-6440 (after hours answering service; physician will return call within 30 minutes)

- CH2M HILL Director of Health and Safety

Name: Marty Mathamel/WDC
Phone: 703/471-1441

- District Health and Safety Manager

  Name: Allen Macenski
  Phone: 714/250-5522

- Health and Safety Plan Approver

  Name: Mollie Netherland
  Phone: 206/453-5000

- Radiation Health Officer

  Name: George Stevens/ORO
  Phone: 615/483-9032

- CH2M HILL/CVO Occupational Physician

  Name: Corvallis Clinic
  Phone: 503/754-1150
  Address: Corvallis, Oregon

- CH2M HILL/SAC Occupational Physician

  Name: Dr. Patrick J. Clancy, ERGO Test and Diagnostic Medical Group
  Phone: 916/444-2717
  Address: 2828 Q Street, Sacramento, CA

- CH2M HILL/PDX Occupational Physician

  Name: Dr. Kirby Griffin, Center for Occupational Health
  Phone: 503/297-4411
  Address: 9205 SW Barnes Road, Suite 103, Portland, OR

- CH2M HILL Program Manager

  Name: Starr Dehn/SAC
  Phone: 916/920-0300

- Client Contact

  Name: Mr. Fran Slavich
  Phone: 916/643-1250

- CH2M HILL Regional Manager

  Name: Steve DeCou/SAC
  Phone: 916/920-0300

- Personnel Office

  Name: Lynne Robertson/CVO
  Phone: 503/752-4271

  Name: Scott Olson/SAC
  Phone: 916/920-0300

If an injury occurs, notify the injured person's personnel office as soon as possible after obtaining medical attention for the injured. Notification MUST be made within 24 hours of the injury.

- CH2M HILL Director of Health and Safety for Waste Management and Industrial Processes

  Name: Marty Mathamel/WDC
  Phone: 703/471-1441

- CH2M HILL Corporate Personnel Office

  Name: Beth Brown/DEN
  Phone: 303/771-0900

Health and Safety Attachments:

- Appendix Q: Form 311, Emergency Phone Numbers
- Appendix R: Form 533, Record of Hazardous Waste Field Activity
- Appendix S: Material Safety Data Sheets
- Appendix T: Health and Safety Site Meeting Signature Page
- Appendix U: Health and Safety, Subcontractor Activities

Distribution of approved plan:

Project Manager (responsible for distribution to team members and client)
Director of Health and Safety

Plan Approval

This site safety plan has been written for the use of CH2M HILL's employees and subcontractors. CH2M HILL claims no responsibility for its use by others. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if these conditions change.

PLAN PREPARED BY: Robert Evangelista/SAC Date: 4/24/90
(name/office/home phone)

APPROVED BY: Jane Stansfield/DEN Date: 4/27/90
(name/office/home phone)

(Note to Preparer: SSPs for sites where the potential exists for exposure to ionizing radiation require the approval of the Radiation Health Officer.)

MODIFIED BY: Calvin Noling/CVO Date: 6/26/92
503/752-4271

MODIFICATIONS
APPROVED BY: Mollie Netherland/SEA Date: 7/9/92
(206/453-5005)

CH2M HILL Site Safety Plan Addendum No. 1

Note: This addendum pertains to work previously conducted and does not cover the activities that are currently being conducted. Consequently, no attachments or appendices to this addendum are included.

The health and safety program for CH2M HILL personnel working at McClellan Air Force Base (McClellan AFB) consists of a base site safety plan (SSP) and task-specific addendums. The base SSP contains general information that applies to all or most areas of the site. The base SSP contains: the project description, personnel responsibilities, site hazards, personal protective equipment (PPE), air monitoring guidelines, site control, decontamination procedures, and an emergency response plan. The task-specific addendums are written to add additional information regarding the specific source areas and field activities. The addendums not only define the specific field activities and team members, but they contain changes or clarifications of the potential hazards, air monitoring requirements, PPE, decontamination procedures, and emergency contacts. The addendums can be more or less restrictive than the base SSP, depending on the type of filed activities being conducted. **Neither the base SSP or the addendums are stand-alone documents; both documents contain important information and they must be used in conjunction with each other.**

Client: McClellan Air Force Base
Project No.: SAC28722.19
Project Manager: Jerry Tracy/CVO
Field Task Manager: Dave Myers/CVO
Site Name: McClellan Air Force Base, Operable Unit (OU) D, Site S (see Figure 1-1 in Section 1)
Dates of Field Visit: June through November, 1991
Overall Hazard: Low to moderate

Purpose of Field Visit: A soil vapor extraction (SVE) treatability investigation will be conducted at Site S in OU D. Soil samples will be taken from borings drilled on the site, and onsite headspace analyses will be conducted. Air permeability testing and SVE pilot testing will be performed at the site.

Physical Hazards

Because the drilling and sampling activities will be taking place during the summer months and PPE is being worn, heat stress is a major concern. See Attachment B to the base SSP for detailed information on heat stress.

To help lessen the effects of heat stress, personnel will be acclimated prior to working in extreme conditions. For nonacclimated workers in good physical condition, full acclimization takes 4 to 5 days. Work schedule will be adjusted as necessary to take advantage of the cooler, early morning hours. Provisions will be made to provide adequate lighting for predawn activities.

The work/rest schedule, as outlined in Attachment B, will be followed. In addition, cooling devices such as MSA's Core Control or Ice Chest Cooling Vest will be utilized, if necessary. To determine the effectiveness of these work and engineering controls, heat stress monitoring will be conducted when the ambient temperature is above 85° to 90°F.

Certain chemical substances will be provided by CH2M HILL to accomplish the field work. In accordance with 20 CFR 1920.1200, Hazard Communication, Material Safety Data Sheets for these products are included as appendixes.

Soil boring activities pose safety hazards to personnel in the immediate vicinity of the drill rig. To protect personnel from overhead falling objects (i.e., bolts, wrenches, pieces of pipe), hard hats must be worn in the immediate vicinity of the drill rig. Safety glasses are also required to protect against flying projectiles that could be caused by hammering fittings/connections and drive casings. No overhead powerlines or buried utilities are anticipated where the drilling is being conducted. Hearing protection (ear plugs) will also be required when working around the drilling equipment.

Because sampling will take place on the top of the cap and near the wells in OU D, trip, slip, and fall hazards are expected. During the rainy season (December to February), the potential for slipping and falling is greater than during the drier months.

Chemical Hazards

The contamination at the site is confined to the soils and the underlying groundwater. Because the site is covered with an impermeable, multilayer cap, the contaminated soil is not expected to present a hazard at the site until disturbed by drilling activities.

In all areas of the site during drilling, the volatile organic compounds shown in Table 1 (not presented) may be encountered in the soil at concentrations ranging from 1 to 100 ppm. In addition, the compounds listed in Table 2 (not shown) have been detected in soils onsite at levels less than 1 ppm. Except for 1,1,1-trichloroethane, all of these compounds can be detected using a 10.2 eV photoionization detector (PID).

Semivolatile organic compounds detected in the soils at Site S include the chemicals in Table 3 (not shown). These compounds would not be expected to volatilize, but exposures could occur via inhalation of dust particles. At the concentrations that were detected in the soils, exposures that would occur for dust concentrations below the nuisance dust level of 5 mg/m^3 would be acceptable.

Cyanide was detected in soils on and near Site S at levels ranging from 13 to 33 ppm. The permissible exposure limit (PEL) for cyanide is 5 mg/m^3, so the acceptable level for cyanide would not be exceeded for air particulate concentrations less than the nuisance dust levels.

Freon 113 has been detected at other waste sites within OU D, and there is a possibility that it could be encountered during drilling activities in Site S. Freon 113 has a high ionization potential (11.78 eV) and, therefore, cannot be detected with a photoionization detector. It can be detected with an organic vapor analyzer (OVA). The PEL for Freon 113 is 1,000 ppm.

Because OU D contains burn pits used for transformer oils and chlorinated solvents, dioxin could be present. Samples taken at another burn pit area on the Base indicates that the dioxin levels are very low (less than 0.17 ppb). However, because the allowable exposure level is also very low, it is possible that overexposures could occur at dust levels below the detection limit of the mini RAM detector. Therefore, Level C must be worn when drilling through the waste pit area, estimated to extend to 20 feet below ground surface.

Site Personnel: This Addendum adds site personnel as follows:

Starr Dehn/SAC	Project Administrator/Observer
Jo Danko/CVO	Project Engineer
Ken White	Project Geologist
Dave Myers/CVO	Project Engineer & Field Task Manager
Teresa Danovich/CVO	Project Hydrogeologist
Barry Collom/CVO	Field Technician/Level C SSC
Kevin Leary/PDX	Project Hydrogeologist

Level of Protection:

A: __ B: __ C: X D: X

Level C is required while drilling through the waste pit area. It is estimated that the first 20 feet of drilling will be completed in Level C, but the depth of the waste pit and other action levels will dictate when Level C is worn. After the drilling has been completed in the waste pit area the levels of protection will be determined based on the action levels outlined in the base SSP and in this addendum. This addendum is not approved for work in Level B.

Monitoring Equipment:

1. Explosimeter/0_2 meter. Monitoring frequencies and action levels outlined in the base SSP will be used.

2. Mini-Rad. Monitoring frequencies and action levels outlined in the base SSP will be used.

3. HNu. Monitoring frequencies and action levels outlined in the base SSP will be used.

4. Vinyl Chloride Detector Tubes. Monitoring frequencies and action levels outlined in the base SSP will be used.

5. OVA. The OVA will be used for the initial survey of each soil boring at the site to check for the presence of Freon 113 and other compounds with ionization potentials (IPs) above 10.2 eV. If during the initial survey it is determined that such compounds are present, OVA monitoring will be completed during all drilling at that location. If elevated readings are obtained on the OVA, it must first be determined if the elevated readings are due to methane. If the OVA and HNu readings are the same and explosimeter readings are not above background, the compounds being detected are those with an IP below 10.2 eV and methane is not present. The action levels for the HNu in the base plan will be followed.

   If the OVA readings are elevated and are higher than the HNu readings, the difference may be due to methane or compounds which have an IP greater than 10.2 eV. If the OVA and explosimeter readings indicate that methane is present, the explosimeter action levels in the base plan will be followed. If it is determine that the elevated readings are not due to methane, the HNu action levels in the base plan will be followed.

Addendum Written By: Kathy Brewer

Date: 4/12/91

Addendum Approved By: Mollie Netherland

Date: 4/22/91

CH2M HILL Site Safety Plan Addendum No. 2

The health and safety program for CH2M HILL personnel working at McClellan Air Force Base (McClellan AFB) consists of a base site safety plan (SSP) and task specific addendums. The base SSP contains general information that applies to all or most areas of the site. The base SSP contains: the project description, personnel responsibilities, site hazards, personal protective equipment (PPE), air monitoring guidelines, site control, decontamination procedures, and an emergency response plan. The task-specific addendums are written to add additional information regarding the specific source areas and field activities. The addendums not only define the specific field activities and team members, but they contain changes or clarifications of the potential hazards, air monitoring requirements, PPE, decontamination procedures, and emergency contacts. The addendums can be more or less restrictive than the base SSP, depending on the type of field activities being conducted. **Neither the base SSP or the addendums are stand-alone documents; both documents contain important information and they must be used in conjunction with each other.**

General Information

Client: McClellan Air Force Base
Project No.: SAC28722.38
Project Manager: Jerry Tracy/CVO
Field Task Manager: Ken White/SAC
Site Name: McClellan Air Force Base, Operable Unit (OU) D, Site S
Dates of Field Visit: June 1992 through May 1993
Overall Hazard: Low to moderate

Purpose of Field Visit: A soil vapor extraction (SVE) treatability investigation will be conducted at Site S in OU D. Soil samples will be taken from borings drilled on the site and SVE pilot testing will be performed at the site. Additional tasks will be conducted by Terra Vac, a CH2M HILL subcontractor. See Appendix T for the Health and Safety Plan that discusses Terra Vac's activities and the associated hazards.

Site Characteristics

The site characteristics are outlined in the base SSP.

Waste Characteristics

The waste characteristics are discussed in the base SSP.

Hazard Evaluation

Physical Hazards

Temperature Extremes. Because some of the drilling and sampling activities will be taking place during the summer months and PPE is being worn, heat stress is a major concern. See the base SSP for detailed information on heat stress.

To help lessen the effects of heat stress, personnel will be acclimated prior to working in extreme conditions. For nonacclimated workers in good physical condition, full acclimization takes 4 to 5 days. Work schedule will be adjusted as necessary to take advantage of the cooler, early morning hours. Provisions will be made to provide adequate lighting for predawn activities. The work/rest schedule, as outlined in the base SSP, will be followed. In addition, cooling devices such as MSA's Core Control or Ice Chest Cooling Vest will be utilized, if necessary. To determine the effectiveness of these work and engineering controls, heat stress monitoring will be conducted when the ambient temperature is above 73°F.

Other work during the SVE treatability study will take place during the cooler winter months. Although Sacramento is not prone to frequent sub-freezing temperatures, cold stress may be a concern. See the base SSP for detailed information on cold stress. To help lessen the effects of cold stress, personnel should wear layered clothing and have a change of clothing available onsite. If clothing becomes wet, it should be changed immediately. Personnel should take breaks in a heated area and drink warm fluids, but avoid those containing caffeine. They should avoid prolonged work when the wind chill factor is below 0°F and schedule a warmup break at least every 2 hours.

Soil boring activities pose safety hazards to personnel in the immediate vicinity of the drill rig. To protect personnel from overhead falling objects (i.e., bolts, wrenches, pieces of pipe), hard hats must be worn in the immediate vicinity of the drill rig. Safety glasses are also required to protect against flying projectiles that could be caused by hammering fittings/connections and drive casings. Loose clothing and long hair are prohibited in the area immediately adjacent to the drill rig. No overhead powerlines or buried utilities are anticipated where the drilling is being conducted, but location of buried utilities will be verified prior to drilling. Hearing protection (ear plugs) will also be required when working around the drilling equipment.

Trip, slip, and fall hazards are expected to be present especially during the rainy season (December to February). Personnel will use care when working in wet or muddy areas. In areas of extreme mud, pallets or similar devices will be used to reduce the slip and fall hazards.

Hazards typically encountered at construction sites will be a concern at this site. These include slippery ground surfaces, uneven terrain, holes/trenches, and operation of heavy equipment. The basic safety apparel such as steel-toed shoes, hard hats, and safety glasses will be worn during all construction activities by all employees involved. Personnel will remain at least 2 feet from the edge of holes and trenches and will not enter any excavations deeper than 4 feet unless properly shored or sloped in accordance with Cal-OSHA regulations. Personnel will remain in visual contact with the equipment operator and will remain outside of the equipment's working area.

Environmental Hazards

When weather conditions change, the Project Manager and the SSC will be responsible for determining if work procedures can be performed safely. If engineering controls are required to continue work, the procedures must be approved by the Site Safety Coordinator.

Noise Stress

Noise is defined as any undesirable sound. Excessive noise can destroy the ability to hear and may put stress on other parts of the body including the heart. Prevention from excessive exposure is the only way to avoid the health hazards of noise. Hearing protection will be provided to employees who work within 25 feet of the drill rig; in areas where conversations must be shouted at a distance of 3 feet. If it is anticipated that the 8-hour time weighted average (TWA) is 85 dbA or greater, monitoring is required. See the base SSP for sound level monitoring action levels.

Biologic Hazards

Venomous snakes and spiders may be found at this site. These cold-blooded animals are likely to be found in sunny locations during cold weather. During warm days they will most likely be found in shadow. Employees will be advised to take precautions. Long pants (e.g., tyvek) and boots will be worn to help protect employees from these hazards.

Chemical Hazards

The contamination at the site is confined to the soils and the underlying groundwater. Because the site is covered with an impermeable, multilayer cap, the contaminated soil is not expected to present a hazard at the site until disturbed by drilling activities. Since the site is covered with an impermeable, multi-layered cap, the contaminated soil is not expected to present a hazard during operation of the vacuum extraction system.

The primary hazard onsite is the possible release of potentially hazardous levels of volatile organic compounds from soils as the result of soil disturbance activities. In general, the soil contaminants have been shown to consist of various volatile and semivolatile organic compounds. A list of expected compounds with exposure limits is detailed in Table 8-5. Common symptoms of overexposure to compounds at the site are drowsiness, headache, dizziness, loss of coordination, fatigue, tremors or irritation of the eyes, nose, or throat. Compound-specific symptoms of overexposure are found in Table 8-5.

Table 8-5
Known Contaminants of Concern

Page 1 of 5

Contaminant	Location[c] and Highest Concentration (solid media: mg/kg or liquid media: µg/l)	PEL, REL, or TLV[a] (ppm)	IDLH[d,e] (ppm)	Symptoms and Effects of Exposure	PIP[b] (eV)
Acetone	S 170	250	20,000	Irrit eyes, nose, throat; head, dizz; derm	9.69
Ethylbenzene	S 6.7	100	2,000	Irrit eyes, muc memb; head; derm; narco, coma	8.76
Toluene	S 160	100	2,000	Ftg weak; conf, euph, dizz; head; dil pup; ner musc ftg; insom	8.82
Xylenes (o-/m-/p-)	S 200	100	1,000	Dizz, drow, inco, staggering gait; irrit eyes, nose, throat; vomit	8.45-8.56
Butanone	S 16	200	3,000	Irrit eyes, nose; head, dizz; vomit	9.48
4-Methyl-2-Pentanone (MIBK)	S 14	50	300	Irrit eyes, muc memb; head; dermal	9.30
Benzene	S 0.3	0.01	Ca	Irrit eyes, nose, resp syst; dizzy; head; nau; bone marrow depres; abdom pain	9.25
2-Hexanone	S 1,700	50	5,000	Irrit eyes, nose; peripheral neuropathy; weak, pares; derm; head; drow	9.34
Carbon tetrachloride	S 0.032	2	Ca	CNS depres; nau, vomit; liver, kidney damage; skin irrit	11.28
Chloroform	S 0.001	2	Ca	Dizz, mental dullness; nau; head; ftg; hepatomegaly; irrit eye, skin	11.42
benzyl alcohol	S 49	NL[e]	NL	Irrit eyes, skin	NL
bis(2-ethylhexyl)phthalate	S 61	5 mg/m^3	Ca	Irrit eyes, muc memb, nau; diarr	NL
di-N-butylphthalate	S 0.55	5 mg/m^3	NL	Systemic eye effects by ingestion	NL
phenol	S 0.92	5	250	Irrit eyes, nose, throat; anor, low-wgt; weak; urine; cyan; liver, kidney damage	8.50
1,2,4 trichlorobenzene	S 4	5 (ceiling)	NL	No information found in literature	9.37
butylbenzylphthalate	S 2	NL	NL	Moderately toxic by inhalation	NL
phenanthrene	S 2	NL	NL	Skin photosensitizer	NL
4-methylphenol	S 5.1	5	250	CNS effects, conf depres, resp fail, dysp, irreg rapid resp, weak pulse, sking and eye burns; derm	NL
benzoic acid	S 170	NL	NL	Irrit eyes and sking	NL
2,4-dimethylphenol	S 0.62	NL	NL	No information found in literature	NL
2-methylphenol	S 0.065	5	250	CNS effects, cont. depres, rep failure, dysp, irreg rapid resp, weak pule, skin and eye burns, derm	NL
2-methylnaphthalene	S 8.8	NL	NL	No information found in literature	NL

Table 8-5
Known Contaminants of Concern

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Contaminant	Location[c] and Highest Concentration (solid media: mg/kg or liquid media: µg/l)	PEL, REL, or TLV[a] (ppm)	IDLH[d,e] (ppm)	Symptoms and Effects of Exposure	PIP[b] (eV)
Fluoranthene	S 5.8	NL	NL	Toxic by ingestion and skin contact	NL
Napthalene	S 3.3	10	500	Eye irrit; head; conf; hema, hemog bladder, profuse sweat	8.14
2,4,5-trichlorophenol	S 0.5	NL	NL	*Toxic by ingestion and subcutaneous route*	NL
Fluorene	S 3.3	NL	NL	No information found in literature	NL
2,4,7,8-tetrachlorodibenzo-p-dioxin (TCDD) Equivalents	*S 0.00109*	*4x10^{-11} mg/m^3*	NL	*Carcinogenic*	NL
1,1,1-trichloroethene	S 414	25	Ca	Head, verti, vis dist, tremors, som, nau, vomit, irrit eyes, derm, card arrhy, pares	9.45
cis/trans 1,2-dichloroethene	S 35	200	4,000	Irrit eyes, resp sys; CNS depression	9.65
methylene chloride	S 4,548	50	Ca	Ftg weak, sleep, li-head, vertigo, worsen angino	11.35
trichloroethene	S 172		Ca	Head, vertigo, vis dist, tremors, somnolence; card, arrhy	9.47
1,2-dichlorobenzene	S 21	50 (ceiling)	1,000	Irrit eye, skin, mucous memb	9.07
1,3-dichlorobenzene	S 28	NL	NL	No information found in literature	9.12
1,4-dichlorobenzene	S 50	75	Ca	Head, eye irrit, ahor, nau, vomit, jaun	8.94
chlorobenzene	S 200	10	2,400	Irrit skin, eyes, nose; drow, inco; liver damage	9.07
1,1,1-trichloroethane	S 687	350	1,000	Head, lass, CNS depres, poor equi, irri eyes, derm, card arrhy	11.25
1,1,2-trichloroethane	S 0.08	10	Ca	Irrit nose, eyes; CNS depression; liver, kidney damage	NL
1,1-dichloroethane	S 16	100	4,000	Irrit nose, eyes; CNS depression; liver, kidney damage	11.06
1,1,2,2-tetrachloroethane	S 0.02	1	Ca	Nau, vomit, abdomin pain, tremer fingers; kidney damage, pares	11.10
1,1-dichloroethene	S 1.6	100	4,000	Irrit eyes, resp syst; CNS depression	9.65
Freon 113	S 14		4,500	Irrit throat, drow, derm	11.99
tetrachloroethene	S 425	25	Ca	Irrit eyes, nose; throat; nau; flush face, vertigo, somn	9.32
vinyl chloride	S 0.007	1	Ca	Weak, abdom pain, GI bleeding, hematomegaly	10.00

Table 8-5
Known Contaminants of Concern

Contaminant	Location[c] and Highest Concentration (solid media: mg/kg or liquid media: µg/l)	PEL, REL, or TLV[a] (ppm)	IDLH[d,e] (ppm)	Symptoms and Effects of Exposure	PIP[b] (eV)
1,2-dichloroethane	S 0.28	1	CA	CNS depres, nau, vomit, derm, irrit eyes, corneal opacity	11.04
trichlorofluoromethane	S 0.03	10	NL	Systemic eye and PNS effects	NL
1,2-dichloropropane	S 5	75	Ca	Irrit eyes, drow, li-head, irrit skin	10.87
Aroclor-1260	S 3.1	0.001 mg/m^3	Ca	Irrit eyes and skin	NL
Aroclor-1254	S 2.4	0.001 mg/m^3	Ca	Irrit eyes, skin, acne-form derm	NL
Heptachlor	S 0.001	0.05 mg/m^3	Ca	Tremors, convuls, liver damage	NL
4,4'-DDD	S 0.17	0.05 mg/m^3 (DDT)	Ca (DDT)	Pares tongue, lips, face; tremor, appre, dizz, conf, head, ftg, convuls, irrit skin, eyes	NL
4,4'-DDE	S 0.04	0.05 mg/m^3 (DDT)	Ca (DDT)	Pares tongue, lips, face; tremor, appre, dizz, conf, head, ftg, convuls, irrit skin, eyes	NL
Aldrin	S 12	0.25 mg/m^3	Ca	Head, dizz; nau, vomit, mal; myoclanic jerks of limbs	NL
Endrin	S 4	0.1 mg/m^3	2,000 mg/m^3	Epileptiform convuls, stupor, vomit, aggressive confusion, head, dizz, abdom discomfort	NL
Total petroleum hydrocarbons (TPH)	S 1,900	NL	NL	Irrit eye, skin; headache	NL
JP-5	S 25,000	NL	NL	No information found in literature	NL
Diesel	S 4,900	NL	NL	Irrit eye, skin; headache	NL
Aluminum (Al)	S 42,500	10 mg/m^3 (metal dusts)	NL	Pulm fibrosis, Alzheimers	NL
Antimony (Sb)	S 4.4	0.5 mg/m^3	80 mg/m^3	Irrit nose, throat, mouth; cough; dizz; head, unable to smell; cardiac	NL
Arsenic (As)	S 13	0.5 mg/m^3 (soluble compounds)	Ca	Ulceration of nas septum, derm, GI disturbances, hyperpig of skin	NL
Barium (Ba)	S 574	0.5 mg/m^3	250 mg/m^3	Upper resp irrit; GI; musc spas, slow pulse, extra systoles	NL
Beryllium (Be)	S 2.4	0.002 mg/m^3 0.0005 mg/m^3 (ceiling	Ca	Resp symptoms, weak, ftg; weight loss	NL
Cadmium (Cd)	S 40	0.05 mg/m^3 (dusts and salts	Ca	Plum adema dysp, cough, tight chest; nau, diarr, anos, emphy	NL

Table 8-5
Known Contaminants of Concern

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Contaminant	Location[c] and Highest Concentration (solid media: mg/kg or liquid media: µg/l)	PEL, REL, or TLV[a] (ppm)	IDLH[d,e] (ppm)	Symptoms and Effects of Exposure	PIP[b] (eV)
Calcium (total) (Ca)	S 10,800	NL	NL	Irrit eyes, upper resp tract; ulcer, perforate nasal septum	NL
Chromium (dissolved) (Cr)	S 365	0.5 mg/m^3 (Cr III, Cr metal) 0.05 mg/m^3 (Cr VI)	NE[f]	Histologic fibrosis of lungs, sens derm	NL
Cobalt (Co)	S 25.1	0.05 mg/m^3 (dust and metal fumes)	20 mg/m^3	Cough, resp hypersensitivity diffuse nodular fibrosis	NL
Copper (Cu)	S 313	1 mg/m^3 (dusts and mists)	NE	Irrit muc memb, pharynx, nas perforation, eye irrit	NL
Iron (Fe)	S 51,500	1 mg/m^3 (soluble salts)	NL	(Iron oxide dust and fumes) Benign pneumoconiosis, x-ray shadows	NL
Lead (Pb)	S 713	0.05 mg/m^3 (inorganic dusts and fumes)	700 mg/m^3	Lass; insom; hypotense; anemia, gingival lead line	NL
Magnesium (dissolved) (Mg)	S 17,000	NL	NL	(Mn oxide) Irrit eyes, nose; flu-like fever; cough, chest pain	NL
Manganese (dissolved) (Mn)	S 1,420	5 mg/m^3 (dusts and compounds)	NE	Parkinson's, asthenia, dry throat, low-back pain, vomit, mal; ftg	NL
Mercury (Hg)	S 1.8	0.01 mg/m^3 (alkyl compounds) 0.05 mg/m^3 (all forms except alkyl vapor)	28 mg/m^3 (vapor) 10 mg/m^3 (alky/ compounds)	(Hg vapor) Cough, tremor, indecision; stomatitis, irrit eyes, skin. (Akly compounds) Pares, atoxia, vision and hearing dist, spastic jerking; dizz; salv; lac; nau, vomit; diarr	NL
Nickel (Ni)	S 95.3	0.015 mg/m^3 0.1 mg/m^3 (inorganic and aryl compounds)	Ca	Head; vert; nau, vomit	NL
Potassium (dissolved) (K)	S 7,340	NL	NL	Toxicity dependant on toxicity of anion	NL
Selenium (Se)	S 0.33	0.2 mg/m^3	NL	Irrit eyes, nose, throat, blur eyes, garlic breath, GI derm	NL
Silver (Ag)	S 35	0.01 mg/m^3 (metal)	NE	Blue-gray eyes, nasal septum, throat, skin; irrit	NL
Sodium (dissolved) (Na)	S 1,290			Toxicity depends on compound	NL
Vanadium (V)	S 269	NL	NL	Irrit eyes, resp tract	NL
Zinc (Zn)	S 981	NL	NL	Irrit skin, pulm syst	NL

Table 8-5
Known Contaminants of Concern

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Contaminant	Location[c] and Highest Concentration (solid media: mg/kg or liquid media: µg/l)	PEL, REL, or TLV[a] (ppm)	IDLH[d,e] (ppm)	Symptoms and Effects of Exposure	PIP[b] (eV)
Cyanide	S 3.1	5 mg/m³	50 mg/m³	Asphyxia and death can occur; slow gasping resp; eye, skin irrit	NL
Thormium (dissolved) (Th)	S 0.68	NL	NL	Neurit derm	NL

[a] Lower value of PEL, REL, or TLV listed.
[b] PIP = photoionization potential.
[c] Location refers to physical location.
[d] Ca = NIOSH recommends substance be treated as a potential human carcinogen; IDLHs are not listed for these compounds.
[e] NL = No level found in literature.
[f] NE = No level established.

abdom = abdominal
anor = anorexia
anos = anosmia
appre = apprehension
arrhy = arrhythmias
asth = asthma
blur = blurred
card = cardiac
CNS = central nervous system
conf = confusion
convuls = convulsions
cyan = cyanosis
depres = depressant/depression
derm = dermatitis
diarr = diarrhea
dil = dilated
drow = drowsiness
dysp = dyspnea
emphy = emphysema
equi = equilibrium
euph = euphoria
ftg = fatique
GI = gastrointestinal
hema = hematuria
hemog = hemoglobinuria
inco = incoordination
insom = insomnia
irreg = irregular
irrit = irritation
jaun = jaundice

lac = lacrimation
lass = lassitude
li-head = *lightheadedness*
low-wgt = weight loss
mal = malaise
muc memb = mucous membrane
musc = muscle
narco = narcosis
nas = nose/nasal
nau = nausea
ner = nervousness
neur = neurologic
pares = paresthesia
PNS = *Periphal nervous system*
pulm = pulminary
pup = pupil
resp syst = respiratory system
sens = sensitization
som = somnolence
spas = spasm
verti = vertigo
vis dist = visual disturbance
vomit = vomiting
weak = weakness

Table 8-6
Personal Protective Equipment (PPE) Specification (Reference CH2M HILL SOP HS-07 and HS-08)

Task	Level	Body	Foot	Head[1]	Eye	Hand	Respirator
All tasks except those in the waste pit	D (modified)	Cotton coveralls; coated Tyvek if splash potential present	Neoprene steel-toed/shanked boots	Hardhat	Safety glasses Safety goggles if splash potential present	Nitrile inner and outer gloves, taped to tyvek if splash potential present.	None required.
All tasks in waste pit or when OVA action levels are exceeded.	C[2]	Tyvek. Coated Tyvek if splash potential present.	Neoprene steel-toed/shanked boots taped to Tyvek.	Hardhat	Not applicable with full face respirator.	Neoprene outer and nitrile inner gloves taped to Tyvek.	APR, full face, MSA Ultratwin or equivalent cartridges: GMC-H or equivalent.

Note 1: The SSC shall specify hardhat areas.
Note 2: Level C will not protect against vinyl chloride, methylene chloride, or hydrogen cyanide.

Table 8-7
Reasons to Upgrade or Downgrade Level of Protection

Upgrade	Downgrade
• Request of individual performing task. • Change in work task that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decreases the hazard. • Change in work task that will reduce contact with hazardous materials.

Table 8-8
Potential Routes of Exposure

Dermal: Dermal contact with contaminated media can occur during all sampling activities. This potential route of exposure will be controlled through the use of Personal Protective Equipment (PPE).	**Inhalation:** Inhalation of volatile vapors or contaminated dust can occur. Exposure from this route will be controlled through use of good work practices and engineering controls and the use of PPE.	**Other:** Incidental ingestion of contaminated material can occur if personnel do not wash their hands and face prior to eating, drinking, and smoking.

Semivolatile organic compounds detected in the soils at Site S would not be expected to volatilize, but exposures could occur via inhalation of dust particles. At the concentrations that were detected in the soils, exposures that would occur for dust concentrations below the nuisance dust level of 5 mg/m^3 would be acceptable.

Although dioxins and furans were detected in several soil samples at Site S, no TCDDs or TCDFs, the compounds of primary concern, were detected. The toxicity of the mixture of isomers at the reported concentrations was calculated using EPA's I-TEF/89 2,4,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxic equivalency methodology and factors. The highest TCDD equivalent concentration calculated was 1.09 ppb, considerably less than the 10 ppb threshold contaminant level for TCDD used under California law to define a hazardous waste. However, because the allowable exposure level is also very low, it is possible that overexposures could occur at dust levels below the detection limit of the mini RAM detector. Therefore, Level C must be worn when drilling through the waste pit area, estimated to extend to 20 feet below ground surface. Samples collected below the waste pit which were analyzed for dioxin did not contain detectable concentrations.

Certain chemical substances will be provided by CH2M HILL to accomplish the field work. In accordance with 29 CFR 1920.1200, Hazard Communication, Material Safety Data Sheets for these products are included in Appendix L.

Procedures

Site Personnel

The training requirements for the site personnel are identified in the base SSP.

Team Member/Office	Responsibilities
Jo Danko/CVO	SVE Technical Coordinator
Ken White/SAC	Project Geologist & Field Task Leader
Barry Collom/CVO	Field Technician/Level C SSC

Level of Protection

A: __ B: __ C: X D: X

Tables 8-6 and 8-7 outline the required personal protective equipment (PPE), and reasons to up- and down-grade levels of protection, respectively. Table 8-8 outlines the potential routes of exposure to contaminants.

Monitoring Equipment

1. Explosimeter/0_2 meter. Monitoring frequencies and action levels outlined in the base SSP will be used.

2. Mini-Rad. Monitoring frequencies and action levels outlined in the base SSP will be used.

3. HNu. The HNu with a 10.2 eV lamp cannot detect a variety of compounds, including Freon 12, 1,1,1-TCA, 1,1-DCA, and methylene chloride, detected at the site. Because of this limitation, the HNu with a 10.2 eV cannot be used as the sole instrument for health and safety monitory. The HNu with a 11.7 eV lamp or an OVA will be used. If the HNu with an 11.7 eV lamp is used, follow the action levels in the base SSP. (If the OVA is used, see OVA monitoring requirements below.)

4. Vinyl Chloride Detector Tubes. Monitoring frequencies and action levels outlined in the base SSP will be used. If there is a color change in the detector tube, Level B protection is required unless laboratory analysis indicates that vinyl chloride is not present.

5. OVA. The OVA will be used for the initial survey of each soil boring at the site to check for the presence of compounds with ionization potentials (IPs) above 10.2 eV. If during the initial survey it is determined that such compounds are present, OVA monitoring will be utilized during all drilling at that location. If elevated readings are obtained on the OVA, it must be determined if the elevated readings are due to methane. This can be determined by using a charcoal filter provided with the OVA. The action levels in the base SSP will be followed.

Emergency Response Plan

This section is addressed in the base SSP.

Emergency Contacts

This section is addressed in the base SSP.

Plan Approval

Addendum Written By: Calvin Noling/CVO

Date: 6/29/92

Addendum Approved By: Mollie Netherland/SEA

Date: 7/9/92

Section 9

Residuals Management

Soil

Drill cuttings from the soil borings will be temporarily stored onsite in rolloff bins and/or 55-gallon drums. Two grab samples from each bin or one from every 10 drums will be collected at the conclusion of each sampling period (pre-operation, mid-operation, and post-operation soil investigations) and analyzed in accordance with the toxicity characteristic leaching procedure (TCLP), and for total petroleum hydrocarbon (TPH) (EPA Method 8015/8020), and aquatic toxicity (EPA/600/4-90/027). Samples will also be tested for comparison with total threshhold limit concentration (TTLC). The analytical data will be used to determine the identification and disposition for the waste stream. Ultimate disposition of the drill cuttings will be handled by McClellan AFB.

Sample Designation

The rolloff bins will be labeled to enable cross referencing of the soil samples with rolloff bins.

The station code for soil characterization samples will be CHAR for characterization. The sample code will consist of a dash (-) followed by a sequential sample number beginning with 01. The letters A and B will be used to designate pairs of grab samples collected from a single bin.

Example:	CHAR-01A	(soil characterization, Bin No. 1, first grab sample)
	CHAR-03B	(soil characterization, Bin No. 3, second grab sample)
	CHAR-04	(soil characterization, drum, grab sample)

Water

Waste liquids generated during the drilling program will consist of water used for decontamination of drilling/testing equipment and personnel. Water will also be generated in the air/water separator during operation of the pilot system. CH2M HILL will coordinate handling and disposal of the wastewater at the on-base wastewater treatment plant. Wastewater will be temporarily held onsite until it can be disposed.

Solid Waste

Disposable materials contaminated during the sampling operations (e.g., tyveks, booties, gloves, teflon tubing) will be placed in plastic bags for disposal. Ultimate responsibility for the disposal of the accumulated materials will lie with McClellan AFB.

Carbon canisters used for soil gas treatment during the soil gas sampling will be disposed of offsite by a CH2M HILL subcontractor. McClellan AFB will be listed as the generator of this waste.

Section 10
Reports

In addition to the Work Plan, the following reports are required for Phases II and III of the SVE treatability investigation:

- Data Management Manual—refer to Section 7 for discussion of this document.

- Operations and Maintenance Plan—This report will provide operating and maintenance data for the process equipment, valves, and instrumentation. Startup and shutdown procedures, including automatic shutdown features for the catalytic oxidation system, will also be included.

- Pilot System Evaluation Final Report—This report will summarize the sampling and analytical data and other information obtained during the SVE treatability investigation. Estimates will be made of the mass of contaminants removed during the pilot test and the degree of biodegradation in the waste pit and the intermediate zone. The impact of hot air enhancement will be evaluated, and the overall SVE system evaluated considering implementability, cost, mass of contaminants removed, and adherence to ARARs. Recommendations will be made as to the full-scale implementation of SVE at OU D and other McClellan sites.

- Monthly Operations Reports—Monthly operations reports will be prepared during those months the pilot system is in operation. The reports will summarize operational data gathered during the field test such as extraction well offgas concentrations, total mass of contaminants removed, destruction efficiency of the catalytic oxidizer, and discussion of any system shutdowns.

The Work Plan, the Pilot System Installation and Site Characterization Summary Report, and the Pilot System Evaluation Final Report will be submitted in a three-stage approach as follows:

- Working draft copy for internal review by McClellan AFB
- Draft copy for regulatory agency review
- Formal written response to agency review comments on the draft copy

The Data Management Plan, Operations and Maintenance Manual, and the monthly Operations Reports will be submitted to McClellan AFB as internal documents. No agency review of these documents is planned. A draft copy will be submitted initially for McClellan AFB review, followed by a final copy that incorporates the review comments.

Section 11
Schedule

A copy of the current project schedule is shown on Figure 11-1. The Phase II work began in February with the preparation of the draft data management plan and will continue through April 1993 with submission of the response to review comments for the Installation and Site Characterization Technical Memorandum. At that time, it is anticipated that the Phase III effort (operation of the pilot system and analysis of the resultant data) will be under contract and in progress.

A list of Phase II deliverables and their contractual deliverable dates is shown in Table 11-1.

Table 11-1
SVE Schedule

Deliverable	Due Date
Draft Copy-Data Management Plan	March 20, 1992
Final Copy-Data Management Plan	April 15, 1992
Working Copy-Work Plan (w/SAP,etc.)	April 16, 1992
Draft Copy-Work Plan (w/SAP,etc.)	May 8, 1992
Agency review comments	June 8, 1992
Draft Copy-O&M Plan	May 11, 1992
Final Copy-O&M Plan	July 30, 1992
Responses to agency review comments on Work Plan	July 17, 1992
Working Copy–Bioventing Performance Report	TBD
Draft Copy–Bioventing Performance Report	TBD
Agency review comments–Draft copy Bioventing Performance Report	TBD
Response to agency review comments on draft copy Bioventing Performance Report	TBD
Working Copy–Pilot System Evaluation Report	TBD
Draft Copy–Pilot System Evaluation Report	TBD
Agency review comments on draft copy Pilot System Evaluation Report	TBD
Response to agency review comments on draft copy Pilot System Evaluation Report	TBD

TBD = To be determined.

Phase II SVE Treatabi
McCl
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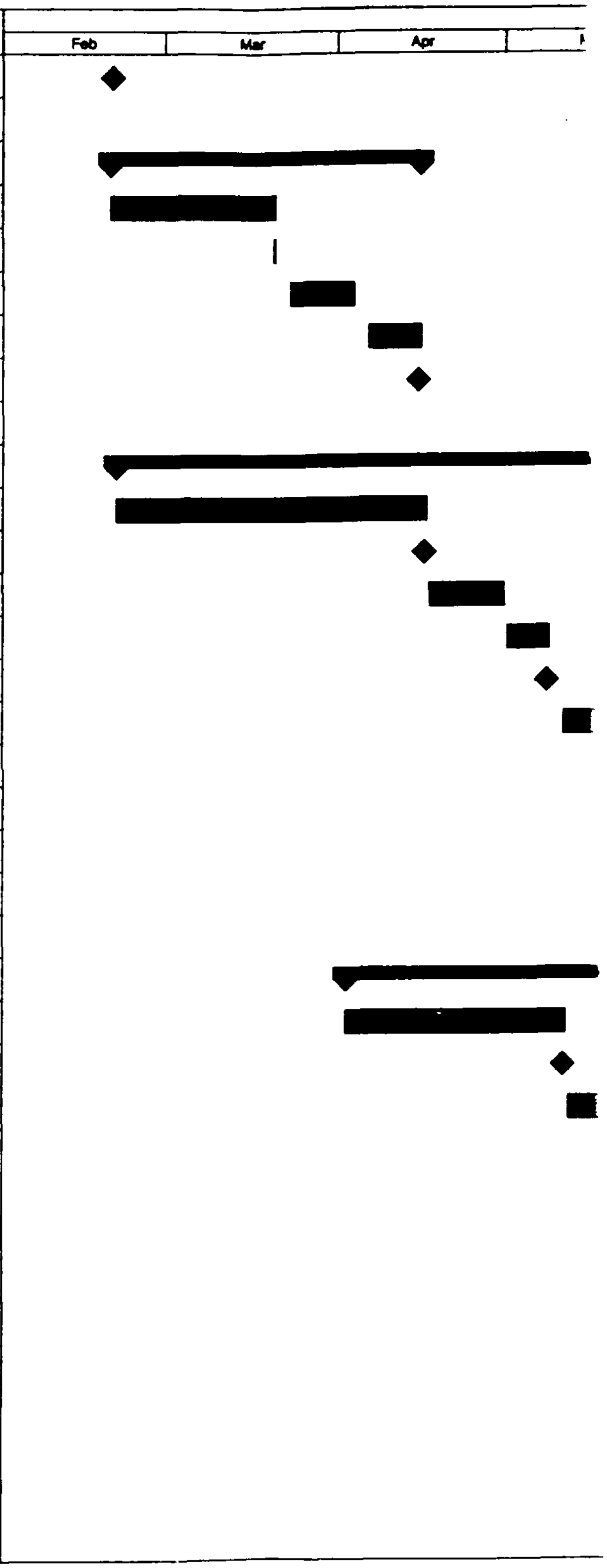
ID	Name	Duration	Scheduled Start	Scheduled Finish
1	Project Kickoff	0d	2/20/92 5:00pm	2/20/92 5:00pm
2				
3	Data Management Plan	40d	2/20/92 8:00am	4/15/92 5:00pm
4	Prepare Draft Copy	22d	2/20/92 8:00am	3/20/92 5:00pm
5	Submit Draft Copy	0.38ed	3/20/92 8:00am	3/20/92 5:00pm
6	AF Review	11.38ed	3/23/92 8:00am	4/3/92 5:00pm
7	Prepare Final Copy	8d	4/6/92 8:00am	4/15/92 5:00pm
8	Submit Final Copy	0d	4/15/92 8:00am	4/15/92 8:00am
9				
10	Work Plan w/SAP, QAPP, & HASP	136d	2/21/92 8:00am	8/28/92 5:00pm
11	Prepare Working Copy	55.38ed	2/21/92 8:00am	4/16/92 5:00pm
12	Submit Working Copy	0d	4/16/92 8:00am	4/16/92 8:00am
13	AF Review	2w	4/17/92 8:00am	4/30/92 5:00pm
14	Prepare Draft Copy	6d	5/1/92 8:00am	5/8/92 5:00pm
15	Submit Draft Copy	0d	5/8/92 8:00am	5/8/92 8:00am
16	Agency Review	30ed	5/11/92 8:00am	6/10/92 8:00am
17	Prepare Draft Final Copy & Response to Comme	37.38ed	6/10/92 8:00am	7/17/92 5:00pm
18	Submit Draft Final Copy & Response to Commer	0d	7/17/92 8:00am	7/17/92 8:00am
19	Prepare Final Copy	2w	8/17/92 8:00am	8/28/92 5:00pm
20	Submit Final Copy	0d	8/28/92 8:00am	8/28/92 8:00am
21				
22	O&M Manual	48d	4/2/92 8:00am	6/8/92 5:00pm
23	Prepare Draft Copy	39.38ed	4/2/92 8:00am	5/11/92 5:00pm
24	Submit Draft Copy	0d	5/11/92 8:00am	5/11/92 8:00am
25	Prepare Final Copy	27.38ed	5/12/92 8:00am	6/8/92 5:00pm
26	Submit Final Copy	0d	6/8/92 8:00am	6/8/92 8:00am
27				
28	Pre-demonstration Wells & Analytical Testing	89d	6/12/92 8:00am	10/14/92 5:00pm
29	Subcontractor Procurement	20.38ed	6/12/92 8:00am	7/2/92 5:00pm
30	Install Wells	22.38ed	7/20/92 8:00am	8/11/92 5:00pm
31	Analytical Testing	42.38ed	8/5/92 8:00am	9/16/92 5:00pm
32	Data Validation	5w	9/10/92 8:00am	10/14/92 5:00pm
33				
34	Vadose Zone Process Analysis	25d	9/17/92 8:00am	10/21/92 5:00pm
35	Analyze Vadose Zone Transport Mechanisms	34.38ed	9/17/92 8:00am	10/21/92 5:00pm

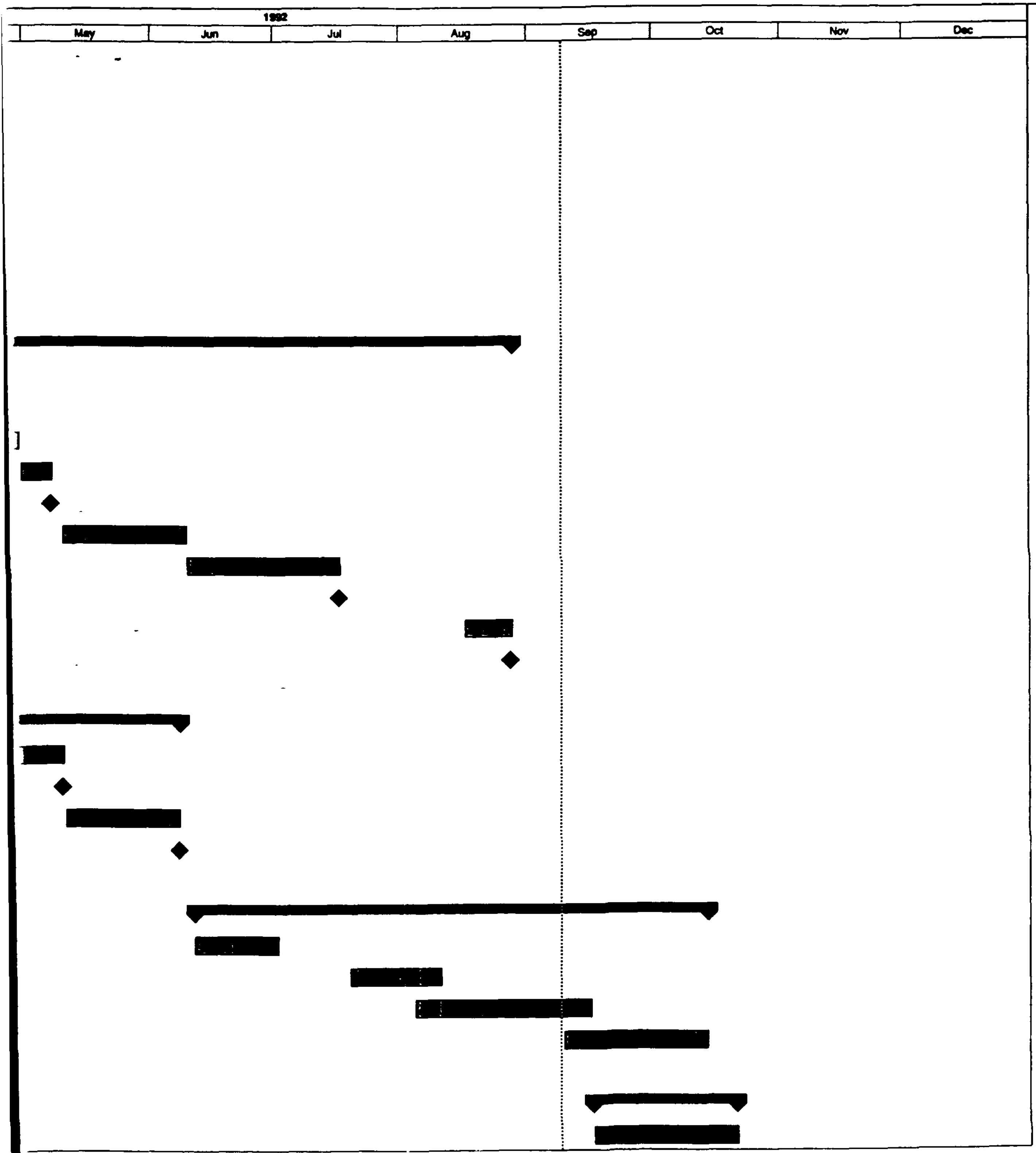


oject: McClellan AFB
Date: 9/9/92

Critical ■ Noncritical ■ Progress ▬ Milestone

SVEphIIMP

Treatability Investigation Schedule
McClellan AFB
August 1992



Milestone ◆ Summary Rolled Up ◇

Figure 11-1

2

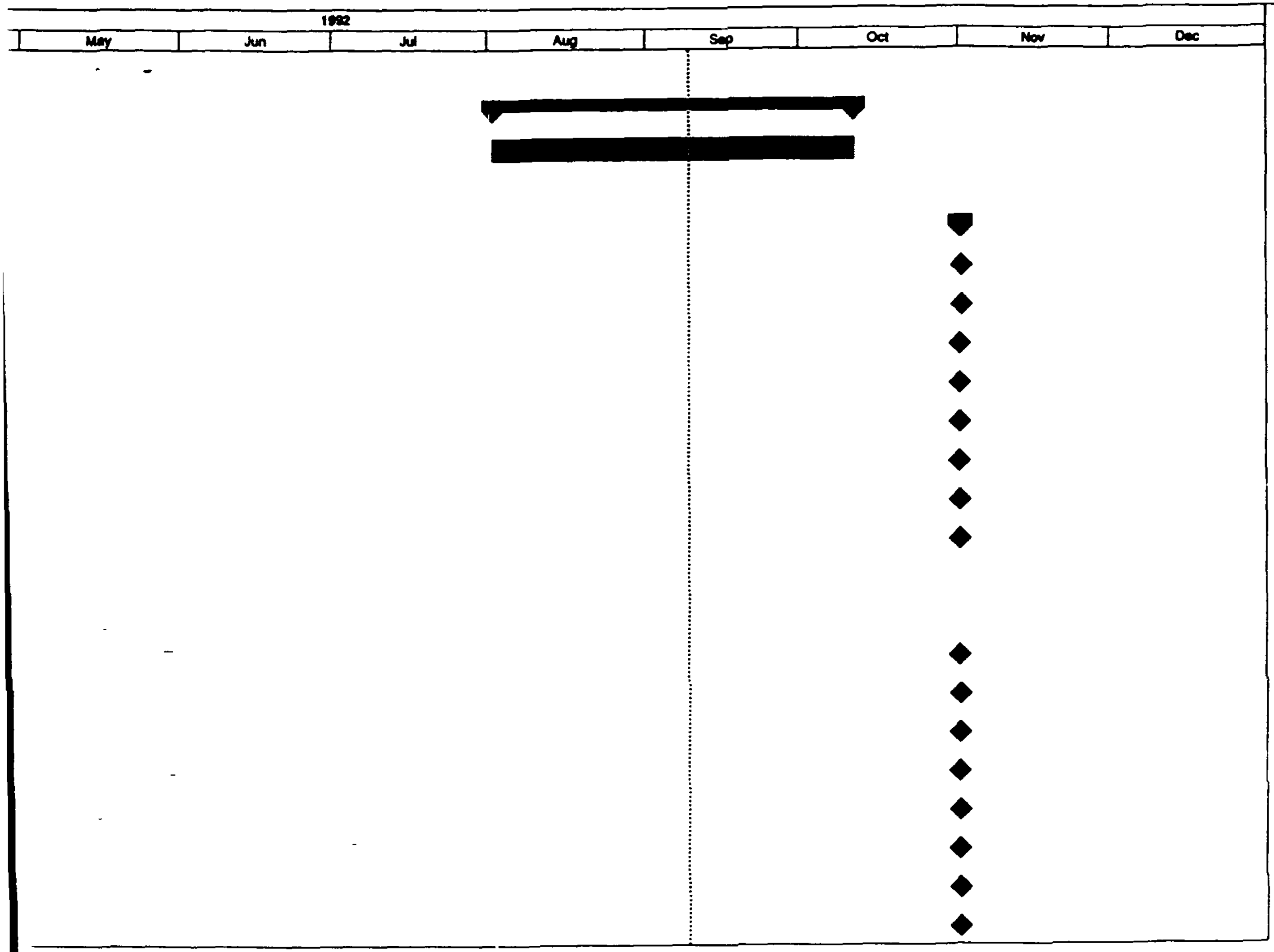
Phase II SVE Treatability I
McClellan
August 1

ID	Name	Duration	Scheduled Start	Scheduled Finish	Feb	Mar	Apr	May
36								
37	Process Equipment Installation	50d	8/2/92 8:00am	10/11/92 5:00pm				
38	Install Equipment	70.38ed	8/2/92 8:00am	10/11/92 5:00pm				
39								
40	Bioventing Performance Report	0d	11/1/92 8:00am	11/1/92 5:00pm				
41	Prepare Working Copy	0d	11/1/92 5:00pm	11/1/92 5:00pm				
42	Submit Working Copy	0d	11/1/92 5:00pm	11/1/92 5:00pm				
43	AF Review	0d	11/1/92 8:00am	11/1/92 8:00am				
44	Prepare Draft Copy	0d	11/1/92 8:00am	11/1/92 8:00am				
45	Submit Draft Copy	0d	11/1/92 8:00am	11/1/92 8:00am				
46	Agency Review	0d	11/1/92 8:00am	11/1/92 8:00am				
47	Prepare Response to Comments	0d	11/1/92 8:00am	11/1/92 8:00am				
48	Submit Response to Comments	0d	11/1/92 8:00am	11/1/92 8:00am				
49								
50	Pilot System Evaluation Report	0d	11/1/92 8:00am	11/1/92 8:00am				
51	Prepare Working Copy	0d	11/1/92 8:00am	11/1/92 8:00am				
52	Submit Working Copy	0d	11/1/92 8:00am	11/1/92 8:00am				
53	AF Review	0d	11/1/92 8:00am	11/1/92 8:00am				
54	Prepare Draft Copy	0d	11/1/92 8:00am	11/1/92 8:00am				
55	Submit Draft Copy	0d	11/1/92 8:00am	11/1/92 8:00am				
56	Agency Review	0d	11/1/92 8:00am	11/1/92 8:00am				
57	Prepare Response to Comments	0d	11/1/92 8:00am	11/1/92 8:00am				
58	Submit Response to Comments	0d	11/1/92 8:00am	11/1/92 8:00am				

Project: McClellan AFB
Date: 9/9/92

Critical ■ Noncritical ■ Progress ▬ Milestone ◆

Treatability Investigation Schedule
McClellan AFB
August 1992



Milestone ◆ Summary ▬ Rolled Up ◇

Figure 11-1

Section 12
Management and Staffing

Overall project responsibilities for the basewide RI/FS are presented and described in the existing IRP Quality Assurance Project Plan (QAPP). The specific responsibilities relating to the SVE treatability investigation are described below.

CH2M HILL Project Staff

CH2M HILL has overall responsibility for all phases of the SVE treatability investigation. Some of the work will be subcontracted, including drilling, analytical testing, and assistance with in situ permeability testing. CH2M HILL will perform project management and coordinate all subcontracted efforts, as well as prepare the design of the pilot-scale SVE system and all project reports related to the treatability investigation.

Table 12-1 shows key CH2M HILL project team members and their responsibilities.

Project Management

Mr. Starr Dehn is the Program Manager for all CH2M HILL work at McClellan AFB. He is responsible for the contractual aspects of all CH2M HILL projects at McClellan AFB, and provides coordination and continuity among the various projects. Mr. Dehn is located in CH2M HILL's Sacramento, California, office.

Mr. John Lucero is the Subprogram Manager for work at McClellan AFB. He is responsible for the administrative aspects and coordination of CH2M HILL's activities within OU D.

Mr. Jerry Tracy is the Project Manager for the Soil Vapor Extraction Treatability Investigation at Site S. He is responsible for managing the daily project activities and ensuring that the project objectives are met. Mr. Tracy is located in CH2M HILL's Corvallis, Oregon, office where the specific design activities will be conducted.

Mr. Joseph Danko is the Technical Coordinator for the project. He is responsible for coordinating the implementation of soil vapor extraction technology to the project-specific conditions. He is also responsible for coordinating analytical testing and in situ air permeability testing requirements and ensuring that the designated QA procedures are followed. Mr. Danko is located in CH2M HILL's Corvallis, Oregon, office.

Table 12-1
Project Staffing and Organization

Responsibility	Team Member/Location/Phone #
McClellan Program Manager	Starr Dehn/SAC/X-296
McClellan Sub-Program Manager	John Lucero/RDD/X-3285
Project Manager	Jerry Tracy/CVO/X-3562
SVE Technical Coordinator	Jo Danko/CVO/X-3527
Assistant Project Manager and Data Coordinator	Calvin Noling/CVO/X-3599
Data Management	Mary Camarata/CVO/X-3539
Data Validation	Donna Morgans/CVO/X-3500
Vadose Zone Transport Processes	Fritz Carlson/RDD/X-3332
Field Team Leader (Borings)	Ken White/SAC/X-236
Community Relations and Permitting Issues	Pamela Beekley/SAC/X-292
Contracting Issues	Tom McCubbins/SFO/X-2259

Notes: SAC = Sacramento, CA, office, phone #: 916/920-0300.
RDD = Redding, CA, office, phone #: 916/243-5831.
CVO = Corvallis, OR, office, phone #: 503/752-4271.
SFO = San Francisco, CA, office, phone #: 510/652-2426.

Mr. Calvin Noling is the Assistant Project Manager and Data Coordinator for the SVE Treatability Investigation. He will assist the project manager in executing the project tasks. As data coordinator, Mr. Noling will be responsible for overseeing data entry and reporting operations and ensuring that only validated data are used for project decisionmaking. Mr. Noling is located in CH2M HILL's Corvallis, Oregon, office.

Key Staff

Ms. Mary Camarata is Data Manager for the project. She is responsible for developing the Data Management Plan and ensuring that the plan is consistent with IRPIMS. She is also responsible for coordinating the format of data deliverables from the subcontractors. Ms. Camarata is located in CH2M HILL's Corvallis, Oregon, office.

Mr. Ken White is the Field Team Leader. He will supervise CH2M HILL staff during the fieldwork and coordinate the activities of the field subcontractors. Mr. White is located in CH2M HILL's Sacramento, California, office.

Ms. Donna Morgans is the Data Validation Coordinator. She is responsible for reviewing the analytical data and validating that the data meets the QC objectives of the project. Her review and documentation of the analytical data occur before the data is released for use by other members of the project team. Ms. Morgans is located in CH2M HILL's Corvallis, Oregon, office.

Ms. Mollie Netherland is responsible for development of the health and safety plan addendum. She is also responsible for ensuring that the health and safety procedures are understood by the field team leader for implementation at the project site.

Project Organization

An organization chart identifying the individuals responsible on the SVE project is presented in Figure 12-1.

04-16-92

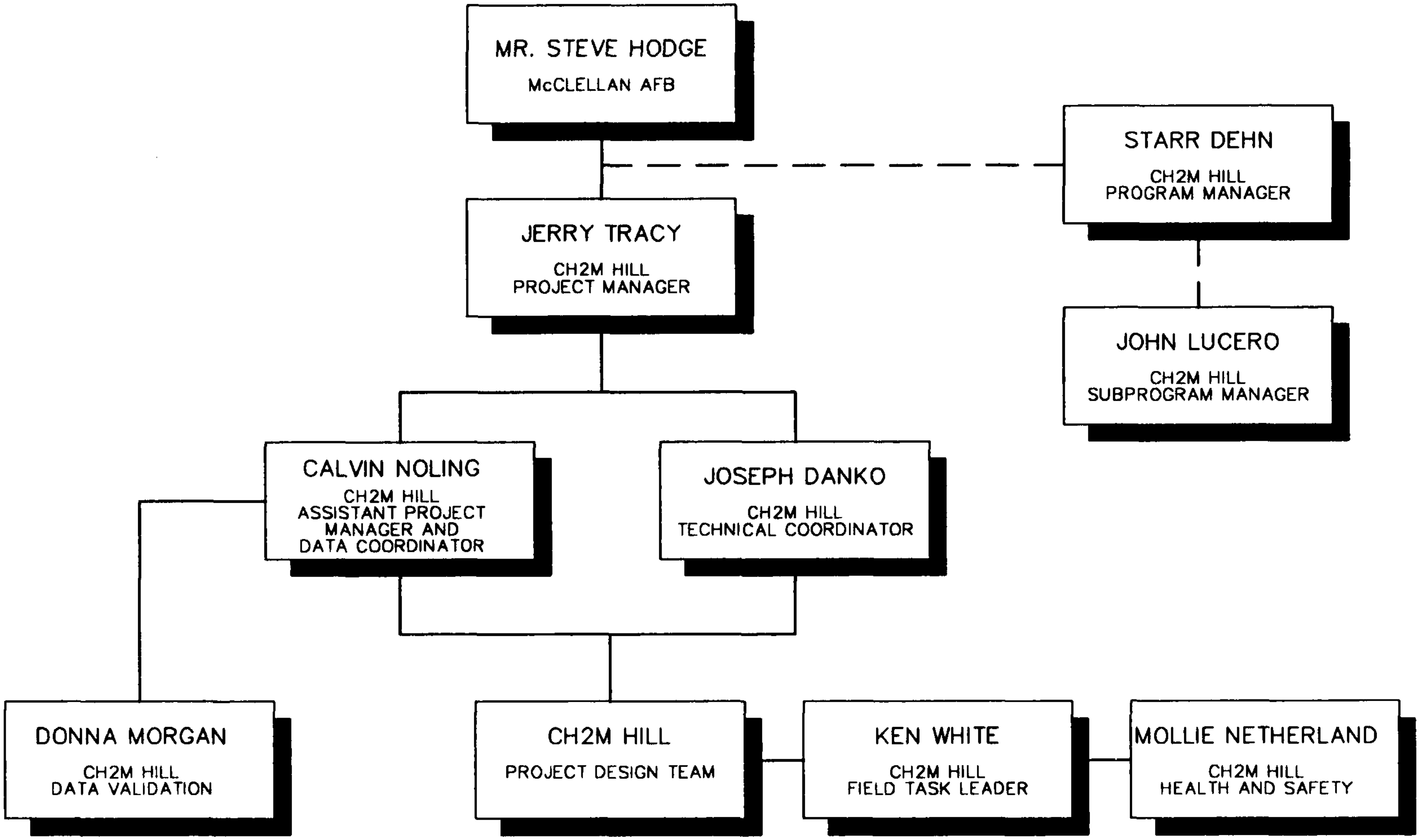


FIGURE 12-1

PROJECT ORGANIZATION
SVE TREATABILITY INVESTIGATION
McCLELLAN AIR FORCE BASE

Section 13

Community Relations

CH2M HILL will continue to provide support to the ongoing community relations program as it applies to Phase II of the SVE treatability investigation. It is anticipated that these activities will include the following tasks:

- Preparation of Fact Sheets for public distribution. The Fact Sheets will present updated information regarding the scope, design, and installation of the pilot-scale system. It is anticipated that up to three Fact Sheets may be prepared during the Phase II effort.

- Preparation of visual aids for Technical Review Committee meetings, to assist in updating the public and the regulatory agencies on the status of the SVE treatability investigation.

The community relations support activities will occur intermittently over the course of the project.

Section 14
References

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CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-01	SHEET 1 OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SAMPLING PORT WSP-SB, SITE S, AREA D
ELEVATION APPROXIMATELY 85.4' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 104.5, 06/11/91 START 06/07/91 1110 FINISH 06/10/91 1205 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
						1110 set up over sampling port
	1.0 2.5	1-SS	1.5	6-11-19 (30)	SILTY SAND (SM), brown, dry, micaceous, medium to fine grained (fill)	down hole hammer run by wireline on winch for split spoon sampling Driller: Jay, helper: Binky (Jeff).
5	5.0 6.5	2-SS	1.2	16-21-50 (71)	SILTY SAND (SM), as above	cuttings: brown SM 2-SS, hard driving, hammered out sampler Note: using sand catcher in sampler PID = 0 PPM
	7.5 9.5	3-SS	1.2	13-24-24-32 (56)	SILTY GRAVEL WITH SAND (GM), grayish brown, dry, very dense, hard, angular to subrounded gravel to 1/2-inch, mostly fine sand	7'-11' - hard gravel in cuttings PID = 0 PPM
10	10.0 12.0	4-SS	1.4	7-9-9-11 (20)	SILTY SAND (SM), mixture of brown and gray pieces, dry, coarse to fine sand, mostly fine sand, some gravel fragments to 1-inch, noticeable odor	cuttings becoming grey PID = 60 PPM
	12.5 14.5	5-SS	1.7	-- (--)	SILTY SAND (SM), similar to above, one 1/4-inch layer of oily/greasy looking material, headspace sample has black ashy layers, strong odor	winch working very slow, driller thinks there is too much friction between hammer and inside of augers. pull hammer, hammer is bent, hammer is replaced. PID = 180 PPM
	15.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-01	SHEET 2 OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SAMPLING PORT WSP-SB, SITE S, AREA D

ELEVATION APPROXIMATELY 65.4' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 104.5, 06/11/91 START 06/07/91 1110 FINISH 06/10/91 1205 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	15.5 17.0	6-SS	0.8	6-9-8-10 (8)	SILTY SAND (SM), brownish gray, dry, micaceous, medium to fine sand, several oily globs, noticeable odor	grey cuttings balling up, appear moist, still too much friction on hammer - not free falling, PID = 90 PPM
	17.5 19.5	7-SS	1.5	30-49-28-25 (53)	POORLY GRADED SAND WITH SILT (SP-SM) to SILTY SAND (SM), brownish gray to greenish gray, dry, coarse to fine sand, slight odor	17' cuttings becoming dark grey, hammer not free falling wireline broke hammering out sample, drill out sample from now on PID = 120 PPM
20	20.0 21.3	8-SS	1.3	8-27-39-50/4" (50/4")	soil varies from SILTY SAND (SM) to POORLY GRADED SAND WITH SILT (SP-SM), greenish gray to brown mottling, slightly moist, medium to fine sand, noticeable odor	dark grey cuttings, hammer still not free falling, drilling thinks there may be some slough in first 6-inches of drive PID = 220 PPM
	22.5 24.5	9-SS	1.8	9-23-35-41 (76)	POORLY GRADED SAND WITH SILT (SP-SM), greenish gray, moist, micaceous, medium to fine sand, few partially lithified fragments, odor	hammer continues to not free fall smoothly, note hammer as above unless noted otherwise in comments PID = 300 PPM
25	25.0 26.3	10-SS	1.8	8-13-32-56/4" (56/4")	POORLY GRADED SAND WITH SILT (SP-SM) to SILTY SAND (SM), similar to above, yellowish brown, slight odor	PID = 130 PPM
	27.5 29.1	11-SS	2.0	30-27-49-60/3" (60/2")	SILT (ML), greenish gray to olive gray, dry, low dry strength, trace fine sand, slight odor	cuttings similar to 10-SS PID = 90 PPM
	30.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-01
SHEET 3 OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SAMPLING PORT WSP-3B, SITE S, AREA D
ELEVATION APPROXIMATELY 65.4'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 104.5, 06/11/91
START 06/07/91 1110
FINISH 06/10/91 1205
LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	30.0 31.3	12-SS	1.3	9-10-26-42 (68)	SILT (ML), as above, to (31.5'): SILTY SAND (SM), greenish gray, dry, fine sand, headspace sample has strong odor	PID = 130 PPM
	31.3 32.5					
	32.5 33.9	13-SS	1.0	9-29-60/5" (60/5")	Interlayered SILT (ML) and POORLY GRADED SAND (SP), 20%, silt as above, sand: greenish gray with little brown mottling, slightly moist, micaceous, fine grained	PID = 30 PPM
	33.9 35.0					
35	35.0 36.5	14-SS	1.5	11-29-60 (89)	SILTY SAND (SM), olive brown, moist, micaceous, coarse to fine sand, mostly fine, partialy lithified fragments, cannot smell any odors, headspace sample (35.0'-35.5') has sandy clay layer	14-SS, only drove 18 inches, note color change PID = 90 PPM
	36.5 37.5					
	37.5 39.5	15-SS	2.0	11-20-26-40 (66)	SILTY SAND (SM), brown to olive gray, micaceous, medium to fine sand, mostly fine, root holes (?) in tip have FeOx staining, noticeable odor	PID = 50 PPM respool wireline
	39.5 40.0					
40	40.0 42.0	16-SS	1.3	5-9-13-22 (35)	upper middle sleeve (40.5'-41.0'): SANDY SILT (ML/CL), olive gray, fine sand, lower middle sleeve (41.0'-41.5'): SILTY SAND (SM), as above, below (41.5'-42.0'): POORLY GRADED SAND (SP), gray, slightly moist, micaceous, fine grained, odor	16-SS, D. Myers noted slight odor PID = 120 PPM
	42.0 42.5					
	42.5 44.5	17-SS	1.6	11-17-26-37 (63)	POORLY GRADED SAND WITH SILT (SP-SM), similar to bottom of 16-SS, slight odor	PID = 60 PPM
	44.5 45.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33	BORING NUMBER VES-01

SHEET 4 OF 8

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SAMPLING PORT WSP-SB, SITE S, AREA C

ELEVATION APPROXIMATELY 65.4' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 104.5, 06/11/91 START 06/07/91 1110 FINISH 06/10/91 1205 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	45.0 46.3	18-SS	2.0	10-25-40-60/4" (60/4")	SILTY SAND (SM) TO SANDY SILT (ML), olive gray with brown FeOx mottling, micaceous, fine sand, slight odor tip (46.3'): POORLY GRADED SAND (SP), fine	PID = 130 PPM
	47.5					
	49.0	19-SS	1.0	6-28-60 (88)	top of lower middle sleeve (48.0'-48.3'): SANDY LEAN CLAY (CL), gray, dry, hard, and SILTY SAND (SM), similar to 18-SS, below (48.3'-49.0'): POORLY GRADED SAND (SP), yellowish brown, micaceous, fine, slight odor	PID = 40 PPM
50	50.0					
	51.5	20-SS	1.5	15-34-60 (94)	top of upper middle sleeve (50.0'-50.3'): POORLY GRADED SAND (SP), as above, below (50.3'-51.5'): SANDY SILT (ML), olive gray with brown FeOx staining, moist, less than 10% fine sand	PID = 320 PPM brown cuttings
	52.5					
	53.5	21-SS	1.0	8-60 (68)	headspace sample (52.5'-53.0'): POORLY GRADED SAND WITH SILT (SP-SM), dry, micaceous, medium to fine sand; SANDY SILT (ML), olive gray with brown FeOx staining, dry, micaceous, fine sand laminae, possible odor	PID = 50 PPM grey cuttings
55	55.0					
	57.0	22-SS	1.5	3-8-18-35 (53)	SANDY SILT (ML), similar to above tip (57.0'): POORLY GRADED SAND WITH SILT (SP-SM), yellow brown, dry, micaceous, medium to fine sand, mostly fine, possible odor.	PID = 100 PPM
	57.5					
	59.5	23-SS	1.5	8-38-50-60 (110)	top 0.3' SILTY SAND (SM), olive gray with brown FeOx staining, dry, fine sand below (58.3'-59.5'): POORLY GRADED SAND (SP), yellow brown, dry, micaceous, medium to fine sand, mostly fine.	Note: typically getting about 1 inch of slough at top of sample - slough is being discarded PID = 50 PPM
	60.0					aluminum band in cuttings

PROJECT NUMBER	SAC28722.19.33
BORING NUMBER	VES-01

SHEET 3 OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB S/E TREATABILITY STUDY LOCATION SAMPLING PORT #SP-5B, SITE S, AREA D

ELEVATION APPROXIMATELY 65.4' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 104.5, 06/11/91 START 06/07/91 1110 FINISH 06/10/91 1205 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	60.0–62.0	24-SS	1.5	8-19-17-25 (42)	POORLY GRADED SAND (SP), brown and gray mottling with FeOX streaks, dry, micaceous, coarse to fine, mostly fine, no sample in tip	PID = 70 PPM
	62.5–64.5	25-SS	1.5	4-15-18-45 (63)	top of upper middle sleeve (63.0):POORLY GRADED SAND (SP), similar to above, approx. 10 chips of cement (?) slough (?) below: (63.3'-64.5') SILTY SAND (SM), olive brown, dry, micaceous, fine sand, no cement (?) chips	moist grey cuttings, augers are off vertical - angling to southwest PID = 140 PPM
65	65.0–66.3	26-SS	2.0*	4-40-60/4" (60/4")	SILT (ML), olive brown with some gray mottling, dry, < 15% fine sand	*overdrove (?), slough (?) PID = 40 PPM mixture of brown and grey soil in cuttings, slow augering
	67.5–69.5	27-SS	2.0	6-13-32-42 (74)	SANDY SILT (ML), olive brown to brown, dry	hole is tight - per driller, driller reamed hole to 70 feet PID = 130 PPM 70 feet END 6/8/91
70	70.0–71.0	28-SS	2.0*	50-100 (100)	SAND SILT (ML), light brown with FeOx mottling, dry, micaceous, medium to fine sand, mostly fine	START 6/10/91 PID = 18 PPM *tight per driller, 28-SS, driller says he drove sampler 1 foot, but got 2 feet of recovery - assume slough
	72.5–74.5	29-SS	1.5	2-9-20-39 (59)	top of upper middle sleeve (73.0'): SANDY SILT (ML), similar to above, below (73.3'-74.5'): POORLY GRADED SAND (SP), yellowish brown, dry, medium to fine sand, mostly fine	PID = 32 PPM
	75.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER
SAC28722.19.33	VES-01

SHEET 8 OF 8

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY

LOCATION SAMPLING PORT WSP-SB, SITE S, AREA D

ELEVATION APPROXIMATELY 65.4'

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 104.5, 06/11/91

START 06/07/91 1110

FINISH 06/10/91 1205

LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	5.0 77.0	30-SS	2.0	9-24-37-50 (87)	top 2" of upper sleeve (75.0'-75.2'): POORLY GRADED SAND (SP), as above, may be slough. Below (75.2'-77.0'): SILT (ML), light olive gray with FeOx mottling, dry, fine sand	PID = 260 PPM
	77.5 79.5	31-SS	2.0	5-27-36-42 (78)	SILTY SAND (SM), light olive gray, black (Mn staining ?) spots, 1/4" near vertical zones of dark gray material (sand?), dry, medium to fine sand, mostly fine. headspace sample (78.5'-79.0') has SANDY SILT (ML) layers	PID = 52 PPM
80	80.0 82.0	32-SS	2.0	5-9-14-22 (36)	SANDY SILT (ML), similar to above, fine sand	PID = 58 PPM
	82.5 84.5	33-SS	1.3	4-9-39-50 (89)	SILTY SAND (SM), olive gray with few brown streaks (FeOx), dry, fine	PID = 17 PPM
85	85.0 87.0	34-SS	1.1	6-29-29-50 (79)	SILTY SAND (SM), similar to above but laminae of fine sand	PID = 71 PPM
	87.5 89.5	35-SS	1.2	2-7-16-40 (56)	top of lower middle sleeve (88.5'): SILTY SAND (SM), olive gray with FeOx streaks, dry, medium to fine sands. Below (89.0'-89.5'): POORLY GRADED SAND (SP), gray with FeOx streaks, dry, micaceous, medium to fine sands.	noted some root (?) holes and vesicles, headspace sample (88.5'-89.0') has SANDY CLAY layers (CL) PID = 27 PPM
	90.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-01	SHEET 7 OF 8

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SAMPLING PORT WSP-SB, SITE S, AREA D
ELEVATION APPROXIMATELY 65.4' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 104.5, 08/11/91 START 08/07/91 1110 FINISH 08/10/91 1205 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	90.0 92.0	36-SS	2.0	11-15-26-40 (66)	SANDY SILT (ML), gray with FeOx staining, wet, micaceous, fine sand	36-SS, wet - may be perched PID = 188 PPM
	92.5 94.5	37-SS	1.6	6-8-12-30 (42)	SANDY SILT (ML), olive gray with black (MnOx) spots, dry to slightly moist, medium to fine sand, mostly fine	PID = 140 PPM
95	95.0 97.0	38-SS	2.0	2-4-18-40 (58)	SILTY SAND (SM), olive gray with trace FeOx staining, dry, fine sand headspace sample (96.0'-96.5') borderline SILTY SAND TO SANDY SILT (SM/ML)	PID = 34 PPM
	97.5 99.5	39-SS	1.2	2-5-8-10 (18)	SILTY SAND (SM), similar to above, dry to moist, noted possible root holes with black (Mn) staining, holes are open	PID = 102 PPM
100	100.0 102.0	40-SS	1.6	2-7-14-44 (58)	SILTY SAND to SANDY SILT (SM/ML), similar to above, but light olive brown	PID = 34 PPM
	102.5 104.5	41-SS	2.0	2-4-10-21 (31)	SILTY SAND (SM), olive brown, moist, fine sand, bottom sleeve A (104.5') POORLY GRADED SAND (SP), brown, wet, micaceous, medium to fine sand	41-SS, wet PID = 16 PPM
	105.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-01	SHEET 3 OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SAMPLING PORT WSP-SB, SITE S, AREA D

ELEVATION APPROXIMATELY 65.4' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 104.5, 06/11/91 START 06/07/91 1110 FINISH 06/10/91 1205 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	105.0 106.0	42-SS	1.0	9-17 (--)	POORLY GRADED SAND (SP), brown with FeOx staining, wet, medium to fine sands, mostly fine	after driving 1 foot ran out of wireline - not enough on spool PID = 20 PPM
					Bottom of Boring at 106.0, 06/10/91	sample is wet therefore end boring at 106.0 feet 4" well installed - see well construction log. END OF LOG PID = photoionization detector for organic vapors
110						
115						

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER ES-02A
SHEET 1 OF 1

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.3'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/14/91
START 06/12/91 1010
FINISH 06/14/91 0725
LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL	SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
						0730 start hand digging in 080. downhole hammer run for sampling by wireline on winch
	2.5 4.3	1-S	1.5	7-11-13-50/3" (50/3")	HDPE LINER at 2.3' with clay layer beneath Top: SILT WITH SAND (ML), light gray with orangish brown (FeOx) staining, fine sand bottom of lower sleeve (4.0'-4.3') and tip: WELL GRADED GRAVEL WITH SAND (GW), light gray, 10 YR 7/2, dry, coarse to fine sand, angular to subround graval fragments to 3/4", hard	possible rock at tip, made driving quite difficult in last 3" PID* = 12 PPM
5	5.0 6.0	2-S	0.5	50-50 (50+)	WELL GRADED GRAVEL WITH SAND (GW), similar to above, brown, 10 YR 5/3 (moist)	hard driving, stop at 1', drill out sample PID = 12 PPM
	7.5 9.5	3-S	1.5	10-27-28-31 (59)	Top of upper middle sleeve (8.0'): SILTY SAND (SM), brown, dry, micaceous, medium to fine sand, mostly fine. Below (8.3'-9.5') SILTY SAND (SM), similar to above but greenish gray	PID = 105 PPM
10	10.0 12.0	4-S	1.3	5-7-10-8 (18)	POORLY GRADED SAND (SP), gray, 5 YR 5/1, dry, micaceous, coarse to fine sands, mostly fine	color may be due to staining, moist color PID = 177 PPM
	12.5 14.5	5-S	1.2	4-4-4-4 (8)	POORLY GRADED SAND WITH SILT (SP-SM), gray, 5 YR 5/1, dry, micaceous, medium to fine sands, mostly fine	color may be due to staining PID = 142 PPM end 6/12/91
	15.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-02A

SHEET 2 OF [illegible]

SOIL BORING LOG

PROJECT McCLELLAN AFB SVS TREATABILITY STUDY

LOCATION SITE S, AREA C

ELEVATION APPROXIMATELY 65.3'

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 102.5, 06/14/91

START 06/12/91 1010

FINISH 06/14/91 0725

LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE: INTERVAL	SAMPLE: NUMBER AND TYPE	SAMPLE: RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	15.0 17.0	6-SS	1.0	2-4-6-8 (14)	[illegible] (15.0'-16.2'): SILTY SAND (SM), mottled brown and gray, dry, medium to fine sand, bottom (16.2'-17.0'): POORLY GRADED SAND WITH SILT to SILY SAND (SP-SM) to (SM), similar to 5-SS, tip has oily material and scrap metal	start 6/13/91, KW & KL 0252 starting. Note: colors likely to be "off" due to artifical lights. PID = 128 PPM
	17.5 19.5	7-SS	0.8	3-9-15-25 (40)	lower middle sleeve (18.7'-19.0'): wood fragments and soil, bottom sleeve (19.0'-19.5'): POORLY GRADED SAND WITH SILT (SP-SM), similar to above but oily and with wood fragments, strong odor	bit PID = 320 PPM
20	20.0 22.0	8-SS	1.8	7-21-26-50 (76)	POORLY GRADED SAND WITH SILT to SILTY SAND (SP-SM to SM), brown, coarse micaceous, coarse to fine sand, mostly fine, upper sleeves (20.5') have oily sheen, odor	PID = 390 PPM
	22.5 24.5	9-SS	1.8	15-28-21-26 (47)	lower middle sleeve (23.5'-24.0'): POORLY GRADED SAND WITH SILT (SP-SM), similar to above. Below (24.0'-24.5'): WELL GRADED SAND (SP), yellowish gray, dry, mostly fine sand, noticeable odor	drill out sampler Note: oily material from upper sleeves may have run down to lower sleeves -- cross contaminate? drill out sampler, driller says feels like wood on bit since it drills hard but drives easy PID = 395 PPM
25	25.0 27.0	10-SS	1.1	8-14-25-32 (57)	POORLY GRADED SAND (SP), gray, dry, medium to fine sand, end of tip (27.0') possibly SILT (ML)	0.2' oily slough at top of upper sleeve PID = >485 PPM
	27.5 29.3	11-SS	1.8	6-8-30-50/4" 50/4"	SANDY SILT (ML), olive gray, dry, fine sand, laminated, some very fine sand laminae	PID = 240 PPM
	30.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-02A
SHEET 3 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA 3
ELEVATION APPROXIMATELY 65.3'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/14/91
START 06/12/91 1010
FINISH 06/14/91 0725
LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	30.0 31.8	12-SS	1.6	8-30-48-50/3" (50/3")	Interlayered SANDY SILT (ML) (80%) and POORLY GRADED SAND (SP) (20%), olive gray with a few black (Mn?) streaks, slightly moist, micaceous, fine sand	PID = 335 PPM
	32.5 34.5	13-SS	1.7	11-25-42-30 (72)	Top (32.8'-33.0'): SANDY SILT (ML), as above, bottom 3 sleeves (33.0' (33.0'-34.5'): SILTY SAND (SM), olive gray with some white calcareous (?) streaks, dry, fine sand	PID = 260 PPM
35	35.0 37.0	14-SS	2.0	6-11-15-21 (36)	SILTY SAND (SM), similar to above, bottom of drive shoe (37.0'): SANDY LEAN CLAY (CL), olive gray, slightly moist, fine sand	driller says augering faster now, stop for 10 min to grease rig, PID = 420 PPM
	37.5 39.5	15-SS	1.9	10-15-22-35 (57)	SANDY LEAN CLAY to SANDY SILT (CL to ML), olive gray, dry to slightly moist, medium to fine sand, some layers/laminae of POORLY GRADED SAND (SP), SILTY SAND (SM)	0515 suspect 1-2" slough in upper sleeve PID = 420 PPM
40	40.0 42.0	16-SS	1.7	7-12-25-28 (53)	POORLY GRADED SAND (SP), gray, dry, micaceous, fine grained	PID = 415 PPM
	42.5 44.5	17-SS	1.5	5-11-12-21 (33)	POORLY GRADED SAND (SP), similar to above, tip (44.5'), laminated LEAN CLAY and SILT (CL and ML), gray with brown (FeOx)	PID = 210 PPM
	45.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-02A

SHEET 4 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY

LOCATION SITE S, AREA C

ELEVATION APPROXIMATELY 65.3'

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 102.5, 06/14/91

START 06/12/91 1010

FINISH 06/14/91 0725

LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	45.0 46.3	18-SS	1.5	10-21-50/4" (50/4")	upper middle sleeve (45.0'-45.3'): SILTY SAND (SM), olive gray, fine sand. Below (45.3'-46.3'): SANDY SILT (ML) olive gray with some FeOx mottling, dry, fine sand, root (?) holes	PID = 90 PPM
	47.5					0555 rig engine runing poorly, shut down to check, 0600 drill out sampler
	49.3	19-SS	1.2	4-7-31-50/3" (50/3")	SANDY SILT (ML) similar to above, with layers of SILTY SAND (SM)	PID = 108 PPM
	50.0					
50	51.3	20-SS	1.5	8-10-39-50/4" (50/4")	Soil varies from SANDY SILT to SILTY SAND (ML to SM), similar to above, olive gray with FeOx mottling, dry, fine sand, ML-60%, SM-40%	PID = 105 PPM
	52.5					
	54.0	21-SS	1.3	6-18-60 (78)	Mostly interlayered SANDY SILT and SILTY SAND (ML to SM), as above. Top of lower middle sleeve (53.0'): SANDY LEAN CLAY (CL), olive gray, fine sand	PID = 97 PPM
	55.0					refusal
55	57.0	22-SS	1.5	5-15-42-50 (92)	SILTY SAND (SM), olive gray with streaks of FeOx, dry, micaceous, some pores, fine sand, several layers of POORLY GRADED SAND (SP) and SILT (ML)	PID = 100 PPM
	57.5					
	59.5	23-SS	1.5	5-17-40-60 (100)	Top of upper middle sleeve (58.0'): POORLY GRADED SAND (SP), gray with FeOx staining, dry, micaceous, fine sand, bottom (58.2'-59.5'): SANDY SILT (ML), olive gray with some FeOx mottling, dry, fine sand	PID = 74 PPM
	60.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-02A	SHEET 5 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 55.3' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/14/91 START 06/12/91 1010 FINISH 06/14/91 0725 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	60.0 62.0	24-SS	1.5	6-9-21-35 (56)	Top (60.0'): POORLY GRADED SAND (SP), yellowish brown, 10 YR 5/4, dry, micaceous, fine sand, top of lower middle sleeve (61.0'): CLAYEY SAND (SC), yellowish brown, dry, fine sand to (62.0'): POORLY GRADED SAND WITH SILT (SP-SM)	0815 starting PID = 36 PPM
	62.5 64.5	25-SS	1.5	3-6-15-28 (43)	SILTY SAND (SM), olive, 5 Y 5/3, dry micaceous, fine sand; grades downward (64.0') to POORLY GRADED SAND (SP), pale brown, 10 YR 6/3, dry, medium to fine sand, mostly fine	PID = 74 PPM
65	65.0 67.0	26-SS	1.7	10-13-21-28 (49)	POORLY GRADED SAND (SP), pale brown, dry, micaceous, coarse to fine sand, mostly fine	0900 problems with wireline, continue with SS-26 PID = 32 PPM
	67.5 69.5	27-SS	2.0	8-18-29-31 (60)	POORLY GRADED SAND (SP), similar to above but no coarse fraction	0915 SS-27 wireline tangling with sand line PID = 54 PPM
70	70.0 72.0	28-SS	1.9	8-21-27-28 (55)	POORLY GRADED SAND (SP), similar to above, light brown, dry, micaceous, fine sand	PID = 58 PPM end 6/13/91
	72.5 74.5	29-SS	1.7	11-24-25-29 (54)	POORLY GRADED SAND (SP), similar to above, bottom lower middle sleeve (74.0'): SILTY SAND (SM), similar to SP, light brown with brown FeOx mottling, 10 YR 6/3, top (74.4'-47.5'): bottom two inches change to SP-SM borderline SP-SM/SM	start 6/14/91, 0315 continue driving PID = 158 PPM
	75.0					

CH2M HILL

PROJECT NUMBER
SAC28722.19.33

BORING NUMBER
VES-02A

SHEET 6 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.3' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/14/91 START 06/12/91 1010 FINISH 06/14/91 0725 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	75.0 76.3	30-SS	1.6	6-20-50/4" (50/4")	Interlayered ML, CL, and SC. SANDY SILT (ML), olive gray with brown FeOx mottling, dry, noticeable odor, low dry strength but a few layers with high dry strength may be LEAN CLAY (CL), lower middle sleeve (75.5'-75.8'): CLAYEY SAND (SC), fine sand	SS-29 light gray 10YR [illegible], pale brown 10YR 6/3, PID = 330 PPM
	77.5 79.5	31-SS	2.0	6-19-28-30 (58)	SANDY LEAN CLAY/CLAYEY SAND (CL/SC), mottled light olive brown and olive gray, dry, fine sand	0415 stop, drillers into level C, 0425 drilling out sampler taking a while to bring up cuttings, PID = 118 PPM
80	80.0 81.8	32-SS	1.2	3-9-32-50/4" (50/4")	SILTY SAND (SM), greenish gray with white carbonate (?) nodules, dry, fine sand, a few very hard fragments may be LEAN CLAY (CL) laminae	hard time cleaning cuttings from hole PID = 108 PPM
	82.5 84.5	33-SS	1.5	4-16-50-50 (100)	SILTY SAND (SM), similar to above	PID = 108 PPM
85	85.0 87.0	34-SS	1.5	8-18-21-35 (56)	Upper middle sleeve (85.5'): Top: SILT WITH SAND (ML), olive brown with FeOx stains; Bottom (86.0'): POORLY GRADED SAND WITH SILT (SP-SM), gray, dry, fine sand. Lower middle sleeve (86.0'-86.5'): POORLY GRADED SAND WITH SILT to POORLY GRADED SAND SP-SM to SP. Bottom sleeve: top (86.6'): POORLY GRADED SAND (SP), light brown, dry, fine sand, bottom of sleeve is finer grained; Bottom (86.8'): SANDY SILT (ML), similar to top of upper middle sleeve, tip (87.0'): POORLY GRADED SAND (SP), light gray with FeOx stains, dry, fine sand	PID = 36 PPM
	87.5 89.5	35-SS	1.6	2-18-19-20 (39)	Upper three sleeves (87.5'-89.0'): POORLY GRADED SAND (SP), as in tip of 34-SS. Bottom sleeve (89.0'-89.5'): SILTY SAND (SM), brown, moist, micaceous, fine sand	PID = 68 PPM SS-35 bottom 6", moist FeOx staining very strong in upper sleeves
	90.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-02A
SHEET [illegible] OF [illegible]

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.3'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/14/91
START 06/12/91 1010
FINISH 06/14/91 0725
LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	90.0 92.0	36-SS	1.7	4-13-17-28 (45)	Upper two sleeves (90.0'-90.9'): SILTY SAND (SM), olive brown, moist to slightly wet, fine sand below (90.9-92.0'): SANDY SILT (ML), olive olive gray with FeOx staining, dry, fine sand, low dry strength, pores	PID = 58 PPM
	92.5 94.5	37-SS	2.0	5-6-14-22 (36)	LEAN CLAY WITH SAND (CL), light olive gray with with FeOx spots, locally FeOx is in layers, dry, fine sand, soil is laminated, dry strength varies from moderate to hard, maybe CL-ML	PID = 175 PPM
95	95.0 97.0	38-SS	2.0	4-9-13-18 (31)	FAT CLAY WITH SAND (CH), olive gray with FeOx mottling, moist, coarse to fine sand Bottom two sleeves (96.0'-97.0'): CLAYEY to SILTY SAND (SC to SM), olive gray, dry, fine sand	PID = 320 PPM
	97.5 99.5	39-SS	1.0	2-3-8-11 (17)	SANDY SILT (ML), greenish gray, dry, fine sand, low dry strength, with SANDY LEAN CLAY (CL) layers	PID = 120 PPM top of lower middle sleeve may be slough - take headspace from bottom of sleeve
100	100.0 102.0	40-SS	1.8	3-2-14-23 (37)	Upper sleeve (100.3'-100.5'): similar to 39-SS. Below (100.5'-102.0'): Varies from SANDY LEAN CLAY to CLAYEY SAND (CL to SC), light brown, becoming more moist near bottom, fine sand	PID = 41 PPM
	102.5 104.5	41-SS	2.0	6-12-18-22 (40)	Upper sleeve (102.5'-102.8'), similar to bottom 40-SS. Below (102.8'-104.5'): POORLY GRADED SAND (SP), mottled gray and brown (FeOx), wet, micaeous, fine sand	PID = 24 PPM sampler is wet, two 1" piezometers installed, see field notebook & well construction log END OF LOG
					END OF BORING AT 104.5, 06/14/91	* PID = Photoionization Detector for Organic Vapor

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-03A
SHEET OF

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.4
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/17/91
START 06/14/91 0300
FINISH 06/17/91 1100
LOGGER A. LEARY/T. DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OF CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
					Fill material over HDPE liner	hand dug to HDPE liner
					Woven geotextile at 1.5 feet	
	2.5 4.5	1-SS	1.0	9-7-16-23 (39)	LEAN/FAT CLAY (CL-CH), white with prominant orange mottling, dry, hard, sticky and plastic when wet	PID* = 10 PPM
5	5.0 6.1	2-SS	0.7	19-36-50/1.5" (50/1")	CLAYEY GRAVEL (GC), brown, slightly moist, very dense, massive, gravel/sand/clay mixture	6' bouncing sample obtained at 0525 driller said bouncing on rock came on with auger. PID = 12 PPM
	7.5 9.5	3-SS	1.5	13-17-22-30 (52)	SILTY SAND (SM), yellowish brown, moist, very dense, massive, mixed mineralogy, fining upward from 9 to 7.5 feet, finer material very dark grayish brown, 10 YR 3/2, with prominant rounded clay mottles, fine material CLAYEY SAND (SC)	PID = 85 PPM
10	10.0 12.0	4-SS	1.5	12-13-12-14 (26)	SILTY CLAY (CL), dark gray, 10 YR 4/1, soil stained with red and black contaminants, some orange mottles, interbedded coarser and finer grained materials, burnt wood and glass at 10.5 feet (fill)	In pit, strong odor PID = 295 PPM
	12.5 14.5	5-SS	1.5	8-7-13-14 (27)	SILTY SAND (SM), greenish gray, moist, medium sand, massive, slight fining upward	0555, strong odor, volatile organics, oily appearance. PID = 405 PPM
	15.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-03A
SHEET [illegible] OF [illegible]

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.4
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/17/91
START 06/14/91 0300
FINISH 06/17/91 1100
LOGGER K. LEARY/T. DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	15.0 17.0	6-SS	2.0	11-10-11-14 (25)	SILTY SAND (SM), grading downward into POORLY GRADED SAND (SP), grayish brown, moist, medium sand	oily appearance, strong odor PID = 164 PPM
	19.0	7-SS	1.5	7-8-15-20 (35)	POORLY GRADED SAND (SP), olive, 10 YR 5/3, moist, massive, sand fines upward, medium at 17', coarse at 19', at 18' high in mica - appears to be from granitic source	0634, very strong odor, PID = 250 PPM
20	21.0	8-SS	1.3	10-35-33-40 (73)	CLAYEY SAND (SC), olive, 5 Y 5/3, slightly moist, micaceous, strong odor, slightly sticky, and slightly plastic when wetted.	sample still discolored, strong odor, appears to be from granitic parent material, sand grains getting finer at 21', odor, PID = 310 PPM
	23.0	9-SS	0.8	12-13-19-44 (63)	SILTY SAND (SM), olive, 5 Y 5/3, moist, [illegible] to coarse sand, micaceous (flakes [illegible] mm), appears to be from granitic parent material or gneiss	strong odor, some discoloration from contaminants, PID = 350 PPM
	25.0	10-SS	1.7	28-29-36-42 (78)	POORLY GRADED SAND (SP), yellowish brown, 10 YR 5/4, moist, medium to very coarse sand, grading coarser upward, noncemented, from 24' to 25' about 10% gravel	strong odor, some discoloration from contaminants, oily - leaves discoloration on gloves, high in mica granitic parent material, PID = 210 PPM
25	26.9	11-SS	1.7	19-22-40-51/4" (51/4")	POORLY GRADED SAND (SP) grading downward to CLAYEY SAND (SC), sand yellowish brown, 10 YR 5/4, moist, very coarse, clayey sand, olive gray 5 Y 5/2, slightly sticky and slightly plastic when wetted	mild odor, out of pit, coarser sands appear to be from granitic source PID = 225 PPM
	27.5					
	28.9	13-SS	1.9	13-29-50/4" (50/4")	CLAYEY SAND (SC) (27.9'-28.9') grades upward to CLAYEY SILT (ML) (27.5') olive gray to pale brown, 5 Y 5/2 to 10 YR 6/3, fine sand, slightly sticky and slightly plastic when wetted	strong clay skins with ML soil, no sample 12-SS
	30.0					PID = >280 PPM

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-03A	SHEET 3 OF [illegible]

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.4 DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 102.5, 06/17/91 START 06/14/91 0800 FINISH 06/17/91 1100 LOGGER K. LEARY/T. DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	30.0 31.9	14-SS	2.0	28-38-39-50/4" (50/4")	CLAYEY SAND (SC), brown, 10 YR 5/3, dry, fine sand, common clay skins, slightly sticky and slightly plastic when wetted, massive structure parting to very fine platy structure	strong gleying soil appears like lacustrine deposits - bright orange mottles finer material found in slough PID = 310 PPM
	32.5 34.5	15-SS	2.0	14-31-48-50 (98)	CLAYEY SAND (SC), gray, 10 yr 6/1, 32.5' to 33.5', brown, 10 YR 5/3, 33.5' to 34.5', dry, fine sand, slightly sticky and slightly plastic when wetted, massive	some gleying, PID = 215 PPM
35	35.0 37.0	16-SS	2.0	10-14-34-56 (90)	CLAYEY SAND (SC), brown, 10 YR 4/3, dry, medium sand, dry, peds extremely hard, massive, grades to SILTY SAND (SM) from 36' to 37', olive, 5 Y 5/3	PID = >500 PPM
	37.5 39.5	17-SS	2.0	15-17-33-50 (83)	CLAYEY SAND (SC) grades 39.0' and 39.5' to SILTY SAND (SM) with depth, clayey sand: brown 10 YR 5/3, dry, peds very hard, slightly sticky and slightly plastic when wet, well developed clay skins, silty sand: olive gray, 5 Y 5/2, well	PID = 505 PPM
40	40.0 41.9	18-SS	1.6	11-18-40-58/4" (58/4")	SILTY SAND (SM) grading to POORLY GRADED SAND (SP), color varies from olive to light gray to yellowish brown, silty sand has well-developed clay skins, fine sand, FeOx interlayered with fine sand	PID = 460 PPM
	42.5 44.5	19-SS	2.0	11-16-15-37 (52)	POORLY GRADED SAND (SP), olive, 5 Y 5/3, moist, very fine sand, mixed mineralogy with fine mica, massive, bottom 3 to 5 inches of tip (44.1'-44.5') SILTY SAND (SM), slightly sticky and slightly plastic when wetted	FeOx stains and mottles orange odor PID = 400 PPM
	45.0					

CH2M HILL

PROJECT NUMBER SAC28722.'9.33
BORING NUMBER VES-03A
SHEET 4 OF [illegible]

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.4
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/17/91
START 06/14/91 0300
FINISH 06/17/91 1100
LOGGER K. LEARY/T. DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	45.0 46.4	20-SS	2.0	16-28-60/4" (60/4")	SANDY SILT / CLAY [illegible], very pale brown, 10 YR 7/3, dry, extremely hard, small pocket of CLAYEY SAND (SC) from 45.4' to 45.9', dry, hard, mixed mineralogy, massive	Cl high in orange mottles and stains PID = 32 PPM
	47.5 49.0	21-SS	1.6	11-25-57 (82)	SILTY SAND (SM), light olive gray, 5 Y 6/2, dry, very dense, very fine sand, some old root channels filled with fine sand, slightly plastic when wetted, appears to lacustrine deposit, massive	driller sounded depth, high in orange mottles and stains, PID = 114 PPM
50	50.0 52.0	22-SS		14-27-41-47 (88)	SILTY SAND (SM), olive, 5 Y 5/3, with orange mottling, dry, slightly hard, massive structure parting to thin very fine platy structure, slightly plastic and slightly sticky when wet, appears to be lucustrine deposit	6/15/91, 0 323, drillers cleaned out hole PID = 106 PPM
	52.5 53.5	23-SS	0.3	13-43	SILTY SAND (SM), olive same as above, massive, nonlacustrine	lost coupling down hollow stem, went fishing but wasn't able to retrieve, decided not to continue driving SS, possibily hitting coupling, retrieved sample after 12", PID = 112 PPM
55	54.0 55.9	24-SS	2.0	12-33-55-50/5" (50/5")	SILTY SAND (SM), olive with orange mottles, medium grained sand, nonlacustine grading to POORLY GRADED SAND (SP) between 55.5' and 56'	PID = 114 PPM
	57.0 59.0	25-SS	2.0	22-25-42-50 (92)	SILTY CLAYEY SAND (SM) grading to POORLY GRADED SAND (SP) at 57.5', brown, moist, medium grained sand	PID = 104 PPM
	60.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-03A
SHEET 5 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.4
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/17/91
START 06/14/91 0800
FINISH 06/17/91 1100
LOGGER K. LEARY/T. DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	60.0 61.9	26-SS	1.8	21-19-27-47/5" (47/5")	SILTY/CLAYEY SAND (SM) interbedded with POORLY GRADED SAND (SP), olive, 5 Y 5/3, slightly moist, very fine sand, massive parting to fine plates, appears to be lacustrine deposit - has clay skins	problems with spool, changing cable, rig down, PID = 170 PPM
	61.9 63.0					
	63.0 64.6	27-SS	1.0	9-9-32-57/2" (57/2")	POORLY GRADED SAND (SP) to SILTY SAND (SM), pale brown, 10 YR 6/3, slightly moist, grading to WELL GRADED SAND (SW), nonsticky and nonplastic when wet	sand is loose, PID = 53 PPM
	64.6 65.0					
65	65.0 67.0	28-SS	1.6	29-29-38-50 (88)	POORLY GRADED SAND (SP), light gray, 10 YR 4/2 color, at tip (67.0') changes to pale brown, 10 YR 6/3 at 65', slightly moist, massive (no structure), mixed mineralogy (little clay)	PID = 55 PPM
	67.0 67.5					
	67.5 69.5	29-SS	1.8	10-18-24-33 (57)	POORLY GRADED SAND (SP), light gray, 10 YR 7/2, slightly moist, medium sand, mixed mineralogy (little clay), at sample tip (69.5') material changes to a brown SILTY SAND-CLAYEY SAND (SM -SC), slightly sticky and slightly plastic when wet	PID = 25 PPM
	69.5 70.0					
70	70.0 72.0	30-SS	2.0	18-38-40-50 (90)	Interlayered SILTY SAND (SM) and CLAYEY SAND (SC), yellowish brown, 10 YR 5/4, well developed mottles, clay skins, appears lacustrine, clayey sands slightly sticky and slightly plastic when wet	PID = 134 PPM
	72.0 72.5					drillers stopped to fix wireline.
	72.5 74.5	31-SS	1.8	12-20-18-20 (38)	SILTY SAND (SM), yellowish brown, 10 YR 5/4, slightly moist, changes (73.0' to 73.5') to POORLY GRADED SAND (SP), brown, 10 YR 5/3, slightly moist, massive structure	PID = 34 PPM
	74.5 75.0					

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-03A
SHEET 6 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.4
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/17/91
START 06/14/91 0800
FINISH 06/17/91 1100
LOGGER K. LEARY/T. DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	75.0 76.2	32-SS	2.0	27-53/5"-50/3" (50/3")	CLAYEY SAND (SC) to SANDY LEAN CLAY (CL), brownish yellow, 10 YR 6/6, highly mottled, small beds extremely hard, sticky and plastic when wet, color changes to light olive gray, 5 Y 6/2, from 75.5' to 76'	PID = 95 PPM
	77.5 79.5	33-SS	2.0	14-26-36-47 (83)	CLAYEY SAND (SC), brownish yellow, 10 YR 6/8, highly mottled with some black (Mn) stains, dry, sticky and plastic when wet, grades LEAN/FAT CLAY of CL-CH between 78' and 78.5', pale olive, 5 Y 6/3, dry	well developed clay skins, sticky and plastic when wet, mixed mineralogy PID = 112 PPM
80	80.0 81.3	34-SS	2.0	21-64-50/3" (50/3")	CLAYEY SAND (SC) to SANDY LEAN CLAY (CL), pale olive, 5 Y 6/3, dry, sticky and plastic when wet, clay skins present, massive structure, slight variations in color light olive gray to pale olive	PID = 14 PPM
	82.5 83.7	35-SS	1.3	21-50/4"-50/4" (50/4")	SANDY LEAN CLAY (CL) at 82.7' grading to CLAYEY SAND (SC) at 83.1' both have orange mottles, dry, dense, massive structure, SC is stiff and plastic when wet	6/17/91 50 blows for 4" and an additional 50 blows and still only 4" PID = 142 PPM
85	85.0 86.5	36-SS	1.1	14-31-50 (81)	CLAYEY SAND (SC), well developed clay skins, very fine platy structure, appears to be lacustrine deposit, high in silts, grades into a POORLY GRADED SAND (SP) at 86.0' to 86.5', fine to very fine sand	PID = 30 PPM
	87.5 89.5	37-SS	1.8	20-40-47-50 (97)	POORLY GRADED SAND (SP), highly stained with orange mottling, slightly moist, fine sand from 87.5' to 88.0' grading to medium sand from 88.0' to 89.5', massive structure, mixed mineralogy	PID = 85 PPM sand slightly moist, massive structure loose, mixed mineralogy
	90.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER
SAC28722.19.33	VES-03A

SHEET [illegible] OF [illegible]

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.4 DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 102.5, 06/17/91 START 06/14/91 0300 FINISH 06/17/91 1100 LOGGER K. LEARY/T. DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	90.0 92.0	38-SS	2.0	9-13-25-27 (52)	LEAN CLAY (CL), a few mottles and Mn stains, slightly moist, well developed clay skins, stiff, appears to be of lacustrine origin, moderate plasticity	PID = 100 PPM
	92.5 94.5	39-SS	2.0	5-7-9-11 (20)	LEAN CLAY (CL), a few mottles and FeOx and Mn stains, slightly moist, well developed clay skins, stiff, appears to be of lacustrine origin, platy, structure, grades into a SANDY CLAY (SC) at tip (94.5')	PID = 220 PPM maganese stains, some appear to be in old root channels
95	95.0 96.3	40-SS	1.5	8-25-41-50/4" (50/4")	POORLY GRADED SAND WITH CLAY (SP-SC), slightly moist, very fine sand, massive structure, slightly sticky and slightly plastic when wet	PID = 260 PPM
	97.5 99.3	41-SS	2.0	21-42-50-50/4" (50/4")	WELL GRADED SAND WITH CLAY (SW-SC), (97.5'-98.5') slightly moist, some interfingering of finer material, grades into LEAN CLAY (CL) at 98.5' clay skins present platy structure, appears to be of lacustrine origin, sticky and plastic when wet	clay slightly moist, sticky and plastic when wetted, PID = 180 PPM
100	100.0 102.0	42-SS	1.8	22-29-43-47 (90)	SANDY LEAN CLAY grading into LEAN CLAY (CL) between 100.5' and 101', pale brown, 10 YR 6/3, slightly moist, massive/platy structure, sticky and plastic when wet, appears to be of lacustrine origin, well developed clay skins	PID = 80 PPM
	102.5 102.3	43-SS	1.8	31/4"	SANDY LEAN CLAY (CL), brown, 10 YR 5/3, wet, sticky and plastic, massive structure	encountered water at 102.5' driller went 4" felt soupy, pulled SS out of hole, TD of hole 103.20', PID = 60 PPM
					END OF BORING AT 103.2', 6/17/91	two 1" piezometers installed, see well construction log * PID = Photoionization Detector for Organic Vapor

CH2M HILL

PROJECT NUMBER
SAC28732.19.33

BORING NUMBER
VES-04

SHEET 1 OF 2

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65 FT
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 103.0, 06/13/91
START 06/13/91 0945
FINISH 06/13/91 1300
LOGGER D. DANOVICH / K. LEAR

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
					WELL GRADED SAND WITH SILT AND GRAVEL (SW-SM), light brown, 7.5 YR 6/3, dry, dense to very dense 2.1' HDPE liner	hand dug to HDPE liner
	2.5 3.3	1-SS	0.8	15-14-21-24/3" (24/3")	SILTY CLAY (CL), light gray with brown mottling, 5 YR 7/1, dry, hard	Sampler hit rock, PID = 0 PPM
	4.5 5.0	2-SS	0.3		CLAYEY GRAVEL WITH SAND (GC), brownish gray, dry, very dense, some cementation	
5	5.0 5.3	3-SS	1.0	80-60/4" (60/4")	POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM), orangish brown, moist, dense	Piece of debris in sampler, PID = 0 PPM
	7.5 9.5	4-SS	1.5	8-10-8-10 (18)	WELL GRADED SAND WITH SILT (SW-SM) grading to POORLY GRADED SAND with SILT/CLAY (SP-SC) at bottom (9.5'), dark brown, moist	PID = 13 PPM
10	10.0 11.2	5-SS	1.5	5-17-60/2" (60/2")	SILTY SAND (SM), black, strong odor, waste material Sample tip (11.2'): POORLY GRADED SAND WITH SILT (SP-SM), brown, moist, ~~dense~~, fine sand	PID = 116 PPM
	11.2 12.5	6-SS	0.3	40-51 (91)	Same as in tip of 5-SS	PID = 117 PPM
	12.5 13.5	7-SS	1.0	21-75 (96)	POORLY GRADED SAND WITH SILT AND CLAY (SP-SC/SP-SM), olive gray, moist, very dense, fine sand	PID = 240 PPM
	13.5 15.0	8-SS	1.4	24-61-120 (181)	POORLY GRADED SAND WITH CLAY (SP-SC), plastic (forms good ribbon), massive structure	Strong odor, faint clay skins bridging sand grains, PID = 230 PPM

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-04
SHEET 2 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.7'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 103.0, 06/13/91
START 06/10/91 0945
FINISH 06/13/91 1300
LOGGER T. DANCVICH/ K. LEARY

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	15.5					Stopped drilling 6/10/91
	15.5–17.5	9-SS	1.3	25-19-25-60 (85)	CLAYEY SAND (SC), brown/olive gray, moist, fine to very fine sand, very dense, some mica flakes, odor	Started drilling 6/11/91, 0355 PID = 290 PPM
	17.5–19.5	10-SS	1.2	19-34-35-60 (95)	CLAYEY SAND (SC), dark olive gray discoloration (material is brownish) 5 Y 3/2, moist, some clay lenses, discoloration from solvents (?), odor	PID = 240 PPM
20	20.0–22.0	11-SS	1.7	17-39-60-70 (130)	CLAYEY SAND (SC), same as above, more mica grains, some quatrz grains, more coarse sand in middle of sample (21.0')	PID = 250 PPM
	22.5–24.5	12-SS	1.8	20-24-55-60 (115)	CLAYEY SAND (SC), strong brown, 7.5 YR 5/8 or 4/6, moist, very dense, more coarse to medium sand, lots of mica and quartz grains, discolored to black at 23', odor	PID = 10 PPM
25	25.0–27.0	13-SS	1.8	19-40-62-70 (132)	CLAYEY SAND (SC), light yellowish brown, 10 YR 6/4, moist, very dense, (finer sands 26' to 27', coarse sands at 25')	PID = 20 PPM
	27.5–29.0	14-SS	1.6	28-60-70 (130)	SANDY CLAY/SILT (ML), brown, 10 YR 5/3, faint black mottling, dry to moist, very fine sands, plastic, strong to medium clay skins, massive structure	Rig down to repair frayed cable. PID = 20 PPM
	30.0					

PROJECT NUMBER	BORING NUMBER	
SAC28720.19.33	ES-04	SHEET 3 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.7' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 103.0, 06/13/91 START 06/10/91 0945 FINISH 06/13/91 1300 LOGGER T. DANOVICH/ K. LEAR

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	30.0 31.3	15-SS	1.3	14-50-50/3" (50/3")	SANDY CLAYEY SILT (ML), same as above, grading to CLAYEY SAND (SC) in bottom liner (30.8'-31.3'), damp, very dense, fine sand	PID = 30 PPM
	31.3 32.5					
	32.5 34.1	16-SS	1.1	16-30-50/5.5" (50/2")	CLAYEY SILT (ML), brown, grades to CLAYEY SAND (SC) at 34.0 feet, brown, damp, very dense, gray glazing (reduction zone), found root or worm hole	PID = 38 PPM
	34.1 35.0					
35	35.0 36.3	17-SS	1.0	20-50-50/3" (50/3")	POORLY GRADED SAND WITH SILT (SP-SM), light brown, 7.5 YR 5/3, moist, dense, reddish dark brown FeOx staining, some strong cementation	PID = 36 PPM
	36.3 37.5					
	37.5 38.7	18-SS	1.5	21-50-50/2" (50/2")	CLAYEY SAND (SC) or SANDY SILT/CLAY (ML), brownish yellow, moist, dense, FeOx staining filling old root channels and pores, still some root channels, clay skins (forms good ribbon), very fine sand	PID = 40 PPM
	38.7 40.0					
40	40.0 41.3	19-SS	1.1	30-50/4"-50 (100)	as above (SC or ML), strong cementation, grading in bottom sleeve (40.5'-41.0') to SILTY/CLAYEY SAND (SM), olive yellow, 2.5 YR 6/6, moist, dense, FeOx staining and root channels, fine sand	PID = 96 PPM
	41.3 42.5					Rig down to change frayed wireline (second time today)
	42.5 44.5	20-SS	1.6	19-28-31-27 (58)	CLAYEY SAND (SC), light olive brown, 2.5 Y 5/4, moist, FeOx staining	PID = 192 PPM
	44.5 45.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-04	SHEET 4 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA C

ELEVATION APPROXIMATELY 65.7' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 103.0, 06/13/91 START 06/10/91 0945 FINISH 06/13/91 1300 LOGGER T. DANOVICH/ K. LEAR

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	45.0 46.4	21-SS	1.1	37-50-50/5" (50/5")	top 3 inches (45.0'-45.2') same as above (SC). Below: WELL GRADED SAND (SW), very pale brown, 10 YR 7/4, moist, fine to coarse sand, quartz, feldspar and mafic sand grains. (appears loose when it comes out of split spoon)	PID = 9 PPM
	47.5					PID = 16 PPM
	49.5	22-SS	1.2	17-19-45-50 (95)	POORLY GRADED SAND (SP), yellowish brown, moist, medium to fine sand, angular to subrounded grains	
50	50.0 50.3	23-SS	1.0	50-50/4" (50/4")	POORLY GRADED SAND (SP), yellowish red/brown, moist, medium sand grades to fine at 51.0'	PID = 12 PPM
	52.5 53.5	24-SS	0.5	9-50/3"-50/3" (100/6")	POORLY GRADED SAND (SP), very pale, moist, medium to fine sand, possibly some cementation	Note: sand catcher placed in sampler backwards. PID = 12 PPM
55	55.0 56.3	25-SS	1.2	32-38-50/3" (50/3")	SILTY/CLAYEY SAND (SM), pale brown to light brownish gray, moist, grades to POORLY GRADED SAND (SP) at 56', light brown, moist, fine sand	PID = 38 PPM
	57.5 59.5	26-SS	1.9	17-29-31-39 (70)	POORLY GRADED SAND (SP), light brown, 10 YR 6/3, moist, noncemented, subrounded medium sand, some iron-oxide stains, massive	PID = 30 PPM
	60.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-04	SHEET 6 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.7' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 103.0, 06/13/91 START 06/10/91 0945 FINISH 06/13/91 1300 LOGGER T. CANOVICH/ K. LEAR

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	60.0 62.0	27-SS	1.9	17-22-29-38 (67)	POORLY GRADED SAND (SP), brown, 10 YR 5/3, moist, medium grained, fining downward, massive	PID = 40 PPM
	62.5 64.5	28-SS	1.9	12-14-23-31 (54)	SILTY SAND (SM), pale brown, 10 YR 6/3, moist, poorly graded, fine sand, clay skins common, massive, very few fine orange mottles	PID =38 PPM
65	65.0 66.4	29-SS	2.0	20-40-50/4" (50/4")	CLAYEY SAND (SC), very pale brown, 10 YR 7/4, dry, medium to very dense, massive, mixed mineralogy, very fine sand, 25% clay by volume, common very well developed clay skins, common bright orange mottles	PID = 22 PPM Rig shut down for the day due to engine overheating.
	67.5 69.3	30-SS	2.0	6-24-50-50/3" (50/3")	CLAYEY/SILTY SAND (SC), yellowish brown, varies to darker shade of yellowish brown at 69.0', moist, very dense, reddish/orange brown mottling in lightler material	6/12/91 started drilling 0230 PID = 102 PPM
70	70.0 71.8	31-SS	1.9	48-45-50-50/3" (50/3")	as above, color varies, some large mica grains	PID = 12 PPM
	72.5 74.5	32-SS	1.9	17-22-18-12 (30)	POORLY GRADED SAND (SP), yellowish brown, 10 YR 5/4, medium to fine sand, changes to CLAYEY/SILTY SAND (SC-SM) at ~73.8', light yellowish brown, moist, medium density	PID = 78 PPM
	75.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-04	SHEET 6 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65 FT DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 103.0, 06/13/91 START 06/10/91 0945 FINISH 06/13/91 1300 LOGGER T. DANOVICH/ K. LEARY

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	5.0 77.0	33-SS	2.0	13-21-25-45 (70)	CLAYEY SAND (SC), yellowish brown, moist, dense, numerous darker brown staining in lenticular patterns, clay skins, clays are very plastic, tending toward finer at bottom (77.0')	PID = 110 PPM
	77.5 79.5	34-SS	2.0	12-17-22-35 (57)	LEAN CLAY WITH SAND (CL), light yellowish brown/grayish olive, 2.5 Y 6/3, moist, hard, no mottling or reddish brown staining, also silty	PID = 72 PPM
80	80.0 82.0	35-SS	2.0	17-22-39-66 (105)	CLAYEY SAND (SC), brown, moist, very dense, minor amounts of coarse sand, some staining	PID = 44 PPM
	82.5 83.7	36-SS	1.3	16-50-50/3" (50/3")	SILTY SAND (SM), light yellowish brown, 10 YR 6/4, moist, very dense, (more sandy)	PID = 26 PPM
85	85.0 86.0	37-SS	2.0	45-83-17/0" (17/0")	same as above, some staining, changes back to CLAYEY SAND (SC) at approximately 86 feet, same coloring	PID = 34 PPM
	87.5 89.5	38-SS	2.0	22-29-34-38 (72)	POORLY GRADED SAND (SP), brown, 10 YR 5/3, moist, fine to medium sand, appears loose, subrounded to subangular grains	PID = 4 PPM
	90.0					Note: no sample #39

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-04	SHEET 7 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.7' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 103.0, 06/13/91 START 06/10/91 0945 FINISH 06/13/91 1300 LOGGER T. DANOVICH / K. LEARY

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	90.0 92.0	40-SS	2.0	22-25-36-46 (82)	POORLY GRADED SAND (SP) grading to finer SILT (ML) from 91.5' to 92', dark yellowish brown, 10 YR 4/4, moist, dense, mottling in sample at 92.0', clayey sands filling old root channels	PID = 190 PPM
	92.5 94.3	41-SS	2.0	31-41-45-50/3" (50/3")	CLAYEY SAND (SC), pale yellow, 2.5 YR 7/3, moist, very dense	PID = 54 PPM
95						
	95.5 96.3	42-SS	1.5	17-40-50/3" (50/3")	CLAYEY SAND (SC) grading to SILTY SAND (SM) from 95.5' to 96', light yellowish brown, 2.5 YR 6/3, moist, very dense	PID = 13 PPM
	97.5 99.5	43-SS	2.0	17-20-20-30 (50)	CLAYEY/SILTY SAND (SC/SM), light yellowish brown, 2.5 YR 6/3, moist, very dense	PID = 102 PPM
100	100.0 102.0	44-SS	2.0	26-28-31-36 (67)	CLAYEY SAND (SC), same as above	PID = 70 PPM
	102.5 104.5	45-SS	2.0	13-21-42-50 (92)	SILTY SAND (SM), dark yellowish brown, 10 YR 4/4, wet, dense, massive, no mottling observed	ground water encountered at approximately 103.0', PID = 22 PPM One 3-inch well installed - see well construction log.
					END OF BORING AT 104.5, 6/13/91	*PID = Photoionization Detector for Organic Vapors

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-05	SHEET 1 OF 2

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SAMPLING PORT WSP-SB, SITE S, AREA D

ELEVATION APPROXIMATLEY 65.4 DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61/8" HOLLOW STEM AUGER

WATER LEVELS NOT ENCOUNTERED START 06/17/91 0910 FINISH 06/18/91 1205 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
						0910 setting up, 0920 spinning auger, plan to drill through gravel layer Top of sampling port
						no samples taken to 7.5'
5						
	7.5					
	7.5–9.5	1-SS	1.5	8-11-19-21 (30)	Top of upper middle sleeve (8.0'). SILTY GRAVEL WITH SAND (GM), brown to greenish gray, dry, hard subrounded gravel to 3/4" coarse to fine sand, remainder (8.5'-9.5'): mixture of SILTY SAND (SM), and fat CLAY (CH) greenish gray to dark gray, dry to moist, strong odor	0940 grinding, infer gravel layer, drill until grinding stops - measure at 7.5' PID* = <2 PPM
10	10.0–12.0	2-SS	0.8	4-2-2-3 (5)	POORLY GRADED SAND WITH SILT (SP-SM) TO SILTY SAND (SM), dark greenish gray, some reddish brown, black ashy material, medium to fine sands, mostly fine	PID = 440 PPM
	12.5–14.5	3-SS	1.1	2-2-6-13 (19)	As above, SP-SM to SM, unburned to burned newspaper & wood fragments, one nail in tip, also aluminum, plastic, oily soil	sludge on outside of sampler PID = 400 PPM
	15.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-05

SHEET 2 OF 2

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY

LOCATION SAMPLING PORT WSP-3B, SITE S, AREA D

ELEVATION APPROXIMATLEY 65.4

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61/8" HOLLOW STEM AUGER

WATER LEVELS NOT ENCOUNTERED

START 06/17/91 0910

FINISH 06/18/91 1205

LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	15.0 16.5	4-SS	1.2	9-49-50 (99)	POORLY GRADED SAND WITH SILT (SP-SM), coarse to fine sand, mostly fine, dry, micaceous, possible charcoal fragments - but look similar to micas, strong odor	PID = 510 PPM
	16.5 17.5					Assume still in pit material
	17.5 19.0	5-SS	1.5	19-30-60 (90)	SILTY SAND, (SM),greenish gray, dry, medium to fine sands, micaceous, "oily" soil, strong odor	Infer native soil, PID = 210 PPM
20	19.0 20.0					
	20.0 22.0	6-SS	1.6	19-28-29-30 (59)	SILTY SAND, (SM), similar to above, strong odor	PID = 300 PPM
25					END OF BORING AT 22.0 FEET, 6/18/91	1135 prepare to ream out hole with 10" auger; 1230 hole reamed out; install well on 6/18/91, see well construction diagram * PID = Photoionization Detector for Organic Vapor

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-06A

SHEET 1 OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY

LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.8'

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 106.5, 06/19/91

START 06/18/91 1100

FINISH 06/19/91 1120

LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
						hand dug to HDPE liner
					HDPE liner at 2.1'	Note: driving samples with down hole hammer on wireline winch
5						
					WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM), grayish brown, dry, hard, subrounded gravel to 1", coarse to fine sand (description from cuttings)	driller says thinks we hit gravel at 6', drill until we're below gravel
	7.5 9.5	1-SS	1.6	10-15-17-21 (38)	Top 0.1. (8.0'): SILTY SAND WITH GRAVEL (SM), brown, slough?, Below (8.2'-9.5') SILTY SAND (SM), greenish gray, dry, medium to fine sand, mostly fine	PID* = 20 PPM
10	10.0 12.0	2-SS	1.9	3-6-7-10 (17)	similar to above, may grade to CLAYEY SAND (SC), bottom of bottom sleeve and tip (11.8'-12.0'): SILTY SAND (SM), as above with black oily sludge and ash (?), wire, strong odor	PID = <2 bottom of sample in bit
	12.5 14.5	3-SS	1.5	5-10-15-17 (32)	Varies from POORLY GRADED SAND WITH SILT (SP-SM) to SILTY/CLAYEY SAND (SM/SC), greenish gray, dry, mostly medium to fine sand, local areas of black sludge and/or ash, strong odor	PID = 280 PPM
	15.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-06A

SHEET 2 OF 8

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY

LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.8'

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 106.5, 06/19/91

START 06/18/91 1100

FINISH 06/19/91 1120

LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	15.0 16.0	4-SS	1.4	13-60 (73)	Bottom of upper middle sleeve and top of lower middle sleeve (15.0'): POORLY GRADED SAND WITH SILT (SP-SM), greenish gray, mostly fine sand, bottom of lower middle sleeve and bottom sleeve (15.5'-15.9'): POORLY GRADED SAND (SP), brown dry, medium to fine sand, mostly fine, micaceous, tip 16.0': SILTY SAND (SM), dry, fine sand, micaceous	no advance on 3rd 6", more recovery than we drove 4-ss, t.p. black mica looks similar to ash, PID = 281 PPM
	17.5 19.5	5-SS	1.4	9-28-60 (88)	POORLY GRADED SAND WITH SILT (SP-SM), olive gray, dry, coarse to fine sand, mostly fine, micaceous	PID =480 PPM black mica
20	20.0 22.0	6-SS	1.5	5-18-38-48 (86)	POORLY GRADED SAND WITH SILT (SP-SM), similar to above but brown to olive gray	PID = 480 PPM
25	25.0 27.0	7-SS	1.6	13-30-35-43 (78)	Upper middle sleeve and top of lower middle sleeve (25.5'-26.2'): POORLY GRADED SAND (SP), mottled olive gray and brown, dry, medium to fine sand, bottom of lower middle sleeve and bottom sleeve (26.2'-27.0'): SILT WITH SAND (ML), olive gray, dry, fine sand, some hard layers	PID = 270 PPM some partially lithified layers
	30.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-06A
SHEET 3 OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA C
ELEVATION APPROXIMATELY 65.8'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 106.5, 06/19/91
START 06/18/91 1100
FINISH 06/19/91 1120
LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	30.0 32.0	8-SS	2.0	10-19-15-24 (39)	Upper sleeve and top of upper middle sleeve (30.0'-30.8'): SILT WITH SAND (ML), mottled olive gray and olive brown, dry, fine sand, laminated, may be ML-CL. Bottom of lower middle sleeve and top of lower sleeve (31.2'-31.7'): POORLY GRADED SAND (SP), light brown, dry, fine sand, micaceous, bottom of lower sleeve (31.7'-32.0'): SILTY SAND/SAND SILT (SM/ML), brown, moist, fine sand, micaceous	PID = 12 PPM
35	35.0 37.0	9-SS	2.0	8-9-27-47 (74)	Top of upper sleeve (35.0'-35.3'): SILT WITH SAND (ML) similar to upper sleeve of 8-SS Below (35.3'-37.0'): SILTY SAND (SM), similar to bottom sleeve of 8-SS but medium to fine sand, locally calcareous nodules, a few layers of SANDY SILT (ML)	PID = 104 PPM
40	40.0 42.0	10-SS	1.7	8-12-21-21 (42)	SANDY SILT TO SILTY SAND (ML to SM), (40.2'-41.3') yellowish brown with FeOx stains, fine sand, partially lithified. Bottom of lower middle sleeve and lower sleeve (41.4'-42.0"): POORLY GRADED SAND (SP), light brown, dry, fine sand, micaceous	PID = 36 PPM end 6/18/91, 0400 start 6/19/91, 0400
	45.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-06A
SHEET 4 OF 8

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.8'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS 106.5, 06/19/91
START 06/18/91 1100
FINISH 06/19/91 1120
LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	45.0 46.5	11-SS	1.3	12-25-60 (85)	Interlayered SILTY SAND/SANDY SILT (SM/ML) (80%) and POORLY GRADED SAND (SP), olive gray to brown with orange brown FeOx mottling, dry, fine sand, micaceous, partially lithified zones	drove 18" refusal PID = 76 PPM
50	50.0 51.5	12-SS	1.3	8-30-66 (96)	SILTY SAND/SANDY SILT (SM/ML), as above with POORLY GRADED SAND (SP) laminae as above	PID = 18 PPM driller thinks too much slough in hole, hammers out sampler
55	55.0 57.0	13-SS	1.2	20-36-45-50 (95)	Upper sleeve and top of upper middle sleeve (55.0'-55.7'): SILTY SAND (SM), olive brown with orange brown FeOx streaks and lenses, dry, medium to fine sand, mostly fine. Bottom of upper middle sleeve and top of lower middle sleeve (55.7'-56.3'): POORLY GRADED SAND (SP), dry, medium to fine sand, mostly fine, micaceous. Bottom of lower middle sleeve and top of lower sleeve (56.3'-56.7'): SANDY SILT TO SILTY SAND (ML/SM), olive brown, dry, fine sand. Bottom of lower sleeve and tip (56.7'-57.0'): POORLY GRADED SAND (SP), light brown, dry, fine sand	PID = 116 PPM
	60.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-06A	SHEET 5 OF 8

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.8' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 106.5, 06/19/91 START 06/18/91 1100 FINISH 06/19/91 1120 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	60.0 62.0	14-SS	1.8	11-22-24-27 (51)	POORLY GRADED SAND (SP), light brown with FeOx streaks, dry, fine sand, micaceous, pores. Tip (62.0'): SILTY SAND (SM), olive brown with FeOx streaks and pods, dry, medium to fine sand, mostly fine, micaceous	PID = 22 PPM
65	65.0 67.0	15-SS	1.8	8-15-20-28 (48)	SILT WITH SAND (ML) (65.2'-66.4'), light olive brown, dry, fine sand, pores. Bottom of lower middle sleeve and bottom sleeve (66.4'-67.0'): SILTY SAND (SM), light olive brown, dry, a few FeOx streaks, may vary to a CLAYEY SAND (SC)	PID = 79 PPM driller cleaned cuttings from hole
70	70.0 71.8	16-SS	1.9	9-25-40-50/4" (50/4")	Top of upper sleeve (70.0'-70.3'): SILTY SAND (SM), olive brown, dry, fine sand, partially lithified, pores. Below (70.3'-71.8'): Varies from SILTY SAND to POORLY GRADED SAND WITH SILT (SM to SP-SM), light olive brown with FeOx staining, dry, medium to fine sand, mostly fine, micaceous, may include some CLAYEY SAND (SC) similar to above	PID = 32 PPM Rig down for repairs on kelly bar
	75.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33	BORING NUMBER VES-06A SHEET 8 OF 8

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.3' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 106.5, 06/19/91 START 06/18/91 1100 FINISH 06/19/91 1120 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	75.0 77.0	17-SS	1.9	3-8-11-22 (33)	Mostly SILTY SAND (SM), olive brown with *FeOx staining and a few black (MnOx?)* streaks, dry, fine sand, pores, contains very thin beds or laminae of SANDY SILT (ML), fine sand, possible SANDY CLAY (CL) or partially lithified layers - very hard dry strength	PID = 180 PPM
80	80.0 82.0	18-SS	1.8	6-13-24-40 (64)	Mostly CLAYEY SAND (SC), olive brown with gray streaks, dry, fine sand, varies to SANDY CLAY (CL)	PID = 155 PPM
85	85.0 86.3	19-SS	1.3	12-34-60/4" (60/4")	Interlayered CLAYEY SAND (SC) (50%) and SILTY SAND (SM) (50%), olive gray with FeOx streaks and pods, dry, fine sand, micaceous, pores. Bottom of bottom sleeve and tip (86.0'-86.3'): POORLY GRADED SAND (SP), fine sand with some SILT laminae	PID = 250 PPM Rig engine stalling frequently
	90.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33	BORING NUMBER VES-06A

SHEET [illegible] OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S. AREA D

ELEVATION APPROXIMATELY 65.8' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 106.5, 06/19/91 START 06/18/91 1100 FINISH 06/19/91 1120 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	90.0 92.0	20-SS	1.7	5-14-21-25 (46)	Upper sleeve and top of upper middle sleeve (90.3'-90.8'): POORLY GRADED SAND (SP), mottled light brown and brown with a few black spots, dry, medium to fine sand, mostly fine, remainder is SANDY SILT (ML), olive gray, moist, fine sand, micaceous.	Note: need to sieve since sand is borderline silt-size, checked with #200 sieve. lower middle sleeve is sandy silt PID = 260 PPM
95	95.0 97.0	21-SS	2.0	7-12-32-50 (82)	Top of upper sleeve (95.0'-95.3'): SANDY SILT (ML), olive gray with black streaks, dry, fine sand. Bottom of upper sleeve (95.3'-95.7'): SILTY SAND (SM), yellowish brownish gray, moist, grades downward to SANDY SILT (ML), yellowish brown, dry to slightly moist in tip (97.0')	PID = 280 PPM
100	100.0 102.0	22-SS	2.0	8-17-18-19 (37)	Mostly SANDY SILT (ML), light olive brown, dry, fine sand, locally grades to SILTY SAND (SM). Tip (102.0'): SANDY LEAN CLAY (CL)	Added 5' A-rod to sampler so we don't run out of wireline while driving sampler PID = 30 PPM
	105.0					

PROJECT NUMBER SAC28722.19.33	**BORING NUMBER** VES-06A	SHEET 3 OF 3

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY **LOCATION** SITE S, AREA D

ELEVATION APPROXIMATELY 65.3' **DRILLING CONTRACTOR** BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 106.5, 06/19/91 **START** 06/18/91 1100 **FINISH** 06/19/91 1120 **LOGGER** K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	105.0 107.0	23-SS	1.5	5-10-20-37 (57)	SANDY LEAN CLAY (CL), light olive brown, dry to slightly moist, fine sand, Bottom of lower middle sleeve and bottom sleeve (106.4'-107.0'): POORLY GRADED SAND (SP), wet, fine sand, micaceous	Added another 5' A-rod to drive 23-SS PID = 62 PPM
					End of Boring at 107.0 feet, 6/19/91	Two 1-inch piezometers installed - see well construction log * PID = Photoionization Detector for Organic Vapors
110						
115						

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-07

SHEET 1 OF [illegible]

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY

LOCATION SITE S, AREA C

ELEVATION APPROXIMATELY 65.2'

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 100.5, 06/20/91

START 06/18/91 1108

FINISH 06/20/91 0750

LOGGER T. DANOVICH / K. LEAR

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
						DIRECTION FROM J. DANKO - samples every 2.5' in waste pit S from 30 to 40', otherwise sample every 5'
					HDPE liner at 2.3'	Fill above liner; hand dug to HDPE liner
5	5.0 5.5	1-SS	0.4	66/6" (66/6")	WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM), brown (turns gray when dry), moist, gravel angular to subrounded	not enough sample to obtain PID* measurement
10	10.0 12.0	2-SS	1.0	3-3-2-3 (5)	POORLY GRADED SAND WITH CLAY (SP-SC), grayish brown, moist, very loose, some gravel, roots in sample, solvent odor	PID* = 144 PPM
	12.5 14.5	3-SS	1.1	7-7/18" (7/18")	POORLY GRADED SAND (SP), dark brown when moist, gray/olive when dry, moist, loose, strong solvent odor	PID = 270 PPM
	15.0					

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-07	SHEET [illegible] OF [illegible]

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.2' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 102.5, 06/20/91 START 06/18/91 1108 FINISH 06/20/91 0750 LOGGER T. DANOVICH/K. LEAR

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	15.0 17.0	4-SS	2.0	5-4-4-5 (9)	Grades from POORLY GRADED SAND (SP) to SILTY/CLAYEY SAND (SM/SC) in bottom sleeve (16.5'-17.0'), black, moist, SP is loose, SM/SC is medium dense, strong solvent odor	PID = [illegible] PPM
	17.5 19.5	5-SS	1.8	4-3-4-5 (9)	SILTY SAND (SM), as above, tip (19.5') of this sample very black and discolored, very strong solvent odor, burnt wood, glass, fiberous debris (SLUDGE)	PID = 80 PPM
20	20.0 22.0	6-SS	0.6	3-2-3-6 (9)	Same as above, more black and oily, (SM)	PID = 260 PPM
	22.5 24.5	7-SS	0.8	6-6-5-6 (11)	Same as above and tending to POORLY GRADED SAND (SP), black, oily, woody debris (lots of it), very strong solvent odor, more fine sand and less silt/clay	PID = 350 PPM
25	25.0 27.0	8-SS	1.9	8-17-26-44 (70)	Sample contains intermixed POORLY GRADED SAND (SP), POORLY GRADED SAND WITH SILT (SP-SM), and SILTY SAND (SM), olive gray, moist, loose, fine sand, in tip and in bottom sleeve (26.5'-27.0') noted some black woody debris and discoloration, solvent odor	PID = 500 PPM
	27.5 29.5	9-SS	2.0	6-18-33-46 (79)	SILT (ML), olive gray, 5 Y 4/2, moist, firm, top contains debris - contains debris - slough (?), (no obvious odor except in slough at top)	sample appears lacustine & has clay skins, but has slow/rapid dilatancy and low strength, PID = 116 PPM
	30.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-07	SHEET 3 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA C
ELEVATION APPROXIMATELY 65.2' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/20/91 START 06/18/91 1108 FINISH 06/20/91 0750 LOGGER T. DANOVICH/ K. LEARY

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	30.0 32.0	10-SS	1.9	17-19-32-36 (68)	Interlayered POORLY GRADED SAND (SP) and SILTY SAND (SM), olive gray, moist, fine to very fine sand, slight odor	PID = 480 PPM
	32.5 34.5	11-SS	2.0	10-22-33-30 (63)	SILTY SAND (SM), dark brown except for tip (34.5') - grayish olive, moist, dense to very dense, very fine sand, solvent odor when opening split spoon	PID = >120 PPM
35	35.0 36.7	12-SS	2.0	21-39-50-50/3" (50/3")	SILTY SAND (SM) grades to SILT (ML) in bottom sleeve (36.2'-36.7'), grayish olive, moist, very dense, some orangish mottling	slight solvent odor PID = 500 PPM
	37.5 39.3	13-SS	1.8	12-16-30-50/4" (50/4")	SILTY SAND (SM) olive gray with reddish brown (FeOx) staining, moist, very dense, fine sand	PID = 340 PPM slight solvent odor, 6/18/91 stopped drilling 1340
40	40.0 42.0	14-SS	1.3	10-15-20-36 (56)	POORLY GRADED SAND WITH SILT (SP-SM), brownish gray (difficult to tell due to lighting conditions), moist, loose, fine sand, solvent odor	6/19/91 started drilling 0404 PID = 48 PPM
	45.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-07	SHEET 4 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.2' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS 102.5, 06/20/91 START 06/18/91 1108 FINISH 06/20/91 0750 LOGGER T. DANCVICH/ K. LEARY

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	45.0 46.6	15-SS	2.0	20-29-100/7" (100/7")	CLAYEY SILT (ML), brown, gleying and mottles, moist, hard	sample was sticky like clay, but had a lot of fines and rapid/slow dilatancy PID = 68 PPM
50	50.0 51.7	16-SS	2.0	13-29-100/7" (100/8")	SILT (ML) grading to SILTY/CLAYEY SAND (SM/SC) at 51.2', olive gray, moist, stiff	PID = 134 PPM
55	55.0 57.0	17-SS	1.5	20-28-34-50 (84)	SILTY SAND (SM), olive/brownish with reddish dark brown mottling (filling former root channels, moist, medium density, fine sand	PID = 78 PPM
	60.0					

CH2M HILL

PROJECT NUMBER	BORING NUMBER
SAC28722.19.33	VES-07

SHEET 5 OF 7

SOIL BORING LOG

PROJECT MCCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 65.2' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER

WATER LEVELS 102.5, 06/20/91 START 06/18/91 1108 FINISH 06/20/91 0750 LOGGER T DANOVICH/ K. LEAR

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	60.0 61.4	18-SS	1.7	25-27-100/5" (100/5")	CLAYEY SAND (SC), (grades to nearly CL in tip), olive, 5 Y 5/3, with dark reddish brown filling old root channels, moist, loose	almost laminar structure, PID = 32 PPM
65	65.0 67.0	19-SS	1.9	12-25-30-50 (80)	POORLY GRADED SAND (SP), gray (salt and pepper color, with orange feldspar), moist, very loose (by touch), medium to coarse sand	massive structure, "salt" quartz, "pepper" - mafic minerals PID = 32 PPM
70	70.0 72.0	20-SS	1.9	14-23-29-32 (61)	POORLY GRADED SAND (SP), same as above	PID = 30 PPM
	75.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-07

SHEET 6 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.2'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 100.5, 06/20/91
START 06/18/91 1108
FINISH 06/20/91 0750
LOGGER T. DANOVICH/K. LEAR

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	75.0 77.0	21-SS	1.9	13-16-38-46 (84)	CLAYEY SILT (ML), olive gray with reddish brown FeOx staining, moist, stiff	can see clay skins, but decided to call it ML due to dilatancy & particle size (can see very fine--silts), blocky texture PID = 160 PPM
80	80.0 82.0	22-SS	1.6	10-23-36-50 (86)	same as above (ML), (no FeOx staining), some portions have more fine sand, but still clayey silt, laminar parting appears to be lacustrine deposit	PID = 60 PPM replaced freyed wireline
85	85.0 87.0	23-SS	1.6	16-23-47-50 (97)	LEAN CLAY (CL), olive gray, moist, very stiff, grades to POORLY GRADED SAND (SP) at 35.8', gray with some reddish brown discoloration, moist, loose	PID = 45 PPM SP massive structure hard drilling
	90.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-07
SHEET 7 OF 7

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 65.2'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 6-INCH HOLLOW STEM AUGER
WATER LEVELS 102.5, 06/20/91
START 06/18/91 1108
FINISH 06/20/91 0750
LOGGER T. DANCVICH/ K. LEARY

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	90.0 92.0	24-SS	2.0	14-22-42-53 (95)	SILT (ML), olive gray, 5Y 5/2, moist, firm to stiff, changes to SILTY SAND (SM) at approx. 90.8', same color and density as above	feels gritty like volcanic ash PID = 45 PPM
95	95.0 97.0	25-SS	2.0	16-30-41-47 (88)	SANDY SILT (ML)/SILTY SAND (SM) grades finer downward, olive gray with dark bluish gray precipitate in channels throughout bottom 1 foot of sample (96.0'-97.0'), moist, very dense, fine sand	salt crystals (seen through hand lens) throughout entire sample, blocky structure, PID = 280 PPM
100	100.0 102.0	26-SS	2.0	19-22-31-46 (77)	ELASTIC SILT (MH), brown with bluish gray stringers, moist, stiff	sample had properties of both silt & clay, but no dilatancy, felt sticky, could roll thread, PID = 90 PPM
	103.0 105.0	27-SS	1.5	4-14-23-32 (60)	POORLY GRADED SAND (SP), dark yellowish brown, 10 YR 4/4, wet (saturated), loose, medium sand END OF BORING AT 105.0', 6/20/91	PID = 72 PPM 3" well installed - see well construction log

CH2M HILL

PROJECT NUMBER	BORING NUMBER
SAC28722.19.33	VES-08

SHEET 1 OF 2

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S AREA D
ELEVATION APPROXIMATELY 65.4' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61/6" HOLLOW STEM AUGER
WATER LEVELS NOT ENCOUNTERED START 06/20/91 1100 FINISH 06/21/91 0630 LOGGER T DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
						DIRECTIONS: log & sample every 2.5' in waste pit
					HDPE liner at 2.0'	hand dug to HDPE liner
5						noticed fabric type liner (beach fuss) coming up the auger
	7.5 9.5	1-SS	1.4	13-18-15-18 (33)	CLAYEY SAND (SC), brown, moist, medium density	no obvious odor, laminar structure, looks like phenocrysts in a matrix but actually replacement of coarser/finer soils (fine sands to clays in brown clayey sand/sand matrix) "phenocrysts" are color olive grey, reddish brown, light tan. *PID = 96 PPM
10	10.0 12.0	2-SS	2.0	8-8-9-12 (21)	POORLY GRADED SAND WITH SILT (SP-SM) grades to POORLY GRADED SAND (SP) at 11.0', brownish gray, moist, very loose, strong solvent odor	PID = 162 PPM
	12.5 14.5	3-SS	2.0	4-7-7-6 (13)	POORLY GRADED SAND (SP) changes to CLAYEY SAND (SC) at 14.1', dark brown, moist, loose, massive texture, strong solvent odor	PID = 410 PPM
	15.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-08

SHEET 2 OF 2

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY

LOCATION SITE S AREA D

ELEVATION APPROXIMATELY 65.4'

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61/6" HOLLOW STEM AUGER

WATER LEVELS NOT ENCOUNTERED

START 06/20/91 1100

FINISH 06/21/91 0630

LOGGER T. DANOVICH

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	15.0 17.0	4-SS	1.6	6-9-12-8 (20)	CLAYEY SAND (SC), as above only darker color (black/olive/gray), discoloration possibly due to wastes, strong solvent odor	PID = 480 PPM
	17.5 19.5	5-SS	1.7	5-6-6-6 (12)	CLAYEY SAND (SC), as above, changes at 19.4', organic material and yellowish brown SILT (ML), discolored to gray, dark brown and black, WASTE MATERIAL	black burned material, very strong solvent odor, colors observed in layers (like a chromatograph column) PID = 300 PPM
20	20.0 22.0	6-SS	0.0	7-23-40-50 (98)	black, oily, SANDS in tip, WASTE MATERIAL (not enough recovery to classify sample)	very strong solvent odor; not enough sample to obtain a PID measurment
	22.5 24.5	7-SS	1.7	15-30-38-46 (82)	SILTY SAND (SM), dark olive gray, moist, loose, very fine sands, tends siltier at tip (24.5'), strong solvent odor	pieces of metal & wire in tip & in upper part (22.3') of sample, PID = 310 PPM
25	25.0 27.0	8-SS	1.3	15-32-34-50 (84)	POORLY GRADED SAND WITH CLAY (SP-SC), dark olive gray, 5 Y 3/2, moist, fine sand, loose, strong solvent odor	
					End of Boring at 27.0 feet, 6/20/91	3" well installed - see well construction log. *PID = Photoionization Detector for Organic Vapors

CH2M HILL

PROJECT NUMBER	BORING NUMBER	
SAC28722.19.33	VES-09	SHEET 1 OF 6

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 66.0' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS NOT ENCOUNTERED START 06/20/91 0630 FINISH 06/21/91 1315 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
					Road fill Woven geotextile at 0.9' HDPE liner at 2.2'	Excavated pit by hand to liner prior to augering
5						driller reports gravel layer at about 5'
	7.5	1-SS	1.3	7-14-13-21 (34)	Top of upper middle sleeve (8.2'). SILTY SAND (SM), brown, dry, fine sand, micaceous, some gravel to 0.5 inch (subrounded). Below: SILTY SAND (SM), olive gray, 5 Y 4/2, dry, medium to fine sand, mostly fine, odor, some CLAYEY SAND (SC)	PID* = 97 PPM geotextile fabric in cuttings,non-woven material
	9.5					
10	10.0	2-SS	1.6	7-11-12-13 (25)	SILTY SAND (SM), olive gray, 5 Y 4/2, dry, medium to fine sand, mostly fine, strong odor	PID = 500 PPM
	12.0					driller augered to 15', forgot 12.5' sample, cuttings are dark gray, look like pit material
	15.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33
BORING NUMBER VES-09
SHEET 2 OF 5

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 66.0'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS NOT ENCOUNTERED
START 06/20/91 0630
FINISH 06/21/91 1315
LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	15.0 17.0	3-SS	1.7	6-19-19-22 (41)	Upper sleeve and top of upper middle sleeve (15.3'-15.8'): SILTY SAND (SM), as above, olive gray, 5 Y 4/2. Below (15.8'-17.0'): POORLY GRADED SAND WITH CLAY (SP-SC), yellowish brown, 10 YR 5/8, moist, micaceous, odor	PID = 240 PPM
	17.5 19.5	4-SS	2.0	14-20-21-23 (44)	POORLY GRADED SAND (SP), yellowish brown, coarse to fine sand, mostly medium, slightly plastic fines, micaceous, similar to above	may be out of pit, PID = 170 PPM
20	20.0 22.0	5-SS	1.9	6-21-23-25 (48)	POORLY GRADED SAND WITH SILT (SP-SM), similar to above, soil has a wet appearance and strong odor	looks like native soil, change to 5' sample spacing, PID = 200 PPM
25	25.0 27.0	6-SS	1.6	3-7-17-28 (45)	Top sleeve and top of upper middle sleeve (25.4'-25.8'): SILTY SAND (SM), olive gray, fine sand. Below (25.8'-26.9'): SANDY SILT (ML), dry, fine sand, tip (27.0'): POORLY GRADED SAND WITH SILT (SP-SM), pale brown, 10 YR 6/3, and yellowish brown, 10 YR 5/4, laminated, dry, fine sand, micaceous, MnOx and trace FeOx stains	PID = 360 PPM
	30.0					

CH2M HILL

PROJECT NUMBER SAC28722.19.33

BORING NUMBER VES-09

SHEET 3 OF 5

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY

LOCATION SITE S, AREA D

ELEVATION APPROXIMATELY 66.0'

DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA

DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER

WATER LEVELS NOT ENCOUNTERED

START 06/20/91 0630

FINISH 06/21/91 1315

LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	30.0 32.0	7-SS	1.6	7-25-26-31 (57)	SILT WITH SAND (ML), similar to above, noted one laminae of fine sand	PID = 650 PPM
35	35.0 37.0	8-SS	2.0	6-10-22-36 (58)	Top sleeve and top of upper middle sleeve (35.0'-35.7") SILTY SAND (SM), brown, dry, fine sand, micaceous, partially lithified, pores. Bottom of upper middle sleeve and top of lower middle sleeve (35.7"-36.2'): SILTY SAND (SM), olive gray, dry, fine sand, borderline SANDY SILT (ML). Bottom of lower middle sleeve and bottom sleeve (36.2'-37.0'): SAND SILT (ML), olive gray, dry, fine sand	PID = 320 PPM
40	40.0 42.0	9-SS	1.8	5-15-20-32 (52)	Top sleeve and top of upper middle sleeve (40.3'-40.8'): SANDY SILT (ML), olive brown, slightly moist, fine sand, possible calcareous nodules. Bottom of upper middle sleeve and lower middle sleeve (40.8'-41.7'): laminated SANDY SILT (ML) and SANDY LEAN CLAY (CL), yellowish brown, 10 YR 5/4, dry, fine sand, pores. Bottom sleeve and tip (41.7'-42.0'): POORLY GRADED SAND/SANDY SILT (SP/ML), pale brown, 10 YR 6/3, dry, fine sand, micaceous	PID = 210 PPM
	45.0					

PROJECT NUMBER SAC28722.19.33	BORING NUMBER VES-09	SHEET 4 OF 5

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 66.0' DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS NOT ENCOUNTERED START 06/20/91 0630 FINISH 06/21/91 1315 LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
	45.0 46.9	10-SS	1.3	7-15-42-50/5" (50/5")	Top sleeve, upper middle sleeve and top of lower middle sleeve (45.0'-46.1'): laminated SANDY SILT (ML) (60%) and SILTY SAND (SM) (40%), brown, 10 YR 5/3, moist, fine sand, micaceous, FeOx staining. Bottom of lower middle sleeve (46.1'-46.4'): POORLY GRADED SAND (SP), light brown, fine sand, micaceous. Bottom sleeve and tip (46.4'-46.9'): SANDY SILT (ML), pale brown, 10 YR 6/3, dry, fine sand, micaceous, FeOx staining, mostly low dry strength	sample has a distinctive odor (either of paint thinner, perhaps) that has not been smelled on other samples/boreholes. In tip suspect some layers may be SANDY LEAN CLAY due to high dry strength. PID = 310 PPM
50	50.0 52.0	11-SS	1.6	15-17-30-50 (80)	Upper and upper middle sleeves (50.4'-51.2'): borderline SILTY SAND/SANDY SILT (SM/ML), olive, 5 Y 4/3, dry, fine sand, micaceous, laminated FeOx stains along laminae. Bottom of lower middle sleeve (51.3'-51.5'): 2-inch layer of POORLY GRADED SAND (SP), light brown, dry, fine sand. Bottom of bottom sleeve (51.8'): SILT WITH SAND (ML), color changes from brown to gray, dry fine sand	sample has some odor as in 10-SS described above. PID = 250 PPM
55	55.0 56.7	12-SS	1.6	9-28-50-50/2" (50/2")	Top, upper middle and top of lower middle sleeves (55.0'-56.0'): Mostly SANDY SILT to SANDY LEAN CLAY (ML/CL), olive gray, dry, FeOx streaks in layers and cross-cutting bedding (root holes?), fine sand, low to high dry strength, micaceous. Bottom 1 inch of lower middle sleeve, bottom sleeve and tip (56.1'-56.6'): POORLY GRADED SAND (SP), light brown with FeOx staining, dry, fine sand, micaceous. Bottom of tip (56.7'): ML/CL as above	driller says hard drilling PID = 440 PPM
	60.0					

PROJECT NUMBER	SAC28702.19.33
BORING NUMBER	VES-09

SHEET 5 OF 5

SOIL BORING LOG

PROJECT McCLELLAN AFB SVE TREATABILITY STUDY
LOCATION SITE S, AREA D
ELEVATION APPROXIMATELY 66.0'
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA
DRILLING METHOD AND EQUIPMENT MOBILE B-61 DRILL RIG, 8-INCH HOLLOW STEM AUGER
WATER LEVELS NOT ENCOUNTERED
START 06/20/91 0630
FINISH 06/21/91 1315
LOGGER K. WHITE

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE DRILLING FLUID LOSS TESTS AND INSTRUMENTATION
	60.0 62.0	13-SS	1.6	7-15-19-23 (42)	Top, upper middle, lower middle, and top of bottom sleeves (60.4'- 61.7'): POORLY GRADED SAND (SP), pale brown, 10 YR 6/3, dry, medium to fine sand, mostly fine, micaceous. Bottom of bottom sleeve and tip (61.7'-62.0'): SANDY SILT (ML), olive gray, 5 Y 5/2, dry, fine sand, micaceous, FeOx staining, low dry strength	PID = 260 PPM
						driller says hard augering
65	65.0 67.0	14-SS	1.8	6-26-22-23 (45)	Top and upper middle sleeves (65.2'-65.8'): Interlayered SILTY SAND (SM) (60%) and SANDY SILT (ML) (40%), olive brown, dry, fine sand, micaceous. Below (65.8'-67.0'): POORLY GRADED SAND (SP), light brown, dry, medium to fine sand, mostly fine, micaceous	PID = 157 PPM
70	70.0 71.7	15-SS	2.0	8-43-44-50/3" (50/3")	Top of top sleeve (70.0'-70.1'): SANDY SILT (ML), pale olive, 5 Y 6/3, dry, fine sand, low dry strength, may have some LEAN CLAY (CL) laminae. Bottom of upper and top of upper middle sleeves (70.1'-70.5'): SILYT SAND (SM), yellowish brown, 10 YR 5/4, dry, fine sand, micaceous. Bottom of upper middle sleeve (70.5'-71.0'): SANDY SILT (ML) as described above. Below (71.0'-71.7'): SILTY SAND (SM), as described above	PID = 320 PPM
					End of Boring at 71.7 feet, 6/20/91	two 1-inch piezometers installed - see well construction log *PID = Photoionization Detector for Organic Vapors

VAPOR EXTRACTION WELL RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 01 FIELD OBSERVERS K WHITE
ELEV, NGVD (top of well casing) ±67.5' SURFACE ELEV, NGVD ±65.4'
WATER LEVEL ELEV/DATE ±104.5' BGS (6/11/91) START DATE 6/07/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/12/91
DRILLING METHOD 6-INCH O.D. HOLLOW STEM AUGER

WELL CONSTRUCTION MATERIALS

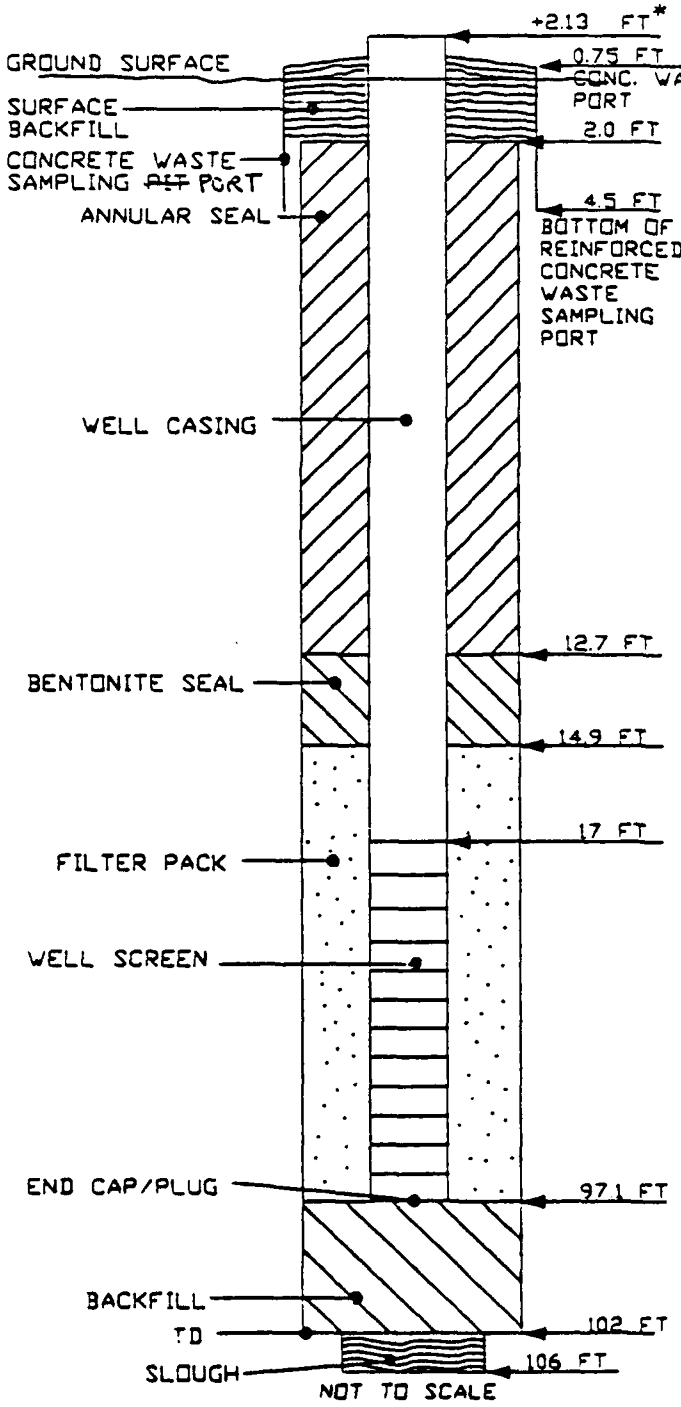
BOREHOLE DIA(S) 10" INCHES TO 102' FT BGS
6" INCHES TO 106' FT BGS
INCHES TO FT BGS
CASING TYPE PVC DIAMETER 4½" ID
COUPLING TYPE THREADED
SCREEN TYPE PVC DIAMETER 4½" OD
SLOT SIZE 0.02" SCREEN LENGTH 80'
TOP CAP TYPE PVC SLIP CAP
END CAP/PLUG TYPE SLIPCAP - HELD W/SST SCREWS
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) NOT USED
FILTER PACK TYPE 45 100# BAGS LONESTAR SAND #3
GRADATION MED-COARSE SAND

SEAL(S)

BENTONITE 2-50# BUCKETS BENTONITE PELLETS
ANNULAR 4-94# BAGS CEMENT (PORTLAND TYPE I-II) W/4% BENTONITE
SURFACE COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL
BACKFILL 6-50# BUCKETS BENTONITE PELLETS

COMMENTS

ADDED 5 GAL WATER PER 50 LB BAG BENTONITE



* DEPTHS ABOVE/BELOW GROUND SURFACE

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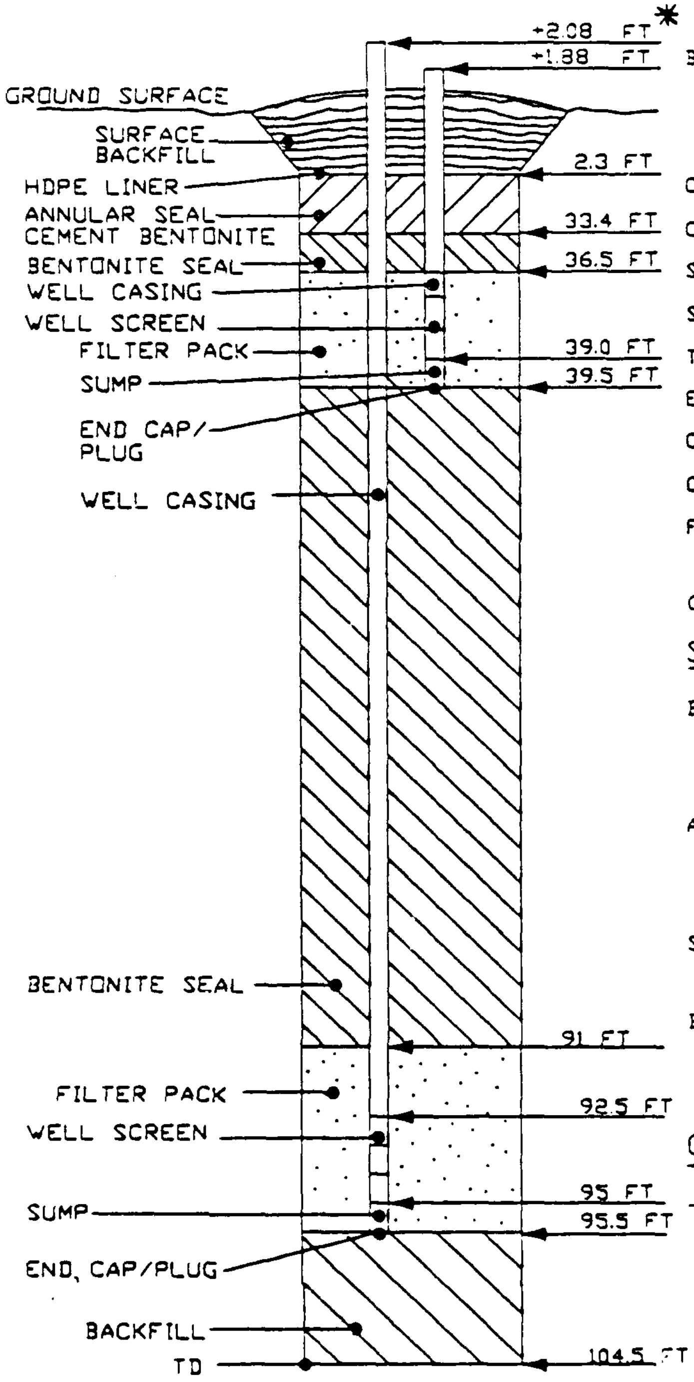
PIEZOMETER RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 02A FIELD OBSERVERS K WHITE, D MEYERS
ELEV, NGVD (top of well casing) ±67.3 SURFACE ELEV, NGVD ±65.3'
WATER LEVEL ELEV/DATE ±102.5' BGS 6/14/91 START DATE 6/12/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/15/91
DRILLING METHOD 8-INCH O.D. HOLLOW STEM AUGER



NOT TO SCALE
* DEPTHS ABOVE/BELOW GROUND SURFACE

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WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 8" INCHES TO 104.5' FT BGS
____ INCHES TO ____ FT BGS
____ INCHES TO ____ FT BGS
CASING TYPE GRAY PVC - SCH 80 DIAMETER 1"
COUPLING TYPE THREADED
SCREEN TYPE PVC DIAMETER 1"
SLOT SIZE 0.02" SCREEN LENGTH 2.5' EACH
TOP CAP TYPE PVC SLIP CAP
END CAP/PLUG TYPE 1" DIA. 5.5" LONG PVC SCREW ON
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) N/A
FILTER PACK TYPE #3 SAND - SHALLOW - 3-100# BAGS
DEEPER - 2-100# BAGS
GRADATION 8x10 COARSE - MEDIUM SAND

SEAL(S)

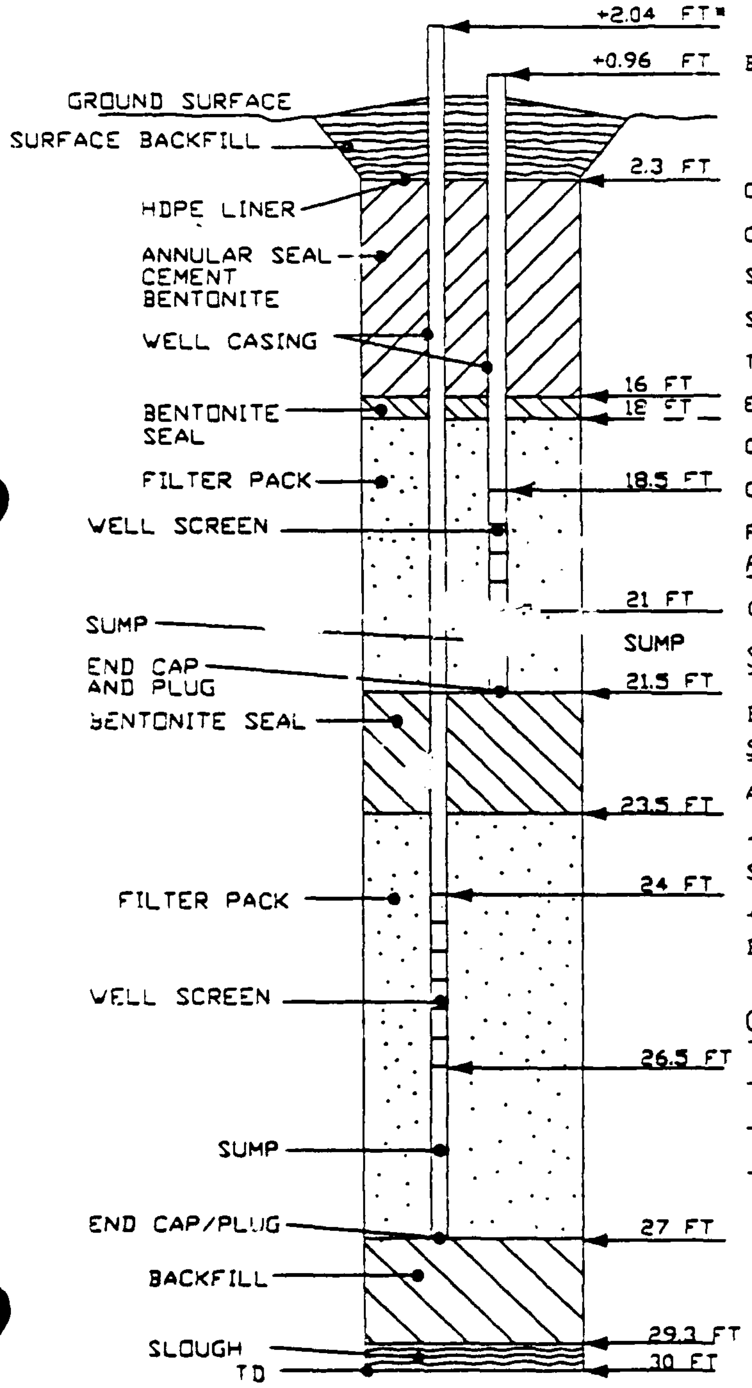
BENTONITE SHALLOW SEAL - 2-50# BUCKETS
DEEPER - 18-100# BAGS/BUCKETS
1/4" AND 3/8" PELLETS VOLCLAY
ANNULAR CEMENT BENTONITE GROUT, 85 GAL WATER,
1-50# BENTONITE, 5-94# BAGS CEMENT
(TYPE I-II) PORTLAND
SURFACE COMPACTED MIXTURE OF 20%
BENTONITE & CLEAN FILL
BACKFILL 4½-50# BAGS COARSE (3/8") BENTONITE
CHIPS

COMMENTS

PVC BOOT INSTALLED AT HDPE LINER

PIEZOMETER RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 2B FIELD OBSERVERS K WHITE
ELEV, NGVD (top of well casing) ±66.3', ±66.4' SURFACE ELEV, NGVD ±65.3'
WATER LEVEL ELEV/DATE, NGVD NOT ENCOUNTERED START DATE 6/17/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/17/91
DRILLING METHOD 8-INCH O.D. HOLLOW STEM AUGER



TD 106 FT
NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 8" INCHES TO 30' FT BGS
INCHES TO FT BGS
INCHES TO FT BGS
CASING TYPE 1" GRAY PVC DIAMETER 1"
COUPLING TYPE THREADED
SCREEN TYPE PVC DIAMETER 1"
SLOT SIZE 0.02" SCREEN LENGTH 2.5' EACH
TOP CAP TYPE PVC SLIP CAP
END CAP/PLUG TYPE THREADED 0.5" LONG
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) N/A
FILTER PACK TYPE #3 SAND (DEEPER AND SHALLOWER FILTER PACK) 2-100# BAGS EACH
GRADATION MEDIUM-COARSE SAND

SEAL(S)

BENTONITE DEEPER SEAL - 1¼-50# BUCKETS; SHALOWER SEAL - 1¾-50# BUCKETS ¼" PELLETS VOLCLAY
ANNULAR 17 LBS GRANULATED BENTONITE + 4-94# BAGS PORTLAND CEMENT
SURFACE COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL
BACKFILL 1½-50# BAGS HOLEPLUG BENTONITE CHIPS

COMMENTS

PVC BOOT INSTALLED AT HDPE LINER
CAPS MARKED, SHALLOW AND DEEP

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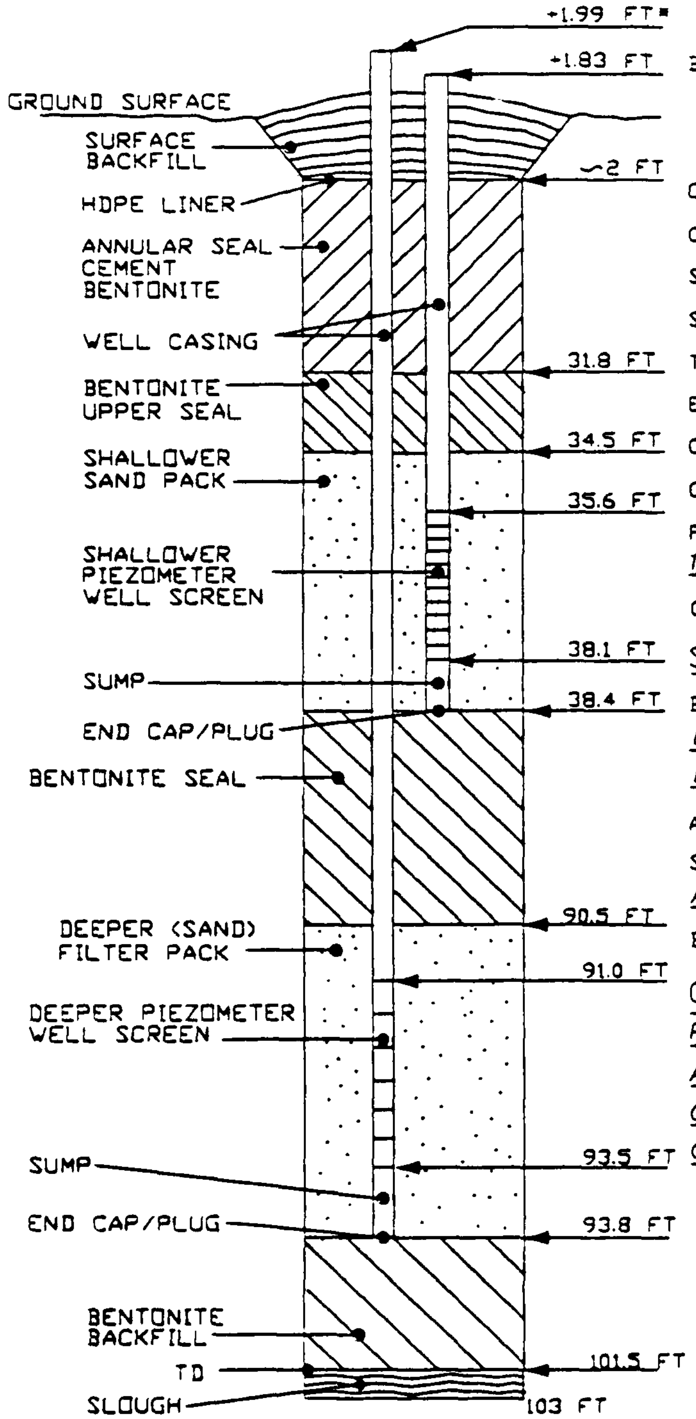
PIEZOMETER RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 03A FIELD OBSERVERS T DANOVICH/K LEARY
ELEV, NGVD (top of well casing) ±67.2', ±67.4 SURFACE ELEV, NGVD ±65.4'
WATER LEVEL ELEV/DATE ±102.5' BGS 6/17/91 START DATE 6/14/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/17/91
DRILLING METHOD 6" O.D. HOLLOW STEM AUGER



NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 6" INCHES TO 103' FT BGS
INCHES TO FT BGS
INCHES TO FT BGS
CASING TYPE SCH 80 PVC DIAMETER 1"
COUPLING TYPE PVC FLUSH THREADED
SCREEN TYPE PVC DIAMETER 1"
SLOT SIZE 0.02" SCREEN LENGTH 2.5'
TOP CAP TYPE PVC SLIP CAP (SCH 40)
END CAP/PLUG TYPE PVC SCREW PLUG (SCH 40)
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) N/A
FILTER PACK TYPE 2-100# BAGS (SHALLOW)
1½ 100# BAGS (DEEP)
GRADATION MEDIUM COARSE #3 8x20 SAND

SEAL(S)

BENTONITE 24½-50# BAGS/BUCKETS BENTONITE. DEEPER SEAL. UPPER (SHALLOW) SEAL - 1½ BUCKETS #50 VOLCLAY ¼" DIA BENTONITE PELLETS
ANNULAR 33LBS BENTONITE + 9-94# PORTLAND CEMENT
SURFACE COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL
BACKFILL 3¼ BAGS 50# BENTONITE

COMMENTS

PVC BOOT INSTALLED AT HDPE LINER
ADDED 5 GAL WATER PER 50 LB BAG BENTONITE CHIPS/PELLETS TO HYDRATE (PRIOR TO ADDING CHIPS/PELLETS)

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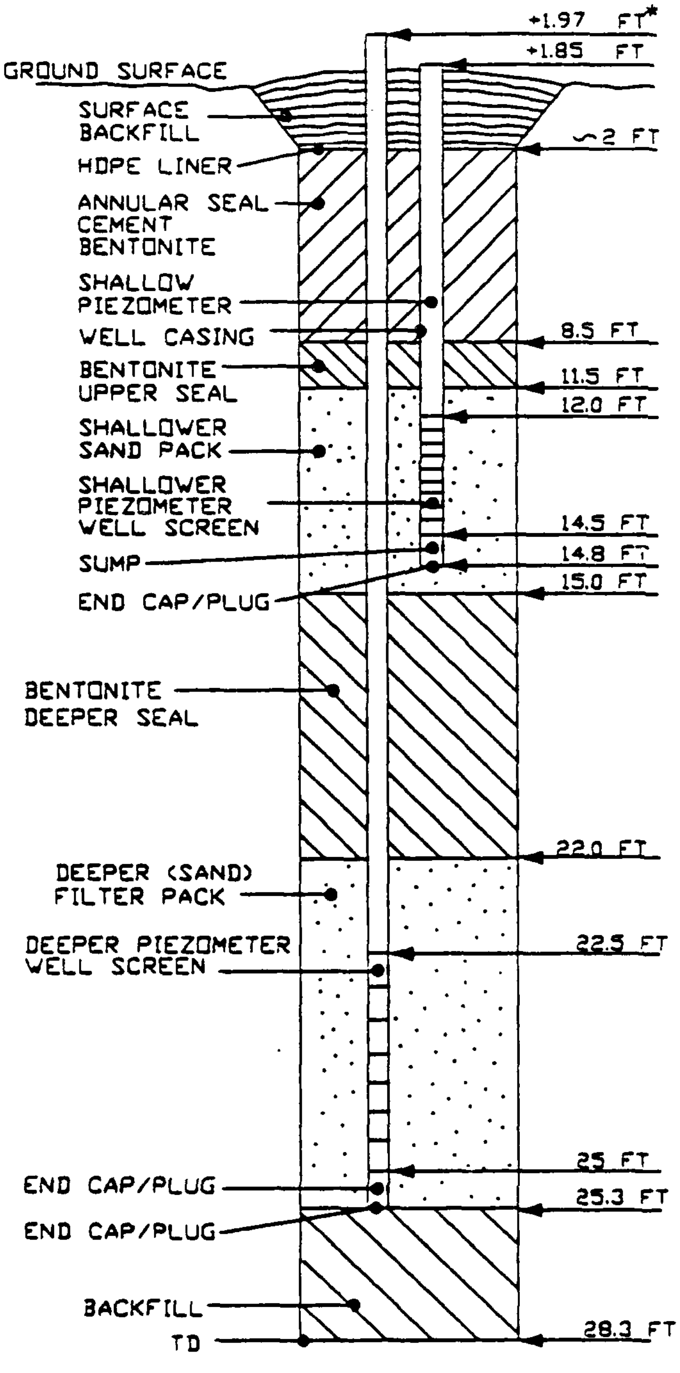
PIEZOMETER RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 38 FIELD OBSERVERS T DANOVICH/D MEYERS
ELEV, NGVD (top of well casing) ±67.3', ±67.4' SURFACE ELEV, NGVD ±65.4'
WATER LEVEL ELEV/DATE, NGVD NOT ENCOUNTERED START DATE 6/18/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/18/91
DRILLING METHOD 6" O.D. HOLLOW STEM AUGER



NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

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WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 6" INCHES TO 28.3' FT BGS
INCHES TO FT BGS
INCHES TO FT BGS
CASING TYPE SCH 80 PVC DIAMETER 1"
COUPLING TYPE PVC FLUSH THREADED
SCREEN TYPE PVC DIAMETER 1"
SLOT SIZE 0.02" SCREEN LENGTH 2.5'
TOP CAP TYPE PVC SLIP CAP (SCH 40)
END CAP/PLUG TYPE PVC SCREW PLUG (SCH 40)
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) N/A
FILTER PACK TYPE LONESTAR SAND. SHALLOWER - 1¼-100# BAGS DEEPER - 1-100# BAG
GRADATION #3 (COARSE-MEDIUM) 8x20 SAND

SEAL(S)

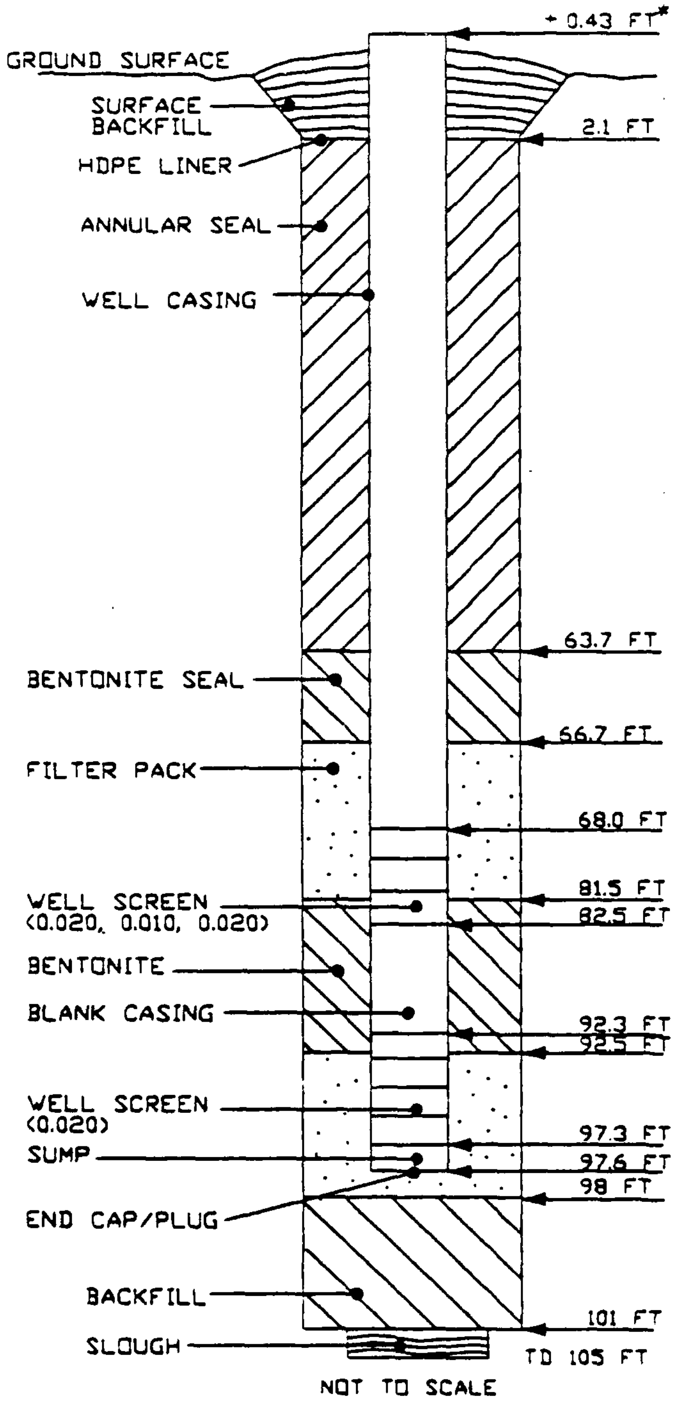
BENTONITE DEEPER SEAL - 4-50# BUCKETS/BAGS BENTONITE. UPPER (SHALLOW) SEAL - 1¼ BUCKETS 50# VOLCLAY ¼ BENTONITE PELLETS
ANNULAR 7LBS BENTONITE + 2-94# PORTLAND CEMENT
SURFACE COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL
BACKFILL 1¼ 50# BUCKETS VOLCLAY ¼" DIA BENTONITE PELLETS

COMMENTS

PVC BOOT INSTALLED AT HDPE LINER
ADDED 5 GAL WATER PER 50 LB BAG BENTONITE WHEN BENTONITE ADDED TO HOLE

VAPOR EXTRACTION WELL RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME *McCLELLAN SVE* PROJECT NO. *SAC28722.19.33*
WELL NO. *VES 04* FIELD OBSERVERS *T DANOVICH*
ELEV, NGVD (top of well casing) *±66.1'* SURFACE ELEV, NGVD *±65.7'*
WATER LEVEL ELEV/DATE *±103.0' BGS 6/13/91* START DATE *6/10/91*
DRILLING CONTRACTOR *BEYLIK DRILLING, SACRAMENTO, CA* FINISH DATE *6/13/91*
DRILLING METHOD *6" O.D. HOLLOW STEM AUGER*



NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

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WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) *10"* INCHES TO *101'* FT BGS
6" INCHES TO *105'* FT BGS
INCHES TO FT BGS
CASING TYPE *SCH 80 PVC* DIAMETER *3"*
COUPLING TYPE *PVC FLUSH THREADED*
SCREEN TYPE *PVC* DIAMETER *3"*
SLOT SIZE *15'-0.020"* *5'-0.010"* SCREEN LENGTH *5' BOTTOM* *15' TOP*
TOP CAP TYPE *PVC SLIP CAP (SCH 40)*
END CAP/PLUG TYPE *PVC SCREW PLUG (SCH 40)*
CENTRALIZER TYPE *NOT USED*
CENTRALIZER LOCATION(S) *N/A* *15' SCREEN 8-100#*
FILTER PACK TYPE *LONESTAR SAND* *5' SCREEN 3-100#*
GRADATION *#3 (COARSE-MEDIUM) 8x20 SAND*

SEAL(S)

BENTONITE *(TOP) 4½-50# BUCKETS BENTONITE*
ANNULAR *BENTONITE CEMENT GROUT MIX, 16-94# BAGS CEMENT, 300 GAL WATER, 2½-50# BAGS BENTONITE*
BENTONITE (BETWEEN WELL SCREENS) 10½-50# BUCKETS BENTONITE

SURFACE *COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL*
BACKFILL *(BOTTOM) 3-50# BUCKETS BENTONITE*

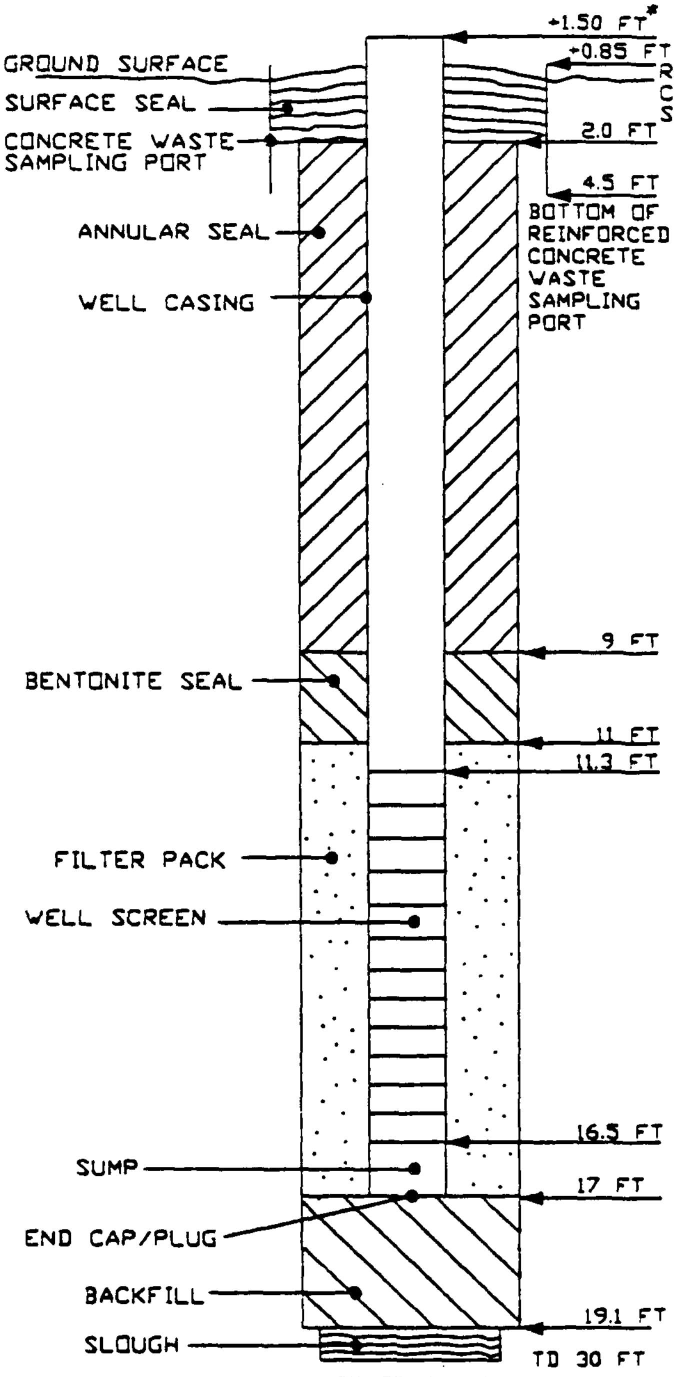
COMMENTS

PVC BOOT INSTALLED AT HDPE LINER
TOTAL PVC LENGTH PUT IN HOLE = 90.0'

X

VAPOR EXTRACTION WELL RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME *McCLELLAN SVE* PROJECT NO. *SAC28722.19.33*
WELL NO. *VES 05* FIELD OBSERVERS *K WHITE*
ELEV, NGVD (top of well casing) *±66.9'* SURFACE ELEV, NGVD *±65.4'*
WATER LEVEL ELEV/DATE, NGVD *NOT ENCOUNTERED* START DATE *6/17/91*
DRILLING CONTRACTOR *BEYLIK DRILLING, SACRAMENTO, CA* FINISH DATE *6/18/91*
DRILLING METHOD *10" O.D. HOLLOW STEM AUGER*



NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) *10"* INCHES TO *19.1'* FT BGS
8" INCHES TO *30'* FT BGS
INCHES TO FT BGS
CASING TYPE *SCH 80 GRAY PVC* DIAMETER *3"*
COUPLING TYPE *PVC FLUSH THREADED*
SCREEN TYPE *PVC* DIAMETER *3"*
SLOT SIZE *0.02"* SCREEN LENGTH *5.2'*
TOP CAP TYPE *PVC SLIP CAP (SCH 40)*
END CAP/PLUG TYPE *PVC SCREW PLUG (SCH 40)*
CENTRALIZER TYPE *NOT USED*
CENTRALIZER LOCATION(S) *N/A*
FILTER PACK TYPE *4-100# BAGS #3 SAND*
GRADATION *MEDIUM-COARSE (8x20) CLEMENTINA*

SEAL(S)

BENTONITE *2-50# BUCKETS VOLCLAY ¼" DIA BENTONITE PELLETS*
ANNULAR *BENTONITE CEMENT GROUT MIX. 7½-94# BAGS CEMENT + 100 GAL WATER, ½-50# SACK BENTONITE*
SURFACE *COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL*
BACKFILL *2½-50# BAGS COARSE GRAINED BENTONITE*

COMMENTS

HOLE DRILLED TO 30' WITH 8" DIA AUGER AND THEN REAMED WITH 10" AUGER. ADDED ALL BACKFILL THROUGH AUGER

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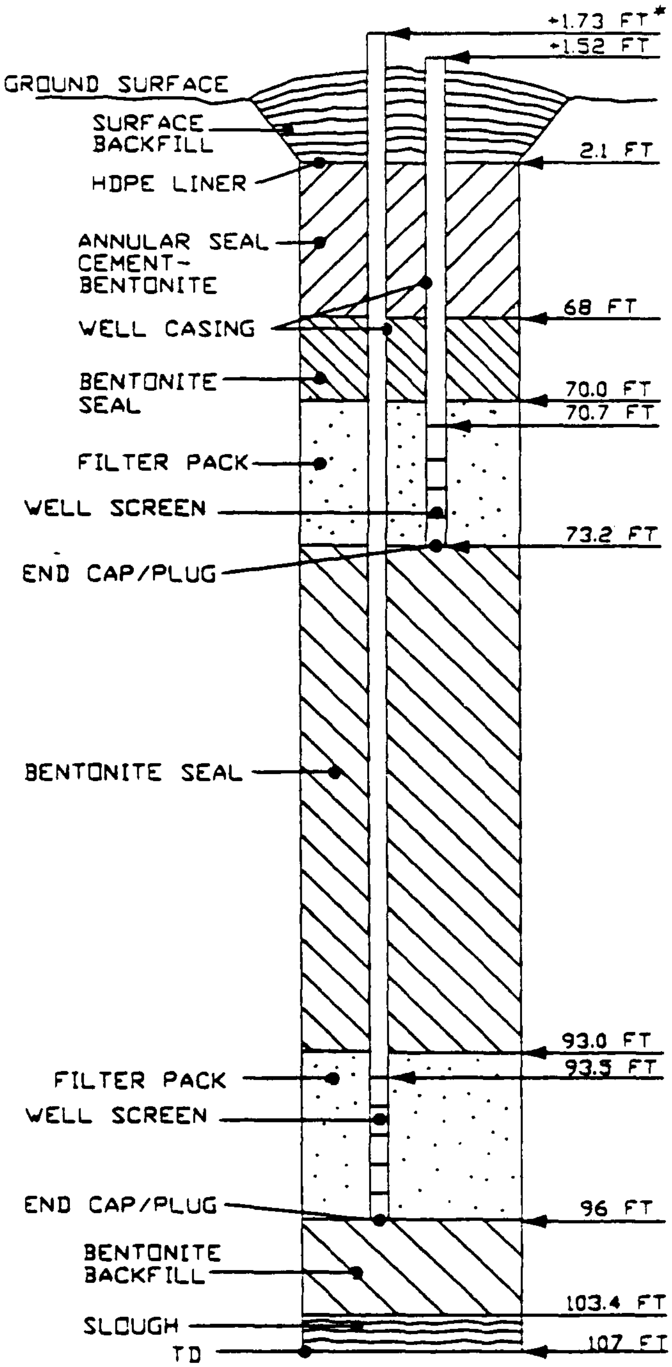
PIEZOMETER RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME *McCLELLAN SVE* PROJECT NO. *SAC28722.19.33*
WELL NO. *VES 06A* FIELD OBSERVERS *K WHITE*
ELEV, NGVD (top of well casing) *±67.3', ±67.5'* SURFACE ELEV, NGVD *±65.8'*
WATER LEVEL ELEV/DATE *±106.5' BGS 6/19/91* START DATE *6/18/91*
DRILLING CONTRACTOR *BEYLIK DRILLING, SACRAMENTO, CA* FINISH DATE *6/19/91*
DRILLING METHOD *8" HOLLOW STEM AUGER*



NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

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WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) *8"* INCHES TO *107'* FT BGS
____ INCHES TO ____ FT BGS
____ INCHES TO ____ FT BGS
CASING TYPE *SCH 80 PVC* DIAMETER *1"*
COUPLING TYPE *PVC FLUSH THREADED*
SCREEN TYPE *SCH 80 PVC* DIAMETER *1"*
SLOT SIZE *0.02"* SCREEN LENGTH *2.5' EACH*
TOP CAP TYPE *PVC SLIP CAP*
END CAP/PLUG TYPE *SLIP CAP W/SST SCREWS*
CENTRALIZER TYPE *NOT USED*
CENTRALIZER LOCATION(S) *N/A*
FILTER PACK TYPE *#3 SAND, SHALLOWER-1½ 100# BAGS DEEPER-1½ 100# BAGS*
GRADATION *MEDIUM-COARSE (8x20)*

SEAL(S)

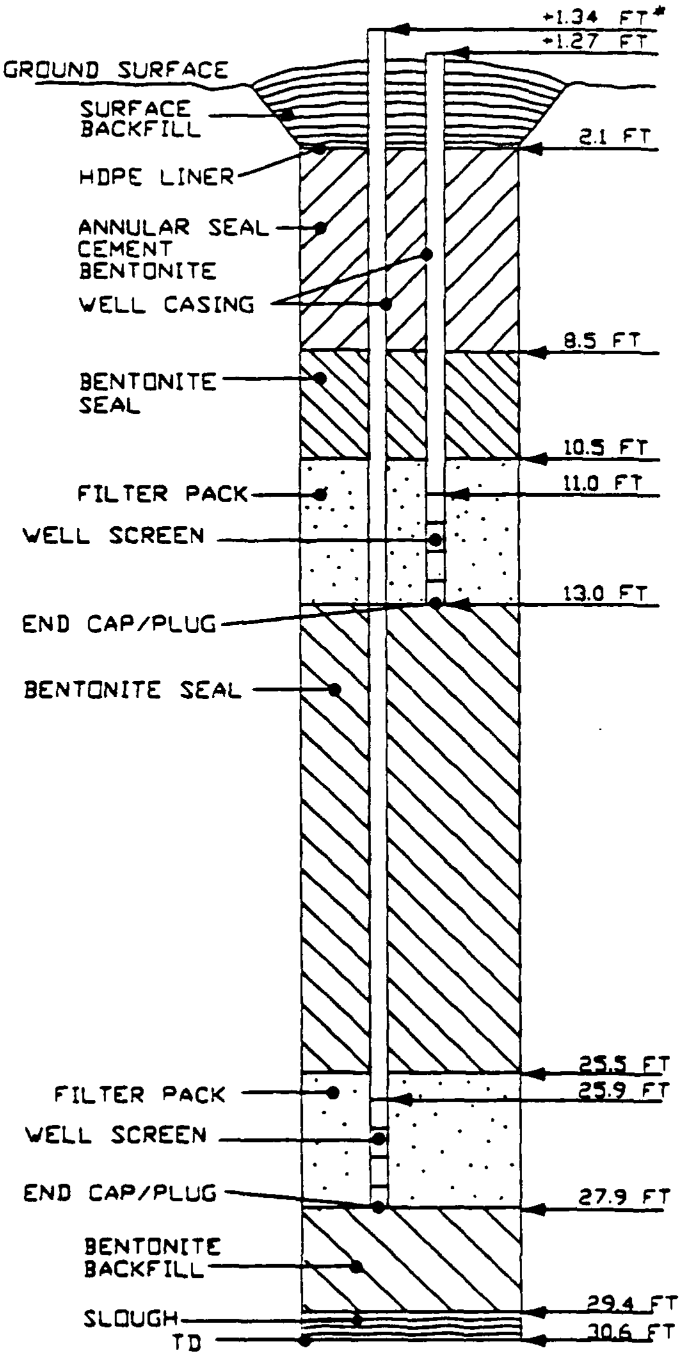
BENTONITE *UPPER (SHALLOW) 2-50# BUCKETS BENTONITE, DEEPER - 13 50# BUCKETS BENTONITE*
ANNULAR *60# GRANULATED BENTONITE + 19-94# BAGS PORTLAND CEMENT + 225 GAL WATER*
SURFACE *COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL*
BACKFILL *4½-50# BAGS HOLEPLUG BENTONITE CHIPS*

COMMENTS

PVC BOOT INSTALLED AT HDPE LINER

PIEZOMETER RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 06B FIELD OBSERVERS K WHITE
ELEV, NGVD (top of well casing) ±67.1' SURFACE ELEV, NGVD ±65.8'
WATER LEVEL ELEV/DATE, NGVD NOT ENCOUNTERED START DATE 6/21/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/21/91
DRILLING METHOD 8" O.D. HOLLOW STEM AUGER



NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

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WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 8 INCHES TO 30.6 FT BGS
INCHES TO FT BGS
INCHES TO FT BGS
CASING TYPE SCH 80 PVC DIAMETER 1"
COUPLING TYPE THREADED
SCREEN TYPE SCH 80 PVC DIAMETER 1"
SLOT SIZE ~1/16"* SCREEN LENGTH 2'
TOP CAP TYPE PVC SLIP CAP
END CAP/PLUG TYPE SLIP CAP W/SST SCREWS
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) N/A
FILTER PACK TYPE #3 SAND, SHALLOWER 2-100# BAGS DEEPER 1-100# BAG
GRADATION MEDIUM-COARSE (8x20)

SEAL(S)

BENTONITE VOLCLAY 1/4" AND 3/8" PELLETS, SHALLOWER 1 1/4-50# BUCKETS, DEEPER 8-50# BUCKETS/BAGS
ANNULAR CEMENT-BENTONITE GROUT, 7 BAGS 94# CEMENT + 85 GAL WATER + 25# BENTONITE
SURFACE COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL
BACKFILL 1-50# BAG HOLEPLUG 3/8" BENTONITE, COARSE

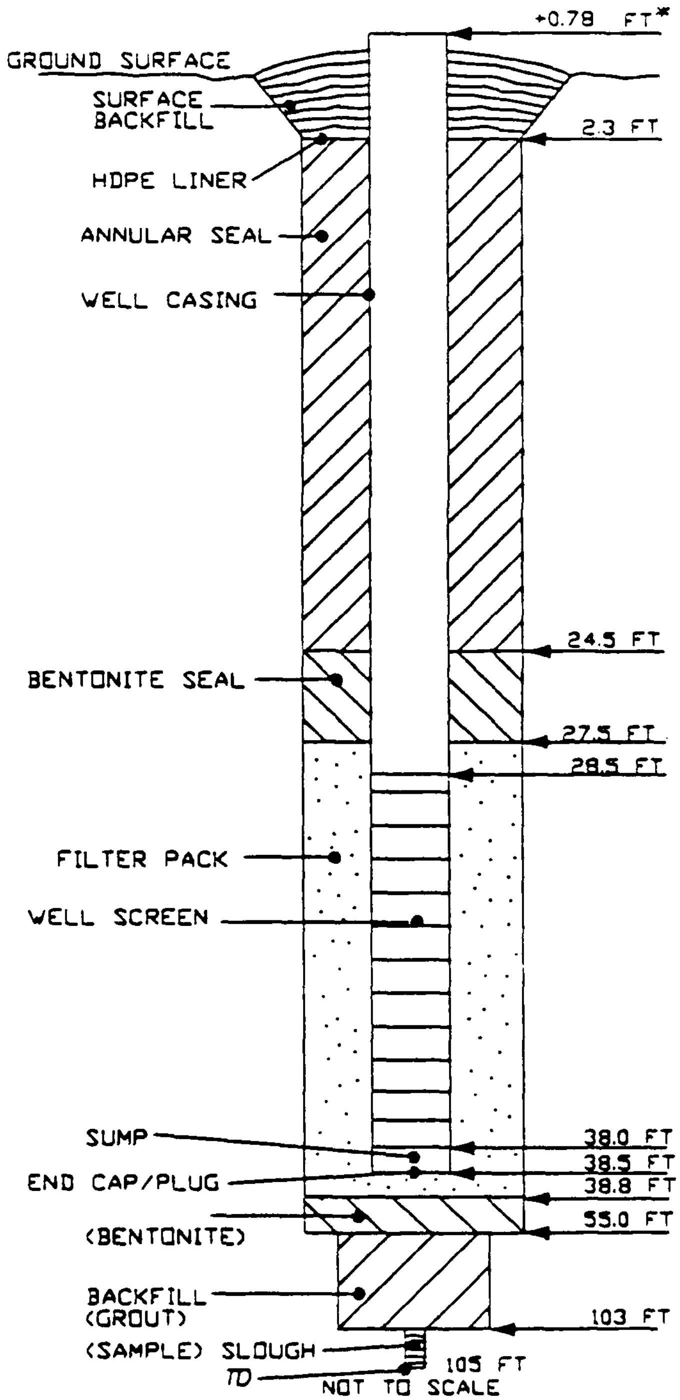
COMMENTS

PVC BOOT INSTALLED AT HDPE LINER

*BOTH SCREEN SLOTS WERE CUT WITH HACKSAW ON ONE SIDE OF CASING. BOTH SLOTTED SECTIONS ARE ORIENTED FACING EAST.

VAPOR EXTRACTION WELL RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 07 FIELD OBSERVERS D MYERS/T DANOVICH
ELEV, NGVD (top of well casing) ±66.0' SURFACE ELEV, NGVD ±55.2'
WATER LEVEL ELEV/DATE ±102.5' BGS 6/20/91 START DATE 6/18/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/20/91
DRILLING METHOD 6" O.D. HOLLOW STEM AUGER



NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

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WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 10 INCHES TO 55 FT BGS
6 INCHES TO 103 FT BGS
INCHES TO FT BGS

CASING TYPE SCH 80 PVC DIAMETER 3"
COUPLING TYPE FLUSH THREADED
SCREEN TYPE PVC DIAMETER 3"
SLOT SIZE 0.02" SCREEN LENGTH 9.5'
TOP CAP TYPE PVC SLIP CAP
END CAP/PLUG TYPE PVC SCREW PLUG
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) N/A
FILTER PACK TYPE CLEMENTINA SAND, 7 2/3-100# BAGS
GRADATION #3 8x20 GRADED MONTEREY SAND

SEAL(S)

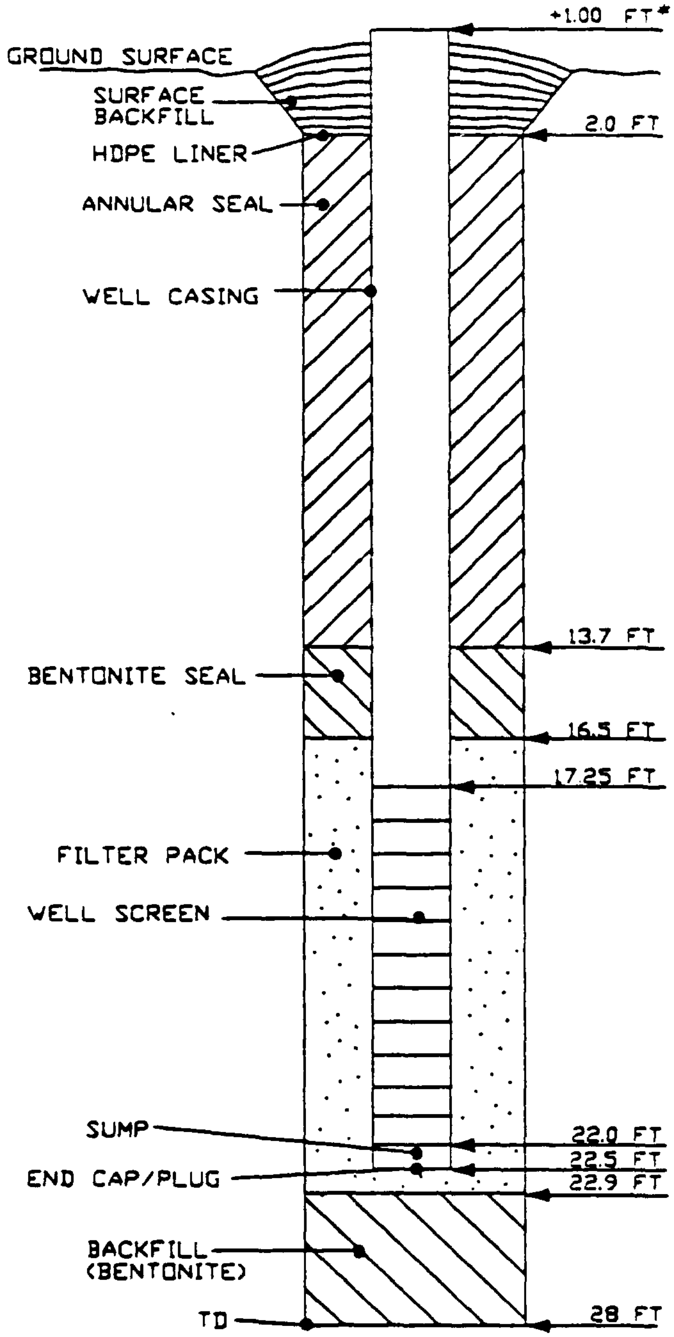
BENTONITE 2½-50# BUCKETS BENTONITE
ANNULAR BENTONITE CEMENT GROUT MIX, 14 BAGS 94# CEMENT + 100 GAL WATER, 28 LBS BENTONITE
SURFACE COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL
BACKFILL (BENTONITE) 12½-50# BUCKETS/BAGS ¼" AND ⅛" BENTONITE PELLETS AND CHIPS
BACKFILL (GROUT) BENTONITE CEMENT GROUT MIX, 14-94# BAGS CEMENT + 175 GAL WATER +1-50# BAG BENTONITE

COMMENTS

PVC BOOT INSTALLED AT HDPE LINER
ADDED 5 GAL WATER PRIOR TO EACH 50 LBS BENTONITE IN HOLE

VAPOR EXTRACTION WELL RECORD DRAWING & CONSTRUCTION

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 08 FIELD OBSERVERS D MYERS/T DANOVICH
ELEV, NGVD (top of well casing) ±66.4' SURFACE ELEV, NGVD ±65.4'
WATER LEVEL ELEV/DATE, NGVD NOT ENCOUNTERED START DATE 6/20/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/21/91
DRILLING METHOD 10" O.D. HOLLOW STEM AUGER



NOT TO SCALE
* DEPTHS ABOVE/BELOW GROUND SURFACE

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WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 10 INCHES TO 28 FT BGS
6 INCHES TO 27 FT BGS
INCHES TO FT BGS
CASING TYPE SCH 80 PVC DIAMETER 3"
COUPLING TYPE FLUSH THREADED
SCREEN TYPE PVC DIAMETER 3"
SLOT SIZE 0.02" SCREEN LENGTH 4.75'
TOP CAP TYPE PVC SLIP CAP
END CAP/PLUG TYPE PVC SCREW PLUG
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) N/A
FILTER PACK TYPE CLEMENTINA SAND, 4-100# BAGS
GRADATION #3 8x20 GRADED MONTEREY SAND

SEAL(S)

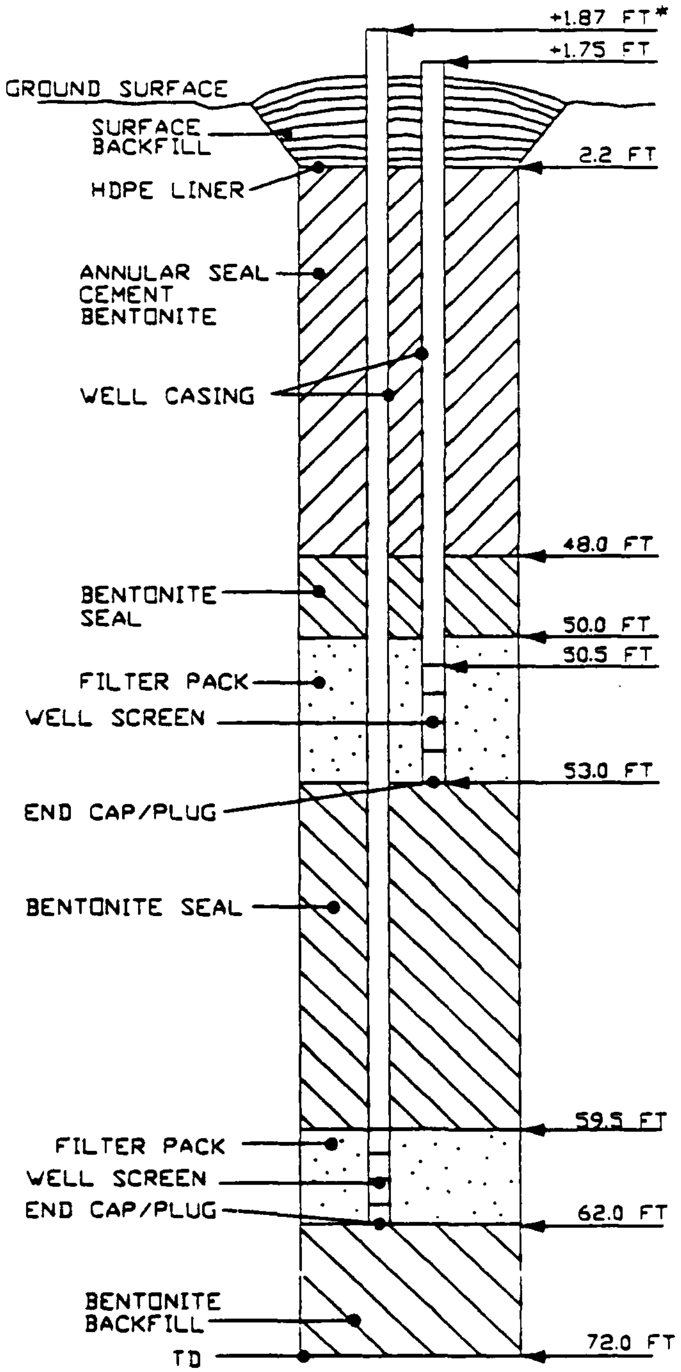
BENTONITE 2½-50# BUCKETS/BAGS ¼" PELLETS/ CHIPS BENTONITE
ANNULAR BENTONITE CEMENT GROUT MIX, 6-94# BAGS CEMENT + 75 GAL WATER + 20 LBS BENTONITE
SURFACE COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL
BACKFILL 4½-50# BAGS/BUCKETS ¼" CHIPS/PELLETS BENTONITE

COMMENTS

PVC BOOT INSTALLED AT HDPE LINER
ADDED 5 GAL WATER PRIOR TO EACH 50 LBS BENTONITE IN HOLE

PIEZOMETER RECORD DRAWING & CONSTRUCTION LOG

PROJECT NAME McCLELLAN SVE PROJECT NO. SAC28722.19.33
WELL NO. VES 09 FIELD OBSERVERS K WHITE
ELEV, NGVD (top of well casing) ±66.8' SURFACE ELEV, NGVD ±66.0'
WATER LEVEL ELEV/DATE, NGVD NOT ENCOUNTERED START DATE 6/20/91
DRILLING CONTRACTOR BEYLIK DRILLING, SACRAMENTO, CA FINISH DATE 6/21/91
DRILLING METHOD 8" HOLLOW STEM AUGER



NOT TO SCALE

* DEPTHS ABOVE/BELOW GROUND SURFACE

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WELL CONSTRUCTION MATERIALS

BOREHOLE DIA(S) 8 INCHES TO 72 FT BGS
INCHES TO FT BGS
INCHES TO FT BGS
CASING TYPE SCH 80 PVC DIAMETER 1"
COUPLING TYPE THREADED
SCREEN TYPE SCH 80 PVC DIAMETER 1"
SLOT SIZE 0.02" SCREEN LENGTH 2.5' EACH
TOP CAP TYPE PVC SLIP CAP
END CAP/PLUG TYPE SLIP CAP W/SST SCREWS
CENTRALIZER TYPE NOT USED
CENTRALIZER LOCATION(S) N/A
FILTER PACK TYPE #3 SAND, SHALLOWER - 1½-100# BAGS, DEEPER - 1½-100# BAGS
GRADATION MEDIUM-COARSE (8x20)

SEAL(S)

BENTONITE VOLCLAY ¼" AND ⅜" PELLETS, SHALLOWER - 2-50# BUCKETS, DEEPER - 3½-50# BUCKETS/BAGS
ANNULAR CEMENT BENTONITE GROUT MIX, 7-94# BAGS CEMENT + 85 GAL WATER + 25 LBS BENTONITE
SURFACE COMPACTED MIXTURE OF 20% BENTONITE AND CLEAN FILL
BACKFILL 6 1/3-50# BAGS HOLEPLUG ⅜" BENTONITE CHIPS

COMMENTS

PVC BOOT INSTALLED AT HDPE LINER

STANDARD PROCEDURES FOR LOGGING OF SOIL BORINGS

January 1990

CH2M HILL

CONTENTS

TABLES

FIGURES

Date: January 1990

STANDARD PROCEDURES
FOR LOGGING OF
SOIL BORINGS

INTRODUCTION

The purpose of this document is to assist CH2M HILL staff in accurately recording and presenting all field data that are necessary to sufficiently describe, label, and package soil samples recovered from borings. Adherence to a standard format for recording data will help streamline our project efforts and ensure a consistent presentation of subsurface data.

All CH2M HILL staff members are encouraged to present their suggestions for clarification or improvements to these procedures. Please submit all suggestions or comments in writing to the Discipline Group Directors of Geotechnical Engineering or Groundwater Resources.

POLICY

These soil boring procedures must be used for all CH2M HILL projects in which soil boring techniques are used during field exploration. These procedures establish the minimum kinds of information that must be recorded in the field to adequately characterize recovered soil samples.

Because each of our projects is unique and because job requirements can vary widely, the minimum standards presented may need to be supplemented with additional technical descriptions or field test results. However, all soil boring field logs, regardless of special project circumstances, must include information addressed in this policy document to achieve minimum acceptable standards required by CH2M HILL.

CH2M HILL Standard Form D1586, the Soil Boring Log Form, must be used on all CH2M HILL projects for field logging (see Figure 1). All heading information must be completely filled out on each log sheet, and all technical items in each column must be addressed in the field.

The boring log should be completed in the field according to the instructions that follow. Forms should be filled out neatly and completely. Laboratory testing, if required, should be initiated immediately after completion of the field work. Field classifications of samples should be checked against the laboratory test results, and corrections should be noted in red, initialed, and dated on the field log.

INSTRUCTIONS FOR COMPLETING SOIL BORING LOG, FORM D1586

Form D1586 is a standard CH2M HILL form that is available in weatherproof paper from all regional form distributors.

Following are instructions for completing the log forms in the field. See Figure 2 for an example of a field log completed according to the instructions.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples should also be checked to see that information is correctly recorded on both jar lids and labels, and on the log sheets.

HEADING INFORMATION

Project Number. Use standard region code, contract I.D. (5-digit), and appropriate point number.

Boring Number. Enter the boring number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring. If rock core log sheets are also used, continue the consecutive numbering.

Project. Fill in the name of the project or client.

Location. If stationing, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as *approximate* or *estimated* as appropriate. If this information is not available, identify the client facility (e.g., Richland STP, center of Clarifier No. 2 site), or the town and state.

Elevation. Enter the elevation. If it is estimated from a topographic map, or if it is roughly determined using a hand level, use the modifier *approximate*. It is important to tie the boring elevation to a recoverable reference point (e.g., fire hydrant, floor slab) if no other elevation data are available. Such points can be picked up later in a site survey and boring elevations can be determined. Or, if no survey is done, at least the relative boring elevation with respect to pertinent project facilities will be known.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger, air track). Information on the drilling equipment (e.g., CME 55, Mobile B61) is also entered.

Water Level and Date. Enter the depth below ground surface to the static water level in the borehole. Frequent water measurements are recommended. The information should be recorded in the Comments column. If free water is not encountered during drilling, or cannot be detected because of the drilling method, this information should be noted. Generally, water levels should be measured each morning before resuming drilling and at the completion of each boring. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day may be added if several borings are performed on the same day.

Logger. Enter the first initial and full last name.

TECHNICAL DATA

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Draw horizontal lines at the top and bottom depth of each sample interval. These lines should extend to the soil description column. For a very short sample interval, the bottom line can be lowered after the interval column to provide room for writing the information (see Figure 2). Enter the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. For instance, 1-S = first sample, split spoon. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement.

Standard Penetration Test Results. In this column enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the last two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, and 4 is recorded as 2-3-4 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of more than 6 inches but less than 12 inches with a blow count of 100, or a penetration of less than 6 inches with a blow count of 50. A partial penetration of 50 blows for 4 inches is recorded as 50/4". See the *Standard Penetration Test Procedures* subsection for additional discussion.

Soil Description. The soil classification should follow the format described in the *Field Classification of Soil* subsection.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). Also note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Drilling interval through a boulder
- The results of pocket penetrometer or torvane test reported as: "PP = ____ TSF" or "TV = ____TSF," respectively

The depth of piezometers and the results of in situ tests should be noted in the Comments column.

FIELD CLASSIFICATION OF SOIL

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488-84. Visual-Manual Procedure for Description and Identification of Soils, which is included in the Appendix to this document.

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests (ASTM D 2487). It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). Also, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field. Corrections and additions to the field classification can be provided, when necessary, by laboratory testing of the soil samples.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities between consecutive samples should be stressed rather than differences.

Soil descriptions must be recorded in the Soil Description column for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488-84 Group Name) with appropriate modifiers
2. Group symbol
3. Color
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488-84. Examples of soil descriptions are provided in Table 1.

SOIL NAME

The basic name of a soil should be identical to the ASTM D 2488-84 Group Name based on visual estimates of gradation and plasticity. The soil name should be capitalized. The only acceptable soil names are those listed in Figure 3, which are from ASTM D 2488-84.

Examples of acceptable soil names are illustrated by the following descriptions:

> A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
>
> Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488-84. There is no need to further document the gradation. However, the maximum size and angularity or roundedness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488-84.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as *Interlayered Sand and Silt*, should be used. Also, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488-84.

GROUP SYMBOL

The appropriate group symbol from ASTM D 2488-84 (see Figure 3) must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488-84, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

COLOR

The basic color of a soil, such as brown, gray, or red, must be given. The color term can be modified, if necessary, by adjectives such as light, dark, or mottled. Especially note staining, iron staining, or mottling. This information may be useful to establish water table fluctuations or contamination. As an alternative, consider using the Munsel rock color chart designation.

MOISTURE CONTENT

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

RELATIVE DENSITY OR CONSISTENCY

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586-84). If the presence of large gravel or disturbance of the sample makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

SOIL STRUCTURE, MINERALOGY, AND OTHER DESCRIPTORS

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information should be noted. Cementation, abundant mica, or unusual mineralogy should be described, as well as other information such as organic debris or odor.

Other descriptors can be included if important for the project or for describing the sample. These include particle size, range and percentages, particular angularity, particle shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and cementation.

Residual soils have characteristics of both rock and soil and can be difficult to classify. Relict rock structure should be described and the parent rock identified if possible.

STANDARD PENETRATION TEST PROCEDURES

Standard Penetration Tests (SPT) are conducted to obtain a measure of the resistance of the soil to penetration of the sampler and to recover a disturbed soil sample. Standard Penetration Tests should be conducted in accordance with ASTM D 1586-84, Penetration Test and Split Barrel Sampling of Soils.

EQUIPMENT AND CALIBRATION

Before starting the testing, the necessary equipment should be inspected for compliance with the requirements of ASTM D 1586-84. The split-barrel sampler should measure 2-inch O.D., with 1-3/8-inch I.D., and should have a split tube at least 18 inches long. The dimensions should conform with those indicated on Figure 1 of ASTM D 1586-84. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

PROCEDURES

Standard Penetration Tests should be conducted at every change of strata or, within a continuous stratum, at intervals not exceeding 5 feet. Before driving the split-barrel sampler, all loose and foreign material should be removed from the bottom of the borehole. It may be helpful to measure the rod *stickup* to ensure that the sampler is being driven from the bottom of the borehole. The Standard Penetration Test should be performed by driving a standard split-barrel sampler 18 inches into undisturbed soil at the bottom of the borehole by a 140-pound guided hammer or ram, falling freely from a height of 30 inches.

The number of blows required to drive the sampler for three 6-inch intervals, for a total of 18 inches, should be observed and recorded on the soil boring log. The sum of the number of blows required to drive the sampler the second and third 6-inch intervals is considered the Standard Penetration Resistance (N) or the *blow-count.* If the sampler is driven less than 18 inches, but more than 1 foot, the penetration resistance (N) is that for the last 1 foot of penetration. If less than 1 foot is penetrated, the log must state the number of blows and the fraction of 1 foot penetrated. It is important that the field logger observe the sampler being driven and count the blows for each sample attempt.

GENERAL CONSIDERATIONS

The following comments and suggestions should be considered when performing Standard Penetration Testing:

1. The borehole should be cleaned out before every sample attempt. Because a minor amount of caving can be expected, the borehole can be considered to be adequately cleaned if no more than 4 inches of loose or foreign material has collected at the bottom of the borehole. A greater amount of caving is sufficient cause to require the hole to be cleaned again.

2. The ball check valve in the split-barrel sampler should be cleaned and working properly for each sample. Bent, chipped, or damaged shoes should be replaced. The split-barrel halves should not be warped. In case of zero sample recovery (i.e., if the sample is lost during first attempt), a spring catcher should be used during subsequent attempts to facilitate recovery.

3. During SPT sampling, it is important that all rod connections be tight and that the hammer guide be connected securely to the drill rods. If the hammer guide connection becomes loose, much of the hammer energy may be lost because of deflection of the hammer coupling. The lifting rope should not rub against the mast. Each hammer fall should be 30 inches.

4. During SPT sampling, it is important that the drill rods be positioned at the center of the drill hole. This is necessary to preclude the development of friction between drill rods and the walls of the borehole or casing.

5. If the hammer weight is raised by means of a cathead, generally two wraps on the cathead should be used. The optimum number of wraps will vary with the condition of the rope and cathead and the weather. Most importantly, the driller should exercise care to prevent friction of the rope on the cathead during the fall of the hammer.

6. Occasionally, nonstandard procedures or equipment are used for obtaining samples (such as 3-inch O.D. split-barrel samplers, or 300-pound hammers). Any nonstandard practice should be described on the boring log form. Also, the blow counts should be clearly marked as not conforming to SPT values.

SAMPLE LABELING AND PACKAGING

The samples recovered from the borehole are an important part of the boring record and must be properly packaged and labeled. Samples that are improperly or inadequately labeled are not useful. The following description outlines the minimum requirements for packaging and labeling of samples.

Disturbed samples should be placed in jars that are marked both on the jar lid and on a label on the side of the jar. Standard CH2M HILL jar labels are available (Form No. 131, Soil Sample Labels) for this purpose. The following information should be clearly marked on the jars: job number, boring number, sample number, sample depth, blow counts, sample recovery, and date. Use an indelible marker or a metal scriber on the jar lid. If moisture content tests are anticipated, jar samples should be tightly sealed, then sent to the laboratory and the testing initiated as soon as possible (within one week). See Figure 4 for labeling details.

Boxes containing the jars should be labeled on top and on one end with the following information: job name, job number, boring number, sample numbers and sample depths, date, and name. It is helpful to start a new box for each new boring if the boxes are at least one-half full.

Shelby tubes should be cleaned of mud and moisture. When dry, use an indelible marker to label them with the following information: an arrow indicating which way is up, job number, boring number, sample number and depth, amount of recovery, and date. The top and bottom of the sample can be circumscribed on the outside of the tube with a marker.

Waxing of Shelby tubes is essential if sample testing will not occur within a few days. In all cases, lids should be placed on the ends and taped with airtight tape. Make certain that the holes in the top of the tube are sealed. The open portion of the tube above the sample should be packed to prevent shifting of the soil. Dampened newspaper is generally adequate for this purpose, but it should be separated from the soil sample by a wax seal or an inverted cap. See Figure 4 for labeling and packing materials.

FIELD EQUIPMENT CHECKLIST

Table 5 lists equipment and supplies that are necessary or useful for soil boring exploration.

SELECTED REFERENCES

American Society for Testing and Material. 1989. ASTM D 1586, Standard Method for Penetration Test and Split-Barrel Sampling of Soils. Annual Book of ASTM Standards, Section 4, Vol. 04.08.

_____. 1989. ASTM D 1587, Standard Method for Thin-Walled Tube Sampling of Soils. Annual Book of ASTM Standards, Section 4, Vol. 04.08.

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_____. 1989. ASTM D 2488, Standard Practice for Description of Soils (Visual-Manual Procedure). Annual Book of ASTM Standards, Section 4, Vol. 04.08.

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Bell, F. G. 1981. Engineering Properties of Soils and Rocks. London: Butterworth Publishers, Inc.

Burmister, D. M. 1949. Principles and Techniques of Soil Identification. Proceedings of the Highway Research Board, pp. 402-433.

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Kovacs, W. D., L. A. Salomone, and F. Y. Yokel. 1981. Energy Measurement in tne Standard Penetration Test. U.S. Dept. of Commerce, National Bureau of Standards, Building Science Series 135.

Matula, M. 1981. Rock and Soil Description and Classification for Engineering Geological Mapping. Report by the IAEG Commission on Engineering Geological Mapping. Bulletin of the International Association of Engineering Geology, No. 24, pp. 235-274.

Sowers, G. F. 1979. Introductory Soil Mechanics and Foundations: Geotechnical Engineering. MacMillan Publishing Co., New York, 4th edition. 621 pp.

U.S. Bureau of Reclamation. 1974. Earth Manual. 2nd ed. Washington, D.C.: U.S. Government Printing Office.

Tables

Table 1
EXAMPLE SOIL DESCRIPTIONS

POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size

FAT CLAY (CH), dark gray, moist, stiff

SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max

POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense

ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica

SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick;

LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick

SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation

LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff

WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with 1/2-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with 1/2-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with 1/2-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with 1/2-in. steel rod driven with 5-lb hammer
50	Very Dense	Penetrated only a few inches with 1/2-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	<0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

Table 5
FIELD EQUIPMENT CHECKLIST FOR SOIL BORING LOGGING

Siting

___Lath, flagging, and orange spray paint
___Lumber crayon
___100-foot tape
___Brunton or Silva compass

Logging Equipment

___Soil Boring Guideline
___Clipboard
___Form D1586 on all-weather paper
___Pens/pencils
___Engineer's pocket tape measure with tape lock
___Field notebook on all-weather paper
___Squirt bottle with water
___Spatula
___HCL, 10 percent solution

Sampling and Packaging

___Jars with lids and labels (Form #131)
___Shelby tubes and plastic end caps
___Airtight tape (e.g., electrical)
___Newspaper
___Wax, stove, melting pot, and matches
___Indelible fine felt-tipped markers (e.g., *Sharpie* brand)

Test Equipment

___Pocket penetrometer
___Torvane
___Well sounder

Other

___Camera, film
___Hand lens
___Rags
___Ear protectors
___Screwdrivers
___Hard hat
___Sunscreen
___Insect repellent

Figures

PROJECT NUMBER DEN 22371.G5
BORING NUMBER BL-3
SHEET 1 OF 3

SOIL BORING LOG

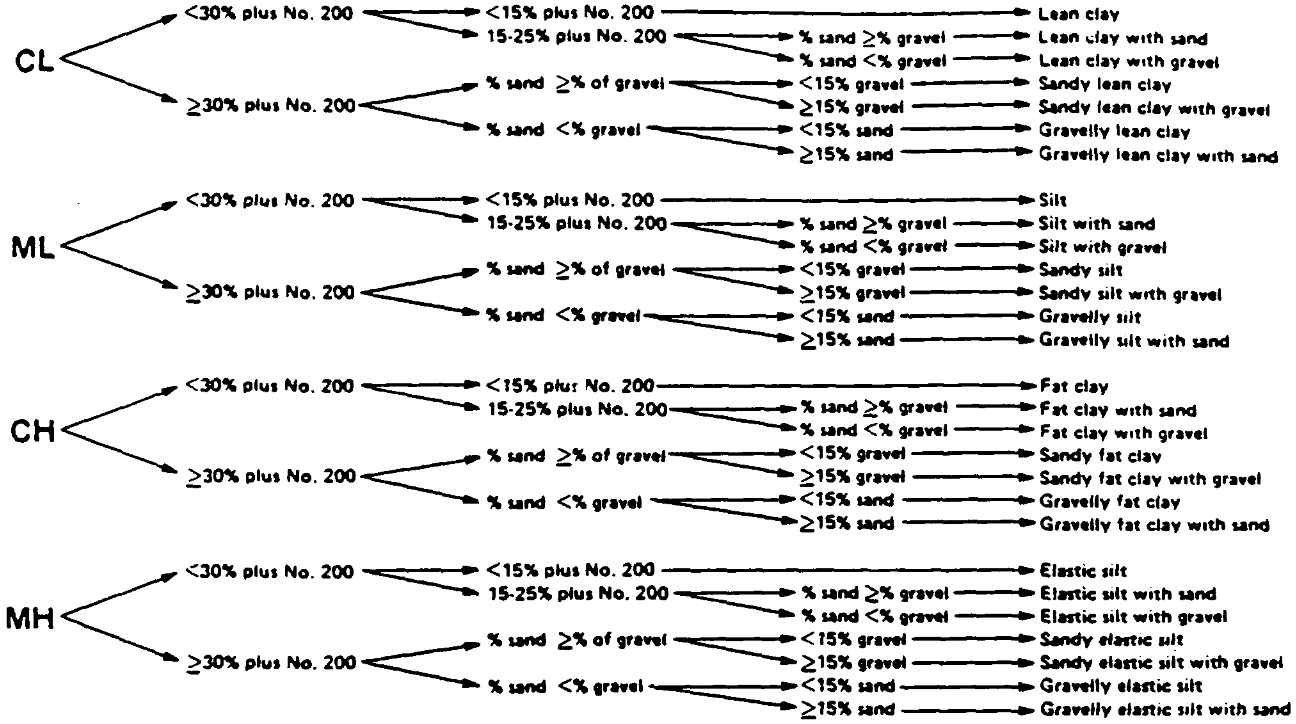
PROJECT Howard Ave Landslide
LOCATION Howard & 24th Ave, Centennial, CO
ELEVATION 5136 Feet
DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado
DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig
WATER LEVELS 3.2 Feet, 8/5/89
START August 4, 1989
FINISH August 8, 1989
LOGGER J.A Michner

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0	2.5				Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
	5.0					
5	6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft, strong H_2S odor, many fine roots up to about 1/4 inch	Driller notes very soft drilling 4ft. dark grey, wet silty cuttings.
	8.0					
	10.0	3-ST	1.3	—	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730 Driller notes rough drilling action and chatter @ 13 ft
15	15.0					
	15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
20	20.0					Driller notes smoother, firm drilling @ 19 ft some angular rock chips @ bot tip of 6-S, poss boulders or rock
	21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedroc
	23.0					
	23.1	7-S	-0-	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

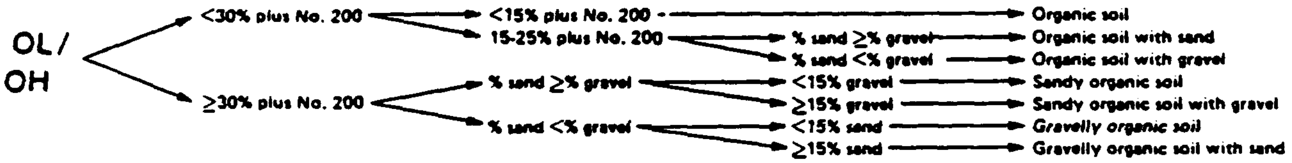
Figure 2
EXAMPLE OF COMPLETED LOG FORM

REV 11/89 FORM D1586

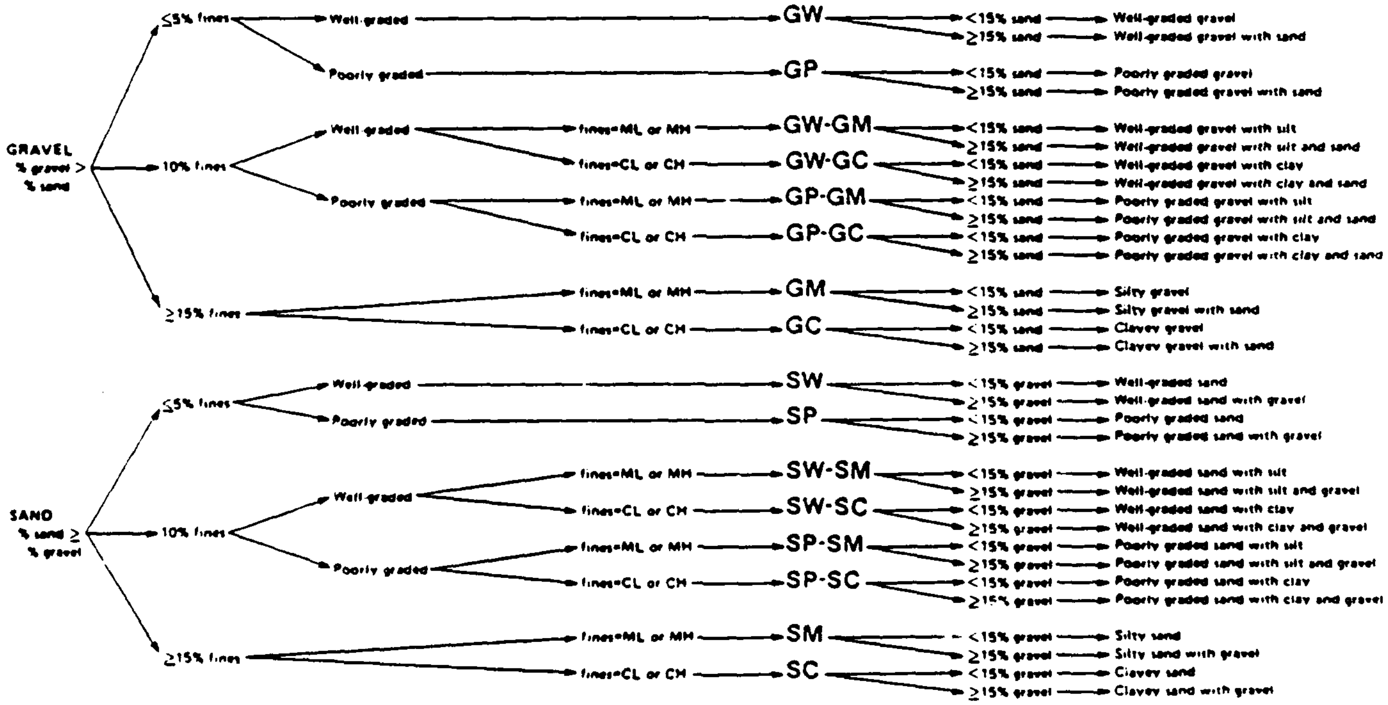
FLOW CHART FOR IDENTIFYING INORGANIC FINE–GRAINED SOIL (50% OR MORE FINES)



FLOW CHART FOR IDENTIFYING ORGANIC FINE–GRAINED SOIL (50% OR MORE FINES)

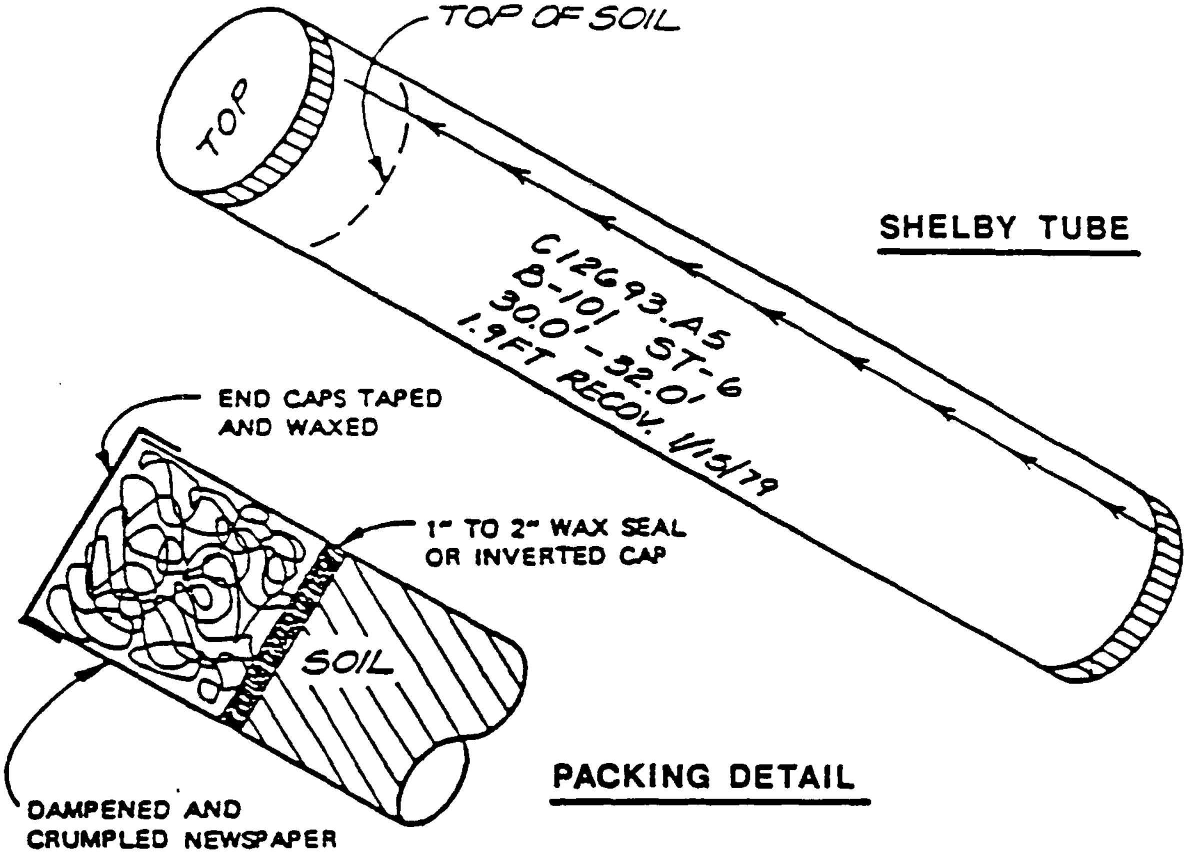


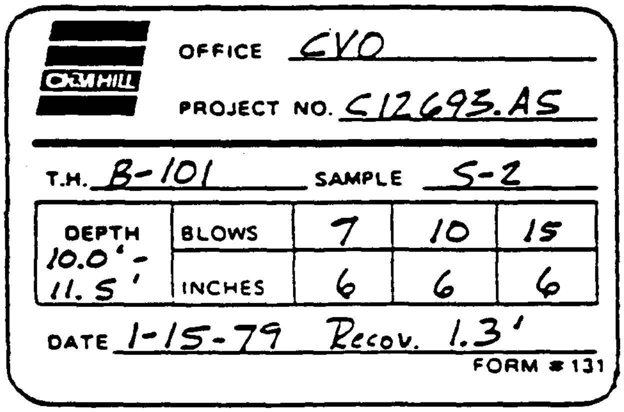
FLOW CHART FOR IDENTIFYING COARSE–GRAINED SOILS (LESS THAN 50% FINES)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

Figure 3
FLOW CHARTS FOR CLASSIFICATION OF
FINE–GRAINED AND COARSE–GRAINED SOILS





CH2M HILL

OFFICE CVO

PROJECT NO. C12693.A5

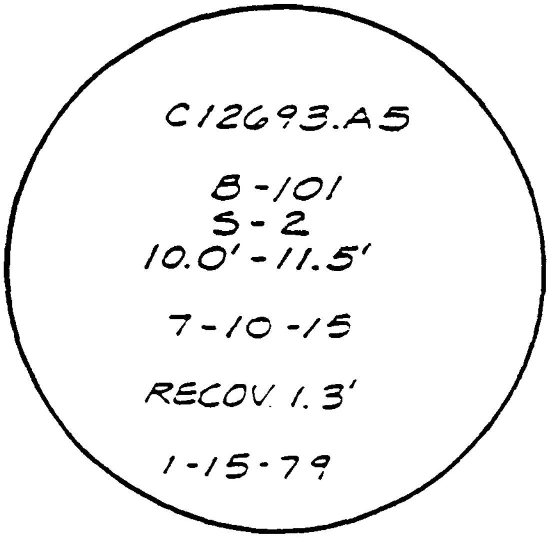
T.H. B-101 SAMPLE S-2

DEPTH 10.0'- 11.5'	BLOWS	7	10	15
	INCHES	6	6	6

DATE 1-15-79 Recov. 1.3'

FORM # 131

SIDE LABEL



C12693.A5

B-101
S-2
10.0'-11.5'

7-10-15

RECOV. 1.3'

1-15-79

LID

JAR SAMPLES

Figure 4
SAMPLE LABELING DETAILS

APPENDIX

ASTM D 2488-84

Designation: D 2488 - $84^{\epsilon 1}$

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

$^{\epsilon 1}$ NOTE—Section 18 was added editorially in January 1989.

1. Scope

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils.

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (See Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.5 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

3. Definitions

3.1 Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

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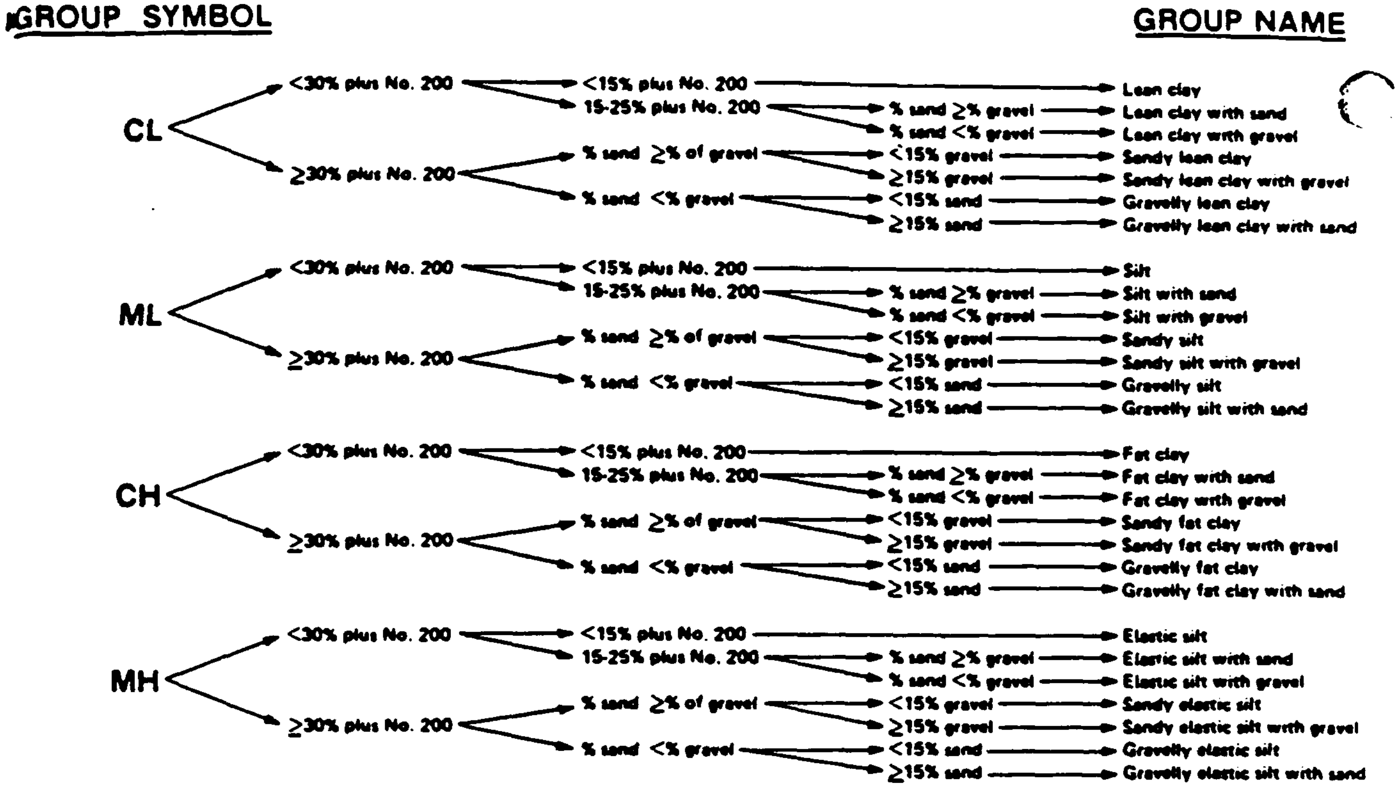
[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Oct. 3, 1984. Published December 1984. Originally published as D 2488 - 66 T. Last previous edition D 2488 - 69 (1975).

[2] *Annual Book of ASTM Standards*, Vol 04.08.



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. *200* (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

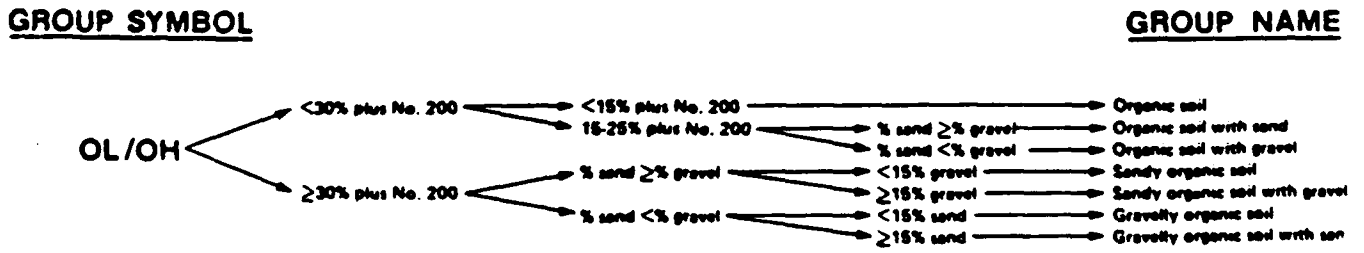
4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Figs. 1a and 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

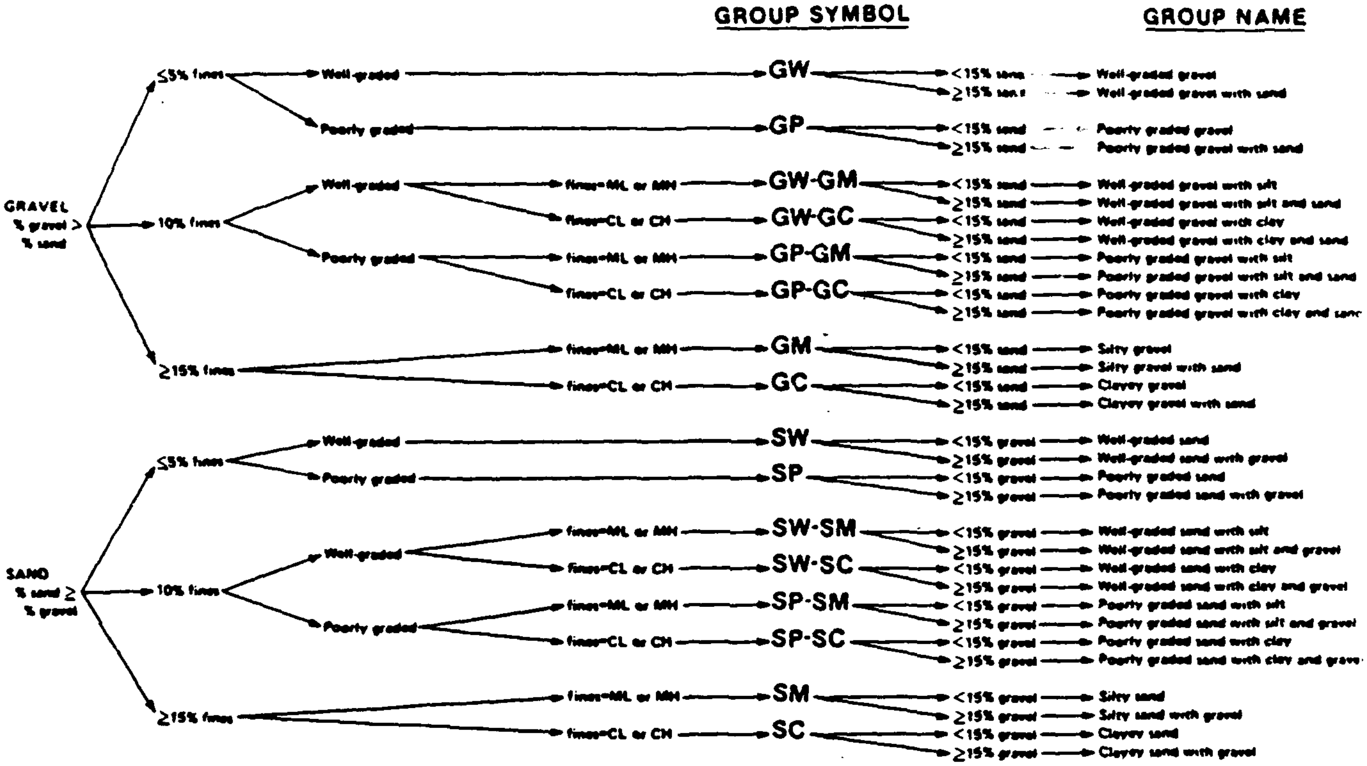
NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)



NOTE—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part

(a) Rounded (b) Angular

(c) Subrounded (d) Subangular

FIG. 3 Typical Angularity of Bulky Grains

concentrated hydrochloric acid (10 N) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 Caution—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 5—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 6—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 7—If random isolated particles are encountered that significantly larger than the particles in the soil matrix, the soil mau... can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

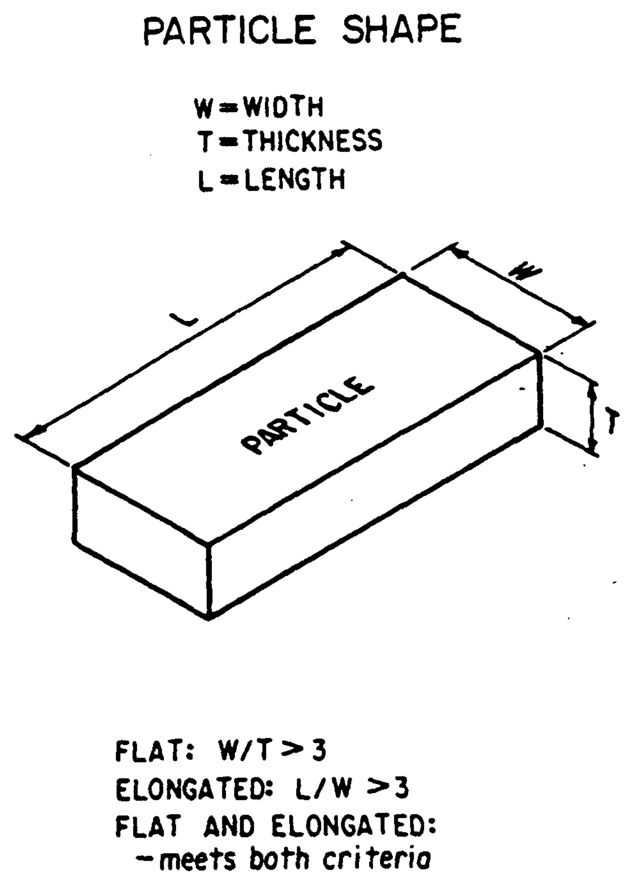


FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.7. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 8—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 9—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 10—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally,

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about 1/8 in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 in. The thread will crumble at a diameter of 1/8 in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 11—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 12—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Figs. 1a and 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:

Gravel—fine, coarse
Sand—fine, medium, coarse

6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

NOTE 13—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 14—Other examples of soil descriptions and identification a given in Appendixes X1 and X2.

NOTE 15—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %
Few—5 to 10 %
Little—15 to 25 %
Some—30 to 45 %
Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Index Terms

18.1 Classification, soil classification, visual classification, soil description, clay, silt, sand, gravel, organic soils.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. *USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE*

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. *SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.*

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

STANDARD OPERATING PROCEDURE FOR DETERMINING TOTAL HYPHAL LENGTH, NUMBERS OF ACTIVE BACTERIA AND LENGTH OF ACTIVE FUNGI.

Elaine R. Ingham
March 19, 1992

I. Scope and Application

The protocol described herein is applicable to determining the numbers of metabolically active bacteria, length of metabolically active hyphae and total length of hyphae in soil, sediment and water samples. This procedure is used to calculate biomass of these organisms.

II. Method Summary

Soil, sediment or water is diluted appropriately (the dilution which gives maximum estimates), and a subsample stained with fluorescein diacetate (FDA). A 0.1 to 1 ml aliquot of this suspension is mixed with agar to prevent organism movement, the agar-soil suspension placed on a slide of known volume. Using epi-fluorescent microscopy (using fluorescein wavelengths, 400-425 exciter wavelengths, 490-500 barrier filter), the length of fluorescent hyphae is measured. Using phase contrast microscopy, the length and width (diameter) of all hyphae are measured. Using epi-fluorescent oil-immersion microscopy, numbers and size of fluorescent bacteria are determined.

III. Sample Preparation

Since this method measures activity, samples must be processed as soon as possible after collection since microbial activity begins to change within days of collection (3 days when temperatures are high, 7 days when temperatures are low) even when samples are kept at cool (4 to 10 C). Samples can not be frozen as freezing destroys activity.

Once stained, the stained organisms must be observed within seven hours even when kept refrigerated because the fluorescein is eliminated as a metabolite from the cells. The agar films will dry within several minutes after preparation, so these must be kept moist (tray with a wet towel) and the measurements made soon after staining is performed.

Direct estimates of active and total fungi. A 1 gram soil or sediment sample or 10 ml water sample (actual volume determined by assessing volume which gives maximum estimates) are diluted in 9 mL sterile tap water or phosphate buffer (1:10 dilution), and shaken at approximately 120 rpm for 5 minutes. One to five mL aliquots will be removed from the 1:10 dilution and prepared for active (FDA stained) and total (phase contrast microscopy) fungal biomass estimations (Ingham and Klein, 1984) by staining for 3 minutes with 1 mL of a 20 ug/mL FDA solution in 0.1 M phosphate buffer, pH 6.5. One mL of 1.5% agar in pH 9.5 0.1 M phosphate buffer will be added to the FDA-soil suspension, mixed well, and an aliquot placed on a slide with a well of known depth. The length of FDA-stained hyphae, using epi-fluorescent microscopy, and the length and diameter of all hyphae, using phase contrast microscopy (Zeiss epi-fluorescent microscope), will be measured and recorded from three 18 mm length transects of each agar film. Total magnification used is 160X and one agar film is observed per sample. Background contamination is determined by measuring hyphal lengths using sterile water samples instead of soil suspensions.

Direct estimates of active bacterial numbers are determined by placing oil on the coverslip of the FDA-stained soil suspension-agar film (see above) and the number of FDA-stained (e.i., active) bacteria counted in each of ten fields on each slide.

IV. Interference/Limitations

Determining the appropriate dilution for use can take some time. The soil particles or dissolved partiluate matter must be diluted to the point that the sand, silt, clay and organic particles do not obscure hyphae, but the hyphae and bacteria should not be diluted beyond the point where no organisms are observed in a transect of the coverslip over the agar aliquot in the slide. Especially in agricultural soils, where fungal length can be very low (less than 5 meters per gram dry soil), this can be a time-consuming step. Soil containing high amounts of fungi are not a problem because increasing the dilution step is therefore not difficult.

Soil pH can be a problem with respect to fluorescein fading. Fluorescein maintains fluorescence only at alkaline pH (above 7.2). If the pH of the soil is 6 or lower, the fluorescein will fade rapidly and determining the number or length of stained organisms can become more difficult. The pH of the stained sample can be raised by addition of high pH agar solution, after staining is completed. Since changes in pH could alter microbial activity, the staining step must be carried out at in situ pH. This can be assured by using a dilution buffer that is of similar pH to that of the soil.

Each person performing measurements must be trained to recognize fungal hyphae and bacterial cells. Either one person should perform all readings or routine standardization of the measurements must be performed by all who are involved. This is simplified by the use of a video monitor so all those performing readings can compare sizes, shapes, and fluorescence problems. Once any operator has experience recognizing fungi and bacteria, as compared to extraneous soil material, operator error is usually less than the variability inherent in the field samples.

Procedural limitations are based on the need to have as little time lapse between collection of samples from the field and measurement in the lab. The longer the soils are held in non-realistic conditions, the more likely it is that changes will occur which do not correspond to what is occuring in the field.

VI. Calculations

Calculation of fungal and bacterial biomass is performed using measured parameters. First, hyphal and bacterial biovolume (in cm^3) is calculated, by multiplying pi by $radius^2$ for cocci, and pi times length times radius for hyphae and bacterial rods, to biomass. Biomass is calculated by converting direct estimates of bacterial and fungal biovolume to biomass using hyphal density averages of $0.41 g/cm^3$, and bacterial density averages of $0.33 g/cm^3$ (Van Veen et al. 1984).

Biomass is converted from grams or volume of sample to some dry weight basis (i.e., per gram dary soil). If dilutions were used, and if only some portion of the agar film was examined, the actual volume of agar film examined must be calculated and biomass calculated per gram or volume of <u>original</u> sample.

VII. QA/QC

For microscopy, image analysis is routinely performed. As with any analysis that requires morphological criteria, these criteria are routinely compared among the various operators in the project. Routine controls are checked to make certain that bacteria and fungi do not occur in sterile water, buffers or agar.

Calibrations of micrometers and grids are routinely made, although in the case of occular micrometers, calibrations do not change unless the microscope is moved. All microscopes are routinely cleaned and serviced by Bartels and Stout, Inc., Portland, OR.

Each sample taken for analysis will be uniquely labeled. For example, each sample receives a unique numerical designator upon receival. Data are recorded in standard lab notebooks and transferred into computer files within two weeks of collection. Lotus or Symphony spreadsheet programs are pre-programmed with data reduction equations stored as templates in data files. Data in computer files are checked by the person entering and by the director to ascertain accuracy of entry.

Statistical comparisons, such as ANOVA, correlation coefficients and regression, can be performed using SPSS, upon request. Mean separation of values are determined by Least Significant Differences (LSD) protected by F significance (F-protected LSD).

Copies of the data will be sent as soon as all data collection is complete. Updates of activity are available on request and the file(s) can be obtained on computer disk. Copies are kept at Dr. Ingham's private residence, with periodic up-dates. Along with maintenance of the original lab books, copies of the data will be available in four separate locations. These copies will be archived in these locations.

VIII. References

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IX. Appendices

Attachment 1. Assessment of Organism Responses

Measure	Units	Expected range	Accur -acy	Precision
Active/total bacterial biomass	ug g^{-1} dry soil	Between 0.001 and 10 ug g^{-1} dry soil	Within 10%	LSD = 1 ug
Active/total fungal biomass	ug g^{-1} dry soil	Between 0.01 and 10^5 ug g^{-1} dry soil	Within 15%	LSD = 10 ug

29-3.5.3 MODIFIED MEBIUS PROCEDURE

29-3.5.3.1 Special Apparatus.

1. Erlenmeyer flasks (125 ml) fitted with female standard-taper 24/40 ground-glass joints (Corning 5000 or Kimble 26510).
2. West condensers (30 cm) fitted with male standard-taper 24/40 ground-glass joints at the lower end (Corning 2800 or Kimble 18190).
3. Electric hot plate extraction unit (six plates per unit) fitted with individual rheostat controls (Labconco 60300, Precision 65500, Lab-Line Multi-Unit Extraction Heater, or equivalent).

29-3.5.3.2 Reagents.

1. Potassium dichromate solution ($K_2Cr_2O_7$), 0.5*N*: Dissolve 24.5125 g of $K_2Cr_2O_7$ (oven-dry) in 200 ml of deionized water, and dilute to 1 liter.
2. Sulfuric acid (H_2SO_4), concentrated, not less than 96%.
3. Ferrous ammonium sulfate hexahydrate solution [$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$], 0.2*N*: Dissolve 78.390 g of $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ in 50 ml of conc H_2SO_4, and dilute to 1 liter with deionized water (must be standardized daily because of slow oxidation).
4. Indicator solution: Dissolve 0.100 g of *N*-phenylanthranilic acid and 0.107 g of sodium carbonate (Na_2CO_3) in 100 ml of water.

29-3.5.3.3 Procedure. Weigh an amount of < 100-mesh soil (≤ 0.5 g) containing not greater than 8 mg of organic C into a 125-ml Erlenmeyer flask. Add exactly 10 ml of 0.5*N* $K_2Cr_2O_7$ solution and 15 ml of conc H_2SO_4 (H_2SO_4 may be added by burette). Attach the flask to the West condenser, and place on a preheated electric hot plate. Include a blank in each group of five soil samples to be heated and at least two unboiled blanks (unboiled blanks are unheated mixtures of 10 ml of 0.5*N* $K_2Cr_2O_7$ and 15 ml of conc H_2SO_4) for each day that analyses are performed. The normality of the $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ solution is determined by titrating the unboiled blank. Gently boil each sample for 30 min, and then insert an asbestos pad between the hot plate and bottom of the Erlenmeyer flask. Allow the flask to cool for about 15 min, and rinse the inside of the condenser with deionized water. Remove the flask from the condenser, and dilute the contents to about 60 ml with deionized water. Add about 0.2 ml of indicator solution, and titrate the samples, boiled blanks, and unboiled blanks with $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ solution using a magnetic stirrer and a lighted background. The color change at the endpoint is rapid and proceeds from violet to gray to bright green. It may be necessary to add additional indicator solution near the end of the titration to sharpen the endpoint.

29-3.5.3.4 Calculations. The difference in titration values between the blank and the sample is proportional to the amount of organic C in soil. The blank minus titration (B − T) value must be corrected, however, for the amount of $Cr_2O_7^{2-}$ consumed during boiling. The correction is done by titrating the unboiled blank and determining the normality of the ferrous ammonium sulfate hexahydrate solution from this titration. The difference between the unboiled and boiled blank is then divided by the amount of ferrous ammonium sulfate hexahydrate solution required for the unboiled blank. This correction value (in the range of 0.04) is multiplied by the B − T value, and the product is added to the B − T value. This gives a corrected value A, or

$$A = (\text{ml}_{BB} - \text{ml}_{sample}) \times \left(\frac{\text{ml}_{UB} - \text{ml}_{BB}}{\text{ml}_{UB}}\right) + (\text{ml}_{BB} - \text{ml}_{sample})$$

where UB is unboiled blank, and BB is boiled blank.

Organic C concentration is then calculated by Eq. [14]:

$$\%\ \text{organic C} = \frac{(A) \times [N \text{ of } Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O] \times (0.003) \times (100)}{\text{g oven-dry soil}}. \qquad [14]$$

29-3.5.3.5 Comments. Interferences noted in Walkley-Black procedures are also a problem with the Mebius procedure. However, the Mebius method gives complete decomposition of organic C compounds and thus does not require a factor to account for incomplete oxidation of organic matter. Organic C in soil extracts may be estimated by the Mebius procedure merely by carrying out the procedure with 5 ml of extract and 5 ml of 1N $K_2Cr_2O_7$ solution instead of 10 ml of 0.5N $K_2Cr_2O_7$ solution. When extracts are analyzed, it may be necessary to add glass beads to promote smooth boiling.

The ratio of the volumes of $K_2Cr_2O_7$ solution to H_2SO_4 is critical for accurate organic C measurements. Therefore, flasks should be clean and dry, and amounts of $K_2Cr_2O_7$ and H_2SO_4 added should be accurately measured. The ferrous ammonium sulfate hexahydrate solution must be standrdized each day because of slow oxidation of Fe^{2+} to Fe^{3+}. The $K_2Cr_2O_7$ solution is the primary standard for the procedure, and therefore care should be taken in its preparation.

Onsite Soil Gas Analysis

The following are modifications that will be made to the standard operating procedure (SOP) for onsite soil gas analysis at McClellan AFB. The following sections refer to those in the SOP. The sections are being modified specifically for the analysis of soil gas samples generated during the pilot operations of the SVE system at Site S, OU D.

Section 2.0 Equipment

The gas chromatograph (GC) configuration will be a Hewlett-Packard 5890A equipped with an O.I. PID and ELCD detectors in series, along with a DB-624 capillary column connected to a universal packed injection port. Data will be collected by a dual channel electronic integrator.

Section 4.0 GC Operating Conditions

GC operating conditions will be developed that will provide adequate separation of the components outlined in Section 5.1. Because of the instrumental configuration, it will only be necessary to run each sample once.

Section 5.1 Initial Calibration

Table E-1 shows the target list for this project and the associated detection limit and detector used for quantitation. Vinyl chloride will be confirmed and quantitated on both detectors.

Section 5.2 Daily Calibration and QA Check

In addition to the stated QC analysis, an audit sample provided by CH2M HILL will be analyzed each week. This sample is to be analyzed and reported in the same manner as field samples.

In addition to the changes outlined above, CH2M HILL will require the following to be provided by the operators of the onsite GC.

- **Demonstration of Capabilities.** This will consist of analysis of an audit sample provided by CH2M HILL. The analysis may be performed prior to mobilization to the field or may be completed in the field. The results of this analysis must be within ±30 percent of the true value for all analytes. Field samples will not be submitted to the field lab until the audit sample is successfully analyzed.

- **Final Data Deliverable.** This will consist of providing a final data package to CH2M HILL for review. The data package will include all elements shown in Table E-2, using the organizational structure outlined in Table E-2. The deliverable is due 3 weeks after the analysis of the last sample in the field.

- **Comparable Equipment.** Comparable equipment must be utilized.
- **GC Downtime.** If GC downtime exceeds 48 hours, samples may be sent offsite for analysis.

Table E-1
SVE Onsite GC Target Analyte List

Compound	Detection Limit (ppbv)	Detector
Freon 12	10	ELCD
Vinyl Chloride	10	ELCD/PID
1,1-Dichoroethene	10	PID
Freon 113	10	ELCD
1,1-Dichloroethane	10	ELCD
Methylene Chloride	10	ELCD
cis-1,2-Dichloroethene	10	ELCD
1,1,1-Trichloroethane	10	ELCD
Benzene	50	PID
Trichloroethene	10	ELCD
Toluene	50	PID
m,p-Xylene	50	PID
o-Xylene	50	PID
Ethylbenzene	50	PID
Chlorobenzene	10	PID
1,2,4-Trimethylbenzene	50	PID
1,2-Dichlorobenzene	10	ELCD

Table E-2
Onsite GC Data Deliverable Requirements

1. Table of Contents

2. Cross reference table clearly identifying Sample ID, Lab ID, and QC samples; should include order of analysis identified by time and date

3. Syringe cleaning QC-identifying syringe batches with corresponding syringe blank results

4. QA/QC Summaries

    a) Initial calibration results

    b) Continuing calibration results (initial and continuing calibration information should include actual and expected concentrations and percent recoveries)

    c) System blank results for each day of analysis

    d) Laboratory duplicates clearly identified with relative percent differences (RPDs) calculated

    e) System audit results

5. Hard copies of all raw data

Attachment 1

RADIAN
CORPORATION

RADIAN SOP FOR ON-SITE SOIL GAS ANALYSIS FOR THE McCLELLAN OU B RI, OCTOBER 1991 THROUGH MARCH 1992

1.0 PURPOSE

The purpose of this Standard Operating Procedures (SOP) is to describe the protocol for analyzing soil gas samples on site using a HP-5890 II gas chromatograph (GC) with capillary column and photoionization detector/electron capture detector (PID/ECD).

2.0 EQUIPMENT

- Hewlett Packard 5890 series II GC (2) with PID and ECD detectors.
- Hewlett Packard 3396 integrator (2).
- Glass 50 cc syringe with 1-½ inch S.S. luer lok needle and interchangeable ground glass barrel, Popper & Sons.
- Pressure Lok A-2 gas tight syringe, 250 μL (2), Alltech & Associates, 050031.
- Mininert Teflon® on/off valve with luer lok fitting, Alltech & Associates, 654051.
- DB 624 capillary column, 30 m x 0.53 mm (2), Curtis Matheson Scient., 256-434.
- Syringe cleaning oven capable of maintaining 160°C ±5°.

3.0 GAS STANDARDS

- Aromatic hydrocarbon gas standard containing 100 ppmv each of benzene, toluene, o-xylene, and p-xylene in UHP nitrogen, 140 cubic feet, Scott Specialty Gas.

- Chlorinated hydrocarbon gas standard containing 2 ppmv each of cis-1,2-dichloroethene, trans-1,2-dichloroethene, chloroform, 1,1,1-trichloroethane, trichloroethene, and tetrachloroethene in UHP nitrogen, 140 cubic feet, Scott Specialty Gas.

- A Scott Specialty Gas single component gas standard containing 10 ppmv of vinyl chloride in UHP N_2.

- Working standards are prepared from the Scott Specialty Gas standards in low pressure 15 L stainless steel canisters. The working standards are prepared by Radian Austin's QA group by dilution with UHP N_2. The halogenated hydrocarbons are 100 ppbv in the canister standard. Vinyl chloride and aromatic hydrocarbons are 500 ppbv in the canister standard.

4.0 GC OPERATING CONDITIONS

Operating parameters on the HP5890 PID/ECD are as follows:

- Injection temp: 150°C
- Detector temp: PID/175°C; ECD/300°C
- Column oven temp:
  - PID Initial temperature 35°C, for 12 minutes.
    Temperature ramp rate 15°C/minute
    Final temperature 75°C, hold 5 minutes
  - ECD 35°C isothermal

- Carrier gas flow: N_2, 10 ml/minute
- Makeup gas flow: N_2, ECD/40 ml/minute

5.0 CALIBRATION

5.1 Initial Calibration

- The HP5890 PID and ECD will be calibrated by injecting 250 μl of Nitrogen and three different volumes (250 μl, 100 μl, and 50 μl) of a canister gas standard containing:

Compound	Concentration ppbv	Integrator
Vinyl chloride	500	ECD/PID
cis/trans-1,2-DCE	200	PID
Chloroform	100	ECD
1,1,1-TCA	100	ECD
TCE	100	ECD
PCE	100	ECD
Benzene	500	PID
Toluene	500	PID
p-Xylene	500	PID
o-Xylene	500	PID
Nitrogen	Balance	—

- A retention time (RT) for each calibrated peak is entered into the integrator used for that compound/detector.
- A RT window of four percent is entered into the integrator for identification of calibrated compounds in the field samples.
- Using the data from the four standard concentrations above, a linear regression is calculated for each of the calibrated compounds by plotting area versus concentration.

- A correlation coefficient of 0.990 or better must be achieved for each analyte or the calibration is repeated.

- The slope for the linear regression is entered into the integrator for each compound and is used as the response factor (RF).

- The intercept from the linear regression line is assumed to contribute a negligible amount to the final concentration for field screening. The absolute value of the intercept should be less than 3.0 for halogenated compounds and aromatic compounds or the concentration of the analyte in the field samples must be calculated using the slope <u>and</u> intercept. Each time a new multi-point calibration is performed, the value of the intercept is checked and documented in the logbook.

- The intercept from the linear regression is also used by the GC operator to determine if the sensitivity of the instrument is increasing or decreasing.

- If the intercept for a compound increases by more than fifty percent from the previous multi-point calibration the system is checked for leaks and plugs.

5.2 Daily Calibration and QC Check

- The daily calibration check standard is analyzed at the beginning of every analysis day that the multi-point calibration is not performed.

- The calibration check standard is a 100 μl mixture of the analytes of interest (40 ppbv of halogenated hydrocarbons and 200 ppbv of aromatic hydrocarbons and vinyl chloride).

- The recoveries of each analyte should be within ± 30 percent of the true value. If the recovery of one analyte exceeds the ±30 percent criteria but is less than ±50 percent recovery, sample analysis may proceed and all samples analyzed that day containing that analyte must be flagged with a "Q". If more than one component of the calibration check standard does not meet this criteria or if any component exceeds ±50 percent recovery, the standard is rejected. If the second calibration check standard does not meet the criteria, corrective action must be taken and/or a new multi-point calibration must be analyzed.

- At the end of the day, a mid-level calibration standard is injected and the percent recovery is calculated for each calibrated compound. If any analyte in the QC check sample varies from the true value by more than 30 percent, all results are flagged with "Q" for the analyte.

6.0 SAMPLE ANALYSES

- A 50 cc glass sampling syringe is delivered to the laboratory with a chain-of-custody form.
- The operator signs the chain-of-custody and records the time.
- A 250 microliter aliquot is taken from the 50 cc syringe and injected into the GC. A smaller aliquot is injected if the OVM reading exceeds ambient levels as indicated on the chain-of-custody. The sample identification number, amount injected, date, and run number are recorded in a bound instrument logbook.
- After the end of the run, the operator enters the results for calibrated compounds on the Analytical Results Summary Sheet.
- Results for any unidentified compounds are calculated using the RF for the calibrated compound closest in retention time to the peak of the unknown compound. The result is entered on the Analytical Results Summary Sheet along with the identity of the closest calibrated compound.

- If any calibrated compounds are above the calibrated concentration range, a second injection is made at a reduced volume. If a sample is injected at the lowest dilution (25 μL), and the concentration of a compound still exceeds the calibration range, the value is flagged with an "E".

- All analyses are completed within a 4-hour holding time.

- The 250 microliter syringe is purged with ambient air in between samples and a 250 microliter sample of air is injected following high level samples (> 50 ppbv on ECD or > 250 ppbv on PID).

7.0 BLANKS

7.1 System Blank

- A system blank is analyzed daily.

- An injection is made with a 250 microliter aliquot of UHP N_2. This injection should be less than 5 ppbv for all halogenated compounds and less than 25 ppbv for all aromatic compounds. This prepares the GC for analysis of the field blank.

7.2 Field Blank

- A field blank (or equipment blank) is analyzed daily.

- A 50 cc sampling syringe is selected at random from the batch cleaned the previous night and given to the field crew to use for the field blank.

- The field blank is run immediately after the system blank by injecting a 250 microliter aliquot. The field blank should be less than 10 ppbv for halogenated compounds and less than 50 ppbv for aromatic compounds.

- If the field blank exceeds these concentrations, the field task leader is notified and another field blank is collected. If the second field blank does not meet the criteria, all data for that day containing the analyte(s) which did not meet the criteria are flagged with an "FB". Corrective action must be taken before the next sampling day.

7.3 Ambient Blank

- A 250 microliter aliquot of ambient air is taken from the on-site lab or a sampling site and analyzed. An ambient blank is collected when contamination from ambient air, either during analysis or sampling, is suspected.

8.0 DUPLICATE INJECTIONS

- Every five samples, a duplicate sample is taken from the 50 cc sampling syringe for injection into the GC to monitor analytical reproducibility.

- If the relative percent difference is greater than 30 percent for analytes within the calibration range, the GC system is checked for leaks or plugs and a third aliquot is injected. If the RPD of the third aliquot is greater than 30 percent, the next sample is analyzed in duplicate similarly. If the RPD of those duplicates are greater than 30 percent, corrective action must be taken before sample analysis can proceed.

9.0 DETECTION LIMIT STUDY

A detection limit study is performed at the beginning of each soil gas sampling and analysis project by analyzing a low-level mixed standard seven times. The method detection limit is calculated by multiplying the standard deviation of the replicates for each analyte by three. This method is outlined in Appendix B, Part 136 of the Federal Register 40 CFR. Values will not be reported below the detection limit.

10.0 SHUTDOWN FOR OVERNIGHT

- The column is cooled to 35° C and the septa are replaced in the injection port of each GC.
- The column is heated to 125° C for overnight bakeout.
- Used 50 cc sampling syringes are disassembled and put in the syringe cleaning oven at 160° C for decontamination.

11.0 CORRECTIVE ACTIONS AND PREVENTATIVE MAINTENANCE

11.1 Leak-Checking the Sampling Syringe

At the end of the GC run, the 50 cc sampling syringe is checked for leaks or plugs by the following procedure.

- The mininert valve is opened and the plunger is pushed forward to expel soil gas from the needle. This is done in a well ventilated area.
- If excess resistance is encountered the mininert valve and stainless steel needle are inspected for plugs. This is noted in the logbook and on the Analytical Results Summary Sheet for the sample.
- If the mininert valve fits loosely on the 50 cc syringe it is discarded. This is noted on the Analytical Results Summary Sheet.

11.2 Changing Injection Port Septum

- The injection port septum is changed at the end of each day to allow overnight conditioning.
- If the RTs of calibrated compounds shift by more than 0.08 and the air peak also shifts, the septum is changed before running any more samples.

11.3 Gas Purifying Filter

- If the background signal from the PID/ECD detector suddenly changes and no leaks are found, a new gas purifying filter is installed in the carrier gas line.

11.4 Downtime on GCs

- If one of the GCs cannot be calibrated due to an instrument malfunction, an emergency (24 hour) service visit will be requested from U.S. Analytical Instruments.
- If downtime is projected to exceed 48 hours a backup HP5890 ECD/FID from the Radian office will be brought on site.
- A spare 10.6 EV lamp for each PID detector will be on-site to minimize downtime from lamp burnout.

12.0 REPORT FLAGS

The following flags will be used on the Analytical Results Summary Sheet to qualify data. These flags may be entered by the analyst or a member of the QA staff who reviews the data. A comment is included on the Analytical Results Summary Sheet by the analyst if unusual circumstances are encountered or further explanation may be helpful in assessing the quality of the data.

REPORT FLAG DEFINITIONS FOR DOWNHOLE SOIL GAS

FB = Detected in field blank at similar concentration
B = Detected in system blank at similar concentration
G = Indicates an estimated value due to GC interferences
PL = Duplicate injection RPD outside control limits
NA = Not analyzed
ND = Not detected at specified detection limit
E = Value exceeds the calibration range
Q = Lower accuracy than expected evidenced by calibration or QC check standard outside quality control limits
Y = Value suspect due to plugged or leaking sampling syringe.
J = Estimated value of tentatively identified compound.
PF = Duplicate field sample RPD outside control limits.
@ = Results are less than five times the method detection limit.

McClellan AFB SVE Treatability Investigation

Summa Canister Analysis

BACKGROUND

CH2M HILL is currently under contract with McClellan Air Force Base in Sacramento, California to perform a soil vapor extraction (SVE) treatability investigation at the base. Wells and piezometers are currently being installed as part of the work. Following well installation, air permeability tests will be conducted to aid in the design of a pilot-scale SVE system. Soil gas samples of the off-gas will be collected during the air permeability testing and analyzed by a contract laboratory in accordance with modified EPA Method TO-14, "Determination of Volatile Organic Compounds (VOC's) in Ambient Air Using SUMMA Passivated Canister Sampling and Gas Chromatography Analysis". Modification of method TO-14 shall consist of the quantification of Total Petroleum Hydrocarbon (TPH) as gasoline. CH2M HILL is requesting quotes to perform the analytical testing.

REQUIREMENTS

The selected laboratory will be required to supply sixteen 15-liter SUMMA passivated canisters prepared and evaluated to EPA TO-14 specifications. The cost to prepare and ship the canisters to CH2M HILL's Sacramento California office shall be included in the price quote for each sample analysis. Each canister shall be cleaned, evaluated and evacuated in the laboratory in accordance with method TO-14. All canisters and sampling equipment to be used on the project shall be pre-screened and verified clean to a level of <0.2 ppbv of any target analyte species or 20 ppbv total chromatographical organics. After cleaning and evaluation, and prior to shipment, each canister shall be evacuated to a level of at least -27 inches Hg and the absolute pressure recorded. Verification of required cleaning limits shall be submitted with the canisters.

At least six pre-cleaned (as per TO-14) and calibrated flow controllers shall be supplied with the canisters. The flow rate for the controllers shall be pre-set to deliver 80 percent of the canister volume in 30 minutes. A stainless steel 7 micron filter shall be attached to each flow controller prior to shipment to remove particulate material in the gas stream prior to the gas entering the canister.

Six stainless steel sample probes shall be supplied to allow extraction of the sample gas from each source to the canister. The probes shall be sized to fit the flow controllers and canister assemblies. Each probe length shall be no less than three feet.

Gas collection will be performed at McClellan AFB by CH2M HILL personnel. It is anticipated that sampling will take place between June 24 and 29, 1991. At the conclusion of the desired sample period, or when the canister pressure reaches approximately -8 inches Hg, sampling will be discontinued. Following sample collection, the canisters will be returned to the laboratory for analysis. The original laboratory shipping containers will be used to return the canisters to the laboratory via Federal Express.

Upon arrival at the laboratory, the canister sample information shall be recorded from the Chain of Custody form and logged into the laboratory sample tracking system. Samples shall then be tested in accordance with EPA Method TO-14 as modified to quantify TPH. For the purposes of the quote, assume that at least 13 of the 16 canisters will require modified TO-14 testing. Up to 3 of the canisters may be returned to laboratory unused. The analysis shall be conducted using the GC/MS (SIM) option of detection and reporting, or whatever detector series the laboratory proposes to quantify the target analytes shown on Table 1. Quantitation limits for GC/MS (SIM) shall be 0.2 ppbv. If an alternate detector series is proposed, then the laboratory shall provide the associated quantitation limit with its quotation. GC/MS (full scan) will also be required to identify and quantitate the top 10 TICs and for quantifying TPH as gasoline. Quantitation limits for GC/MS (full scan) shall be 1.0 ppbv. If an alternative detector series for quantification of TPH as gasoline is proposed, then the laboratory shall provide a description of associated detectors and methodology with its quotation. Laboratory level 1 QA/QC procedures and validation shall be followed for all laboratory testing.

INFORMATION TO BE SUBMITTED WITH LABORATORY QUOTE

To be considered responsive to this request for quote, a signed copy of the attached Agreement for Professional Services must be returned to CH2M HILL by 3:00 p.m., June 20, 1991. A fax copy may be transmitted, followed by a mailed copy. All correspondence should be addressed to :

CH2M HILL
2300 N.W. Walnut Blvd.
Corvallis, Oregon 97339
Attention: Mr. Joseph Danko

Attachments A (Compensation) and B (Certifications and Representations) must be completed and returned with the signed Standard Agreement for Professional Services.

TABLE 1
TO-14 Analyte List

Freon 12
Freon 114
Chloromethane
Vinyl Chloride
Bromomethane
Chloroethane
Freon 11
1,1-Dichloroethene
Freon 113
Methylene Chloride
1,1-Dichloroethane
cis-1,2-Dichloroethene
Chloroform
1,1,1-Trichloroethane
Carbon Tetrachloride
Benzene
1,2-Dichloroethane
Trichloroethene
1,2-Dichloropropane
trans-1,3-Dichloropropene
Toluene
cis-1,3-Dichloropropene
1,1,2-Trichloroethane
Tetrachloroethene
Ethylene Dibromide
Chlorobenzene
Ethyl Benzene
m,p-Xylene
o-Xylene
Styrene
1,1,2,2-Tetrachloroethane
1,3,5-Trimethylbenzene
1,2,4-Trimethylbenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Chlorotoluene
1,2-Dichlorobenzene
1,2,4-Trichlorobenzene
Trans-1,2-Dichloroethene

Total Petroleum Hydrocarbons

METHOD TO12

DETERMINATION OF NON-METHANE ORGANIC COMPOUNDS (NMOC) IN AMBIENT AIR USING CRYOGENIC PRECONCENTRATION AND DIRECT FLAME IONIZATION DETECTION (PDFID)

Revision 1.0
June, 1988

1. Scope

1.1 In recent years, the relationship between ambient concentrations of precursor organic compounds and subsequent downwind concentrations of ozone has been described by a variety of photochemical dispersion models. The most important application of such models is to determine the degree of control of precursor organic compounds that is necessary in an urban area to achieve compliance with applicable ambient air quality standards for ozone (1,2).

1.2 The more elaborate theoretical models generally require detailed organic species data obtained by multicomponent gas chromatography (3). The Empirical Kinetic Modeling Approach (EKMA), however, requires only the total non-methane organic compound (NMOC) concentration data; specifically, the average total NMOC concentration from 6 a.m. to 9 a.m. daily at the sampling location. The use of total NMOC concentration data in the EKMA substantially reduces the cost and complexity of the sampling and analysis system by not requiring qualitative and quantitative species identification.

1.3 Method TO1, "Method for The Determination of Volatile Organic Compounds in Ambient Air Using Tenax® Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)", employs collection of certain volatile organic compounds on Tenax® GC with subsequent analysis by thermal desorption/cryogenic preconcentration and GC/MS identification. This method (TO12) combines the same type of cryogenic concentration technique used in Method TO1 for high sensitivity with the simple flame ionization detector (FID) of the GC for total NMOC measurements, without the GC columns and complex procedures necessary for species separation.

1.4 In a flame ionization detector, the sample is injected into a hydrogen-rich flame where the organic vapors burn producing ionized molecular fragments. The resulting ion fragments are then collected and detected. The FID is nearly a universal detector. However, the detector response varies with the species of [functional group in] the organic compound in an oxygen atmosphere. Because this method employs a helium or argon carrier gas, the detector response is nearly one for all compounds. Thus, the historical short-coming of the FID involving varying detector response to different organic functional groups is minimized.

1.5 The method can be used either for direct, in situ ambient measurements or (more commonly) for analysis of integrated samples collected in specially treated stainless steel canisters. EKMA models generally require 3-hour integrated NMOC measurements over the 6 a.m. to 9 a.m. period and are used by State or local agencies to prepare State Implementation Plans (SIPs) for ozone control to achieve compliance with the National Ambient Air Quality Standards (NAAQS) for ozone. For direct, in situ ambient measurements, the analyst must be present during the 6 a.m. to 9 a.m. period, and repeat measurements (approximately six per hour) must be taken to obtain the 6 a.m. to 9 a.m. average NMOC concentration. The use of sample canisters allows the collection of integrated air samples over the 6 a.m. to 9 a.m. period by unattended, automated samplers. This method has incorporated both sampling approaches.

2. Applicable Documents

2.1 ASTM Standards

D1356 - Definition of Terms Related to Atmospheric Sampling and Analysis

E260 - Recommended Practice for General Gas Chromatography Procedures

E355 - Practice for Gas Chromatography Terms and Relationships

2.2 Other Documents

U. S. Environmental Protection Agency Technical/Assistance Documents (4,5)

Laboratory and Ambient Air Studies (6-10)

3. Summary of Method

3.1 A whole air sample is either extracted directly from the ambient air and analyzed on site by the GC system or collected into a precleaned sample canister and analyzed off site.

3.2 The analysis requires drawing a fixed-volume portion of the sample air at a low flow rate through a glass-bead filled trap that is cooled to approximately -186°C with liquid argon. The cryogenic trap simultaneously collects and concentrates the NMOC (either via condensation or adsorption) while allowing the methane, nitrogen, oxygen, etc. to pass through the trap without retention. The system is dynamically calibrated so that the volume of sample passing through the trap does not have to be quantitatively measured, but must be precisely repeatable between the calibration and the analytical phases.

3.3 After the fixed-volume air sample has been drawn through the trap, a helium carrier gas flow is diverted to pass through the trap, in the opposite direction to the sample flow, and into an FID. When the residual air and methane have been flushed from the trap and the FID baseline restabilizes, the cryogen is removed and the temperature of the trap is raised to approximately 90°C.

3.4 The organic compounds previously collected in the trap revolatilize due to the increase in temperature and are carried into the FID, resulting in a response peak or peaks from the FID. The area of the peak or peaks is integrated, and the integrated value is translated to concentration units via a previously-obtained calibration curve relating integrated peak areas with known concentrations of propane.

3.5 By convention, concentrations of NMOC are reported in units of parts per million carbon (ppmC), which, for a specific compound, is the concentration by volume (ppmV) multiplied by the number of carbon atoms in the compound.

3.6 The cryogenic trap simultaneously concentrates the NMOC while separating and removing the methane from air samples. The technique is thus direct reading for NMOC and, because of the concentration step, is more sensitive than conventional continuous NMOC analyzers.

4. Significance

4.1 Accurate measurements of ambient concentrations of NMOC are important for the control of photochemical smog because these organic compounds are primary precursors of atmospheric ozone and other oxidants. Achieving and maintaining compliance with the NAAQS for ozone thus depends largely on control of ambient levels of NMOC.

4.2 The NMOC concentrations typically found at urban sites may range up to 5-7 ppmC or higher. In order to determine transport of precursors into an area, measurement of NMOC upwind of the area may be necessary. Upwind NMOC concentrations are likely to be less than a few tenths of 1 ppm.

4.3 Conventional methods that depend on gas chromatography and qualitative and quantitative species evaluation are excessively difficult and expensive to operate and maintain when speciated measurements are not needed. The method described here involves a simple, cryogenic preconcentration procedure with subsequent, direct, flame ionization detection. The method is sensitive and provides accurate measurements of ambient NMOC concentrations where speciated data are not required as applicable to the EKMA.

5. Definitions

[Note: Definitions used in this document and in any user-prepared Standard Operating Procedures (SOPs) should be consistent with ASTM Methods D1356 and E355. All abbreviations and symbols are defined within this document at point of use.]

5.1 Absolute pressure - Pressure measured with reference to absolute zero pressure (as opposed to atmospheric pressure), usually expressed as pounds-force per square inch absolute (psia).

5.2 Cryogen - A substance used to obtain very low trap temperatures in the NMOC analysis system. Typical cryogens are liquid argon (bp -185.7) and liquid oxygen (bp-183.0).

5.3 *Dynamic calibration - Calibration of an analytical system* with pollutant concentrations that are generated in a dynamic, flowing system, such as by quantitative, flow-rate dilution of a high concentration gas standard with zero gas.

5.4 EKMA - Empirical Kinetics Modeling Approach; an empirical model that attempts to relate morning ambient concentrations of nonmethane organic compounds (NMOC) and NO_x with subsequent peak, downwind ambient ozone concentrations; used by pollution control agencies to estimate the degree of hydrocarbon emission reduction needed to achieve compliance with national ambient air quality standards for ozone.

5.5 Gauge pressure - Pressure measured with reference to atmospheric *pressure (as opposed to absolute pressure). Zero gauge pressure* (0 psig) is equal to atmospheric pressure, or 14.7 psia (101 kPa).

5.6 *In situ* - In place; *In situ* measurements are obtained by direct, on-the-spot analysis, as opposed to subsequent, remote analysis of a collected sample.

5.7 *Integrated sample* - A sample obtained uniformly over a specified time period and representative of the average levels of pollutants during the time period.

5.8 NMOC - Nonmethane organic compounds; total organic compounds as measured by a flame ionization detector, excluding methane.

5.9 ppmC - Concentration unit of parts per million carbon; for a specific compound, ppmC is equivalent to parts per million by volume (ppmv) multiplied by the number of carbon atoms in the compound.

5.10 Sampling - The process of withdrawing or isolating a representative portion of an ambient atmosphere, with or without the simultaneous isolation of selected components for subsequent analysis.

6. Interferences

6.1 In field and laboratory evaluation, water was found to cause a positive shift in the FID baseline. The effect of this shift is minimized by carefully selecting the integration termination point and adjusted baseline used for calculating the area of the NMOC peak(s).

6.2 When using *helium as a carrier gas,* FID response is quite uniform for most hydrocarbon compounds, but the response can vary considerably for other types of organic compounds.

7. Apparatus

7.1 Direct Air Sampling (Figure 1)

7.1.1 Sample manifold or sample inlet line - to bring sample air into the analytical system.

7.1.2 Vacuum pump or blower - to draw sample air through a sample manifold or long inlet line to reduce inlet residence time. Maximum residence time should be no greater than 1 minute.

7.2 Remote Sample *Collection in Pressurized Canisters (Figure 2)*

7.2.1 Sample canister(s) - stainless steel, Summa®-polished vessel(s) of 4-6 L capacity (Scientific Instrumentation Specialists, Inc., P.O. Box 8941, Moscow, ID 83843), used for automatic collection of 3-hour integrated field air samples. Each canister should have a unique identification number stamped on its frame.

7.2.2 Sample pump - stainless steel, metal bellows type (Model MB-151, Metal Bellows Corp., 1075 Providence Highway, Sharon, MA 02067) capable of 2 atmospheres minimum output pressure. Pump must be free of leaks, clean, and uncontaminated by oil or organic compounds.

7.2.3 Pressure gauge - 0-30 psig (0-240 kPa).

7.2.4 Solenoid valve - special electrically-operated, bistable solenoid valve (Skinner Magnelatch Valve, New Britain, CT), to control sample flow to the canister with negligible temperature rise (Figure 3). The use of the Skinner Magnelatch valve avoids any substantial temperature rise that would occur with a conventional, *normally* closed solenoid valve, which would have to be energized during the entire sample period. This temperature rise in the valve could cause outgasing of organics from the Viton valve seat material. The Skinner Magnelatch valve requires only a brief electrical pulse to open or close at the appropriate start and stop times and therefore experiences no temperature increase. The pulses may be obtained with an electronic timer that can be programmed for short (5 to 60 seconds) ON periods or with a conventional mechanical timer and a special pulse circuit. Figure 3 [a] illustrates a simple electrical pulse circuit for operating the Skinner Magnelatch solenoid valve with a conventional mechanical timer. However, with this simple circuit, the valve may operate unpredictably during brief power interruptions or if the timer is manually switched on and off too fast. A better circuit incorporating a time-delay relay to provide more reliable valve operation is shown in Figure 3[b].

7.2.5 Stainless steel orifice (or short capillary) - capable of maintaining a substantially constant flow over the sampling period (see Figure 4).

7.2.6 Particulate matter filter - 2 micron stainless steel sintered in-line type (see Figure 4).

7.2.7 Timer - used for unattended sample collection. Capable of controlling pump(s) and solenoid valve.

7.3 Sample Canister Cleaning (Figure 5)

7.3.1 Vacuum pump - capable of evacuating sample canister(s) to an absolute pressure of <5 mm Hg.

7.3.2 Manifold - stainless steel manifold with connections for simultaneously cleaning several canisters.

7.3.3 Shut off valve(s) - seven required.

7.3.4 Vacuum gauge - capable of measuring vacuum in the manifold to an absolute pressure of 5 mm Hg or less.

7.3.5 *Cryogenic trap* (2 required) - U-shaped open tubular trap cooled with liquid nitrogen or argon used to prevent contamination from back diffusion of oil from vacuum pump, and to provide clean, zero air to sample canister(s).

7.3.6 Pressure gauge - 0-50 psig (0-345 kPa), to monitor zero air pressure.

7.3.7 Flow control valve - to regulate flow of zero air into canister(s).

7.3.8 Humidifier - water bubbler or other system capable of providing moisture to the zero air supply.

7.4 Analytical System (Figure 1)

7.4.1 FID detector system - including flow controls for the FID fuel and air, temperature control for the FID, and signal processing electronics. The FID burner air, hydrogen, and helium carrier flow rates should be set according to the manufacturer's instructions to obtain an adequate FID response while maintaining as stable a flame as possible throughout all phases of the analytical cycle.

7.4.2 *Chart recorder* - compatible with the FID output signal, to record FID response.

7.4.3 Electronic integrator - capable of integrating the area of one or more FID response peaks and calculating peak area corrected for baseline drift. If a separate integrator and chart recorder are used, care must be exercised to be sure that these components do not interfere with each other electrically. Range selector controls on both the integrator and the FID analyzer may not provide accurate range ratios, so individual calibration curves should be prepared for each range to be used. The integrator should be capable of marking the beginning and ending of peaks, constructing the appropriate baseline between the start and end of the integration period, and calculating the peak area.

Note: The FID (7.4.1), chart recorder (7.4.2), integrator (7.4.3), valve heater (7.4.5), and a trap heating system are conveniently provided by a standard laboratory chromatograph and associated integrator. EPA has adapted two such systems for the PDFID method: a Hewlett-Packard model 5880 (Hewlett-Packard Corp., Avondale, PA) and a Shimadzu model GC8APF (Shimadzu Scientific Instruments Inc., Columbia, MD; see Reference 5). Other similar systems may also be applicable.

7.4.4 Trap - the trap should be carefully constructed from a single piece of chromatographic-grade stainless steel tubing (0.32 cm O.D, 0.21 cm I.D.) as shown in Figure 6. The central portion of the trap (7-10 cm) is packed with 60/80 mesh glass beads, with small glass wool (dimethyldichlorosilane-treated) plugs to retain the beads. The trap must fit conveniently into the Dewar flask (7.4.9), and the arms must be of an appropriate length to allow the beaded portion of the trap to be submerged below the level of liquid cryogen in the Dewar. The trap should connect directly to the six-port valve, if possible, to minimize line length between the trap and the FID. The trap must be mounted to allow the Dewar to be slipped conveniently on and off the trap and also to facilitate heating of the trap (see 7.4.13).

7.4.5 Six-port chromatographic valve - Seiscor Model VIII (Seismograph Service Corp., Tulsa, OK), Valco Model 9110 (Valco Instruments Co., Houston, TX), or equivalent. The six-port valve and as much of the interconnecting tubing as practical should be located inside an oven or otherwise heated to 80 - 90°C to minimize wall losses or adsorption/desorption in the connecting tubing. All lines should be as short as practical.

7.4.6 Multistage pressure regulators - standard two-stage, stainless steel diaphram regulators with pressure gauges, for helium, air, and hydrogen cylinders.

7.4.7 Pressure regulators - optional single stage, stainless steel, with pressure gauge, if needed, to maintain constant helium carrier and hydrogen flow rates.

7.4.8 Fine needle valve - to adjust sample flow rate through trap.

7.4.9 Dewar flask - to hold liquid cryogen to cool the trap, sized to contain submerged portion of trap.

7.4.10 Absolute pressure gauge - 0-450 mm Hg,(2 mm Hg [scale divisions indicating units]), to monitor repeatable volumes of sample air through cryogenic trap (Wallace and Tiernan, Model 61C-1D-0410, 25 Main Street, Belleville, NJ).

7.4.11 Vacuum reservoir - 1-2 L capacity, typically 1 L.

7.4.12 Gas purifiers - gas scrubbers containing Drierite® or silica gel and 5A molecular sieve to remove moisture and organic impurities in the helium, air, and hydrogen gas flows (Alltech Associates, Deerfield, IL). Note: Check purity of gas purifiers prior to use by passing zero-air through the unit and analyzing according to Section 11.4. Gas purifiers are clean if produce [contain] less than 0.02 ppmC hydrocarbons.

7.4.13 Trap heating system - chromatographic oven, hot water, or other means to heat the trap to 80° to 90°C. A simple heating source for the trap is a beaker or Dewar filled with water maintained at 80-90°C. More repeatable types of heat sources are recommended, including a temperature-programmed chromatograph oven, electrical heating of the trap itself, or any type of heater that brings the temperature of the trap up to 80-90°C in 1-2 minutes.

7.4.14 Toggle shut-off valves (2) - leak free, for vacuum valve and sample valve.

7.4.15 Vacuum pump - general purpose laboratory pump capable of evacuating the vacuum reservoir to an appropriate vacuum that allows the desired sample volume to be drawn through the trap.

7.4.16 Vent - to keep the trap at atmospheric pressure during trapping when using pressurized canisters.

7.4.17 Rotameter - to verify vent flow.

7.4.18 Fine needle valve (optional) - to adjust flow rate of sample from canister during analysis.

7.4.19 Chromatographic-grade stainless steel tubing (Alltech Applied Science, 2051 Waukegan Road, Deerfield, IL, 60015, (312) 948-8600) and stainless steel plumbing fittings - for interconnections. All such materials in contact with the sample, analyte, or support gases prior to analysis should be stainless steel or other inert metal. Do not use plastic or Teflon® tubing or fittings.

7.5 Commercially Available PDFID System (5)

7.5.1 A convenient and cost-effective modular PDFID system suitable for use with a conventional laboratory chromatograph is commercially available (NuTech Corporation, Model 8548, 2806 Cheek Road, Durham, NC, 27704, (919) 682-0402).

7.5.2 This modular system contains almost all of the apparatus items needed to convert the chromatograph into a PDFID analytical system and has been designed to be readily available and easy to assemble.

8. Reagents and Materials

8.1 Gas cylinders of helium and hydrogen - ultrahigh purity grade.

8.2 Combustion air - cylinder containing less than 0.02 ppm hydrocarbons, or equivalent air source.

8.3 Propane calibration standard - cylinder containing 1-100 ppm (3-300 ppmC) propane in air. The cylinder assay should be traceable to a National Bureau of Standards (NBS) Standard Reference Material (SRM) or to a NBS/EPA-approved Certified Reference Material (CRM).

8.4 Zero air - cylinder containing less than 0.02 ppmC hydrocarbons. Zero air may be obtained from a cylinder of zero-grade compressed air scrubbed with Drierite® or silica gel and 5A molecular sieve or activated charcoal, or by catalytic cleanup of ambient air. All zero air should be passed through a liquid argon cold trap for final cleanup, then passed through a hyrdocarbon-free water bubbler (or other device) for humidification.

8.5 Liquid cryogen - liquid argon (bp -185.7°C) or liquid oxygen, (bp -183°C) may be used as the cryogen. Experiments have shown no differences in trapping efficiency between liquid argon and liquid oxygen. However, appropriate safety precautions must be taken if liquid oxygen is used. Liquid nitrogen (bp -195°C) should not be used because it causes condensation of oxygen and methane in the trap.

9. Direct Sampling

9.1 For direct ambient air sampling, the cryogenic trapping system draws the air sample directly from a pump-ventilated distribution manifold or sample line (see Figure 1). The connecting line should be of small diameter (1/8" O.D.) stainless steel tubing and as short as possible to minimize its dead volume.

9.2 Multiple analyses over the sampling period must be made to establish hourly or 3-hour NMOC concentration averages.

10. Sample Collection in Pressurized Canister(s)

For integrated pressurized canister sampling, ambient air is sampled by a metal bellows pump through a critical orifice (to maintain constant flow), and pressurized into a clean, evacuated, Summa®-polished sample canister. The critical orifice size is chosen so that the canister is pressurized to approximately one atmosphere above ambient pressure, at a constant flow rate over the desired sample period. Two canisters are connected in parallel for duplicate samples. The canister(s) are then returned to the laboratory for analysis, using the PDFID analytical system. Collection of ambient air samples in pressurized canisters provides the following advantages:

- Convenient integration of ambient samples over a specific time period
- Capability of remote sampling with subsequent central laboratory analysis
- Ability to ship and store samples, if necessary

- Unattended sample collection
- Analysis of samples from multiple sites with one analytical system
- Collection of replicate samples for assessment of measurement precision

With canister sampling, however, great care must be exercised in selecting, cleaning, and handling the sample canister(s) and sampling apparatus to avoid losses or contamination of the samples.

10.1 Canister Cleanup and Preparation

10.1.1 All canisters must be clean and free of any contaminants before sample collection.

10.1.2 Leak test all canisters by pressurizing them to approximately 30 psig [200 kPa (gauge)] with zero air. The use of the canister cleaning system (see Figure 5) may be adequate for this task. Measure the final pressure - close the canister valve, then check the pressure after 24 hours. If leak tight, the pressure should not vary more than ± 2 psig over the 24-hour period. Note leak check result on sampling data sheet, Figure 7.

10.1.3 Assemble a canister cleaning system, as illustrated in Figure 5. Add cryogen to both the vacuum pump and zero air supply traps. Connect the canister(s) to the manifold. Open the vent shut off valve and the canister valve(s) to release any remaining pressure in the canister. Now close the vent shut off valve and open the vacuum shut off valve. Start the vacuum pump and evacuate the canister(s) to $\leq$ 5.0 mm Hg (for at least one hour). [Note: On a daily basis or more often if necessary, blow-out the cryogenic traps with zero air to remove any trapped water from previous canister cleaning cycles.]

10.1.4 Close the vacuum and vacuum gauge shut off valves and open the zero air shut off valve to pressurize the canister(s) with moist zero air to approximately 30 psig [200 kPa (gauge)]. If a zero gas generator system is used, the flow rate may need to be limited to maintain the zero air quality.

10.1.5 Close the zero shut off valve and allow canister(s) to vent down to atmospheric pressure through the vent shut off valve. Close the vent shut off valve. Repeat steps 10.1.3 through 10.1.5 two additional times for a total of three (3) evacuation/pressurization cycles for each set of canisters.

10.1.6 As a "blank" check of the canister(s) and cleanup procedure, analyze the final zero-air fill of 100% of the canisters until the cleanup system and canisters are proven reliable. The check can then be reduced to a lower percentage of canisters. Any canister that does not test clean (compared to direct analysis of humidified zero air of less than 0.02 ppmC) should not be utilized.

10.1.7 The canister is then re-evacuated to $\leq$ 5.0 mm Hg, using the canister cleaning system, and remains in this condition until use. Close the canister valve, remove the canister from the canister cleaning system and cap canister connection with a stainless steel fitting. The canister is now ready for collection of an air sample. Attach an identification tag to the neck of each canister for field notes and chain-of-custody purposes.

10.2 Collection of Integrated Whole-Air Samples

10.2.1 Assemble the sampling apparatus as shown in Figure 2. The connecting lines between the sample pump and the canister(s) should be as short as possible to minimize their volume. A second canister is used when a duplicate sample is desired for quality assurance (QA) purposes (see Section 12.2.4). The small auxiliary vacuum pump purges the inlet manifold or lines with a flow of several L/min to minimize the sample residence time. The larger metal bellows pump takes a small portion of this sample to fill and pressurize the sample canister(s). Both pumps should be shock-mounted to minimize vibration. Prior to field use, each sampling system should be leak tested. The outlet side of the metal bellows pump can be checked for leaks by attaching the 0-30 psig pressure gauge to the canister(s) inlet via connecting tubing and pressurizing to 2 atmospheres or approximately 29.4 psig. If pump and connecting lines are leak free pressure should remain at ±2 psig for 15 minutes. To check the inlet side, plug the sample inlet and insure that there is no flow at the outlet of the pump.

10.2.2 Calculate the flow rate needed so that the canister(s) are pressurized to approximately one atmosphere above ambient pressure (2 atmospheres absolute pressure) over the desired sample period, utilizing the following equation:

$$F = \frac{(P)(V)(N)}{(T)(60)}$$

where:

F = flow rate (cm^3/min)
P = final canister pressure (atmospheres absolute)
= $(P_g/P_a) + 1$
V = volume of the canister (cm^3)
N = number of canisters connected together for simultaneous sample collection
T = sample period (hours)
P_g = gauge pressure in canister, psig (kPa)
Pa = standard atmospheric pressure, 14.7 psig (101 kPa)

For example, if one 6-L canister is to be filled to 2 atmospheres absolute pressure (14.7 psig) in 3 hours, the flow rate would be calculated as follows:

$$F = \frac{2 \times 6000 \times 1}{3 \times 60} = 67 \text{ cm}^3/\text{min}$$

10.2.3 Select a critical orifice or hypodermic needle suitable to maintain a substantially constant flow at the calculated flow rate into the canister(s) over the desired sample period. A 30-gauge hypodermic needle, 2.5 cm long, provides a flow of approximately 65 cm^3/min with the Metal Bellows Model MBV-151 pump (see Figure 4). Such a needle will maintain approximately constant flow up to a canister pressure of about 10 psig (71 kPa), after which the flow drops with increasing pressure. At 14.7 psig (2 atmospheres absolute pressure), the flow is about 10% below the original flow.

10.2.4 Assemble the 2.0 micron stainless steel in-line particulate filter and position it in front of the critical orifice. A suggested filter-hypodermic needle assembly can be fabricated as illustrated in Figure 4.

10.2.5 Check the sampling system for contamination by filling two evacuated, cleaned canister(s) (See Section 10.1) with humidified zero air through the sampling system. Analyze the canisters according to Section 11.4. The sampling system is free of contamination if the canisters contain less than 0.02 ppmC hydrocarbons, similar to that of humidified zero air.

10.2.6 During the system contamination check procedure, check the critical orifice flow rate on the sampling system to insure that sample flow rate remains relatively constant (±10%) up to about 2 atmospheres absolute pressure (101 kPa). Note: A drop in the flow rate may occur near the end of the sampling period as the canister pressure approaches two atmospheres.

10.2.7 Reassemble the sampling system. If the inlet sample line is longer than 3 meters, install an auxiliary pump to ventilate the sample line, as illustrated in Figure 2.

10.2.8 Verify that the timer, pump(s) and solenoid valve are connected and operating properly.

10.2.9 Verify that the timer is correctly set for the desired sample period, and that the solenoid valve is closed.

10.2.10 Connect a cleaned, evacuated canister(s) (Section 10.1) to the non-contaminated sampling system, by way of the solenoid valve, for sample collection.

10.2.11 Make sure the solenoid valve is closed. Open the canister valve(s). Temporarily connect a small rotameter to the sample inlet to verify that there is no flow. Note: *Flow detection would indicate a leaking (or open)* solenoid valve. Remove the rotameter after leak detection procedure.

10.2.12 Fill out the necessary information on the Field Data Sheet (Figure 7).

10.2.13 Set the automatic timer to start and stop the pump or pumps to open and close the solenoid valve at the appropriate time for the intended sample period. Sampling will begin at the pre-determined time.

10.2.14 After the sample period, close the canister valve(s) and disconnect the canister(s) *from* the sampling system. Connect a pressure gauge to the canister(s) and briefly open and close the canister valve. Note the canister pressure on the Field Data Sheet (see Figure 7). The canister pressure should be approximately 2 atmospheres *absolute [1 atmosphere or 101 kPa (gauge)]. Note: If* the canister pressure is not approximately 2 atmospheres absolute (14.7 psig), determine and correct the cause before next sample. Re-cap canister valve.

10.2.15 Fill out the identification tag on the sample canister(s) and complete the Field Data Sheet as necessary. Note any activities or special conditions in the area (rain, smoke, etc.) that may affect the sample contents on the sampling data sheet.

10.2.16 Return the canister(s) to the analytical system for analysis.

11. Sample Analysis

11.1 Analytical System Leak Check

11.1.1 Before sample analysis, the analytical system is assembled (see Figure 1) and leak checked.

11.1.2 To leak check the analytical system, place the six-port gas valve in the trapping position. Disconnect and cap the absolute pressure gauge. Insert a pressure gauge capable of recording up to 60 psig at the vacuum valve outlet.

11.1.3 Attach a valve and a zero air supply to the sample inlet port. Pressurize the system to about 50 psig (350 kPa) and close the valve.

11.1.4 Wait approximately 3 hrs. and re-check pressure. If the pressure did not vary more than ± 2 psig, the system is considered leak tight.

11.1.5 If the system is leak free, de-pressurize and reconnect absolute pressure gauge.

11.1.5 The analytical system leak check procedure needs to be performed during the system checkout, during a series *of analysis or if leaks are suspected.* This should be part of the user-prepared SOP manual (see Section 12.1).

11.2 Sample Volume Determination

11.2.1 The vacuum reservoir and absolute pressure gauge are used to meter a precisely repeatable volume of sample air through the cryogenically-cooled trap, as follows: With the sample valve closed and the vacuum valve open, the reservoir is first evacuated with the vacuum pump to a predetermined pressure (e.g., *100 mm Hg*). Then the vacuum valve is closed and the sample valve is opened to allow sample air to be drawn through the cryogenic trap and into the evacuated reservoir until a second predetermined reservoir pressure is reached (e.g., *300 mm Hg*). The *(fixed)* volume of air thus sampled is determined by the pressure rise in the vacuum reservoir (difference between the predetermined pressures) as measured by the absolute pressure gauge (see Section 12.2.1).

11.2.2 The sample volume can be calculated by:

$$V_s = \frac{(\Delta P)(V_r)}{(P_s)}$$

where:

V_s = volume of air sampled (standard cm^3)
ΔP = pressure difference measured by gauge (mm Hg)
V_r = volume of vacuum reservoir (cm^3) usually 1 L
P_s = standard pressure (760 mm Hg)

For example, with a vacuum reservoir of 1000 cm^3 and a pressure change of 200 mm Hg (100 to 300 mm Hg), the volume sampled would be 263 cm^3. [Note: Typical sample volume using this procedure is between 200-300 cm^3.]

11.2.3 The sample volume determination need only be performed once during the system check-out and shall be part of the user-prepared SOP Manual (see Section 12.1).

11.3 Analytical System Dynamic Calibration

11.3.1 Before sample analysis, a complete dynamic calibration of the analytical system should be carried out at five or more concentrations on each range to define the calibration curve. This should be carried out initially and periodically thereafter [may be done only once during a series of analyses]. This should be part of the user-prepared SOP Manual (See Section 12.1). The calibration should be verified with two or three-point calibration checks (including zero) each day the analytical system is used to analyze samples.

11.3.2 Concentration standards of propane are used to calibrate the analytical system. Propane calibration standards may be obtained directly from low concentration cylinder standards or by dilution of high concentration cylinder standards with zero air (see Section 8.3). Dilution flow rates must be measured accurately, and the combined gas stream must be mixed thoroughly for successful calibration of the analyzer. Calibration standards should be sampled directly from a vented manifold or tee. Note: Remember that a propane NMOC concentration in ppmC is three times the volumetric concentration in ppm.

11.3.3 Select one or more combinations of the following parameters to provide the desired range or ranges (e.g., 0-1.0 ppmC or 0-5.0 ppmC): FID attenuator setting, output voltage setting, integrator resolution (if applicable), and sample volume. Each individual range should be calibrated separately and should have a separate calibration curve. Note: Modern GC integrators may provide automatic ranging such that several decades of concentration may be covered in a single range. The user-prepared SOP manual should address variations applicable to a specific system design (see Section 12.1).

11.3.4 Analyze each calibration standard three times according to the procedure in Section 11.4. Insure that flow rates, pressure gauge start and stop readings, initial cryogen liquid level in the Dewar, timing, heating, integrator settings, and other variables are the same as those that will be used during analysis of ambient samples. Typical flow rates for the gases are: hydrogen, 30 cm^3/minute; helium carrier, 30 cm^3/minute; burner air, 400 cm^3/minute.

11.3.5 Average the three analyses for each concentration standard and plot the calibration curve(s) as average integrated peak area reading versus concentration in ppmC. The relative standard deviation for the three analyses should be less than 3% (except for zero concentration). Linearity should be expected; points that *appear to deviate abnormally* should be repeated. Response has been shown to be linear over a wide range (0-10,000 ppbC). If nonlinearity is observed, an effort should be made to identify and correct *the problem. If the problem cannot be corrected*, additional points in the nonlinear region may be needed to define the calibration curve adequately.

11.4 Analysis Procedure

11.4.1 Insure the analytical system has been assembled properly, leaked checked, and properly calibrated through a dynamic *standard calibration. Light the FID detector and allow to* stabilize.

11.4.2 Check and adjust the helium carrier pressure to provide the correct carrier flow rate for the system. Helium is used to purge residual air and methane from the trap at the end of the sampling phase and to carry the re-volatilized NMOC from the trap into the FID. A single-stage auxiliary regulator between the cylinder and the analyzer may not be necessary, but is recommended to regulate the helium pressure better than the multistage cylinder regulator. When an auxiliary regulator is used, the secondary stage of the two-stage regulator must be set at a pressure higher than the pressure setting of the single-stage regulator. Also check the FID hydrogen and burner air flow rates (see 11.3.4).

11.4.3 *Close the sample valve and open the vacuum valve to* evacuate the vacuum reservoir to a specific predetermined value (e.g., 100 mm Hg).

11.4.4 With the trap at room temperature, place the six-port valve in the inject position.

11.4.5 Open the sample valve and adjust the sample flow rate needle valve for an appropriate trap flow of 50-100 cm^3/min. Note: The flow will be lower later, when the trap is cold.

11.4.6 Check the sample canister pressure before attaching it to the analytical system and record on Field Data Sheet (see Figure 7). Connect the sample canister or direct sample inlet to the six-port valve, as shown in Figure 1. For a canister, either the canister valve *or an optional fine needle valve* installed between the canister and the vent is used to adjust the canister flow rate to a value slightly higher than the trap flow rate set by the sample flow rate needle valve. The excess flow exhausts through the vent, which assures that the sample air flowing through the trap is at atmospheric pressure. The vent is connected to *a flow indicator* such as a rotameter as an indication of vent flow to assist in adjusting the flow control valve. Open the canister valve and adjust the canister valve or the sample flow needle valve to obtain a *moderate vent flow as indicated by the rotameter*. The sample flow rate will be lower (and hence the vent flow rate will be higher) when the the trap is cold.

11.4.7 Close the sample valve and open the vacuum valve (if not already open) to evacuate the vacuum reservoir. With the six-port valve in the inject position and the vacuum valve open, open the sample valve for 2-3 minutes [with both valves open, the pressure reading won't change] to flush and condition the inlet lines.

11.4.8 Close the sample valve and evacuate the *reservoir* to the predetermined sample starting pressure (typically *100 mm Hg) as indicated by the absolute pressure gauge*.

11.4.9 Switch the six-port valve to the sample position.

11.4.10 Submerge the trap in the cryogen. Allow a few minutes for the trap to cool completely (indicated when the cryogen stops boiling). Add cryogen to the initial level used during system dynamic calibration. The level of the cryogenic liquid should remain constant with respect to the trap and should completely cover the beaded portion of the trap.

11.4.11 Open the sample valve and observe the increasing pressure on the pressure gauge. When it reaches the specific predetermined pressure (typically 300 mm Hg) representative of the desired sample volume (Section 11.2), close the sample valve.

11.4.12 Add a little cryogen or elevate the Dewar to raise the liquid level to a point slightly higher (3-15 mm) than the initial level at the beginning of the trapping. Note: This insures that organics do not bleed from the trap and are counted as part of the NMOC peak(s).

11.4.13 Switch the 6-port valve to the inject position, keeping the cryogenic liquid on the trap until the methane and upset peaks have deminished (10-20 seconds). Now close the canister valve to conserve the remaining sample in the canister.

11.4.14 Start the integrator and remove the Dewar flask containing the cryogenic liquid from the trap.

11.4.15 Close the GC oven door and allow the GC oven (or alternate trap heating system) to heat the trap at a predetermined rate (typically, 30°C/min) to 90°. Heating the trap volatilizes the concentrated NMOC such that the FID produces integrated peaks. A uniform trap temperature rise rate (above 0°C) helps to reduce variability and facilitates more accurate correction for the moisture-shifted baseline. With a chromatograph oven to heat the trap, the following parameters have been found to be acceptable: initial temperature, 30°C; initial time, 0.20 minutes (following start of the integrator); heat rate, 30°/minute; final temperature, 90°C.

11.4.16 Use the same heating process and temperatures for both calibration and sample analysis. Heating the trap too quickly may cause an initial negative response that could hamper accurate integration. Some initial experimentation may be necessary to determine the optimal heating procedure for each system. Once established, the procedure should be consistent for each analysis as outlined in the user-prepared SOP Manual.

11.4.17 Continue the integration (generally, in the range of 1-2 minutes is adequate) only long enough to include all of the organic compound peaks and to establish the end point FID baseline, as illustrated in Figure 8. The integrator should be capable of marking the beginning and ending of peaks, constructing the appropriate operational baseline between the start and end of the integration period, and calculating the resulting corrected peak area. This ability is necessary because the moisture in the sample, which is also concentrated in the trap, will cause a slight positive baseline shift. This baseline shift starts as the trap warms and continues until all of the moisture is swept from the trap, at which time the baseline returns to its normal level. The shift always continues longer than the ambient organic peak(s). The integrator should be programmed to correct for this shifted baseline by ending the integration at a point after the last NMOC peak and prior to the return of the shifted baseline to normal (see Figure 8) so that the calculated operational baseline effectively compensates for the water-shifted baseline. Electronic integrators either do this automatically or they should be programmed to make this correction. Alternatively, analyses of humidified zero air prior to sample analyses should be performed to determine the water envelope and the proper blank value for correcting the ambient air concentration measurements accordingly. Heating and flushing of the trap should continue after the integration period has ended to insure all water has been removed to prevent buildup of water in the trap. Therefore, be sure that the 6-port valve remains in the inject position until all moisture has purged from the trap (3 minutes or longer).

11.4.18 Use the dynamic calibration curve (see Section 11.3) to convert the integrated peak area reading into concentration units (ppmC). Note that the NMOC peak shape may not be precisely reproducible due to variations in heating the trap, but the total NMOC peak area should be *reproducible*.

11.4.19 Analyze each canister sample at least *twice and report* the average NMOC concentration. Problems during an analysis occasionally will cause erratic or inconsistent results. If the first two analyses do not agree within ± 5% relative standard deviation (RSD), additional analyses should be made to identify inaccurate measurements and produce a more accurate average (see also Section 12.2.).

12. Performance Criteria and Quality Assurance

This section summarizes required quality assurance measures and provides guidance concerning performance criteria that should be achieved within each laboratory.

12.1 Standard Operating Procedures (SOPs)

12.1.1 Users should generate SOPs describing and documenting the following activities in their laboratory: (1) assembly, calibration, leak check, and operation of the specific sampling system and equipment used; (2) preparation, storage, shipment, and handling of samples; (3) assembly, leak-check, calibration, and operation of the analytical system, addressing the specific equipment used; (4) canister storage and cleaning; and (5) all aspects of of data recording and processing, including lists of computer hardware and software used.

12.1.2 SOPs should provide specific stepwise instructions and should be readily available to, and understood by, the laboratory personnel conducting the work.

12.2 Method Sensitivity, Accuracy, Precision and Linearity

12.2.1 The sensitivity and precision of the method is proportional to the sample volume. However, ice formation in the trap may reduce or stop the sample flow during trapping if the sample volume exceeds 500 cm^3. Sample volumes below about 100-150 cm^3 may cause increased measurement variability *due to dead* volume in lines and valves. For most typical ambient NMOC concentrations, sample volumes in the range of 200-400 cm^3 appear to be appropriate. If a response peak obtained with a 400 cm^3 sample is off scale or exceeds the calibration range, a second analysis can be carried out with a smaller volume. The actual sample volume used need not be accurately known if it is precisely repeatable during both calibration *and analysis*. Similarly, the actual volume of the vacuum reservoir need not be accurately known. But the reservoir volume should be matched to the pressure range and resolution of the absolute pressure gauge so that the measurement of the pressure change in the reservoir, hence the sample volume, is repeatable within 1%. A 1000 cm^3 vacuum reservoir and a pressure change of 200 mm Hg, measured with the specified pressure gauge, have provided a sampling precision of ± 1.31 cm^3. A smaller volume reservoir may be used with a greater pressure change to accommodate absolute pressure gauges with lower resolution, and vice versa.

12.2.2 Some FID detector systems associated with laboratory chromatographs may have autoranging. Others may provide attenuator control and internal full-scale output voltage selectors. An appropriate combination should be chosen so that an adequate output level for accurate integration is obtained down to the detection limit; however, the electrometer or integrator must not be driven into saturation at the upper end of the calibration. Saturation of the electrometer may be indicated by flattening of the calibration curve at high concentrations. Additional adjustments of range and sensitivity can be provided by adjusting the sample volume used, as discussed in Section 12.2.1.

12.2.3 System linearity has been documented (6) from 0 to 10,000 ppbC.

12.2.4 Some organic compounds contained in ambient air are "sticky" and may require repeated analyses before they fully appear in the FID output. Also, some adjustment may have to be made in the integrator off time setting to accommodate compounds that reach the FID late in the analysis cycle. Similarly, "sticky" compounds from ambient samples or from contaminated propane standards may temporarily contaminate the analytical system and can affect subsequent analyses. Such temporary contamination can usually be removed by repeated analyses of humidified zero air.

12.2.5 Simultaneous collection of duplicate samples decreases the possibility of lost measurement data from samples lost due to leakage or contamination in either of the canisters. Two (or more) canisters can be filled simultaneously by connecting them in parallel (see Figure 2(a)) and selecting an appropriate flow rate to accommodate the number of canisters (Section 10.2.2). Duplicate (or replicate) samples also allow assessment of measurement precision based on the differences between duplicate samples (or the standard deviations among replicate samples).

13. Method Modification

13.1 Sample Metering System

13.1.1 Although the vacuum reservoir and absolute pressure gauge technique for metering the sample volume during analysis is efficient and convenient, other techniques should work also.

13.1.2 A constant sample flow could be established with a vacuum pump and a critical orifice, with the six-port valve being switched to the sample position for a measured time period.

A gas volume meter, such as a wet test meter, could also be used to measure the total volume of sample air drawn through the trap. These alternative techniques should be tested and evaluated as part of a user-prepared SOP manual.

13.2 FID Detector System

13.2.1 A variety of FID detector systems should be adaptable to the method.

13.2.2 The specific flow rates and necessary modifications for the helium carrier for any alternative FID instrument should be evaluated prior to use as part of the user-prepared SOP manual.

13.3 Range

13.3.1 It may be possible to increase the sensitivity of the method by increasing the sample volume. However, limitations may arise such as plugging of the trap by ice.

13.3.2 Any attempt to increase sensitivity should be evaluated as part of the user-prepared SOP manual.

13.4 Sub-Atmospheric Pressure Canister Sampling

13.4.1 Collection and analysis of canister air samples at sub-atmospheric pressure is also possible with minor modifications to the sampling and analytical procedures.

13.4.2 Method TO-14, "Integrated Canister Sampling for Selective Organics: Pressurized and Sub-atmospheric Collection Mechanism," addresses sub-atmospheric pressure canister sampling. Additional information can be found in the literature (11-17).

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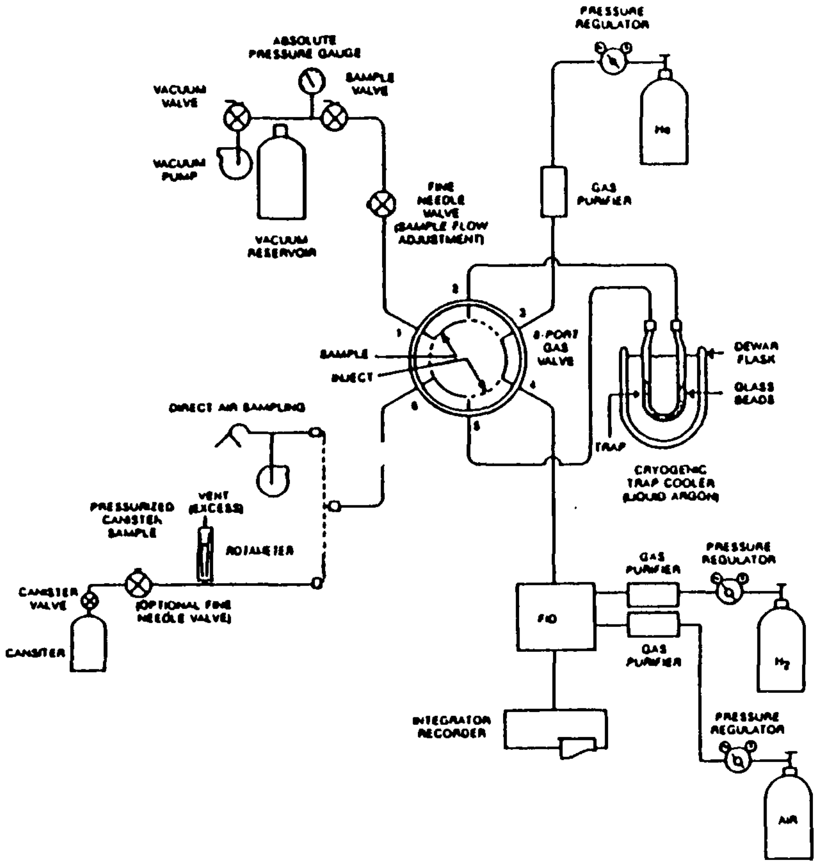

FIGURE 1. SCHEMATIC OF ANALYTICAL SYSTEM FOR NMOC—TWO SAMPLING MODES

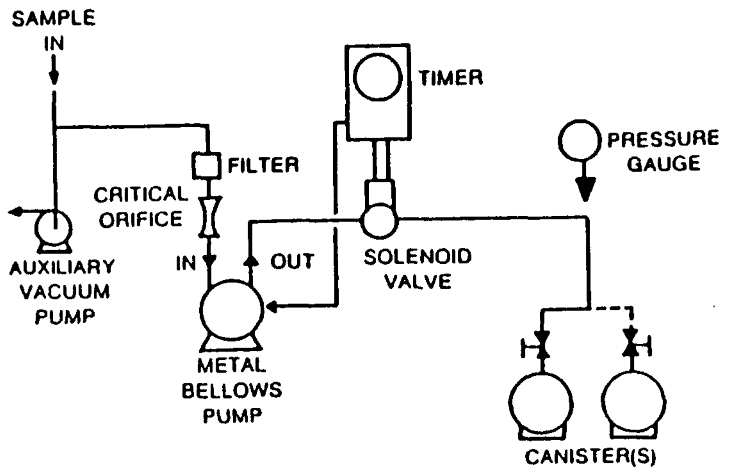

FIGURE 2. SAMPLE SYSTEM FOR AUTOMATIC COLLECTION OF 3-HOUR INTEGRATED AIR SAMPLES

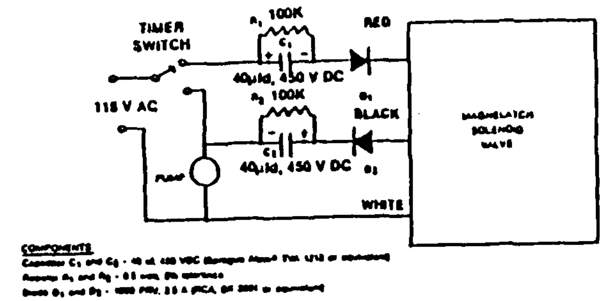

FIGURE 3(a). SIMPLE CIRCUIT FOR OPERATING MAGNELATCH VALVE

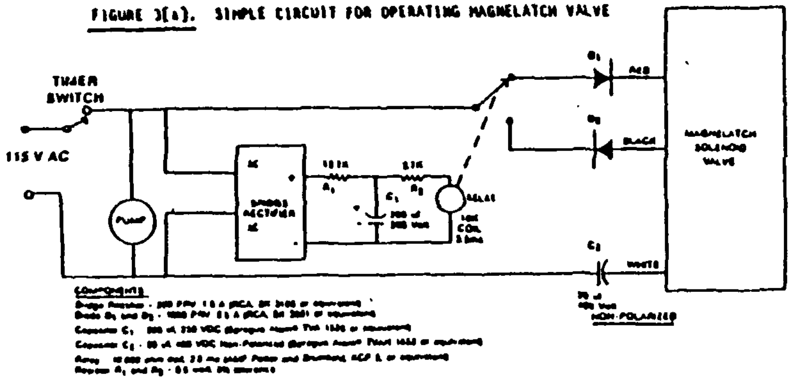

FIGURE 3(b). IMPROVED CIRCUIT DESIGNED TO HANDLE POWER INTERRUPTIONS

FIGURE 3. ELECTRICAL PULSE CIRCUITS FOR DRIVING SKINNER MAGNELATCH SOLENOID VALVE WITH A MECHANICAL TIMER

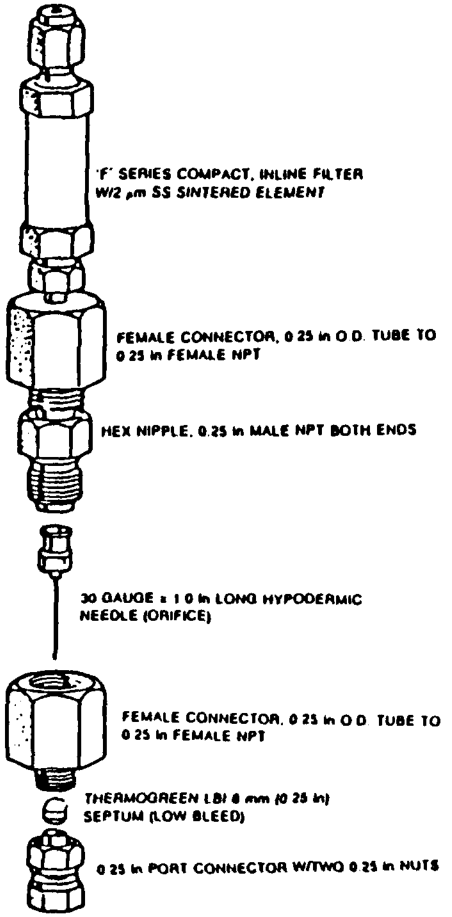

FIGURE 4. FILTER AND HYPODERMIC NEEDLE ASSEMBLY FOR SAMPLE INLET FLOW CONTROL

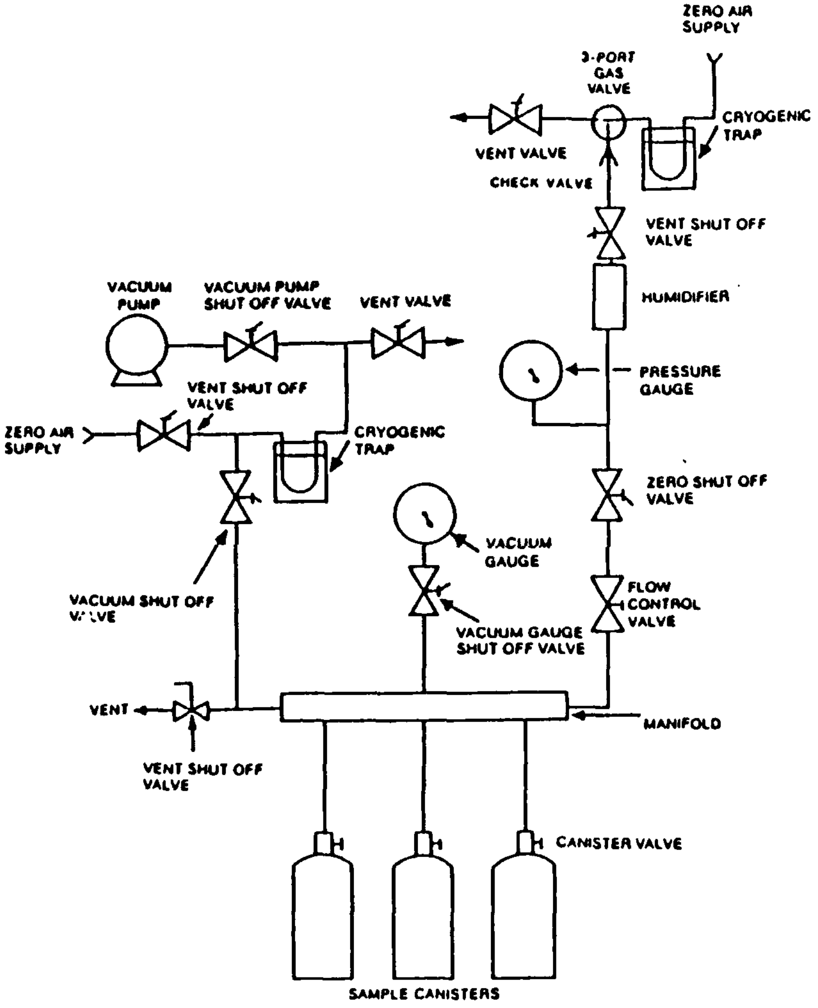

FIGURE 5. CANISTER CLEANING SYSTEM

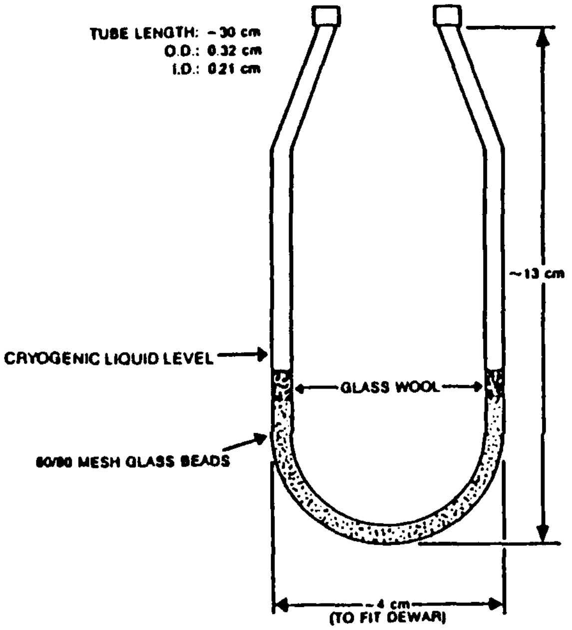

FIGURE 6. CRYOGENIC SAMPLE TRAP DIMENSIONS

PRESSURIZED CANISTER SAMPLING DATA SHEET

GENERAL INFORMATION:

PROJECT: __________
SITE: __________
LOCATION: __________
MONITOR STATION NUMBER: __________
PUMP SERIAL NUMBER: __________

OPERATOR: __________
ORIFICE IDENTIFICATION: __________
FLOW RATE: __________
CALIBRATED BY: __________
LEAK CHECK _____ Pass _____ Fail

FIELD DATA:

Date	Canister Serial Number	Sample Number	Sample Time		Average Atmospheric Conditions			Canister pressure Final, Laboratory		Comments
			Start	Stop	Temperature	Pressure	Relative Humidity			

Date __________ Title __________ , Signature __________

FIGURE 7. EXAMPLE SAMPLING DATA SHEET

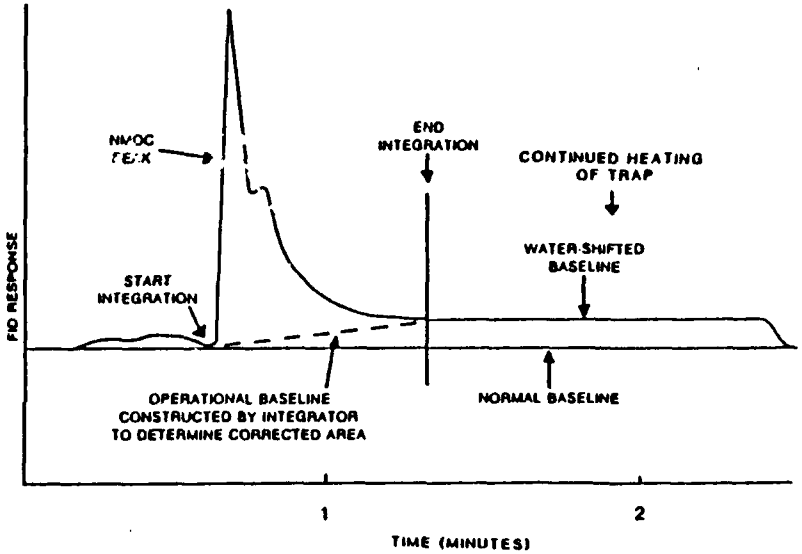

FIGURE 8. CONSTRUCTION OF OPERATIONAL BASELINE AND CORRESPONDING CORRECTION OF PEAK AREA

TABLE 5.—MINIMUM REQUIREMENTS FOR INITIAL AND DAILY CALIBRATION RESPONSE FACTORS—Continued

Compound	Relative response factors	
	Initial calibration RSD	Daily calibration % difference
Alternate Standard: $^{13}C_{12}$-1,2,3,7,8,9-HxCDF	25	25

* * * * *

Method 26—Determination of Hydrogen Chloride Emissions From Stationary Sources

1. Applicability, Principle, Interferences, Precision, Bias, and Stability

1.1 Applicability. This method is applicable for determining hydrogen chloride (HCl) emissions from stationary sources.

1.2 Principle. An integrated sample is extracted from the stack and passed through dilute sulfuric acid. In the dilute acid, the HCl gas is dissolved and forms chloride (Cl^-) ions. The Cl^- is analyzed by ion chromatography (IC).

1.3 Interferences. Volatile materials which produce chloride ions upon dissolution during sampling are obvious interferences. Another likely interferent is diatomic chlorine (Cl_2) gas which reacts to form HCl and hypochlorous acid (HOCl) upon dissolving in water. However, Cl_2 gas exhibits a low solubility in water and the use of acidic, rather than neutral or basic collection solutions, greatly reduces the chance of dissolving any chlorine present. This method does not experience a significant bias when sampling a 400 ppm HCl gas stream containing 50 ppm Cl_2. Sampling a 220 ppm HCl gas stream containing 180 ppm Cl_2 results in a positive bias of 3.4 percent in the HCl measurement.

1.4 Precision and Bias. The within-laboratory relative standard deviations are 6.2 and 3.2 percent at HCl concentrations of 3.9 and 15.3 ppm, respectively. The method does not exhibit a bias to Cl_2 when sampling at concentrations less than 50 ppm.

1.5 Stability. The collected samples can be stored for up to 4 weeks before analysis.

1.6 Detection Limit. The analytical detection limit of the method is 0.1 μg/ml.

2. Apparatus

2.1 Sampling. The sampling train is shown in Figure 26–1, and component parts are discussed below.

2.1.1 Probe. Borosilicate glass, approximately ⅜-in. (9-mm) I.D. with a heating system to prevent moisture condensation. A ⅜-in I.D. Teflon elbow should be attached to the inlet of the pro and a 1-in. (25-mm) length of ⅜-in. I.D. T tubing should be attached to the open en the elbow to permit the opening of the pr to be turned away from the gas stream. T reduces the amount of particulate enter the train. This probe configuration shoul used when the concentration of particula matter in the emissions is high. When hig concentrations are not present, the Teflo elbow is not necessary, and the probe in may be perpendicular to the gas stream. glass wool plug should *not* be used to rem particulate matter since a negative bias in data could result. Instead, a Teflon filter Section 2.1.5) should be installed at the in (for stack temperatures <300 °F) or outle stack temperatures >300 °F) of the pro

2.1.2 Three-way Stopcock. A borosili three-way glass stopcock with a heating system to prevent moisture condensation The heated stopcock should connect dir to the outlet of the probe and the inlet of first impinger. The heating system should capable of preventing condensation up to inlet of the first impinger. Silicone grease be used, if necessary, to prevent leakage.

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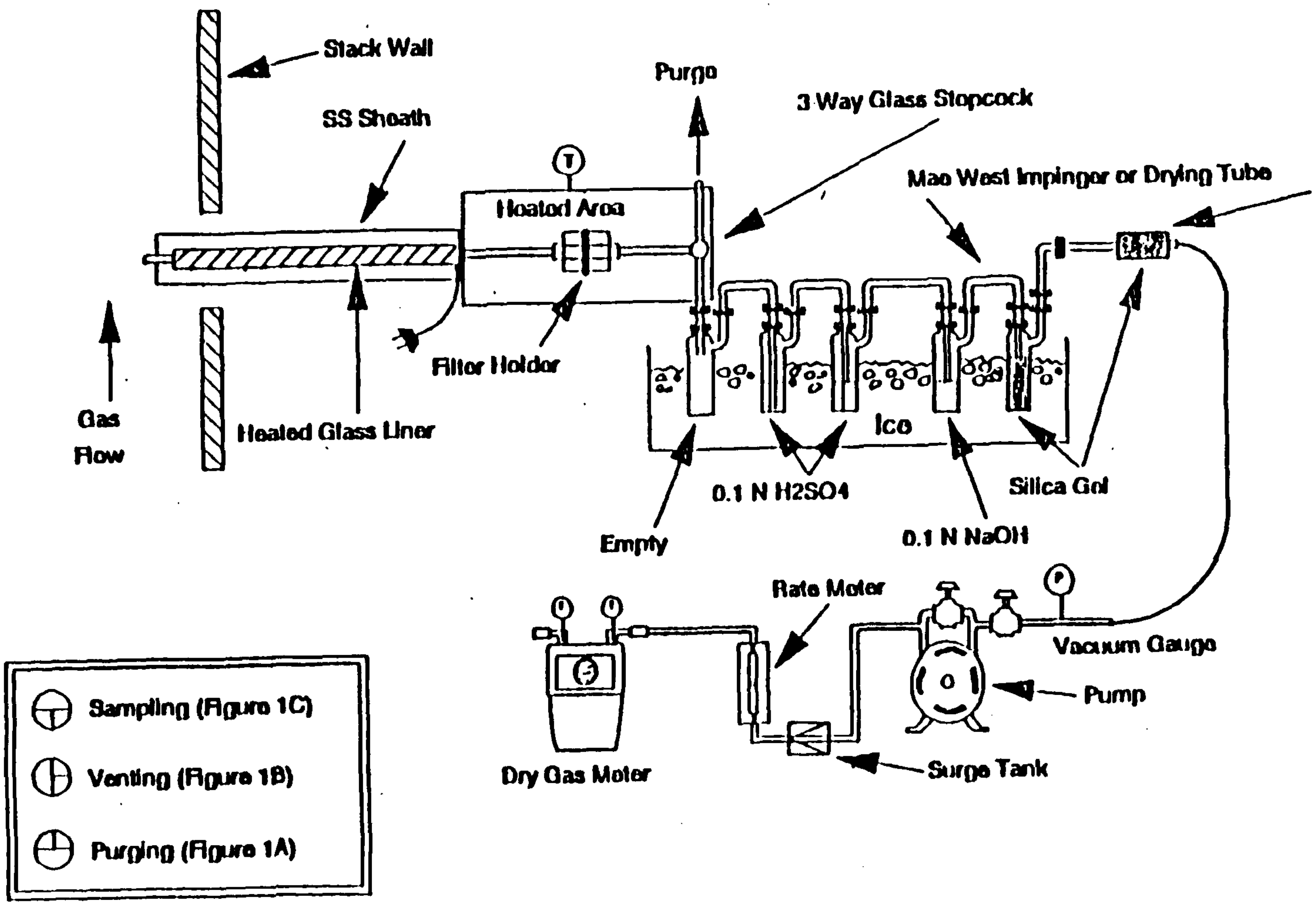

Figure 26-1. Sampling train.

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2.1.3 Impingers. Four 30-ml midget impingers with leak-free glass connectors. Silicone grease may be used. if necessary. to prevent leakage. For sampling at high moisture sources or for sampling times greater than 1 hour. a midget impinger with a shortened stem (such that the gas sample does not bubble through the collected condensate) should be used in front of the first impinger.

2.1.4 Drying Tube or Impinger. Tube or impinger. of Mae West design. filled with 6- to 16-mesh indicating type silica gel. or equivalent. to dry the gas sample and to protect the dry gas meter and pump. If the silica gel has been used previously. dry at 175 °C (350 °F) for 2 hours. New silica gel may be used as received. Alternatively. other types of desiccants (equivalent or better) may be used.

2.1.5 Filter. A 25-mm Teflon mat. Pallflex TX40H175 or equivalent. Locate between the probe liner and Teflon elbow in a glass or quartz filter holder in a filter box heated to 250 °F.

2.1.6 Sample Line. Leak-free. with compatible fittings to connect the last impinger to the needle valve.

2.1.7 Rate Meter. Rotameter. or equivalent. capable of measuring flow rate to within 2 percent of the selected flow rate of 2 liters/min.

2.1.8 Purge Pump. Purge Line. Drying Tube. Needle Valve. and Rate Meter. Pump capable of purging the sampling probe at 2 liters/min. with drying tube. filled with silica gel or equivalent. to protect pump. and a rate meter capable of measuring 0 to 5 liters/min.

2.1.9 Stopcock Grease. Valve. Pump. Volume Meter. Barometer. and Vacuum Gauge. Same as in Method 6. Sections 2.1.4. 2.1.7. 2.1.8. 2.1.10. 2.1.11. and 2.1.12.

2.2 Sample Recovery.

2.2.1 Wash Bottles. Polyethylene or glass. 500-ml or larger. two.

2.2.2 Storage Bottles. 100-ml glass. with Teflon-lined lids. to store impinger samples (two per sampling run). During clean-up. the two front impinger contents (0.1 N H_2SO_4) should be combined. The contents of the two rear impinger (0.1 N NaOH) may be discarded. as these solutions are included only to absorb Cl_2. and thus protect the pump.

2.3 Sample Preparation and Analysis. The materials required for volumetric dilution and chromatographic analysis of samples are described below.

2.3.1 Volumetric Flasks. Class A. 100-ml size.

2.3.2 Volumetric Pipets. Class A. assortment. To dilute samples into the calibration range of the instrument.

2.3.3 Ion Chromatograph. Suppressed or nonsuppressed. with a conductivity detector and electronic integrator operating in the peak area mode. Other detectors. strip chart recorders. and peak height measurements may be used provided the 5 percent repeatability criteria for sample analysis and the linearity criteria for the calibration curve can be met.

3. Reagents

Unless otherwise indicated. all reagents must conform to the specifications established by the Committee on Analytical Reagents of the American Chemical Society (ACS reagent grade). When such specifications are not available. the best available grade shall be used.

3.1 Sampling.

3.1.1 Water. Deionized. distilled water that conforms to ASTM Specification D 1193–77. Type 3.

3.1.2 Absorbing solution. 0.1 N Sulfuric Acid (H_2SO_4). To prepare 100 ml of the absorbing solution for the front impinger pair. slowly add 0.28 ml of concentrated H_2SO_4 to about 90 ml of water while stirring. and adjust the final volume to 100 ml using additional water. Shake well to mix the solution.

3.1.3. Chlorine Scrubber Solution. 0.1 N Sodium Hydroxide (NaOH). To prepare 100 ml of the scrubber solution for the back pair of impingers. dissolve 0.40 g of solid NaOH in about 90 ml of water. and adjust the final solution volume to 100 ml using additional water. Shake well to mix the solution.

3.2 Sample Preparation and Analysis.

3.2.1 Water. Same as in Section 3.1.1.

3.2.2 Blank Solution. A separate blank solution of the absorbing reagent should be prepared for analysis with the field samples. Dilute 30 ml of absorbing solution to 100 ml with water in a separate volumetric flask.

3.2.3 Sodium Chloride (NaCl) Stock Standard Solution. Solutions containing a nominal certified concentration of 1000 mg/l are commercially available as convenient stock solutions from which working standards can be made by appropriate volumetric dilution. Alternately. concentrated stock solutions may be produced from reagent grade NaCl. The NaCl should be dried at 100 °C for 2 or more hours and cooled to room temperature in a desiccator immediately before weighing. Accurately weigh 1.6 to 1.7 g of the dried NaCl to within 0.1 mg. dissolve in water. and dilute to 1 liter. The exact Cl concentration can be calculated using Eq. 26–1.

$$\mu g\ Cl^-/ml = g\ of\ NaCl \times 10^3 \times 35.453/58.44$$

Eq. 26–1

Refrigerate the stock standard solution and store no longer than 1 month.

3.2.4 Chromatographic Eluent. Effec
eluents for nonsuppressed IC using a res
silica-based weak ion exchange column
4 mM potassium hydrogen phthalate sol
adjusted to pH 4.0 using a saturated sod
borate solution. and a 4 mM 4-hydroxy
benzoate solution. adjusted to pH 8.6 usi
N NaCH. An effective eluent for suppres
ion chromatography is a solution contai
mM sodium bicarbonate and 2.4 mM soc
carbonate. Other dilute solutions buffere
a similar pH and containing no interferin
ions may be used. When using suppresse
ion chromatography. if the "water dip"
resulting from sample injection interferes
with the chloride peak. use a 2 mM NaC
mM sodium bicarbonate eluent.

4. Procedure

4.1 Sampling.

4.1.1 Preparation of Collection Train.
Prepare the sampling train as follows: Po
ml of the absorbing solution into each of
first two impingers. and add 15 ml of
scrubber solution to the third and fourth
impingers. Connect the impingers in serie
with the knockout impinger first. followe
the two impingers containing absorbing
solution and the two containing the scrub
solution. Place a fresh charge of silica ge
equivalent in the drying tube or Mae We
impinger.

4.1.2 Leak-Check Procedures. Leak-ch
the probe and three-way stopcock before
inserting the probe into the stack. Connec
the stopcock to the outlet of the probe. an
connect the sample line to the needle val
Plug the probe inlet. turn on the sample p
and pull a vacuum of at least 250 mm Hg
in. Hg). Turn off the needle valve. and no
the vacuum gauge reading. The vacuum
should remain stable for at least 30 secon
Place the probe in the stack at the sampl
location. and adjust the probe and stopco

$$\frac{\mu g\ Cl^-}{ml} = \frac{g\ of\ NaCl \times 10^3 \times 35.453}{58.44}$$

Eq.

Refrigerate the stock standard solution an
store no longer than 1 month.

3.2.4 Chromatographic Eluent. Effect
eluents for nonsuppressed IC using a res
silica-based weak ion exchange column a
4 mM potassium hydrogen phthalate solu
adjusted to pH 4.0 using a saturated sodi
borate solution. and a 4 mM 4-hydroxy
benzoate solution. adjusted to pH 8.6 usi
N NaCH. An effective eluent for suppress
ion chromatography is a solution contai
mM sodium bicarbonate and 2.4 mM sod

carbonate. Other dilute solutions buffered to a similar pH and containing no interfering ions may be used. When using suppressed ion chromatography, if the "water dip" resulting from sample injection interferes with the chloride peak, use a 2 mM NaOH/2.4 mM sodium bicarbonate eluent.

4. Procedure

4.1 Sampling.

4.1.1 Preparation of Collection Train. Prepare the sampling train as follows: Pour 15 ml of the absorbing solution into each of the first two impingers, and add 15 ml of scrubber solution to the third and fourth impingers. Connect the impingers in series with the knockout impinger first, followed by the two impingers containing absorbing solution and the two containing the scrubber solution. Place a fresh charge of silica gel, or equivalent, in the drying tube or Mae West impinger.

4.1.2 Leak-Check Procedures. Leak-check the probe and three-way stopcock before inserting the probe into the stack. Connect the stopcock to the outlet of the probe, and connect the sample line to the needle valve. Plug the probe inlet, turn on the sample pump, and pull a vacuum of at least 250 mm Hg (10 in. Hg). Turn off the needle valve, and note the vacuum gauge reading. The vacuum should remain stable for at least 30 seconds. Place the probe in the stack at the sampling location, and adjust the probe and stopcock heating system to a temperature sufficient to prevent water condensation. Connect the first impinger to the stopcock, and connect the sample line to the last impinger and the needle valve. Upon completion of a sampling run, remove the probe from the stack and leak-check as described above. If a leak has occurred, the sampling run must be voided. Alternately, the portion of the train behind the probe may be leak-checked between multiple runs at the same site as follows: Close the stopcock to the first impinger (see Figure 1A of Figure 26–1), and turn on the sampling pump. Pull a vacuum of at least 250 mm Hg, turn off the needle valve, and note the vacuum gauge reading. The vacuum should remain stable for at least 30 seconds. Release the vacuum on the impinger train by turning the stopcock to the vent position to permit ambient air to enter (see Figure 1B of Figure 26–2). If this procedure is used, the full train leak-check described above must be conducted following the final run, and all preceding sampling runs must be voided if a leak has occurred.

4.1.3 Purge Procedure. Immediately before sampling, connect the purge line to the stopcock, and turn the stopcock to permit the purge pump to purge the probe (see Figure 1A of Figure 26–1). Turn on the purge pump, and adjust the purge rate to 2 liters/min. Purge for at least 5 minutes before sampling.

4.1.4 Sample Collection. Turn on the sampling pump, pull a slight vacuum of approximately 25 mm Hg (1 in. Hg) on the impinger train, and turn the stopcock to permit stack gas to be pulled through the impinger train (see Figure 1C of Figure 26–3). Adjust the sampling rate to 2 liters/min. as indicated by the rate meter, and maintain this rate to within 10 percent during the entire sampling run. Take readings of the dry gas meter volume and temperature, rate meter, and vacuum gauge at least once every 5 minutes during the run. A sampling time of 1 hour is recommended. Shorter sampling times may introduce a significant negative bias in the HCl concentration. At the conclusion of the sampling run, remove the train from the stack, cool, and perform a leak-check as described in section 4.1.2.

4.2 Sample Recovery. Disconnect the impingers after sampling. Quantitatively transfer the contents of the first three impingers (the knockout impinger and the two absorbing solution impingers) to a leak-free storage bottle. Add the water rinses of each of these impingers and connecting glassware to the storage bottle. The contents of the scrubber impingers and connecting glassware rinses may be discarded. The sample bottle should be sealed, shaken to mix, and labeled. The fluid level should be marked so that if any sample is lost during transport, a correction proportional to the lost volume can be applied.

4.3 Sample Preparation for Analysis. Check the liquid level in each sample, and determine if any sample was lost during shipment. If a noticeable amount of leakage has occurred, the volume lost can be determined from the difference between the initial and final solution levels, and this value can be used to correct the analytical results. Quantitatively transfer the sample solution to a 100-ml volumetric flask, and dilute the solution to 100 ml with water.

4.4 Sample Analysis.

4.4.1 The IC conditions will depend upon analytical column type and whether suppressed or nonsuppressed IC is used. An example chromatogram from a nonsuppressed system using a 150-mm Hamilton PRP-X100 anion column, a * * *, 2 l/min flow rate of a 4 mM 4-hydroxy benzoate solution adjusted to a pH of 8.6 using 1 N NaOH, a 50 μl sample loop, and a conductivity detector set on 1.0 μS full scale is shown in Figure 26–2.

4.4.2 Before sample analysis, establish a stable baseline. Next, inject a sample of water, and determine if any Cl^- appears in the chromatogram. If Cl^- is present, repeat the load/injection procedure until no Cl^- is present. At this point, the instrument is ready for use.

4.4.3 First, inject the calibration standards covering an appropriate concentration range, starting with the lowest concentration standard. Next, inject in duplicate, a QC sample followed by a water blank and the field samples. Finally, repeat the injection of calibration standards to allow compensation for any drift in the instrument during analysis of the field samples. Measure the Cl^- peak areas or heights of the samples. Use the average response from the duplicate injections to determine the field sample concentrations using a linear calibration curve generated from the standards.

4.5 Audit Analysis. An audit sample must be analyzed, subject to availability.

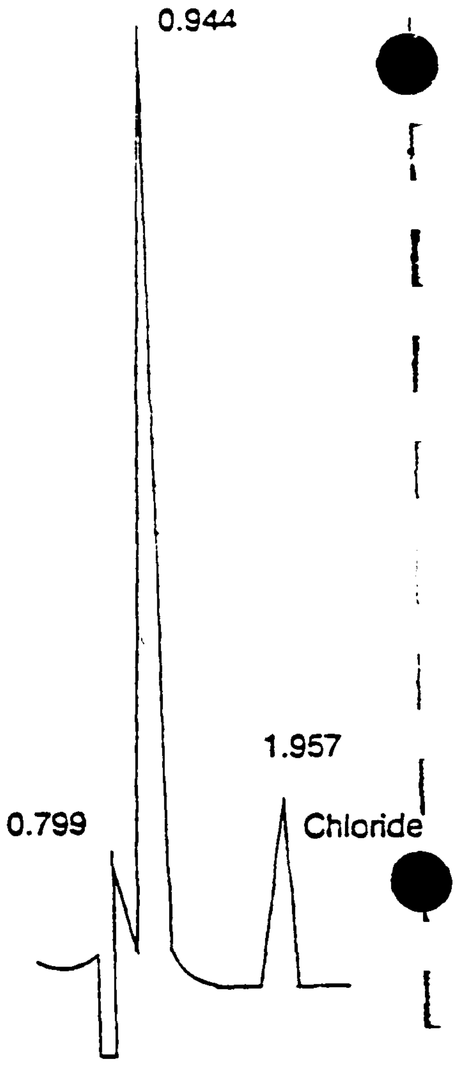

Figure 26-2. Example Chromatogram

5. Calibration

5.1 Dry Gas Metering System, Thermometers, Rate Meter, and Barometer. Same as in Method 6, sections 5.1, 5.2, 5.3, and 5.4.

5.2 Calibration Curve for Ion Chromatograph. To prepare calibration standards, dilute given volumes (1.0 ml or greater) of the stock standard solution, with 0.1 N H_2SO_4 (section 3.1.2) to convenient volumes. Prepare at least four standards that are within the linear range of the instrument and which cover the expected concentration range of the field samples. Analyze the standards as instructed in section 4.4.3, beginning with the lowest concentration standard. Determine the peak measurements, and plot individual values versus Cl^- concentration in μg/ml. Draw a smooth curve through the points. Use linear regression to calculate a formula describing the resulting linear curve.

6. *Quality Assurance*

6.1 Applicability. When the method is used to analyze samples to demonstrate compliance with a source emission regulation, a set of two audit samples must be analyzed.

6.2 Audit Procedure. The audit sample are chloride solutions. Concurrently analyze the two audit samples and a set of compliance samples in the same manner to evaluate the technique of the analyst and the standards preparation. The same analyst, analytical reagents, and analytical system shall be used both for compliance samples and the EPA audit samples. If this condition is met, auditing the subsequent compliance analyses for the same enforcement agency within 30 days is not required. An audit sample set may not be used to validate different sets of compliance samples under the jurisdiction of different enforcement agencies, unless prior arrangements are made with both enforcement agencies.

6.3 Audit Sample Availability. The audit samples may be obtained by writing or calling the EPA Regional Office or the appropriate enforcement agency. The request for the audit samples must be made at least 30 days prior to the scheduled compliance sample analyses.

6.4 Audit Results. Calculate the concentrations in mg/dscm using the specified sample volume in the audit instructions.

Note: Indication of acceptable results may be obtained immediately by reporting the audit results in mg/dscm and compliance results in total µg HCl/ sample to the responsible enforcement agency. Include the results of both audit samples, their identification numbers, and the analyst's name with the results of the compliance determination samples in appropriate reports to the EPA Regional Office or the appropriate enforcement agency. Include this information with subsequent analyses for the same enforcement agency during the 30-day period.

The concentrations of the audit samples obtained by the analyst shall agree within 10 percent of the actual concentrations. If the 10 percent specification is not met, reanalyze the compliance samples and audit samples, and include initial and reanalysis values in the test report.

Failure to meet the 10 percent specification may require retests until the audit problems are resolved. However, if the audit results do not affect the compliance or noncompliance status of the affected facility, the Administrator may waive the reanalysis requirement, further audits, or retests and accept the results of the compliance test. While steps are being taken to resolve audit analysis problems, the Administrator may also choose to use the data to determine the compliance or noncompliance status of the affected facility.

7. *Calculations*

Retain at least one extra decimal figure beyond those contained in the available data in intermediate calculations, and round off only the final answer appropriately.

7.1 Sample Volume, Dry Basis, Corrected to Standard Conditions. Calculate the sample volume using Eq. 6–1 of Method 6.

7.2 Total µg HCl Per Sample.

$$m = \frac{(S-B)(100)(36.46)}{(35.453)} = (102.84)(S-B) \qquad \text{Eq. 26–2}$$

where:

m = Mass of Hcl in sample, µg.
S = Concentration of sample, µg Cl⁻/ml.
B = Concentration of blank, µg Cl⁻/ml.
100 = Volume of filtered and diluted sample, ml.
36.46 = Molecular weight of HCl, µg/µg-mole.
35.453 = Atomic weight of Cl, µg/µg-mole.

7.3 Concentration of HCl in the Flue Gas.

$$C = \frac{K_m}{V_{m(std)}} \qquad \text{Eq. 26–3}$$

where:

C = Concentration of HCl, dry basis, mg/dscm.
K = 10^{-3} mg/µg.
m = Mass of HCl in sample, µg.
$V_{m(std)}$ = Dry gas volume measured by the dry gas meter, corrected to standard conditions, dscm.

8. *Bibliography*

1. Steinsberger, S.C. and J.H. Margeson. "Laboratory and Field Evaluation of a Methodology for Determination of Hydrogen Chloride Emissions from Municipal and Hazardous Waste Incinerators." U.S. Environmental Protection Agency, Off. Research and Development. Report No ______ 1989.

2. State of California, Air Resources Method 421. "Determination of Hydroc Acid Emissions from Stationary Source March 18, 1987.

3. Entropy Environmentalists Inc. "Laboratory Evaluation of a Sampling a Analysis Method for Hydrogen Chlorid Emissions from Stationary Sources: Inte Report." EPA Contract No. 68–02–4442 Research Triangle Park, North Carolina January 22, 1988.

*   *   *   *   *

Appendix A [Amended]

3. Method 19 of appendix A part 60 is amended by adding paragraphs 4.3 and follows: Method 19—Determination of S Dioxide Removal Efficiency and Partic Matter, Sulfur Dioxide, and Nitrogen Ox Emission Rates

*   *   *   *   *

4.3 Daily Geometric Average Polluta Rates from Hourly Values. The geometr average pollutant rate (E_{ga}) is computed the following equation:

$$E_{ga} = EXP\left[(1/n)\sum_{j=1}^{n}\left[\ln(E_{hj})\right]\right]$$

E

where:

E_{ga} = daily geometric average pollutant r ng/J (lbs/million Btu) or ppm correc 7 percent O_2.
E_{hj} = hourly arithmetic average pollutan for hour "j," ng/J (lb/million Btu) or p corrected to 7 percent O_2.
n = total number of hourly averages for which pollutant rates are available within the 24 hr midnight to midnigh daily period.
ln = natural log of indicated value.
EXP = the natural logarithmic base (2.7 raised to the value enclosed by brac

*   *   *   *   *

5.4 Daily Geometric Average Percent Reduction from Hourly Values. The geom average percent reduction (%R_{ga}) is comp using the following equation:

$$\%R_{ga} = 100 \left[1 - EXP\left((1/n) \sum_{j=1}^{n} \ln (E_{jo}/E_{ji})\right)\right]$$

Eq. 19–24a

where:

$\%R_{ga}$ = daily geometric average percent reduction.

E_{jo}, E_{ji} = matched pair hourly arithmetic average pollutant rate, outlet and inlet, respectively, ng/J (lb/million Btu) or ppm corrected to 7 percent O_2.

n = total number of hourly averages for which paired inlet and outlet pollutant rates are available within the 24-hr midnight to midnight daily period.

ln = natural log of indicated value.

EXP = the natural logarithmic base (2.718) raised to the value enclosed by brackets.

Note: The calculation includes only paired data sets (hourly average) for the inlet and outlet pollutant measurements.

* * * * *

[FR Doc. 91–1399 Filed 2–12–91; 8:45 am]

BILLING CODE 6560-50-M

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Parts 672 and 675

[Docket No. 90393–1019]

Groundfish of the Gulf of Alaska; Groundfish of the Bering Sea and Aleutian Islands

AGENCY: National Marine Fisheries Service (NMFS), NOAA, Commerce.

ACTION: Final rule, technical amendment.

SUMMARY: The Secretary of Commerce issues this final rule implementing a technical amendment to reinstate regulatory language that was unintentionally deleted by regulations implementing Amendment 13 to the Fishery Management Plan for the Bering Sea/Aleutian Islands Groundfish (Bering FMP) and Amendment 18 to the Fishery Management Plan for the Gulf of Alaska Groundfish Fishery (Gulf FMP) (54 FR 50383, December 6, 1989).

EFFECTIVE DATE: February 8, 1991.

FOR FURTHER INFORMATION CONTACT: Patricia Peacock (Fishery Management Specialist), NMFS, Plans and Regulations Division, 1335 East-West Highway, Silver Spring, Maryland 20910, telephone 301–427–2343.

SUPPLEMENTARY INFORMATION: Groundfish fisheries in the Exclusive Economic Zone off Alaska are governed by Federal regulations at 50 CFR parts 611, 620, 672, and 675 that implement the Bering and the Gulf FMPs. These FMPs were prepared by the North Pacific Fishery Management Council and approved by the Secretary of Commerce (Secretary) under provisions of the Magnuson Fishery Conservation and Management Act.

This final rule implements a technical amendment that (1) reinstates language unintentionally deleted by amendatory language in 54 FR 50383 (December 6, 1989) and (2) retains the amendatory language of 56 FR 492 (January 7, 1991).

On December 6, 1989, a final rule was published in the Federal Register (54 FR 50386) that was intended only to amend the introductory language of §§ 672.20(a)(2) and 675.20(a)(2). Item 11 of this amendatory language states that * * * paragraphs (a)(2) and (f)(1) are revised * * *; item 20 states that * * * paragraph (a)(2) is revised * * *. This amendatory language revised the introductory text of paragraph (a)(2) in these sections but deleted the remainder of the regulatory language in §§ 672.20(a)(2) and 675.20(a)(2). Paragraphs in § 672.20 that were unintentionally deleted were (a)(2)(i), (a)(2)(ii), (a)(2)(ii)(A), and (a)(2)(ii)(B). Table 1 in § 672.20 also was unintentionally deleted. Paragraphs that were unintentionally deleted in § 675.20 were as follows: (a)(2)(i), (a)(2)(i)(A), and (a)(2)(i)(B).

On January 1, 1991, final rules implementing Amendment 14 to the Bering FMP and Amendment 19 to the Gulf FMP also revised text in §§ 672.20(a)(2) and 675.20(a)(2) (56 FR 492, January 7, 1991). This rule retains the changes to these sections resulting from Amendments 14 and 19.

The Gulf and Bering FMPs were implemented using procedures specified by the Magnuson Act and the Administrative Procedure Act. However, as explained above, the language currently in §§ 672.20(a) and 675.20(a) does not correctly reflect the Gulf or Bering FMPs and subsequent amendments.

This final rule, technical amendment, is reinstating regulatory language needed to implement correctly the Bering and Gulf FMPs as amended.

Classification

This final rule, technical amendment, is issued under parts 672 and 675. Because this rule reinstates regulatory text that was inadvertently deleted during an earlier rulemaking proceeding and makes no substantive changes other than changes determined in rulemaking for Amendments 14 and 19, it is unnecessary under 5 U.S.C. 553(b)(B) to provide for prior public comment and there is good cause under 5 U.S.C. 553(d) not to delay for 30 days its effective date.

Because this rule is being issued without prior comment, a regulatory flexibility analysis is not required under the Regulatory Flexibility Act and none has been prepared.

This rule reinstates language that has been determined not to be a major rule under Executive Order 12291, does not contain policies with federalism implications sufficient to warrant preparation of a federalism assessment under E.O. 12612, and does not contain a collection-of-information requirement for the purposes of the Paperwork Reduction Act. There is no change in the regulatory impacts previously reviewed and analyzed.

List of Subjects in 50 CFR Parts 672 and 675

Fisheries, General limitations.

Dated: February 7, 1991.

Michael F. Tillman,

Acting Assistant Administrator for Fisheries, National Marine Fisheries Service.

For reasons set out in the preamble, 50 CFR parts 672 and 675 are amended as follows:

PART 672—GROUNDFISH OF THE GULF OF ALASKA

1. The authority citation for part 672 continues to read as follows:

Authority: 16 U.S.C. 1801 *et seq.*

2. Section 672.20(a)(2) is revised and Table 1 is added to the section to read as follows:

delayed, timely notice will be published in the **Federal Register**.

ADDRESSES: Copies of the state submittal for this action are available for public inspection during normal business hours at: the Environmental Protection Agency, Region VII, Air Branch, 726 Minnesota Avenue, Kansas City, Kansas 66101; Public Information Reference Unit, Environmental Protection Agency, 401 M Street SW., Washington, DC 20460; Environmental Protection Division, Iowa Department of Natural Resources, Wallace State Office Building, 900 East Grand, Des Moines, Iowa 50319.

FOR FURTHER INFORMATION CONTACT: Wayne Kaiser at (913) 551-7603 (FTS 276-7603).

SUPPLEMENTARY INFORMATION: On October 17, 1988, EPA revised the prevention of significant deterioration (PSD) regulations at 40 CFR 52.21 (see 53 FR 40656) for nitrogen oxides. These regulations establish the maximum increase in ambient nitrogen dioxide concentrations allowed in an area above the baseline concentration; these maximum allowable increases are called increments. The intended effect of these regulations is to require all applicants for major new stationary sources and major modifications emitting nitrogen oxides to account for and, if necessary, restrict emissions so as not to cause or contribute to exceedances of the increment.

On November 20, 1990, the IDNR submitted an amendment to chapter 22.4(455B), "Special Requirements for Major Stationary Sources Located in Areas Designated Attainment or Unclassified (PSD)," which incorporates by reference the revisions to 40 CFR part 52.21, effective October 17, 1988. The state rule was effective November 21, 1990. The state also provided a demonstration that it meets the conditions for approval of adoption of the NO_x increment program as detailed in the EPA guidance memorandum on the subject dated August 17, 1990.

The above memorandum described specific conditions for EPA approval of a state's adoption of the NO_x increment rule. Those conditions pertained to regulatory language, increment consumption analysis, increment consumption for the transition period, and legal authority. EPA has evaluated the state's submittal in accordance with the August 17, 1990, guidance and finds that the state submittal is acceptable. EPA is publishing this action without prior proposal because the Agency views this as a noncontroversial amendment and anticipates no adverse comments. This action will be effective April 15, 1991, unless, within 30 days of its publication, notice is received that adverse or critical comments will be submitted.

If such notice is received, this action will be withdrawn before the effective date by publishing two subsequent notices. One notice will withdraw the final action and another will begin a new rulemaking by announcing a proposal of the action and establishing a comment period. If no such comments are received, the public is advised that this action will be effective April 15, 1991.

EPA Action: EPA is taking final action to approve a revision to Iowa rule 567-22.4(455B) which adopts by reference the PSD NO_x requirements of 40 CFR 52.21 at 53 FR 40656 (October 17, 1988). Nothing in this action should be construed as permitting or allowing or establishing a precedent for any future request for revision to any SIP. Each request for revision to the SIP shall be considered separately in light of specific technical, economic, and environmental factors and in relation to relevant statutory and regulatory requirements. Under 5 U.S.C. 605(b), I certify that this SIP revision will not have a significant economic impact on a substantial number of small entities (See 46 FR 8709).

This action has been classified as a Table 3 action by the Regional Administrator under the procedures published in the **Federal Register** on January 19, 1989 (54 FR 2214-2225). On January 6, 1989, the Office of Management and Budget waived Tables 2 and 3 SIP revisions (54 FR 2222) from the requirements of Section 3 of Executive Order 12291 until April 1991.

Under section 307(b)(1) of the Act, petitions for judicial review of this action must be filed in the U.S. Court of Appeals for the appropriate circuit by April 15, 1991. This action may not be challenged later in proceedings to enforce its requirements. (See section 307(b)(2).)

The Agency has reviewed this request for revision of the federally approved SIP for conformance with the provisions of the 1990 Amendments enacted on November 15, 1990. The Agency has determined that this action conforms with those requirements irrespective of the fact that the adoption of the revision by the state preceded the date of enactment.

List of Subjects in 40 CFR Part 52

Air pollution control, Incorporation by reference, Intergovernmental relations, Nitrogen dioxide, Particulate matter, Sulfur oxides.

Dated: January 28, 1991.

Morris Kay,

Regional Administrator.

40 CFR part 52, subpart Q, is amended as follows:

PART 52—[AMENDED]

1. The authority citation for part 52 continues to read as follows:

Authority: 42 U.S.C. 7401-7642.

2. Section 52.820 is amended by adding paragraph (c)(53) to read as follows:

§ 52.820 Identification of plan.

* * * * *

(c) * * *

(53) Revised chapter 22, rule 22.4(455B), submitted on November 8, 1990, incorporates by reference revised EPA PSD rules pertaining to NO_x increments.

(i) Incorporation by reference

(A) Amendment to chapter 22, "Controlling Pollution," Iowa Administrative Code, subrule 22.4, adopted by the Environmental Protection Commission on October 17, 1990, effective November 21, 1990.

(ii) Additional material

(A) Letter from the state dated November 8, 1990, pertaining to NO_x rules and analysis which certifies the material was adopted by the state on *October 17, 1990.*

[FR Doc. 91-3451 Filed 2-12-91; 8:45 am]

BILLING CODE 6560-50-M

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40 CFR Part 60

[AD-FRL-3867-1]

Standards of Performance for New Stationary Sources; Addition of Methods for Measurement of Polychlorinated Dibenzo-p-Dioxins, Polychlorinated Dibenzofurans, and Hydrogen Chloride Emissions From Stationary Sources

AGENCY: Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: The purpose of this action is to add Method 23, "Determination to Polychlorinated Dibenzo-p-Dioxins (PCDD's) and Polychlorinated Dibenzofurans (PCDF's) from Stationary Sources," and Method 26, "Determination of Hydrogen Chloride Emissions from Stationary Sources" to appendix A of 40 CFR part 60. These methods are being promulgated to determine compliance with subparts Ca and Ea of part 60.

DATES: *Effective Date:* February 13, 1991.

Judicial Review: Under section 307(b)(1) of the Clean Air Act, judicial review of the actions taken by this notice is available only by the filing of a petition for review in the U.S. Court of Appeals for the District of Columbia Circuit within 60 days of today's publication of this rule. Under section 307(b)(2) of the Clean Air Act, the requirements that are the subject of today's notice may not be challenged later in civil or criminal proceedings brought by EPA to enforce these requirements.

ADDRESSES: *Background Information Document.* The Background Information Document for the promulgated test methods may be obtained from Gary McAlister or Roger Shigehara, MD-19, U.S. EPA, Research Triangle Park, North Carolina 27711, telephone number (919) 541-1062. Please refer to "Summary of Comments and Responses for Methods 23 and 26."

Docket. Docket Number A-89-11, containing material relevant to this rulemaking, is available for public inspection and copying between 8:30 a.m. and 3:30 p.m. Monday through Friday, at EPA's Air Docket Section, room M-1500, 1st Floor, Waterside Mall, 401 M Street SW., Washington, DC 20460. A reasonable fee may be charged for copying.

FOR FURTHER INFORMATION CONTACT: Gary McAlister or Roger Shigehara, Emission Measurement Branch (MD-19), Technical Support Division, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, telephone number (919) 541-1062.

SUPPLEMENTARY INFORMATION:

I. The Rulemaking

Under Subparts Ca and Ea, the EPA is regulating emissions from municipal waste combustors (MWC's) including setting emission limits for polychlorinated dibenzo-p-dioxins (PCDD's), polychlorinated dibenzofurans (PCDF's), and hydrochloric acid (HCl). There are presently no methods published in 40 CFR part 60, appendix A, to measure any of these pollutants. This action would promulgate one method to measure the PCDD's and PCDF's and another method to measure the HCl.

Summary of Reference Methods

Method 23 is used to measure the emission of PCDD's and PCDF's from MWC's. A sample is withdrawn isokinetically from the stack through a probe, a filter, and a trap packed with a solid adsorbent. The PCDD's and PCDF's are collected in the probe, on the filter, and on the solid adsorbent. The PCDD's and PCDF's are extracted from the particulate matter and the adsorbent with a hot organic solvent. The extracted PCDD's and PCDF's are separated by capillary gas chromatography, and then, each isomer is identified and measured with mass spectrometry (GC/MS). The total PCDD's and PCDF's are the sum of the individual isomers. Toxicity factors are not used in the calculation.

Method 26 is used to measure the emission of HCl from MWC's. A sample is withdrawn at a constant rate from the stack through a probe and impingers filled with a dilute acid. The HCl is collected in the implinger solution. The chloride ion is separated by ion chromatography and measured by a conductivity detector.

Background

In 1983, the American Society of Mechanical Engineers (ASME) recognized that the testing for PCDD's and PCDF's needed to be standardized. In February of 1984, the ASME convened a committee of government representatives, testing consultants, equipment manufacturers, and incinerator operators to write a standard test procedure for PCDD's and PCDF's. This was eventually distributed as a draft ASME protocol in December of 1984. The procedure that we are promulgating was derived from this draft ASME protocol. There are some changes in the quality assurance (QA) requirements and the solvents used to recover the sample in the promulgated method. Because more labeled compounds are available, the method will require additional labeled internal standards and surrogate compounds which will provide better representation of the entire range of PCDD's and PCDF's. The filter and solid adsorbent are extracted in the laboratory with toluene to assure a high PCDD and PCDF recovery efficiency. Additionally the proposed sample recovery solvents used for rinsing the sample train glassware in the field would be acetone followed by methylene chloride with a final quality assurance rinse using toluene. However, the results from the toluene rinse are not used in calculating the total PCDD and PCDF emissions. EPA will continue to review the toluene field rinse quality assurance results and continue to evaluate the desirability of replacing methylene chloride with toluene for field rinsing sample glassware.

II. Public Participation

The opportunity to hold a public hearing at 10 a.m. on February 7, 1990 was presented, but no one requested a hearing. The public comment period was from December 20, 1989 to March 5, 1990.

III. Significant Comments and Changes to the Proposed Rulemaking

Thirteen comment letters were received on the proposed test methods. These comments have been carefully considered and, where deemed appropriate by the Administrator, changes have been made in the proposed test methods. A detailed discussion of these comments is contained in the background document entitled, "Summary of Comments and Responses for Methods 23 and 26" which is referred to in the **ADDRESSES** section of this preamble.

Several commenters thought that there were not enough stack sampling organizations that were experienced with Method 23 to avoid major delays in securing sampling and analysis contractors. Many of these commenters also thought that there would not be an adequate supply of calibration standards and audit samples. We believe that the number of tests required immediately after promulgation of the regulation will not exceed the capabilities of the available sampling and analytical laboratories and that there will be an adequate supply of labeled standards and audit samples. The full effect of the testing requirements for the new and existing sources will not be felt for about five years. We believe that this is adequate time to allow for the necessary expansion of testing capabilities.

Some commenters requested alternative procedures or methods to Method 23. While testers always have the option of requesting alternative methods, requests should be submitted after the method becomes final. Any request should be in writing and should be accompanied by any supporting data.

Many commenters thought that the gas chromatography columns specified in Method 23 were not the most appropriate choice. The column requirements in the method have been revised to allow the tester to use any column system provided that the tester can demonstrate through calibration and performance checks that the columns provide the necessary isomer separation.

One commenter thought that Method 26 should be modified to allow isokinetic sampling so that it could be applied to sources where hydrochloric acid aerosols are present. We agree that isokinetic sampling may be important at sources other than MWC's. We have compared Method 26 and an isokinetic sampling train and found that they generally give similar results at stack concentrations above 20 PPM. At lower concentrations the isokinetic sampling train seems to have a negative bias. We are continuing to investigate this problem, and may be able to approve an alternative method using isokinetic sampling for future use.

Another commenter wanted EPA to develop a QA audit sample for Method 26. An audit sample is being developed and will be available for validating the results of compliance tests.

IV. Administrative

The docket is an organized and complete file of all the information submitted to or otherwise considered by EPA in the development of this rulemaking. The principal purposes of the docket are: (1) To allow interested parties to identify and locate documents so that they can effectively participate in the rulemaking process and (2) to serve as the record in case of judicial review (except for interagency review materials) (section 307(d)(7)(A)).

Under Executive Order 12291, EPA must judge whether a regulation is "major" and, therefore, subject to the requirement of a regulatory impact analysis. The Agency has determined that this rulemaking would not result in any of the adverse economic effects set forth in Section 1 of the Order as grounds for finding a "major rule." The Agency has, therefore, concluded that this regulation is not a "major rule" under Executive Order 12291.

The Regulatory Flexibility Act (RFA) of 1980 requires the identification of potentially adverse impacts of Federal regulations upon small business entities. The Act specifically requires the completion of an RFA analysis in those instances where small business impacts are possible. Because this rulemaking imposes no adverse economic impacts, an analysis has not been conducted.

Pursuant to the provisions of 5 U.S.C. 605(b), I hereby certify that this promulgated rule will not have an economic impact on small entities because no additional costs will be incurred from this action.

This rule does not contain any information collection requirements currently approved by OMB review under the Paperwork Reduction Act of 1980, 44 U.S.C. 3501 *et seq.*

List of Subjects in 40 CFR Part 60

Air pollution control, Municipal waste combustors, Polychlorinated dibenzo-p-dioxins, Polychlorinated dibenzofurans, Hydrogen chloride.

Dated: January 11, 1991.

F. Henry Habicht,

Acting Administrator.

Title 40, part 60 of the Code of Federal Regulations is amended as follows:

PART 60—[AMENDED]

1. The authority citation for part 60 continues to read as follows:

Authority: 42 U.S.C. 7401, 7411, 7414, 7416, and 7601.

2. By adding in numerical order Methods 23 and 26 to appendix A as follows:

Appendix A—Reference Methods

* * * * *

Method 23—Determination of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans From Stationary Sources

1. Applicability and Principle

1.1 Applicability. This method is applicable to the determination of polychlorinated dibenzo-p-dioxins (PCDD's) and polychlorinated dibenzofurans (PCDF's) from stationary sources.

1.2 Principle. A sample is withdrawn from the gas stream isokinetically and collected in the sample probe, on a glass fiber filter, and on a packed column of adsorbent material. The sample cannot be separated into a particle vapor fraction. The PCDD's and PCDF's are extracted from the sample, separated by high resolution gas chromatography, and measured by high resolution mass spectrometry.

2. Apparatus

2.1 Sampling. A schematic of the sampling train used in this method is shown in Figure 23-1. Sealing greases may not be used in assembling the train. The train is identical to that described in section 2.1 of Method 5 of this appendix with the following additions:

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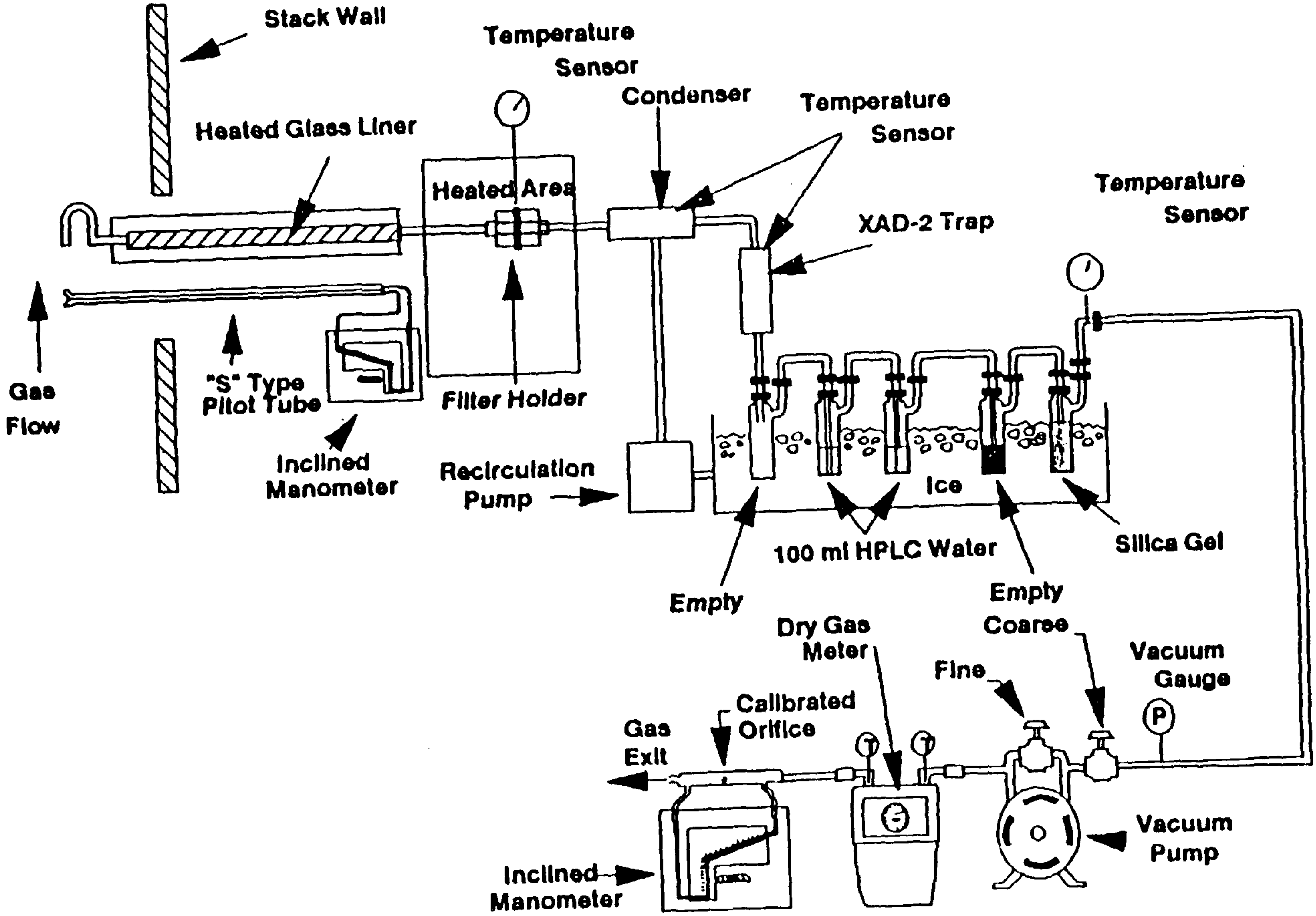

Figure 23.1 Sampling train

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2.1.1 Nozzle. The nozzle shall be made of nickel, nickel-plated stainless steel, quartz, or borosilicate glass.

2.1.2 Sample Transfer Lines. The sample transfer lines, if needed, shall be heat traced, heavy walled TFE (½ in. OD with ⅛ in. wall) with connecting fittings that are capable of forming leak-free, vacuum-tight connections without using sealing greases. The line shall be as short as possible and must be maintained at 120 °C.

2.1.1 Filter Support. Teflon or Teflon-coated wire.

2.1.2 Condenser. Glass, coil type with compatible fittings. A schematic diagram is shown in Figure 23–2.

2.1.3 Water Bath. Thermostatically controlled to maintain the gas temperature exiting the condenser at <20 °C (68 °F).

2.1.4 Adsorbent Module. Glass container to hold the solid adsorbent. A shematic diagram is shown in Figure 23–2. Other physical configurations of the resin trap/condenser assembly are acceptable. The connecting fittings shall form leak-free, vacuum tight seals. No sealant greases shall be used in the sampling train. A coarse glass frit is included to retain the adsorbent.

2.2 Sample Recovery.

2.2.1 Fitting Caps. Ground glass, Teflon tape, or aluminum foil (Section 2.2.6) to cap off the sample exposed sections of the train.

2.2.2 Wash Bottles. Teflon, 500-ml.

2.2.3 Probe-Liner Probe-Nozzle, and Filter-Holder Brushes. Inert bristle brushes with precleaned stainless steel or Teflon handles The probe brush shall have extensions of stainless steel or Teflon, at least as long as the probe. The brushes shall be properly sized and shaped to brush out the nozzle, probe liner, and transfer line, if used.

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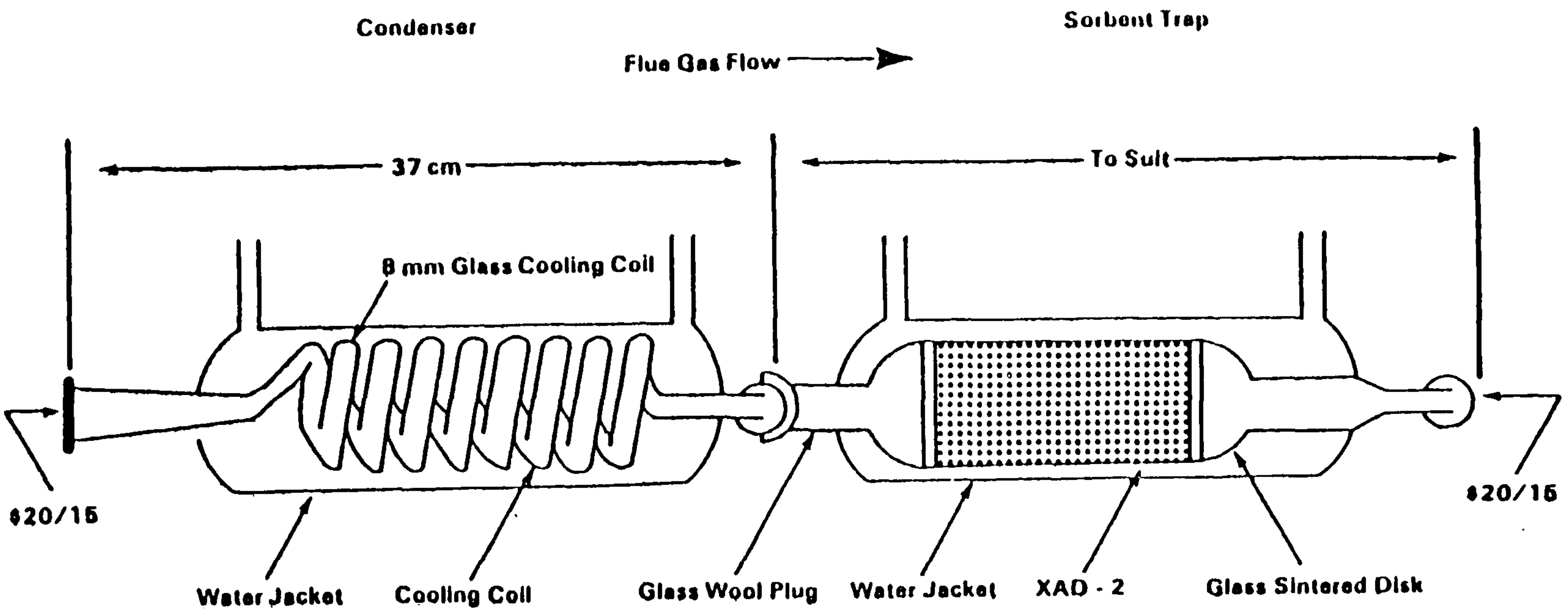

Figure 23.2. Condenser and adsorbent trap

BILLING CODE 6560-50-C

2.2.4 Filter Storage Container. Sealed filter holder, wide-mouth amber glass jar with Teflon-lined cap, or glass petri dish.

2.2.5 Balance. Triple beam.

2.2.6 Aluminum Foil. Heavy duty, hexane-rinsed.

2.2.7 Metal Storage Container. Air tight container to store silica gel.

2.2.8 Graduated Cylinder. Glass, 250-ml with 2-ml graduation.

2.2.9 Glass Sample Storage Container. Amber glass bottle for sample glassware washes, 500- or 1000-ml, with leak free Teflon-lined caps.

2.3 Analysis.

2.3.1 Sample Container. 125- and 250-ml flint glass bottles with Teflon-lined caps.

2.3.2 Test Tube. Glass.

2.3.3 Soxhlet Extraction Apparatus. Capable of holding 43 x 123 mm extraction thimbles.

2.3.4 Extraction Thimble. Glass, precleaned cellulosic, or glass fiber.

2.3.5 Pasteur Pipettes. For preparing liquid chromatographic columns.

2.3.6 Reacti-vials. Amber glass, 2-ml, silanized prior to use.

2.3.7 Rotary Evaporator. Buchi/Brinkman RF-121 or equivalent.

2.3.8 Nitrogen Evaporative Concentrator. N-Evap Analytical Evaporator Model III or equivalent.

2.3.9 Separatory Funnels. Glass, 2-liter.

2.3.10 Gas Chromatograph. Consisting of the following components:

2.3.10.1 Oven. Capable of maintaining the separation column at the proper operating temperature ± °C and performing programmed increases in temperature at rates of at least 40 °C/min.

2.3.10.2 Temperature Gauge. To monitor column oven, detector, and exhaust temperatures ± 1 °C.

2.3.10.3 Flow System. Gas metering system to measure sample, fuel, combustion gas, and carrier gas flows.

2.3.10.4 Capillary Columns. A fused silica column, 60 × 0.25 mm inside diameter (ID), coated with DB-5 and a fused silica column, 30 m × 0.25 mm ID coated with DB-225. Other column systems may be used provided that the user is able to demonstrate using calibration and performance checks that the column system is able to meet the specifications of section 6.1.2.2.

2.3.11. Mass Spectrometer. Capable of routine operation at a resolution of 1:10000 with a stability of ± 5 ppm.

2.3.12 Data System. Compatible with the mass spectrometer and capable of monitoring at least five groups of 25 ions.

2.3.13 Analytical Balance. To measure within 0.1 mg.

3. Reagents

3.1 Sampling.

3.1.1 Filters. Glass fiber filters, without organic binder, exhibiting at least 99.95 percent efficiency (<0.05 percent penetration) on 0.3-micron dioctyl phthalate smoke particles. The filter efficiency test shall be conducted in accordance with ASTM Standard Method D 2986–71 (Reapproved 1978) (incorporated by reference—see § 60.17).

3.1.1.1 Precleaning. All filters shall be cleaned before their initial use. Place a glass extraction thimble and 1 g of silica gel and a plug of glass wool into a Soxhlet apparatus, charge the apparatus with toluene, and reflux for a minimum of 3 hours. Remove the toluene and discard it, but retain the silica gel. Place no more than 50 filters in the thimble onto the silica gel bed and top with the cleaned glass wool. Charge the Soxhlet with toluene and reflux for 16 hours. After extraction, allow the Soxhlet to cool, remove the filters, and dry them under a clean N_2 stream. Store the filters in a glass petri dish sealed with Teflon tape.

3.1.2 Adsorbent Resin. Amberlite XAD-2 resin. Thoroughly cleaned before initial use.

3.1.2.1 Cleaning Procedure. This procedure may be carried out in a giant Soxhlet extractor. An all-glass filter thimble containing an extra-course frit is used for extraction of XAD-2. The frit is recessed 10–15 mm above a crenelated ring at the bottom of the thimble to facilitate drainage. The resin must be carefully retained in the extractor cup with a glass wool plug and a stainless steel ring because it floats on methylene chloride. This process involves sequential extraction in the following order.

Solvent	Procedure
Water	Initial rinse: Place resin in a beaker, rinse once with water, and discard. Fill with water a second time, let stand overnight, and discard.
Water	Extract with water for 8 hours.
Methanol	Extract for 22 hours.
Methylene Chloride	Extract for 22 hours.
Toluene	Extract for 22 hours.

3.1.2.2 Drying.

3.1.2.2.1 Drying Column. Pyrex pipe, 10.2 cm ID by 0.6 m long, with suitable retainers.

3.1.2.2.2 Procedure. The adsorbent must be dried with clean inert gas. Liquid nitrogen from a standard commercial liquid nitrogen cylinder has proven to be a reliable source of large volumes of gas free from organic contaminants. Connect the liquid nitrogen cylinder to the column by a length of cleaned copper tubing, 0.95 cm ID, coiled to pass through a heat source. A convenient heat source is a water-bath heated from a steam line. The final nitrogen temperature should only be warm to the touch and not over 40 °C. Continue flowing nitrogen through the adsorbent until all the residual solvent is removed. The flow rate should be sufficient to gently agitate the particles but not so excessive as the cause the particles to fracture.

3.1.2.3 Quality Control Check. The adsorbent must be checked for residual toluene.

3.1.2.3.1 Extraction. Weigh 1.0 g sample of dried resin into a small vial, add 3 ml of toluene, cap the vial, and shake it well.

3.1.2.3.2 Analysis. Inject a 2 µl sample of the extract into a gas chromatograph operated under the following conditions:

Column: 6 ft × ⅛ in stainless steel containing 10 percent OV-101 on 100/120 Supelcoport.

Carrier Gas: Helium at a rate of 30 ml/min.

Detector: Flame ionization detector operated at a sensitivity of 4×10^{-11} A/mV.

Injection Port Temperature: 250 °C.

Detector Temperature: 305 °C.

Oven Temperature: 30 °C for 4 min; programmed to rise at 40 °C/min until it reaches 250 °C; return to 30 °C after 17 minutes.

Compare the results of the analysis to the results from the reference solution. Prepare the reference solution by injection 2.5 µl of methylene chloride into 100 ml of toluene. This corresponds to 100 µg of methylene chloride per g of adsorbent. The maximum acceptable concentration is 1000 µg/g of adsorbent. If the adsorbent exceeds this level, drying must be continued until the excess methylene chloride is removed.

3.1.2.4 Storage. The adsorbent must be used within 4 weeks of cleaning. After cleaning, it may be stored in a wide mouth amber glass container with a Teflon-lined cap or placed in one of the glass adsorbent modules tightly sealed with glass stoppers. If precleaned adsorbent is purchased in sealed containers, it must be used within 4 weeks after the seal is broken.

3.1.3 Glass Wool. Cleaned by sequential immersion in three aliquots of methylene chloride, dried in a 110 °C oven, and stored in a methylene chloride-washed glass jar with a Teflon-lined screw cap.

3.1.4 Water. Deionized distilled and stored in a methylene chloride-rinsed glass container with a Teflon-lined screw cap.

3.1.5 Silica Gel. Indicating type, 6 to 16 mesh. If previously used, dry at 175 °C (350 °F) for two hours. New silica gel may be used as received. Alternately other types of desiccants (equivalent or better) may be used, subject to the approval of the Administrator.

3.1.6 Chromic Acid Cleaning Solution. Dissolve 20 g of sodium dichromate in 15 ml of water, and then carefully add 400 ml of concentrated sulfuric acid.

3.2 Sample Recovery.

3.2.2 Acetone. Pesticide quality.

3.2.2 Methylene Chloride. Pesticide qualtity.

3.2.3 Toluene. Pesticide quality.

3.3 Analysis.

3.3.1 Potassium Hydroxide. ACS grade, 2-percent (weight/volume) in water.

3.3.2 Sodium Sulfate. Granulated, reagent grade. Purify prior to use by rinsing with methylene chloride and oven drying. Store the cleaned material in a glass container with a Teflon-lined screw cap.

3.3.3 Sulfuric Acid. Reagent grade.

3.3.4 Sodium Hydroxide. 1.0 N. Weigh 40 g of sodium hydroxide into a 1-liter volumetric flask. Dilute to 1 liter with water.

3.3.5 Hexane. Pesticide grade.

3.3.6 Methylene Chloride. Pesticide grade.

3.3.7 Benzene. Pesticide Grade.

3.3.8 Ethyl Acetate.

3.3.9 Methanol. Pesticide Grade.

3.3.10 Toluene. Pesticide Grade.

3.3.11 Nonane. Pesticide Grade.

3.3.12 Cyclohexane. Pesticide Grade.

3.3.13 Basic Alumina. Activity grade 1, 100–200 mesh. Prior to use, activate the alumina by heating for 16 hours at 130 °C before use. Store in a desiccator. Preactivated alumina may be purchased from a supplier and may be used as received.

3.3.14 Silica Gel. Bio-Sil A. 100–200 mesh. Prior to use, activate the silica gel by heating for at least 30 minutes at 180 °C. After cooling, rinse the silica gel sequentially with methanol and methylene chloride. Heat the rinsed silica gel at 50 °C for 10 minutes, then increase the temperature gradually to 180 °C over 25 minutes and maintain it at this temperature for 90 minutes. Cool at room temperature and store in a glass container with a Teflon-lined screw cap.

3.3.15 Silica Gel Impregnated with Sulfuric Acid. Combine 100 g of silica gel with 44 g of concentrated sulfuric acid in a screw capped glass bottle and agitate thoroughly. Disperse the solids with a stirring rod until a uniform mixture is obtained. Store the mixture in a glass container with a Teflon-lined screw cap.

3.3.16 Silica Gel Impregnated with Sodium Hydroxide. Combine 39 g of 1 *N* sodium hydroxide with 100 g of silica gel in a screw capped glass bottle and agitate thoroughly. Disperse solids with a stirring rod until a uniform mixture is obtained. Store the mixture in glass container with a Teflon-lined screw cap.

3.3.17 Carbon/Celite. Combine 10.7 g of AX–21 carbon with 124 g of Celite 545 in a 250-ml glass bottle with a Teflon-lined screw cap. Agitate the mixture thoroughly until a uniform mixture is obtained. Store in the glass container.

3.3.18 Nitrogen. Ultra high purity.

3.3.19 Hydrogen. Ultra high purity.

3.3.20 Internal Standard Solution. Prepare a stock standard solution containing the isotopically labelled PCDD's and PCDF's at the concentrations shown in Table 1 under the heading "Internal Standards" in 10 ml of nonane.

3.3.21 Surrogate Standard Solution. Prepare a stock standard solution containing the isotopically labelled PCDD's and PCDF's at the concentrations shown in Table 1 under the heading "Surrogate Standards" in 10-ml of nonane.

3.3.22 Recovery Standard Solution. Prepare a stock standard solution containing the isotopically labelled PCDD's and PCDF's at the concentrations shown in Table 1 under the heading "Recovery Standards" in 10 ml of nonane.

4. Procedure

4.1 Sampling. The complexity of this method is such that, in order to obtain reliable results, testers should be trained and experienced with the test procedures.

4.1.1 Pretest Preparation.

4.1.1.1 Cleaning Glassware. All glass components of the train upstream of and including the adsorbent module, shall be cleaned as described in section 3A of the "Manual of Analytical Methods for the Analysis of Pesticides in Human and Environmental Samples." Special care shall be devoted to the removal of residual silicone grease sealants on ground glass connections of used glassware. Any residue shall be removed by soaking the glassware for several hours in a chromic acid cleaning solution prior to cleaning as described above.

4.1.1.2 Adsorbent Trap. The traps must be loaded in a clean area to avoid contamination. They may not be loaded in the field. Fill a trap with 20 to 40 g of XAD–2. Follow the XAD–2 with glass wool and tightly cap both ends of the trap. Add 100 μl of the surrogate standard solution (section 3.3.21) to each trap.

4.1.1.3 Sample Train. It is suggested that all components be maintained according to the procedure described in APTD–0576.

4.1.1.4 Silica Gel. Weigh several 200 to 300 g portions of silica gel in an air tight container to the nearest 0.5 g. Record the total weight of the silica gel plus container, on each container. As an alternative, the silica gel may be weighed directly in its impinger or sampling holder just prior to sampling.

4.1.1.5 Filter. Check each filter against light for irregularities and flaws or pinhole leaks. Pack the filters flat in a clean glass container.

4.1.2 Preliminary Determinations. Same as section 4.1.2 of Method 5.

4.1.3 Preparation of Collection Train.

4.1.3.1 During preparation and assembly of the sampling train, keep all train openings where contamination can enter, sealed until just prior to assembly or until sampling is about to begin.

Note: Do not use sealant grease in assembling the train.

4.1.3.2 Place approximately 100 ml of water in the second and third impingers, leave the first and fourth impingers empty, and transfer approximately 200 to 300 g of preweighed silica gel from its container to the fifth impinger.

4.1.3.3 Place the silica gel container in a clean place for later use in the sample recovery. Alternatively, the weight of the silica gel plus impinger may be determined to the nearest 0.5 g and recorded.

4.1.3.4 Assemble the train as shown in Figure 23–1.

4.1.3.5 Turn on the adsorbent module and condenser coil recirculating pump and begin monitoring the adsorbent module gas entry temperature. Ensure proper sorbent temperature gas entry temperature before proceeding and before sampling is initiated. It is extremely important that the XAD–2 adsorbent resin temperature never exceed 50 °C because thermal decomposition will occur. During testing, the XAD–2 temperature must not exceed 20 °C for efficient capture of the PCDD's and PCDF's.

4.1.4 Leak-Check Procedure. Same as Method 5, section 4.1.4.

4.1.5 Sample Train Operation. Same as Method 5, section 4.1.5.

4.2 Sample Recovery. Proper cleanup procedure begins as soon as the probe is removed from the stack at the end of the sampling period. Seal the nozzle end of the sampling probe with Teflon tape or aluminum foil.

When the probe can be safely handled, wipe off all external particulate matter near the tip of the probe. Remove the probe from the train and close off both ends with aluminum foil. Seal off the inlet to the train with Teflon tape, a ground glass cap, or aluminum foil.

Transfer the probe and impinger assemb to the cleanup area. This area shall be clea and enclosed so that the chances of losing contaminating the sample are minimized. Smoking, which could contaminate the sample, shall not be allowed in the cleanu area.

Inspect the train prior to and during disassembly and note any abnormal conditions, e.g., broken filters, colored impinger liquid, etc. Treat the samples as follows:

4.2.1 Container No. 1. Either seal the fi holder or carefully remove the filter from filter holder and place it in its identified container. Use a pair of cleaned tweezers handle the filter. If it is necessary to fold th filter, do so such that the particulate cake inside the fold. Carefully transfer to the container any particulate matter and filter fibers which adhere to the filter holder gasket, by using a dry inert bristle brush a a sharp-edged blade. Seal the container.

4.2.2 Adsorbent Module. Remove the module from the train, tightly cap both en label it, cover with aluminum foil, and stor on ice for transport to the laboratory.

4.2.3 Container No. 2. Quantitatively recover material deposited in the nozzle, probe transfer lines, the front half of the fi holder, and the cyclone, if used, first, by brushing while rinsing three times each w acetone and then, by rinsing the probe thr times with methylene chloride. Collect all rinses in Container No. 2.

Rinse the back half of the filter holder times with acetone. Rinse the connecting between the filter and the condenser thre times with acetone. Soak the connecting l with three separate portions of methylene chloride for 5 minutes each. If using a separate condenser and adsorbent trap, r the condenser in the same manner as the connecting line. Collect all the rinses in Container No. 2 and mark the level of the liquid on the container.

4.2.4 Container No. 3. Repeat the methylene chloride-rinsing described in Section 4.2.3 using toluene as the rinse solvent. Collect the rinses in Container N and mark the level of the liquid on the container.

4.2.5 Impinger Water. Measure the liq in the first three impingers to within ±1 m by using a graduated cylinder or by weig it to within ±0.5 g by using a balance. Re the volume or weight of liquid present. Th information is required to calculate the moisture content of the effluent gas.

Discard the liquid after measuring and recording the volume or weight.

4.2.7 Silica Gel. Note the color of the indicating silica gel to determine if it has been completely spent and make a ment of its condition. Transfer the silica gel fro the fifth impinger to its original container seal.

5. Analysis

All glassware shall be cleaned as described in section 3A of the "Manual o Analytical Methods for the Analysis of Pesticides in Human and Environmental Samples." All samples must be extracte within 30 days of collection and analyzed within 45 days of extraction.

5.1 Sample Extraction.

5.1.1 Extraction System. Place an extraction thimble (section 2.3.4), 1 g of silica gel, and a plug of glass wool into the Soxhlet apparatus, charge the apparatus with toluene, and reflux for a minimum of 3 hours. Remove the toluene and discard it, but retain the silica gel. Remove the extraction thimble from the extraction system and place it in a glass beaker to catch the solvent rinses.

5.1.2 Container No. 1 (Filter). Transfer the contents directly to the glass thimble of the extraction system and extract them simultaneously with the XAD–2 resin.

5.1.3 Adsorbent Cartridge. Suspend the adsorbent module directly over the extraction thimble in the beaker (See section 5.1.1). The glass frit of the module should be in the up position. Using a Teflon squeeze bottle containing toluene, flush the XAD–2 into the thimble onto the bed of cleaned silica gel. Thoroughly rinse the glass module catching the rinsings in the beaker containing the thimble. If the resin is wet, effective extraction can be accomplished by loosely packing the resin in the thimble. Add the XAD–2 glass wool plug into the thimble.

5.1.4 Container No. 2 (Acetone and Methylene Chloride). Concentrate the sample to a volume of about 1–5 ml using the rotary evaporator apparatus, at a temperature of less than 37 °C. Rinse the sample container three times with small portions of methylene chloride and add these to the concentrated solution and concentrate further to near dryness. This residue contains particulate matter removed in the rinse of the train probe and nozzle. Add the concentrate to the filter and the XAD–2 resin in the Soxhlet apparatus described in section 5.1.1.

5.1.5 Extraction. Add 100 µl of the internal standard solution (Section 3.3.20) to the extraction thimble containing the contents of the adsorbent cartridge, the contents of Container No. 1, and the concentrate from section 5.1.4. Cover the contents of the extraction thimble with the cleaned glass wool plug to prevent the XAD–2 resin from floating into the solvent reservoir of the extractor. Place the thimble in the extractor, and add the toluene contained in the beaker to the solvent reservoir. Pour additional toluene to fill the reservoir approximately 2/3 full. Add Teflon boiling chips and assemble the apparatus. Adjust the heat source to cause the extractor to cycle three times per hour. Extract the sample for 16 hours. After extraction, allow the Soxhlet to cool. Transfer the toluene extract and three 10-ml rinses to the rotary evaporator. Concentrate the extract to approximately 10 ml. At this point the analyst may choose to split the sample in half. If so, split the sample, store one half for future use, and analyze the other according to the procedures in sections 5.2 and 5.3. In either case, use a nitrogen evaporative concentrator to reduce the volume of the sample being analyzed to near dryness. Dissolve the residue in 5 ml of hexane.

5.1.6 Container No. 3 (Toluene Rinse). Add 100 µl of the Internal Standard solution (section 3.3.2) to the contents of the container. Concentrate the sample to a volume of about 1–5 ml using the rotary evaporator apparatus at a temperature of less than 37 °C. Rinse the sample container apparatus at a temperature of less than 37 °C. Rinse the sample container three times with small portions of toluene and add these to the concentrated solution and concentrate further to near dryness. Analyze the extract separately according to the procedures in sections 5.2 and 5.3, but concentrate the solution in a rotary evaporator apparatus rather than a nitrogen evaporative concentrator.

5.2 Sample Cleanup and Fractionation.

5.2.1 Silica Gel Column. Pack one end of a glass column, 20 mm x 230 mm, with glass wool. Add in sequence, 1 g silica gel, 2 g of sodium hydroxide impregnated silica gel, 1 g silica gel, 4 g of acid-modified silica gel, and 1 g of silica gel. Wash the column with 30 ml of hexane and discard it. Add the sample extract, dissolved in 5 ml of hexane to the column with two additional 5-ml rinses. Elute the column with an additional 90 ml of hexane and retain the entire eluate. Concentrate this solution to a volume of about 1 ml using the nitrogen evaporative concentrator (section 2.3.7).

5.2.2 Basic Alumina Column. Shorten a 25-ml disposable Pasteur pipette to about 16 ml. Pack the lower section with glass wool and 12 g of basic alumina. Transfer the concentrated extract from the silica gel column to the top of the basic alumina column and elute the column sequentially with 120 ml of 0.5 percent methylene chloride in hexane followed by 120 ml of 35 percent methylene chloride in hexane. Discard the first 120 ml of eluate. Collect the second 120 ml of eluate and concentrate it to about 0.5 ml using the nitrogen evaporative concentrator.

5.2.3 AX–21 Carbon/Celite 545 Column. Remove the botton 0.5 in. from the tip of a 9-ml disposable Pasteur pipette. Insert a glass fiber filter disk in the top of the pipette 2.5 cm from the constriction. Add sufficient carbon/celite mixture to form a 2 cm column. Top with a glass wool plug. In some cases AX–21 carbon fines may wash through the glass wool plug and enter the sample. This may be prevented by adding a celite plug to the exit end of the column. Rinse the column in sequence with 2 ml of 50 percent benzene in ethyl acetate, 1 ml of 50 percent methylene chloride in cyclohexane, and 2 ml of hexane. Discard these rinses. Transfer the concentrate in 1 ml of hexane from the basic alumina column to the carbon/celite column along with 1 ml of hexane rinse. Elute the column sequentially with 2 ml of 50 percent methylene chloride in hexane and 2 ml of 50 percent benzene in ethyl acetate and discard these eluates. Invert the column and elute in the reverse direction with 13 ml of toluene. Collect this eluate. Concentrate the eluate in a rotary evaporator at 50 °C to about 1 ml. Transfer the concentrate to a Reacti-vial using a toluene rinse and concentrate to a volume of 200 µl using a stream of N_2. Store extracts at room temperature, shielded from light, until the analysis is performed.

5.3 Analysis. Analyze the sample with a gas chromatograph coupled to a mass spectrometer (GC/MS) using the instrumental parameters in sections 5.3.1 and 5.3.2. Immediately prior to analysis, add a 20 µl aliquot of the Recovery Standard solution from Table 1 to each sample. A 2 µl aliquot of the extract is injected into the GC. Sample extracts are first analyzed using the DB–5 capillary column to determine the concentration of each isomer of PCDD's and PCDF's (tetra-through octa-). If tetra-chlorinated dibenzofurans are detected in this analysis, then analyze another aliquot of the sample in a separate run, using the DB–225 column to measure the 2,3,7,8 tetra-chloro dibenzofuran isomer. Other column systems may be used, provided that the user is able to demonstrate using calibration and performance checks that the column system is able to meet the specifications of section 6.1.2.2.

5.3.1 Gas Chromatograph Operating Conditions.

5.3.1.1 Injector. Configured for capillary column, splitless, 250°C.

5.3.1.2 Carrier Gas. Helium, 1–2 ml/min.

5.3.1.3 Oven. Initially at 150°C. Raise by at least 40°C/min to 190°C and then at 3°C/min up to 300°C.

5.3.2 High Resolution Mass Spectrometer.

5.3.2.1 Resolution. 10000 m/e.

5.3.2.2 Ionization Mode. Electron impact.

5.3.2.3 Source Temperature 250°C.

5.3.2.4 Monitoring Mode. Selected ion monitoring. A list of the various ions to be monitored is summarized in Table 3.

5.3.2.5 Identification Criteria. The following identification criteria shall be used for the characterization of polychlorinated dibenzodioxins and dibenzofurans.

1. The integrated ion-abundance ratio (M/M+2 or M+2/M+4) shall be within 15 percent of the theoretical value. The acceptable ion-abundance ratio ranges for the identification of chlorine-containing compounds are given in Table 4.

2. The retention time for the analytes must be within 3 seconds of the corresponding ^{13}C-labeled internal standard, surrogate or alternate standard.

3. The monitored ions, shown in Table 3 for a given analyte, shall reach their maximum within 2 seconds of each other.

4. The identification of specific isomers that do not have corresponding ^{13}C-labeled standards is done by comparison of the relative retention time (RRT) of the analyte to the nearest internal standard retention time with reference (i.e., within 0.005 RRT units) to the comparable RRT's found in the continuing calibration.

5. The signal to noise ratio for all monitored ions must be greater than 2.5.

6. The confirmation of 2, 3, 7, 8–TCDD and 2, 3, 7, 8–TCDF shall satisfy all of the above identification criteria.

7. For the identification of PCDF's, no signal may be found in the corresponding PCDPE channels.

5.3.2.6 Quantification. The peak areas for the two ions monitored for each analyte are summed to yield the total response for each analyte. Each internal standard is used to quantify the indigenous PCDD's or PCDF's in its homologous series. For example, the $^{13}C_{12}$-2,3,7,8-tetra chlorinated dibenzodioxin is used to calculate the concentrations of all other tetra chlorinated isomers. Recoveries of the tetra- and penta- internal standards are calculated using the $^{13}C_{12}$–1.2.3.4–TCDD. Recoveries of the hexa- through octa- internal standards are calculated using $^{13}C_{12}$–1.2.3.7.8.9–HxCDD. Recoveries of the surrogate standards are calculated using the corresponding homolog from the internal standard.

6. Calibration

Same as Method 5 with the following additions.

6.1 GC/MS System.

6.1.1 Initial Calibration. Calibrate the GC/MS system using the set of five standards shown in Table 2. The relative standard deviation for the mean response factor from each of the unlabeled analytes (Table 2) and of the internal, surrogate, and alternate standards shall be less than or equal to the values in Table 5. The signal to noise ratio for the GC signal present in every selected ion current profile shall be greater than or equal to 2.5. The ion abundance ratios shall be within the control limits in Table 4.

6.1.2 Daily Performance Check.

6.1.2.1 Calibration Check. Inject on µl of solution Number 3 from Table 2. Calculate the relative response factor (RRF) for each compound and compare each RRF to the corresponding mean RRF obtained during the initial calibration. The analyzer performance is acceptable if the measured RRF's for the labeled and unlabeled compounds for the daily run are within the limits of the mean values shown in Table 5. In addition, the ion-abundance ratios shall be within the allowable control limits shown in Table 4.

6.1.2.2 Column Separation Check. Inject a solution of a mixture of PCDD's and PCDF's that documents resolution between 2.3.7.8–TCDD and other TCDD isomers. Resolution is defined as a valley between peaks that is less than 25 percent of the lower of the two peaks. Identify and record the retention time windows for each homologous series.

Perform a similar resolution check on the confirmation column to document the resolution between 2.3.7.8 TCDF and other TCDF isomers.

6.2 Lock Channels. Set mass spectrometer lock channels as specified in Table 3. Monitor the quality control check channels specified in Table 3 to verify instrument stability during the analysis.

7. Quality Control

7.1 Sampling Train Collection Efficiency Check. Add 100 µl of the surrogate standards in Table 1 to the absorbent cartridge of each train before collecting the field samples.

7.2 Internal Standard Percent Recoveries. A group of nine carbon labeled PCDD's and PCDF's representing, the tetra-through octachlorinated homologues, is added to every sample prior to extraction. The role of the internal standards is to quantify the native PCDD's and PCDF's present in the sample as well as to determine the overall method efficiency. Recoveries of the internal standards must be between 40 to 130 percent for the tetra-through hexachlorinated compounds while the range is 25 to 130 percent for the higher hepta- and octachlorinated homologues.

7.3 Surrogate Recoveries. The five surrogate compounds in Table 2 are added to the resin in the adsorbent sampling cartridge before the sample is collected. The surrogate recoveries are measured relative to the internal standards and are a measure of collection efficiency. They are not used to measure native PCDD's and PCDF's. All recoveries shall be between 70 and 130 percent. Poor recoveries for all the surrogates may be an indication of breakthrough in the sampling train. If the recovery of all standards is below 70 percent, the sampling runs must be repeated. As an alternative, the sampling runs do not have to be repeated if the final results are divided by the fraction of surrogate recovery. Poor recoveries of isolated surrogate compounds should not be grounds for rejecting an entire set of the samples.

7.4 Toluene QA Rinse. Report the results of the toluene QA rinse separately from the total sample catch. Do not add it to the total sample.

8. Quality Assurance

8.1 Applicability. When the method is used to analyze samples to demonstrate compliance with a source emission regulation, an audit sample must be analyzed, subject to availability.

8.2 Audit Procedure. Analyze an audit sample with each set of compliance samples. The audit sample contains tetra through octa isomers of PCDD and PCDF. Concurrently, analyze the audit sample and a set of compliance samples in the same manner to evaluate the technique of the analyst and the standards preparation. The same analyst, analytical reagents, and analytical system shall be used both for the compliance samples and the EPA audit sample.

8.3 Audit Sample Availability. Audit samples will be supplied only to enforcement agencies for compliance tests. The availability of audit samples may be obtained by writing: Source Test Audit Coordinator (MD–77B), Quality Assurance Division, Atmospheric Research and Exposure Assessment Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, or by calling the Source Test Audit Coordinator (STAC) at (919) 541–7834. The request for the audit sample must be made at least 30 days prior to the scheduled compliance sample analysis.

8.4 Audit Results. Calculate the audit sample concentration according to the calculation procedure described in the audit instructions included with the audit sample. Fill in the audit sample concentration and the analyst's name on the audit response form included with the audit instructions. Send one copy to the EPA Regional Office or the appropriate enforcement agency and a second copy to the STAC. The EPA Regional office or the appropriate enforcement agency will report the results of the audit to the laboratory being audited. Include this response with the results of the compliance samples in relevant reports to the EPA Regional Office or the appropriate enforcement agency.

9. Calculations

Same as Method 5, section 6 with the following additions.

9.1 Nomenclature.

A_{ai} = Integrated ion current of the noise at the retention time of the analyte.

A^*_{ci} = Integrated ion current of the two ions characteristic of the internal standard i in the calibration standard.

A_{cij} = Integrated ion current of the two ions characteristic of compound i in the jth calibration standard.

A^*_{cij} = Integrated ion current of the two ions characteristic of the internal standard i in the jth calibration standard.

A_{csi} = Integrated ion current of the two ions characteristic of surrogate compound i in the calibration standard.

A_i = Integrated ion current of the two ions characteristic of compound i in the sample.

A^*_i = Integrated ion current of the two ions characteristic of internal standard i in the sample.

A_{rs} = Integrated ion current of the two ions characteristic of the recovery standard.

A_{si} = Integrated ion current of the two ions characteristic of surrogate compound i in the sample.

C_i = Concentration of PCDD or PCDF i in the sample, pg/M ^{3}.

C_T = Total concentration of PCDD's or PCDF's in the sample, pg/M ^{3}.

m_{ci} = Mass of compound i in the calibration standard injected into the analyzer, pg.

m_{rs} = Mass of recovery standard in the calibration standard injected into the analyzer, pg.

m_{si} = Mass of surrogate compound i in the calibration standard, pg.

RRF_i = Relative response factor.

RRF_{rs} = Recovery standard response factor.

RRF_s = Surrogate compound response factor.

9.2 Average Relative Response Factor.

$$RRF_i = \frac{1}{n} \sum_{j=1}^{n} \frac{A_{cij}\, m^*_{ci}}{A^*_{cij}\, m_{ci}} \qquad \text{Eq. 23–1}$$

9.3 Concentration of the PCDD's and PCDF's.

$$C_i = \frac{m^*_i\, A_i}{A^*_i\, RRF_i\, V_{mstd}} \qquad \text{Eq. 23–2}$$

9.4 Recovery Standard Response Factor.

$$RRF_{rs} = \frac{A^*_{ci}\, m_{rs}}{A_{rs}\, m^*_{ci}} \qquad \text{Eq. 23–3}$$

9.5 Recovery of Internal Standards (R*).

$$R^* = \frac{A^*_i\, m_{rs}}{A_{rs}\, RF_{rs}\, m^*_i} \times 100\% \qquad \text{Eq. 23–4}$$

9.6 Surrogate Compound Response Factor.

$$RRF_s = \frac{A_{cs}^{*}\, m_s}{A_{s}\, m_{cs}^{*}} \qquad \text{Eq. } 23-5$$

9.7 Recovery of Surrogate Compounds (R_s).

$$R_s = \frac{A_s\, m_i^{*}}{A_i^{*}\, RRF_s\, m_s} \times 100\% \qquad \text{Eq. } 23-6$$

9.8 Minimum Detectable Limit (MDL).

$$MDL = \frac{2.5\, A_{si}\, m_i^{*}}{A_{ci}^{*}\, RRF_i} \qquad \text{Eq. } 23-7$$

9.9 Total Concentration of PCDD's and PCDF's in the Sample.

$$C_T = \sum_{i=1}^{n} C_i \qquad \text{Eq. } 23-8$$

Any PCDD's or PCDF's that are reported as nondetected (below the MDL) shall be counted as zero for the purpose of calculating the total concentration of PCDD's and PCDF's in the sample.

10. Bibliography

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TABLE 1.—COMPOSITION OF THE SAMPLE FORTIFICATION AND RECOVERY STANDARDS SOLUTIONS

Analyte	Concentration (pg/µl)
Internal Standards:	
$^{13}C_{12}$-2,3,7,8-TCDD	100
$^{13}C_{12}$-1,2,3,7,8-PeCDD	100
$^{13}C_{12}$-1,2,3,6,7,8-HxCDD	100
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	100
$^{13}C_{12}$-OCDD	100
$^{13}C_{12}$-2,3,7,8-TCDF	100
$^{13}C_{12}$-1,2,3,7,8-PeCDF	100
$^{13}C_{12}$-1,2,3,6,7,8-HxCDF	100
$^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	100
Surrogate Standards:	
$^{37}Cl_4$-2,3,7,8-TCDD	100
$^{13}C_{12}$-1,2,3,4,7,8-HxCDD	100
$^{13}C_{12}$-2,3,4,7,8-PeCDF	100
$^{13}C_{12}$-1,2,3,4,7,8-HxCDF	100
$^{13}C_{12}$-1,2,3,4,7,8,9-HpCDF	100
Recovery Standards:	
$^{13}C_{12}$-1,2,3,4-TCDD	500
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD	500

TABLE 2.—COMPOSITION OF THE INITIAL CALIBRATION SOLUTIONS

Compound	Concentrations (pg/µL)				
	Solution No.				
	1	2	3	4	5
Alternate Standard:					
$^{13}C_{12}$-1,2,3,7,8,9-HxCDF	2.5	5	25	250	500
Recovery Standards:					
$^{13}C_{12}$-1,2,3,4-TCDD	100	100	100	100	100
$^{13}C_{12}$-1,2,3,7,8,9-HxCDD	100	100	100	100	100

TABLE 3.—ELEMENTAL COMPOSITIONS AND EXACT MASSES OF THE IONS MONITORED BY HIGH RESOLUTION MASS SPECTROMETRY FOR PCDD'S AND PCDF'S

Descriptor No.	Accurate mass	Ion type	Elemental composition	Analyte
2	292.9825	LOCK	C_7F_{11}	PFK
	303.9016	M	$C_{12}H_4{}^{35}Cl_4O$	TCDF
	305.8987	M+2	$C_{12}H_4{}^{35}Cl_3{}^{37}ClO$	TCDF
	315.9419	M	$^{13}C_{12}H_4{}^{35}Cl_4O$	TCDF (S)
	317.9389	M+2	$^{13}C_{12}H_4{}^{35}Cl_3{}^{37}ClO$	TCDF (S)
	319.8965	M	$C_{12}H_4{}^{35}Cl_4O_2$	TCDD
	321.8936	M+2	$C_{12}H_4{}^{35}Cl_3{}^{37}ClO_2$	TCDD
	327.8847	M	$C_{12}H_4{}^{37}Cl_4O_2$	TCDD (S)
	330.9792	QC	C_7F_{13}	PFK
	331.9368	M	$^{13}C_{12}H_4{}^{35}Cl_4O_2$	TCDD (S)
	333.9339	M+2	$^{13}C_{12}H_4{}^{35}Cl_3{}^{37}ClO_2$	TCDD (S)
	339.8597	M+2	$C_{12}H_3{}^{35}Cl_4{}^{37}ClO$	PECDF
	341.8567	M+4	$C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O$	PeCDF
	351.9000	M+2	$^{13}C_{12}H_3{}^{35}Cl_4{}^{37}ClO$	PeCDF (S)
	353.8970	M+4	$^{13}C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O$	PeCDF (S)
	355.8546	M+2	$C_{12}H_3{}^{35}Cl_4 37ClO_2$	PeCDD
	357.8516	M+4	$C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O_2$	PeCDD
	367.8949	M+2	$^{13}C_{12}H_3{}^{35}Cl_4{}^{37}ClO_2$	PeCDD (S)
	369.8919	M+4	$^{13}C_{12}H_3{}^{35}Cl_3{}^{37}Cl_2O_2$	PeCDD (S)
	375.8364	M+2	$C_{12}H_4{}^{35}Cl_5{}^{37}ClO$	HxCDPE
	409.7974	M+2	$C_{12}H_3{}^{35}Cl_6{}^{37}ClO$	HpCPDE
3	373.8208	M+2	$C_{12}H_2 35Cl_5{}^{37}ClO$	HxCDF
	375.8178	M+4	$C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O$	HxCDF
	383.8639	M	$^{13}C_{12}H_2{}^{35}Cl_6O$	HxCDF (S)
	385.8610	M+2	$^{13}C_{12}H_2{}^{35}Cl_5{}^{37}ClO$	HxCDF (S)
	389.8157	M+2	$C_{12}H_2{}^{35}Cl_5{}^{37}ClO_2$	HxCDD
	391.8127	M+4	$C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O_2$	HxCDD
	392.9760	LOCK	C_9F_{15}	PFK

TABLE 3.—ELEMENTAL COMPOSITIONS AND EXACT MASSES OF THE IONS MONITORED BY HIGH RESOLUTION MASS SPECTROMETRY FOR PCDD'S AND PCDF'S—Continued

Descriptor No.	Accurate mass	Ion type	Elemental composition	Analyte
	401.8559	M+2	${}^{13}C_{12}H_2{}^{35}Cl_5{}^{37}ClO_2$	HxCDD (S)
	403.8529	M+4	${}^{13}C_{12}H_2{}^{35}Cl_4{}^{37}Cl_2O$	HxCDD (S)
	445.7555	M+4	$C_{12}H_2{}^{35}Cl_6{}^{37}Cl_2O$	OCDPE
	430.9729	QC	C_9F_{17}	PFK
4	407.7818	M+2	$C_{12}H{}^{35}Cl_6{}^{37}ClO$	HpCDF
	409.7789	M+4	$C_{12}H{}^{35}Cl_5{}^{37}Cl_2O$	HpCDF
	417.8253	M	${}^{13}C_{12}H{}^{35}Cl_7O$	HpCDF (S)
	419.8220	M+2	${}^{13}C_{12}H{}^{35}Cl_6{}^{37}ClO$	HpCDF (S)
	423.7766	M+2	$C_{12}H{}^{35}Cl_6{}^{37}ClO_2$	HpCDD
	425.7737	M+4	$C_{12}H{}^{35}Cl_5{}^{37}Cl_2O_2$	HpCDD
	435.8169	M+2	${}^{13}C_{12}H{}^{35}Cl_6{}^{37}ClO_2$	HpCDD (S)
	437.8140	M+4	${}^{13}C_{12}H{}^{35}Cl_5{}^{37}Cl_2O_2$	HpCDD (S)
	479.7165	M+4	$C_{12}H{}^{35}Cl_7{}^{37}Cl_2O$	NCPDE
	430.9729	LOCK	C_9F_{17}	PFK
	441.7428	M+2	$C_{12}{}^{35}Cl_7{}^{37}ClO$	OCDF
	443.7399	M+4	$C_{12}{}^{35}Cl_6{}^{37}Cl_2O$	OCDF
	457.7377	M+2	$C_{12}{}^{35}Cl_7{}^{37}ClO_2$	OCDD
	459.7348	M+4	$C_{12}{}^{35}Cl_6{}^{37}Cl_2O_2$	OCDD
	469.7779	M+2	${}^{13}C_{12}{}^{35}Cl_7{}^{37}ClO_2$	OCDD (S)
	471.7750	M+4	${}^{13}C_{12}{}^{35}Cl_6{}^{37}Cl_2O_2$	OCDD (S)
	513.6775	M+4	$C_{12}{}^{35}Cl_8{}^{37}Cl_2O_2$	DCDPE
	442.9728	QC	$C_{10}F_{17}$	PFK

(a) The following nuclidic masses were used:
H = 1.007825
C = 12.000000
${}^{13}C$ = 13.003355
F = 18.9984
O = 15.994915
${}^{35}Cl$ = 34.968853
${}^{37}Cl$ = 36.965903
S = Labeled Standard
QC = Ion selected for monitoring instrument stability during the GC/MS analysis.

TABLE 4.—ACCEPTABLE RANGES FOR ION-ABUNDANCE RATIOS OF PCDD'S AND PCDF'S

No. of chlorine atoms	Ion type	Theoretical ratio	Control limits Lower	Control limits Upper
4	M/M+2	0.77	0.65	0.89
5	M+2/M+4	1.55	1.32	1.78
6	M+2/M+4	1.24	1.05	1.43
6[a]	M/M+2	0.51	0.43	0.59
7[b]	M/M+2	0.44	0.37	0.51
7	M+2/M+4	1.04	0.88	1.20
8	M+2/M+4	0.89	0.76	1.02

[a] Used only for ${}^{13}C$-HxCDF.
[b] Used only for ${}^{13}C$-HpCDF.

TABLE 5.—MINIMUM REQUIREMENTS FOR INITIAL AND DAILY CALIBRATION RESPONSE FACTORS

Compound	Relative response factors: Initial calibration RSD	Relative response factors: Daily calibration % difference
Unlabeled Analytes:		
2,3,7,8-TCDD	25	25
2,3,7,8-TCDF	25	25
1,2,3,7,8-PeCDD	25	25
1,2,3,7,8-PeCDF	25	25
2,3,4,7,8-PeCDF	25	25
1,2,4,5,7,8-HxCDD	25	25
1,2,3,6,7,8-HxCDD	25	25
1,2,3,7,8,9-HxCDD	25	25
1,2,3,4,7,8-HxCDF	25	25
1,2,3,6,7,8-HxCDF	25	25
1,2,3,7,8,9-HxCDF	25	25
2,3,4,6,7,8-HxCDF	25	25
1,2,3,4,6,7,8-HpCDD	25	25
1,2,3,4,6,7,8-HpCDF	25	25
OCDD	25	25
OCDF	30	30
Internal Standards:		
${}^{13}C_{12}$-2,3,7,8-TCDD	25	25
${}^{13}C_{12}$-1,2,3,7,8-PeCDD	30	30
${}^{13}C_{12}$-1,2,3,6,7,8-HxCDD	25	25
${}^{13}C_{12}$-1,2,3,4,6,7,8-HpCDD	30	30
${}^{13}C_{12}$-OCDD	30	30
${}^{13}C_{12}$-2,3,7,8-TCDF	30	30
${}^{13}C_{12}$-1,2,3,7,8-PeCDF	30	30
${}^{13}C_{12}$-1,2,3,6,7,8-HxCDF	30	30
${}^{13}C_{12}$-1,2,3,4,6,7,8-HpCDF	30	30
Surrogate Standards:		
${}^{37}Cl_4$-2,3,7,8-TCDD	25	25
${}^{13}C_{12}$-2,3,4,7,8-PeCDF	25	25
${}^{13}C_{12}$-1,2,3,4,7,8-HxCDD	25	25
${}^{13}C_{12}$-1,2,3,4,7,8-HxCDF	25	25
${}^{13}C_{12}$-1,2,3,4,7,8,9-HpCDF	25	25

TABLE 5.—MINIMUM REQUIREMENTS FOR INITIAL AND DAILY CALIBRATION RESPONSE FACTORS—Continued

Compound	Relative response factors	
	Initial calibration RSD	Daily calibration % difference
Alternate Standard: $^{13}C_{12}$-1,2,3,7,8,9-HxCDF	25	25

* * * * *

Method 26—Determination of Hydrogen Chloride Emissions From Stationary Sources

1. Applicability, Principle, Interferences, Precision, Bias, and Stability

1.1 Applicability. This method is applicable for determining hydrogen chloride (HCl) emissions from stationary sources.

1.2 Principle. An integrated sample is extracted from the stack and passed through dilute sulfuric acid. In the dilute acid, the HCl gas is dissolved and forms chloride (Cl^-) ions. The Cl^- is analyzed by ion chromatography (IC).

1.3 Interferences. Volatile materials which produce chloride ions upon dissolution during sampling are obvious interferences. Another likely interferent is diatomic chlorine (Cl_2) gas which reacts to form HCl and hypochlorous acid (HOCl) upon dissolving in water. However, Cl_2 gas exhibits a low solubility in water and the use of acidic, rather than neutral or basic collection solutions, greatly reduces the chance of dissolving any chlorine present. This method does not experience a significant bias when sampling a 400 ppm HCl gas stream containing 50 ppm Cl_2. Sampling a 220 ppm HCl gas stream containing 180 ppm Cl_2 results in a positive bias of 3.4 percent in the HCl measurement.

1.4 Precision and Bias. The within-laboratory relative standard deviations are 6.2 and 3.2 percent at HCl concentrations of 3.9 and 15.3 ppm, respectively. The method does not exhibit a bias to Cl_2 when sampling at concentrations less than 50 ppm.

1.5 Stability. The collected samples can be stored for up to 4 weeks before analysis.

1.6 Detection Limit. The analytical detection limit of the method is 0.1 μg/ml.

2. Apparatus

2.1 Sampling. The sampling train is shown in Figure 26-1, and component parts are discussed below.

2.1.1 Probe. Borosilicate glass, approximately ⅜-in. (9-mm) I.D. with a heating system to prevent moisture condensation. A ⅜-in I.D. Teflon elbow should be attached to the inlet of the probe and a 1-in. (25-mm) length of ⅜-in. I.D. Teflon tubing should be attached to the open end of the elbow to permit the opening of the probe to be turned away from the gas stream. This reduces the amount of particulate entering the train. This probe configuration should be used when the concentration of particulate matter in the emissions is high. When high concentrations are not present, the Teflon elbow is not necessary, and the probe inlet may be perpendicular to the gas stream. A glass wool plug should *not* be used to remove particulate matter since a negative bias in the data could result. Instead, a Teflon filter (see Section 2.1.5) should be installed at the inlet (for stack temperatures <300 °F) or outlet (for stack temperatures >300 °F) of the probe.

2.1.2 Three-way Stopcock. A borosilicate, three-way glass stopcock with a heating system to prevent moisture condensation. The heated stopcock should connect directly to the outlet of the probe and the inlet of the first impinger. The heating system should be capable of preventing condensation up to the inlet of the first impinger. Silicone grease may be used, if necessary, to prevent leakage.

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21 Water Content

21-2.2 Gravimetry With Oven Drying

21-2.2.1 INTRODUCTION

Water content measurements by gravimetric methods involve weighing the wet sample, removing the water, and reweighing the sample to determine the amount of water removed. Water content then is obtained by dividing the difference between wet and dry masses by the mass of the dry sample to obtain the ratio of the mass of water to the mass of the dry soil. When multiplied by 100, this becomes the percentage of water in the sample on a dry-mass (or, as often expressed, on a dry-weight) basis. Water content may be described in other ways as indicated in section 21-1. Water may be removed from the sample in any of a number of ways, the principal method in common use being the oven-drying method described here. Accuracy and reproducibility of water content measurements, assuming that weighing precision is consistent with desired precision of water content measurement, depend upon the drying technique and the care with which it is used. (See discussion in section 21-2.1).

21-2.2.2 METHOD

21-2.2.2.1 **Special apparatus.** Apparatus required for gravimetric determination of water content may be used in many different forms, and so exact specifications are not needed. Requirements include an auger or sampling tube or some other suitable device to take a soil sample, soil containers with tight-fitting lids, an oven with means for controlling the temperature to 100 to 110°C, a desiccator with active desiccant, and a balance for weighing the samples. In the field, if soil samples are taken under conditions where evaporation losses may be of sufficient magnitude to affect the desired accuracy of measurement, special equipment for weighing the samples immediately or reducing evaporative loss must be used. Both convective and forced-draft ovens are used, and for precise work a vacuum oven is of particular value. Balances used range all the way from analytical balances to rough platform scales, depending upon the size of the sample to be taken and the precision of measurement desired.

21-2.2.2.2 **Procedure** The procedure to be used must vary with the circumstances of measurement and the equipment. Since these vary widely it is impossible to specify a detailed standard procedure that will fit all of the many uses made of water content measurements. The procedure given here is intended for use in routine work where moderate precision (say, measurements having a precision of ± 0.5% water content) is desired. Replication must depend upon the nature of the sample and soil system for which water content is desired, but it is suggested that samples be run in duplicate as a minimum.

Place samples of 1 to 100 g of soil in weighing bottles or metal cans with tight-fitting lids. Weigh the samples immediately, or store them in such a way that evaporation is negligible. Refer to Fig. 21-2 to find the required weighing precision. (The balance need not be read to a precision greatly exceeding the standard deviation for the balance.) Place the sample in a drying oven with the lid off, and dry it to constant weight. Remove the sample from the oven, replace the cover, and place it in a desiccator containing active desiccant (e.g., magnesium perchlorate or calcium sulfate) until cool. Weigh it again, and also determine the tare weight of the sample container. Compute the water content by one of the following formulas:

$$\theta_{dw} = \frac{(\text{weight of wet soil + tare}) - (\text{weight of dry soil + tare})}{(\text{weight of dry soil + tare}) - (\text{tare})} \qquad [23]$$

$$= \frac{(\text{weight of wet soil + tare}) - (\text{tare})}{(\text{weight of dry soil + tare}) - (\text{tare})} - 1 \qquad [24]$$

$$= \frac{\text{weight of wet soil}}{\text{weight of dry soil}} - 1. \qquad [25]$$

The third of these equations is useful where standardized cans are used and the tare weight is balanced out in the weighing process so that the sample weight is obtained directly. Multiplication by 100 gives the percentage of water in the sample on a dry-mass basis.

12 Soil pH

12-2.6 Glass Electrode-Calomel Electrode pH Meter Method

Practically all laboratories use the glass (indicating) electrode paired with a calomel ($Hg-Hg_2Cl$)(reference) electrode for measuring soil pH. The electrodes are normally plugged into a regular commercial pH meter. Upon proper standardization with buffers of known pH, the meter indicates the pH of the soil suspension from the millivolts of potential generated when the two electrodes are placed in the soil suspension. The glass electrode is the H^+-sensing electrode, which develops changes in potential (voltage) proportional to the logarithm of changes in activity of H^+. Thus it is called the indicating electrode. The calomel electrode (i) contains a saturated KCl bridge that contacts the soil suspension and (ii) has a characteristic potential (voltage) relatively independent of the H^+ activity. Hence it is called the reference electrode.

Many companies make and market highly satisfactory glass and reference electrodes. Similarly, many different brands of pH meters that are quite satisfactory for measuring the soil pH are available. Selections are often made on the basis of such criteria as satisfactory performance, company service, and type of readout.

Individual laboratories differ on the details of soil and water solution measurement, soil/water or soil/solution ratio, containing solution, method of mixing, time of standing before reading, whether or not it is stirred during reading, etc. Some laboratories weigh the soil; others measure a volume of soil. Some use 5 g of soil and 5 g (or 5 ml) of water. Some use $0.01M$ $CaCl_2$ instead of water. Some measure the pH in water, add sufficient $CaCl_2$ to obtain $0.01M$ $CaCl_2$, and measure the pH again. Some laboratories stir the soil suspensions individually or by a manifold arrangement. Others use a time-controlled shaker to mix large numbers of samples simultaneously. A suggested procedure is described to minimize differences in results brought about by discretionary alternatives that often have more than minor influences.

12-2.6.1 STANDARDIZING pH METER

Set the pH meter at pH 7 with standard buffer solution of pH 7, and set the manual temperature compensator at the temperature of buffer. Check to see that the instrument reads very near pH 4 with standard pH 4 buffer. If necessary, adjust the reading to pH 4, using the temperature compensator knob. Repeat the above standardization procedure with both pH 7 and 4 buffers until the instrument reading agrees with both buffer pH's.

12-2.6.2 TROUBLESHOOTING pH METER PROBLEMS

Initial failure of the instrument to agree reasonably well with both buffers usually suggests malfunction of the glass electrodes or of the electrometer tube of the pH meter. The former may require cleaning or replacing, and the latter may require an electronics repair service. When the pH meter appears to be in proper operating condition, as indicated by initial agreement of pH readings of both buffers, or after the above adjustment, check the pH of a soil of known pH. If it gives the correct reading, proceed to the following section; if not, this usually indicates partial plugging of the microscopic opening in the reference electrode. This may be caused by improper venting of the electrode restricting free flow of the saturated KCl, excessive growth of KCl crystals around the fiber wick restricting normal flow of KCl, or plugging of capillary opening with soil particles. These problems may be solved by periodic uncovering or unplugging the air vent, washing out the KCl crystals with distilled water and replacing with several rinses of saturated KCl, and careful grinding of the tip of the electrode with fine emergy cloth or sand paper until the KCl flow shows slight wetting of the glass at the point of the capillary opening, respectively. Instability of the pH meter dial needle usually indicates excessive static electricity from the technician's clothing or floor or table covering. A creeping or sluggish pH meter dial needle may indicate a dirty glass electrode.[3]

12-2.6.3 MAINTAINING ELECTRODES

12-2.6.3.1 Glass Electrode. Glass electrodes frequently become sluggish in their operation, as evidenced by slow changes or drift of the indicated pH when the measurement is made. Such drift or slow response may be caused by a dried layer of clay or precipitated carbonate on the glass bulb that cannot be removed by ordinary washing with water. Or, sluggish response may be caused by an aging of the glass surface of the bulb. Rejuvenation of the glass surface by immersion in a dilute solution of HF for 10 to 15 sec usually corrects the problem.

12-2.6.3.2 Calomel Electrode. The most frequent source of error with calomel electrodes is caused by stoppage of flow of electrolyte through the wick, fiber, porous ceramic, or sleeve. Although the instrument may calibrate satisfactorily in the solutions used for this purpose, it does not give correct values of pH in soil systems. The error tends to be in the direction of soil pH values that are too low and of high pH values in mixtures of soils and buffer solution used for measuring lime requirement. It is essential that the calomel electrode be operated with a functional liquid junction.

Another source of error in this respect occurs when the calomel electrode is forced into soil at the bottom of the cup in which the measurement is made, which stops the free movement of salt from the liquid junction. A stop in the electrode holder, which will prevent the tip of the electrode from penetrating to the bottom of the sample cup, will generally prevent this error.

12-2.6.4 EQUIPMENT AND REAGENTS

1. pH meter equipped with glass (indicating and reference electrodes).
2. Automatic pipette, portable stirrer (optional).
3. Paper cups, 28 g (1 oz), Solo souffle cup (Solo Cup Co. Urbana, Ill.) (optional).
4. Calcium chloride ($CaCl_2$) solution, 1 or 0.01*M* (optional).
5. Standard buffers, pH 7 and 4.
6. Distilled water.

12-2.6.5 pH[4]

1. Weigh or measure 5 g of air-dry soil into a 28-g paper cup. (Other containers, such as 50-ml beakers, may be used, but this may require adjustments in the shaking procedure called for below.)
2. Place cups in a 20- or 40-unit tray designed to go into the mechanical shaker used in the lime requirement determination (described below).
3. With automatic pipette, add 5 ml of distilled water to each cup.
4. Mix thoroughly for 5 sec, preferably with portable mechanical stirrer. (A small stirrer motor, 1,550 rpm, mounted on a handle with a short, slightly bent plastic or glass rod agitator serves very well.)
5. Let stand for 10 min.
6. Insert the electrodes into the container, and stir the soil suspension by swirling the electrodes slightly. Protect the electrodes with a short glass rod attached to the electrode holder and extended just below the tips of the electrodes. If this method of agitation is used, it is not necessary to rinse the electrodes between successive samples.
7. Read the pH immediately on the standardized pH meter. Record as soil pH in water, or pH_w.
8. Optional test: To determine the soil pH in 0.01*M* $CaCl_2$, add 1 drop (0.05 ml) of 1*M* $CaCl_2$ solution to the soil water suspension.
9. Stir intermittently for 30 min.
10. Insert electrodes, and read the pH on the standardized pH meter. Record as soil pH in 0.01*M* $CaCl_2$, or pH_s. Alternatively, the soil pH in 0.01*M* $CaCl_2$ may be determined directly by substituting 0.01*M* $CaCl_2$ for water in no. 3 above.
11. If the lime requirement is to be determined on the samples, save them for this purpose after reading the pH in water or 0.01*M* $CaCl_2$.

33 Nitrogen—Inorganic Forms[1]

33-3 EXTRACTION OF EXCHANGEABLE AMMONIUM,

33-3.2 Method

33-3.2.1 REAGENTS

1. Potassium chloride (KCl) solution, approximately 2*M*: Dissolve 1,500 g of reagent-grade KCl in 8 liters of water, and dilute the solution to 10 liters.

33-3.2.2 PROCEDURE

Place 10 g of soil in a 250-ml, widemouth bottle, and add 100 ml of 2*M* KCl. Stopper the bottle, and shake it on a mechanical shaker for 1 hour. Allow the soil-KCl suspension to settle until the supernatant liquid is clear (usually about 30 min), and perform the analyses described on aliquots of this liquid. If the KCl extract cannot be analyzed soon after its preparation (within 24 hours), filter the soil-KCl suspension (Whatman no. 42 filter paper), and store the filtrate in a refrigerator until analyses can be performed.

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24 Phosphorus

24-5.3 Phosphorus Soluble in Water

24-5.3.1 PRINCIPLES

This method is useful in measuring the P concentration in water or dilute salt (i.e., 0.01*M* $CaCl_2$) extracts of the soil and in displaced soil solutions and saturation extracts of soil. With soils low in available P, root absorption of P and growth of plants increase as P concentration increases in the soil solution up to a limit. As an index of P availability, the objective of this method is to determine the P concentration level in the soil extract that limits growth of plants. In soil testing practices, the water or dilute salt extracts represent an attempt to approximate the soil solution P concentration. A research objective is to obtain the soil solution and determine its composition so that the chemical environment of the plant roots may be defined in quantitative terms (Adams, 1974).

24-5.3.2 METHOD

24-5.3.2.1 Reagents.

1. Ammonium paramolybdate [$(NH_4)_6Mo_7O_{24} \cdot 4H_2O$]: Dissolve 12.0 g of ammonium paramolybdate in 250 ml of distilled water. Dissolve 0.2908 g of potassium antimony tartrate ($KSbO \cdot C_4H_4O_6$) in 100 ml of distilled water. Add these dissolved reagents to 1 liter of 5*N* sulfuric acid (H_2SO_4) (141 ml of conc H_2SO_4 diluted to 1 liter), mix thoroughly, and dilute with distilled water to 2 liters. Store in a Pyrex glass bottle in a dark and cool compartment (reagent A).
2. Ascorbic acid: Dissolve 1.056 g of ascorbic acid in 200 ml of reagent A, and mix. This ascorbic acid (reagent B) should be prepared as required because it does not keep more than 24 hours.

24-5.3.2.2 Procedure. Add 5 g of air-dry soil and 50 ml of distilled water to a flask suitable for continuous shaking. Shake the contents of the flask continuously for 5 min. Centrifuge the mixture until the solution is free of soil mineral particles. This usually occurs in 15 min in a high-speed Sorvall centrifuge at a setting of 100. Obtain clear extracts alternatively by repeated filtration through Whatman no. 42 filter paper. Return to the suspension the first portions coming through the filter paper.

Pipette aliquots containing 1 to 20 μg of P into 25-ml volumetric flasks. Add distilled water to increase the volume to 20 ml, and then add 4 ml of reagent B. Make to 25 ml volume and mix. The color is stable for 24 hours, and the maximum intensity develops in 10 min. The absorption maximum of the blue color formed in the presence of Sb is at 882 nm. Calibrate the method using a standard P solution. Prepare a blank with distilled water and 4 ml of reagent B.

24-5.3.2.3 Comments. Soils in California that showed more than 0.13 ppm of P in the water extract failed to respond in crop yields to P fertilization (Bingham, 1949; Martin & Buchanan, 1950; Martin & Mikkelsen, 1960). Thompson et al. (1960) found a high correlation between P uptake by sorghum (*Sorghum bicolor* L. Moench) and water-soluble P on 22 soils, most of which were acid. Fried and Shapiro (1956) observed a poor relation between water-soluble P and P uptake on eight acid soils for the initial extract but observed a much better correlation for the 14th successive extract. Olsen et al. (1954) observed a high correlation between water-soluble P and "A" values on some groups of soils.

Phosphorus concentration in solution usually increases as the amount of soil increases per unit volume of water. A saturation extract more nearly approaches the P concentration expected to be in a soil solution from which roots absorb P. Such an extract requires more time for preparation, and its analysis for P presents more difficulties. In some cases these factors may not be important, and the results from a saturation extract or the displaced soil solution may be most desirable. For more routine purposes and large numbers of samples, the 1:10 water extraction is more suitable.

The ascorbic acid method has proved to be reliable and less subject to interferences in color development than $SnCl_2$ methods, and the color is stable for 24 hours. A simple test of possible interference in the P analysis is provided by diluting the solution. If the diluted sample is proportionately greater or less in P concentration than indicated by the dilution factor, an interference is evident.

NITROGEN, AMMONIA

Method 350.3 (Potentiometric, Ion Selective Electrode)

STORET NO. Total 00610
Dissolved 00608

1. Scope and Application
    - 1.1 This method is applicable to the measurement of ammonia-nitrogen in drinking, surface and saline waters, domestic and industrial wastes.
    - 1.2 This method covers the range from 0.03 to 1400 mg NH_3–N/1. Color and turbidity have no effect on the measurements, thus, distillation may not be necessary.
2. Summary of Method
    - 2.1 The ammonia is determined potentiometrically using an ion selective ammonia electrode and a pH meter having an expanded millivolt scale or a specific ion meter.
    - 2.2 The ammonia electrode uses a hydrophobic gas-permeable membrane to separate the sample solution from an ammonium chloride internal solution. Ammonia in the sample diffuses through the membrane and alters the pH of the internal solution, which is sensed by a pH electrode. The constant level of chloride in the internal solution is sensed by a chloride selective ion electrode which acts as the reference electrode.
3. Sample Handling and Preservation
    - 3.1 Samples may be preserved with 2 ml of conc. H_2SO_4 per liter and stored at 4°C.
4. Interferences
    - 4.1 Volatile amines act as a positive interference.
    - 4.2 Mercury interferes by forming a strong complex with ammonia. Thus the samples cannot be preserved with mercuric chloride.
5. Apparatus
    - 5.1 Electrometer (pH meter) with expanded mV scale or a specific ion meter.
    - 5.2 Ammonia selective electrode, such as Orion Model 95–10 or EIL Model 8002–2.
    - 5.3 Magnetic stirrer, thermally insulated, and Teflon-coated stirring bar.
6. Reagents
    - 6.1 Distilled water: Special precautions must be taken to insure that the distilled water is free of ammonia. This is accomplished by passing distilled water through an ion exchange column containing a strongly acidic cation exchange resin mixed with a strongly basic anion exchange resin.
    - 6.2 Sodium hydroxide, 10N: Dissolve 400 g of sodium hydroxide in 800 ml of distilled water. Cool and dilute to 1 liter with distilled water (6.1).
    - 6.3 Ammonium chloride, stock solution: 1.0 ml = 1.0 mg NH_3–N. Dissolve 3.819 g NH_4Cl in water and bring to volume in a 1 liter volumetric flask using distilled water (6.1).

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6.4 Ammonium chloride, standard solution: 1.0 ml = 0.01 mg NH_3–N. Dilute 10.0 ml of the stock solution (6.3) to 1 liter with distilled water (6.1) in a volumetric flask.

NOTE 1: When analyzing saline waters, standards must be made up in synthetic ocean water (SOW); found in Nitrogen, Ammonia: Colorimetric, Automated Phenate Method (350.1).

7. Procedure

7.1 Preparation of standards: Prepare a series of standard solutions covering the concentration range of the samples by diluting either the stock or standard solutions of ammonium chloride.

7.2 Calibration of electrometer: Place 100 ml of each standard solution in clean 150 ml beakers. Immerse electrode into standard of lowest concentration and add 1 ml of 10N sodium hydroxide solution while mixing. Keep electrode in the solution until a stable reading is obtained.

NOTE 2: The pH of the solution after the addition of NaOH must be above 11.

Caution: Sodium hydroxide must not be added prior to electrode immersion, for ammonia may be lost from a basic solution.

7.3 Repeat this procedure with the remaining standards, going from lowest to highest concentration. Using semilogarithmic graph paper, plot the concentration of ammonia in mg NH_3–N/1 on the log axis vs. the electrode potential developed in the standard on the linear axis, starting with the lowest concentration at the bottom of the scale.

7.4 Calibration of a specific ion meter: Follow the directions of the manufacturer for the operation of the instrument.

7.5 Sample measurement: Follow the procedure in (7.2) for 100 ml of sample in 150 ml beakers. Record the stabilized potential of each unknown sample and convert the potential reading to the ammonia concentration using the standard curve. If a specific ion meter is used, read the ammonia level directly in mg NH_3–N/1.

8. Precision and Accuracy

8.1 In a single laboratory (EMSL), using surface water samples at concentrations of 1.00, 0.77, 0.19, and 0.13 mg NH_3–N/1, standard deviations were ±0.038, ±0.017, ±0.007, and ±0.003, respectively.

8.2 In a single laboratory (EMSL), using surface water samples at concentrations of 0.19 and 0.13 mg NH_3–N/1, recoveries were 96% and 91%, respectively.

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Test Method
The Determination of Inorganic Anions in Water by Ion Chromatography – Method 300.0

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1. Scope and Application

1.1 This method covers the determination of the following inorganic anions.

Method A.	Storet No. (Total)
Bromide	71870
Chloride	00940
Fluoride	00951
Nitrate-N	00620
Nitrite-N	00615
Ortho-Phosphate-P	70507
Sulfate	00945

Method B.	Storet No. (Total)
Chlorite	50074
Chlorate	
Bromate	

1.2 The matrices applicable to each method are shown below:

A. Drinking water, surface water, mixed domestic and industrial wastewaters, groundwater, reagent waters, solids (after extraction 2.3), leachates (when no acetic acid is used 2.4)

B. Drinking water and reagent waters.

1.3 The Single Laboratory Method Detection Limit (MDL, defined in Section 13) for the above analytes is listed in Tables 1A and 1B. The MDL for a specific matrix may differ from those listed, depending upon the nature of the sample.

1.4 Method A is recommended for drinking and waste waters. The multilaboratory range tested for each anion is as follows in mg/L:

Bromide	0.63 - 21.0
Chloride	0.78 - 26.0
Fluoride	0.26 - 8.49
Nitrate-N	0.42 - 14.0
Nitrite-N	0.36 - 12.0
Ortho-P	0.69 - 23.1
Sulfate	2.85 - 95.0

1.5 This method is recommended for use only by or under the supervision of analysts experienced in the use of ion chromatography and in the interpretation of the resulting ion chromatogram. Each analyst must demonstrate the ability to generate acceptable results with this method, using the procedure described in Section 10.2.

1.6 When this method is used to analyze unfamiliar samples for any of the above anions, anion identification should be supported by the use of

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fortified sample matrix covering the anions of interest. The fortification procedure is described in Section 11.6.

2. Summary of Method

2.1 A small volume of sample, typically 2 to 3 mL, is introduced into an ion chromatograph. The anions of interest are separated and measured, using a system comprised of a guard column, separator column, suppressor device, and conductivity detector.

2.2 The main differences between Method A and B are the separator columns, guard columns and eluents. Sections 6 and 7 will elicit the differences.

2.3 In order to use this method for solids an extraction procedure must be performed (See 11.7).

3. Definitions

3.1 Stock standard solution - a concentrated solution containing a single certified standard that is a method analyte. Stock standard solutions are used to prepare calibration standards.

3.2 Calibration standards (CAL) - a solution of analytes prepared in the laboratory from stock standard solutions and diluted as needed and used to calibrate the instrument response with respect to analytic concentration.

3.3 Quality control sample (QCS) - a solution containing known concentrations of analytes, prepared by a laboratory other than the laboratory performing the analysis. The analyzing laboratory uses this solution to demonstrate that it can obtain acceptable identifications and measurements with a method.

3.4 Performance evaluation sample (PE) - a solution of method analytes distributed by the Quality Assurance Research Division (QARD), Environmental Monitoring Systems Laboratory (EMSL-Cincinnati), USEPA, Cincinnati, Ohio, to multiple laboratories for analysis. A volume of the solution is added to a known volume of reagent *water and analyzed with procedures* used for samples. Results of analyses are used by the QARD to determine statistically the accuracy and precision that can be expected when a method is performed by a competent analyst. Analyte true values are unknown to the analyst.

3.5 Laboratory performance check standards (LPC) - a solution of analytes prepared in the laboratory by adding appropriate volumes of the stock standard solutions to reagent water used to evaluate the performance of the instrument system with respect to a *defined set of method criteria.*

3.6 Laboratory duplicates (LD) - two aliquots of the same sample that are treated exactly the same throughout laboratory analytical procedures. Analyses of laboratory duplicates indicate precision associated with laboratory procedures but not the sample collection, preservation, or storage procedures.

3.7 Field duplicates (FD) - two samples taken at the same time and placed under identical circumstances and treated exactly the same throughout field and laboratory procedures. Analyses of field duplicates indicate the precision associated with sample collection, preservation and storage, as well as with laboratory procedures.

3.8 Laboratory fortified sample matrix (LFM) - An aliquot of an environmental sample to which known quantities of the method analytes are added in the laboratory. The LFM is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the LFM corrected for background concentrations.

3.9 Laboratory fortified blank (LFB) - An aliquot of reagent water to which known quantities of the method analytes are added in the laboratory. The LFB is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control, and whether the laboratory is capable of making accurate and precise measurements at the required method detection limit.

4. Interferences

4.1 Interferences can be caused by substances with retention times that are similar to and overlap those of the anion of interest. Large amounts of an anion can interfere with the peak resolution of an adjacent anion. Sample dilution and/or fortification can be used to solve most interference problems.

4.2 The water dip or negative peak that elutes near and can interfere with the fluoride peak can usually be eliminated by the addition of the equivalent of 1 mL of concentrated eluent (7.3 100X) to 100 mL of each standard and sample.

4.3 Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and other sample processing apparatus that lead to discrete artifacts or elevated baseline in ion chromatograms.

4.4 Samples that contain particles larger than 0.45 microns and reagent solutions that contain particles larger than 0.20 microns require filtration to prevent damage to instrument columns and flow systems.

4.5 Any anion that is not retained by the column or only slightly retained will elute in the area of fluoride and interfere. Known coelution is caused by carbonate and other small organic anions. At concentrations of fluoride above 1.5 mg/L this interference may not be significant, however, it is the responsibility of the user to generate precision and accuracy information in each sample matrix.

4.6 The acetate anion elutes early during the chromatographic run. The retention times of the anions also seem to differ when large amounts of acetate are present. Therefore, this method is not recommended for leachates of solid samples when acetic acid is used for pH adjustment.

4.7 The quantitation of unretained peaks should be avoided, such as low molecular weight organic acids (formate, acetate, propionate, etc.) which are conductive and coelute with or near fluoride and would bias the fluoride quantitation in some drinking and most waste waters.

5. Safety

5.1 Normal, accepted laboratory safety practices should be followed during reagent preparation and instrument operation. No known carcinogenic materials are used in this method.

6. Apparatus and Materials

6.1 Balance - Analytical, capable of accurately weighing to the nearest 0.0001 g.

6.2 Ion chromatograph - Analytical system complete with ion chromatograph and all required accessories including syringes, analytical columns, compressed gasses and detectors.

6.2.1 Anion guard column: A pr[illegible]tor of the separator column. If omitted from the system the retention times will be shorter. Usually packed with a substrate the same as that in the separator column.

6.2.2 Anion separator column: This column produces the separation shown in Figures 1 and 2.

6.2.2.1 Anion separator column (Method A): The separation shown in Figure 1 was generated using a Dionex AS4A column (P/N 37041). An optional column may be used if comparable resolution of peaks is obtained, and the requirements of section 10.2 can be met.

6.2.2.2 Anion separator column (Method B). The separation shown in Figure 2 was generated using a Dionex AS9 column (P/N 42025). An optional column may be used if comparable resolution of peaks is obtained and the requirements of section 10.2 can be met.

6.2.3 Anion suppressor device: The data presented in this method was generated using a Dionex Anion Micro-Membrane Suppressor (P/N 37106).

6.2.4 Detector - Conductivity cell: approximately 1.25 µL internal volume, (Dionex, or equivalent) capable of providing data as required in section 10.2.

6.3 The Dionex AI-450 Data Chromatography Software was used to generate all the data in the attached tables. Systems using a stripchart recorder and integrator or other computer based data system may achieve approximately the same MDL's but the user should demonstrate this by the procedure outlined in Section 10.2.

7. Reagents and Consumable Materials

7.1 Sample bottles: Glass or polyethylene of sufficient volume to allow replicate analyses of anions of interest.

7.2 Reagent water: Distilled or deionized water, free of the anions of interest. Water should contain particles no larger than 0.20 microns.

7.3 Eluent solution (Method A and Method B): Sodium bicarbonate (CAS RN 144-55-8) 1.7 mM, sodium carbonate (CAS RN 497-19-8) 1.8 mM. Dissolve 0.2856 g sodium bicarbonate ($NaHCO_3$) and 0.3816 g of sodium carbonate (Na_2CO_3) in reagent water (7.2) and dilute to 2 liters.

7.4 Regeneration solution (MicroMembrane Suppressor): Sulfuric acid (CAS RN-7664-93-9) 0.025N. Dilute 2.8 mL conc. sulfuric acid (H_2SO_4) to 4 liters with reagent water.

7.5 Stock standard solutions, 1000 mg/L (1 mg/ml): Stock standard solutions may be purchased as certified solutions or prepared from ACS reagent grade materials (dried at 105°C for 30 min.) as listed below.

7.5.1 Bromide (Br^-) 1000 mg/L: Dissolve 1.2876 g sodium bromide (NaBr, CAS RN 7647-15-6) in reagent water and dilute to 1 liter.

7.5.2 Bromate (BrO_3^-) 1000 mg/L: Dissolve 1.3057 g of potassium bromate ($KBrO_3$, CAS RN 7758-01-2) in reagent water and dilute to 1 liter.

7.5.3 Chlorate (ClO_3^-) 1000 mg/L: Dissolve 1.2753 g sodium chlorate ($NaClO_3$, CAS RN 7775-09-9) in reagent water and dilute to 1 liter.

7.5.4 Chloride (Cl^-) 1000 mg/L: Dissolve 1.6485 g sodium chloride (NaCl, CAS RN 7647-14-5) in reagent water and dilute to 1 liter.

7.5.5 Chlorite (ClO_2^-) 1000 mg/L: Dissolve 1.3410 g of sodium chlorite ($NaClO_2$, CAS RN 7758-19-2) in reagent water and dilute to 1 liter.

7.5.6 Fluoride (F^-) 1000 mg/L: Dissolve 2.2100g sodium fluoride (NaF, CAS RN 7681-49-4) in reagent water and dilute to 1 liter.

7.5.7 Nitrate (NO_3^-–N) 1000 mg/L: Dissolve 6.0679 g sodium nitrate ($NaNO_3$, CAS RN 7631-99-4) in reagent water and dilute to 1 liter.

7.5.8 Nitrite (NO_2^-–N) 1000 mg/L: Dissolve 4.9257 g sodium nitrite ($NaNO_2$, CAS RN 7632-00-0) in reagent water and dilute to 1 liter.

7.5.9 Phosphate (HPO_4^{2-}–P) 1000 mg/L: Dissolve 4.3937 g potassium phosphate, monobasic (KH_2PO_4, CAS RN 7778-77-0) in reagent water and dilute to 1 liter.

7.5.10 Sulfate (SO_4^{2-}) 1000 mg/L. Dissolve 1.8141 g potassium sulfate (K_2SO_4, CAS RN 7778-80-5) in reagent water and dilute to 1 liter.

Note: Stability of standards. Stock standards (7.5) are stable for at least one month when stored at 4°C. Dilute working standards should be prepared weekly, except those that contain nitrite and phosphate should be prepared fresh daily.

8. Sample Collection, Preservation and Storage

8.1 Samples should be collected in scrupulously clean glass or polyethylene bottles.

8.2 Sample preservation and holding times for the anions that can be determined by this method are as follow.

Analyte	Preservation	Holding Time
Bromate	None required	28 days
Bromide	None required	28 days
Chlorate	None required	28 days
Chloride	None required	28 days
Chlorite	Cool to 4° C	immed
Fluoride	None required	28 days
Nitrate-N		
chlorinated	Cool to 4° C	28 days
nonchlorinated	conc H_2SO_4 pH < 2	14 days
Nitrite-N	Cool to 4° C	48 hours
O-Phosphate-P	Cool to 4° C	48 hours
Sulfate	Cool to 4° C	28 days

8.3 The method of preservation and the holding time for samples analyzed by this method are determined by the anions of interest. In a given sample, the anion that requires the most preservation treatment and the shortest holding time will determine the preservation treatment. It is recommended that all samples be cooled to 4° C and held no longer than 28 days for Method A and analyzed immediately for Method B.

9. Calibration and Standardization

9.1 Establish ion chromatographic operating parameters equivalent to those indicated in Table 1A or 1B.

9.2 For each analyte of interest, prepare calibration standards at a minimum of three concentration levels and a blank by adding accurately measured volumes of one or more stock standards (7.5) to a volumetric flask and diluting to volume with reagent water. If a sample analyte concentration exceeds the calibration range the sample may be diluted to fall within the range. If this is not possible then three new calibration concentrations must be chosen, two of which must bracket the concentration of the sample analyte of interest. Each attenuation range of the instrument used to analyze a sample must be calibrated individually.

9.3 Using injections of 0.1 to 1.0 mL (determined by injection loop volume) of each calibration standard, tabulate peak height or area responses against the concentration. The results are used to prepare a calibration curve for each analyte. During this procedure, retention times must be recorded.

9.4 The calibration curve must be verified on each working day, or whenever the anion eluent is changed, and after every 20 samples. If the response or retention time for any analyte varies from the expected values by more than ±10%, the test must be repeated, using fresh calibration standards. If the results are still more than ±10%, a new calibration curve must be prepared for that analyte.

9.5 Non-linear response can result when the separator column capacity is exceeded (overloading). The response of the detector to the sample when diluted 1:1, and when not diluted, should be compared. If the calculated responses are the same, samples of this total anionic concentration need not be diluted.

10. Quality Control

10.1 Each laboratory using this method should have a formal quality control program. The minimum requirements of this program consist of an initial demonstration of laboratory capability (10.2) and the analysis of fortified samples as a continuing check on performance. The laboratory should maintain performance records to define and document the quality of data that are generated.

10.1.1 In recognition of the rapid advances occurring in chromatography, the analyst is permitted certain options to improve the separations or lower the cost of measurements. Each time such modifications to the method are made, the analyst is required to repeat the procedure in Section 10.2.

10.1.2 The laboratory should fortify and analyze a minimum of 10% of all samples to monitor continuing laboratory performance. A minimum of 10% of all samples should be run in duplicate.

10.2 Before performing any analyses, the analyst should demonstrate the ability to generate acceptable accuracy and precision with this method, using a laboratory performance standard.

10.2.1 Select a representative check concentration for each analyte to be measured. Using stock standards, prepare a laboratory performance check sample concentrate in reagent water 100 times more concentrated than the selected concentrations.

10.2.2 Using a pipet, add 1.00 mL of the check sample concentrate (10.2.1) to each of a minimum of four 100-mL aliquots of reagent water. Analyze the aliquots according to the procedure in Section 11.

10.2.3 Calculate the average percent recovery, (R), and the standard deviation(s) of the percent recovery, for the results.

10.2.4 Using the appropriate data from Table 2, determine the recovery and single operator precision expected for the method, and compare these results to the values calculated in Section 10.2.3. If the data are not comparable within control limits (10.3.1), review potential problem areas and repeat the test.

10.3 The analyst must calculate method performance criteria and define the performance of the laboratory for each fortified concentration of analyte being measured.

10.3.1 Calculate upper and lower control limits for method performance as follows:

Upper Control Limit (UCL) = $R + 3\ s$
Lower Control Limit (LCL) = $R - 3\ s$

where R and s are calculated as in Section 10.2.3. The UCL and LCL can be used to construct control charts that are useful in observing trends in performance.

10.4 The laboratory should develop and maintain separate accuracy statements of laboratory performance for each matrix being analyzed by the laboratory. An accuracy statement for the method is defined as $R \pm s$. The accuracy statement should be developed by the analyses of four aliquots of water or wastewater, as described in Section 10.2.2, followed by the calculation of R and s.

10.5 Before processing any samples, the analyst must demonstrate through the analysis of an aliquot of reagent water that all glassware and reagent interferences are under control. Each time there is a change in reagents, a laboratory reagent blank must be processed as a safeguard against laboratory contamination.

10.6 It is recommended that the laboratory adopt additional quality assurance practices for use with this method. The specific practices that are most productive depend upon the needs of the laboratory and the nature of the samples. Field duplicates may be analyzed to monitor the precision of the sampling technique. When doubt exists over the identification of a peak in the chromatogram, confirmatory techniques such as sample dilution and fortification, must be used. Whenever possible, the laboratory should perform analysis of quality control check samples and participate in relevant performance evaluation sample studies.

10.7 In order to verify that standards have been prepared correctly a reference standard check should be performed using a standard of known concentration prepared by an independent source.

10.8 With each batch of samples processed analyze a single laboratory fortified blank containing each analyte of concern at a concentration at or near those used in the reagent water data in Tables 2A or 2B. If more than 20 samples are run in a batch analyze one LFB for every 20 samples. Evaluate the accuracy by compairing to Tables 2A of 2B. If acceptable data cannot be obtained, locate the problem and correct it.

10.9 At least quarterly, replicates of LFBs should be analyzed to determine the precision of the laboratory measurements. Add these results to the ongoing control charts to document data quality.

10.10 When using Part B, the analyst should be aware of the purity of the reagents used to prepare standards. Allowances must be made when the solid materials are less than 99% pure.

11. Procedure

11.1 Tables 1A and 1B summarize the recommended operating conditions for the ion chromatograph. Included in this table are estimated retention times that can be achieved by this method. Other columns, chromatographic conditions, or detectors may be used if the requirements of Section 10.2 are met.

11.2 Check system calibration daily and , if required, recalibrate as described in Section 9.

11.3 Load and inject a fixed amount of well mixed sample. Flush injection loop thoroughly, using each new sample. Use the same size loop for standards and samples. Record the resulting peak size in area or peak height units. An automated constant volume injection system may also be used.

11.4 The width of the retention time window used to make identifications should be based upon measurements of actual retention time variations of standards over the course of a day. Three times the standard deviation of a retention time can be used to calculate a suggested window size for each analyte. However, the experience of the analyst should weigh heavily in the interpretation of chromatograms.

11.5 If the response for the peak exceeds the working range of the system, dilute the sample with an appropriate amount of reagent water and reanalyze.

11.6 If the resulting chromatogram fails to produce adequate resolution, or if identification of specific anions is questionable, fortify the sample with an appropriate amount of standard and reanalyze.

Note: Retention time is inversely proportional to concentration. Nitrate and sulfate exhibit the greatest amount of change, although all anions are affected to some degree. In some cases this peak migration may produce poor resolution or identification.

11.7 The following extraction should be used for solid materials. Add an amount of reagent water equal to ten times the weight of dry solid material taken as a sample. This slurry is mixed together for ten minutes using a magnetic stirring device. Filter the resulting slurry before injecting using a 0.45 μ membrane type filter. This can be the type that attaches directly to the end of the syringe. Care should be taken to show that good recovery and identification of peaks is obtained with the users matrix through the use of spikes.

12. Calculation

12.1 Prepare separate calibration curves for each anion of interest by plotting peak size in area, or peak height units of standards against concentration values. Compute sample concentration by comparing sample peak response with the standard curve.

12.2 Report results in mg/L.

12.3 Report NO_2^- as N
NO_3^- as N
HPO_4^{2-} as P

13. Precision and Accuracy - Method Detection Limit

13.1 The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The MDL concentrations listed in Table 1A and 1B were obtained using reagent waters.

13.2 Single operator accuracy and precision for reagent, drinking and surface water, and mixed domestic and industrial wastewater are listed in Table 2A and 2B.

13.3 Multiple laboratory accuracy and precision data for reagent, drinking and waste water using method A are given for each anion in tables 3 through 9. Data from nineteen laboratories were used for this data.

13.4 Some of the bias statements, for example chloride and sulfate, may be misleading due to spiking small increments of the anion into large naturally occuring concentrations of the same anion.

14. References

14.1 "Determination of Inorganic Disinfection By-Products by Ion Chromatography", J. Pfaff, C. Brockhoff. J. Am. Water Works Assoc., Vol 82, No. 4, pg 192.

14.2 Standard Methods for the Examination of Water and Wastewater, Method 4110B, "Anions by Ion Chromatography" proposed for the supplement 17th Edition of Standard Methods.

14.3 Dionex, System 4000 Operation and Maintenance Manual, Dionex Corp., Sunnyvale, California 94086. 1988.

14.4 Method Detection Limit (MDL) as described in "Trace Analyses for Wastewater," J. Glaser, D. Foerst, G. McKee, S. Quave, W. Budde, Environmental Science and Technology, Vol. 15, Number 12, page 1426, December 1981.

Copies of this method provided courtesy Dionex Corporation.

Table 1A. Chromatographic Conditions and Detection Limits in Reagent Water (Method A)

Analyte	Peak #*	Retention Time (min)	MDL (mg/L)
Fluoride	1	1.2	0.01
Chloride	2	1.7	0.02
Nitrite-N	3	2.0	0.004
Bromide	4	2.9	0.01
Nitrate-N	5	3.2	0.002
O-Phosphate-P	6	5.4	0.003
Sulfate	7	6.9	0.02

Standard Conditions:

Columns: as specified in 6.2.2.1
Detector: as specified in 6.2.4
Eluent: as specified in 7.3.1
Pump Rate: 2.0 mL/min.
Sample Loop: 50 µL

MDL calculated from data system using a y-axis selection of 1000 ns and with a stripchart recorder with an attenuator setting of 1 uMHO full scale.

* See figure 1

Table 1B. Chromatographic Conditions and Detection Limits in Reagent Water (Method B)

Analyte	Peak #*	Retention Time (min)	MDL (mg/L)
Chlorite	1	2.8	0.01
Bromate	2	3.2	0.02
Chlorate	4	7.1	0.003

Standard Conditions:

Column: as specified in 6.2.2.2
Detector: as specified in 6.2.4
Eluent: as specified in 7.3
Pump Rate: 1.0 mL/min.
Sample Loop: 50 µL
Attentuation - 1
y - axis - 500 ns

*See figure 2

Table 2A. Single-Operator Accuracy and Precision of Standard Anions (Method A)

Analyte	Sample Type	Spike (mg/L)	Number of Replicates	Mean Recovery %	Standard Deviation (mg/L)
Bromide	RW	5.0	7	99	0.08
	DW	5.0	7	105	0.10
	SW	5.0	7	95	0.13
	WW	5.0	7	105	0.34
	GW	5.0	7	92	0.34
	SD	2.0	7	82	0.06
Chloride	RW	20.0	7	96	0.35
	DW	20.0	7	108	1.19
	SW	10.0	7	86	0.33
	WW	20.0	7	101	5.2
	GW	20.0	7	114	1.3
	SD	20.0	7	90	0.32
Fluoride	RW	2.0	7	91	0.05
	DW	1.0	7	92	0.06
	SW	1.0	7	73	0.05
	WW	1.0	7	87	0.07
	GW	0.4	7	95	0.07
	SD	5.0	7	101	0.35
Nitrate-N	RW	10.0	7	103	0.21
	DW	10.0	7	104	0.27
	SW	10.0	7	93	0.17
	WW	10.0	7	101	0.82
	GW	10.0	7	97	0.47
	SD	10.0	7	82	0.28
Nitrite-N	RW	10.0	7	97	0.14
	DW	10.0	7	121	0.25
	SW	5.0	7	92	0.14
	WW	5.0	7	91	0.50
	GW	10.0	7	96	0.35
	SD	2.0	7	98	0.08
O-Phosphate-P	RW	10.0	7	99	0.17
	DW	10.0	7	99	0.26
	SW	10.0	7	98	0.22
	WW	10.0	7	106	0.85
	GW	10.0	7	95	0.33
Sulfate	RW	20.0	7	99	0.40
	DW	50.0	7	105	3.35
	SW	40.0	7	95	1.7
	WW	40.0	7	102	6.4
	GW	40.0	7	112	3.2

RW = Reagent Water
DW = Drinking Water
SW = Surface Water
WW = Mixed Domestic and Industrial Wastewater
GW = Groundwater
SD = USEPA QC Solid (Shale)

Table 2B. Single-Operator Accuracy and precision of By-Products (Method B)

Analyte	Sample Spike Type	Spike (mg/L)	Number of Replicates	Mean Recovery %	Standard Deviation (mg/L)
Bromate	RW	5.0	7	103	0.07
		1.0	7	98	0.04
		0.1	7	155	0.005
		0.05	7	122	0.01
	DW	5 0	7	95	0.04
		1.0	7	85	0.02
		0.1	7	98	0.005
		0.05	7	98	0.005
Chlorate	RW	5.0	7	101	0.06
		1.0	7	97	0.01
		0.1	7	100	0.01
		0.05	7	119	0.05
	DW	5.0	7	101	0.04
		1.0	7	115	0.01
		0.1	7	121	0.005
		0.05	7	110	0.01
Chlorite	RW	5.0	7	100	0.04
		1.0	7	98	0.01
		0.1	7	86	0.01
		0.05	7	94	0.01
	DW	5.0	7	96	0.03
		1.0	7	100	0.02
		0.1	7	76	0.00
		0.05	7	96	0.01

RW = Reagent Water
DW = Drinking Water

Table 3. Determination of Bias for Fluoride

Water	Am't Added mg/L	Am't Found mg/L	S_t	S_o	Bias %
Reagent	0.26	0.25	0.08	0.11	-3.8
	0.34	0.29	0.11		-14.7
	2.12	2.12	0.07	0.12	0.0
	2.55	2.48	0.14		-2.7
	6.79	6.76	0.20	0.19	-0.4
	8.49	8.46	0.30		-0.4
Drinking	0.26	0.24	0.08	0.05	-7.7
	0.34	0.34	0.11		0.0
	2.12	2.09	0.18	0.06	-1.4
	2.55	2.55	0.16		0.0
	6.79	6.84	0.54	0.25	+0.7
	8.49	8.37	0.75		-1.4
Waste	0.26	0.25	0.15	0.06	-3.8
	0.34	0.32	0.08		-5.9
	2.12	2.13	0.22	0.15	+0.5
	2.55	2.48	0.16		-2.7
	6.79	6.65	0.41	0.20	-2.1
	8.49	8.27	0.36		-2.6

Table 4. Determination of Bias for Chloride

Water	Am't Added mg/L	Am't Found mg/L	S_t	S_o	Bias %
Reagent	0.78	0.79	0.17	0.29	+1.3
	1.04	1.12	0.46		+7.7
	6.50	6.31	0.27	0.14	-2.9
	7.80	7.76	0.39		-0.5
	20.8	20.7	0.54	0.62	-0.5
	26.0	25.9	0.58		-0.4
Drinking	0.78	0.54	0.35	0.20	-30.8
	1.04	0.51	0.38		-51.0
	6.50	5.24	1.35	1.48	-19.4
	7.80	6.02	1.90		-22.8
	20.8	20.0	2.26	1.14	-3.8
	26.0	24.0	2.65		-7.7
Waste	0.78	0.43	0.32	0.39	-44.9
	1.04	0.65	0.48		-37.5
	6.50	4.59	1.82	0.83	-29.4
	7.80	5.45	2.02		-30.1
	20.8	18.3	2.41	1.57	-11.8
	26.0	23.0	2.50		-11.5

Table 5. Determination of Bias for Nitrite - Nitrogen

Water	Am't Added mg/L	Am't Found mg/L	S_t	S_o	Bias %
Reagent	0.36	0.37	0.04	0.04	+2.8
	0.48	0.48	0.06		0.0
	3.00	3.18	0.12	0.06	+6.0
	3.60	3.83	0.12		+6.4
	9.60	9.84	0.36	0.26	+2.5
	12.0	12.1	0.27		+0.6
Drinking	0.36	0.30	0.13	0.03	-16.7
	0.48	0.40	0.14		-16.7
	3.00	3.02	0.23	0.12	+0.7
	3.60	3.62	0.22		+0.6
	9.60	9.59	0.44	0.28	-0.1
	12.0	11.6	0.59		-3.1
Waste	0.36	0.34	0.06	0.04	-5.6
	0.48	0.46	0.07		-4.2
	3.00	3.18	0.13	0.10	+6.0
	3.60	3.76	0.18		+4.4
	9.60	9.74	0.49	0.26	+1.5
	12.0	12.0	0.56		+0.3

Table 6. Determination of Bias for Bromide

Water	Am't Added mg/L	Am't Found mg/L	S_t	S_o	Bias %
Reagent	0.63	0.69	0.11	0.05	+9.5
	0.84	0.85	0.12		+1.2
	5.24	5.21	0.22	0.21	-0.6
	6.29	6.17	0.35		-1.9
	16.8	17.1	0.70	0.36	+1.6
	21.0	21.3	0.93		+1.5
Drinking	0.63	0.63	0.13	0.04	0.0
	0.84	0.81	0.13		-3.6
	5.24	5.11	0.23	0.13	-2.5
	6.29	6.18	0.30		-1.7
	16.8	17.0	0.55	0.57	+0.9
	21.0	20.9	0.65		-0.4
Waste	0.63	0.63	0.15	0.09	0.0
	0.84	0.85	0.15		+1.2
	5.24	5.23	0.36	0.11	-0.2
	6.29	6.27	0.46		-0.3
	16.8	16.6	0.69	0.43	-1.0
	21.0	21.1	0.63		+0.3

Table 7. Determination of Bias for Nitrite - Nitrogen

Water	Am't Added mg/L	Am't Found mg/L	S_t	S_o	Bias %
Reagent	0.42	0.42	0.04	0.02	0.0
	0.56	0.56	0.06		0.0
	3.51	3.34	0.15	0.08	-4.8
	4.21	4.05	0.28		-3.8
	11.2	11.1	0.47	0.34	-1.1
	14.0	14.4	0.61		+2.6
Drinking	0.42	0.46	0.08	0.03	+9.5
	0.56	0.58	0.09		+3.6
	3.51	3.45	0.27	0.10	-1.7
	4.21	4.21	0.38		0.0
	11.2	11.5	0.50	0.48	+2.3
	14.0	14.2	0.70		+1.6
Waste	0.42	0.36	0.07	0.06	-14.6
	0.56	0.40	0.16		-28.6
	3.51	3.19	0.31	0.07	-9.1
	4.21	3.84	0.28		-8.8
	11.2	10.9	0.35	0.51	-3.0
	14.0	14.1	0.74		+0.4

Table 8. Determination of Bias for Ortho-Phosphate

Water	Am't Added mg/L	Am't Found mg/L	S_t	S_o	Bias %
Reagent	0.69	0.69	0.06	0.06	0.0
	0.92	0.98	0.15		+6.5
	5.77	5.72	0.36	0.18	-0.9
	6.92	6.78	0.42		-2.0
	18.4	18.8	1.04	0.63	+2.1
	23.1	23.2	0.35		+0.4
Drinking	0.69	0.70	0.17	0.17	+1.4
	0.92	0.96	0.20		+4.3
	5.77	5.43	0.52	0.40	-5.9
	6.92	6.29	0.72		-9.1
	18.4	18.0	0.68	0.59	-2.2
	23.1	22.6	1.07		-2.0
Waste	0.68	0.64	0.26	0.09	-7.2
	0.92	0.82	0.28		-10.9
	5.77	5.18	0.66	0.34	-10.2
	6.92	6.24	0.74		-9.8
	18.4	17.6	2.08	1.27	-4.1
	23.1	22.4	0.87		-3.0

Table 9. Determination of Bias for Sulfate

Water	Am't Added mg/L	Am't Found mg/L	S_t	S_o	Bias %
Reagent	2.85	2.83	0.32	0.52	-0.7
	3.80	3.83	0.92		+0.8
	23.8	24.0	1.67	0.68	+0.8
	28.5	28.5	1.56		-0.1
	76.0	76.8	3.42	2.33	+1.1
	95.0	95.7	3.59		+0.7
Drinking	2.85	1.12	0.37	0.41	-60.7
	3.80	2.26	0.97		-40.3
	23.8	21.8	1.26	0.51	-8.4
	28.5	25.9	2.48		-9.1
	76.0	74.5	4.63	2.70	-2.0
	95.0	92.3	5.19		-2.8
Waste	2.85	1.89	0.37	0.24	-33.7
	3.80	2.10	1.25		-44.7
	23.8	20.3	3.19	0.58	-14.7
	28.5	24.5	3.24		-14.0
	76.0	71.4	5.65	3.39	-6.1
	95.0	90.3	6.80		-5.0

Method A

Peak	Ret. Time	Ion	mg/L
1	1.17	F^-	2
2	1.73	Cl^-	20
3	2.02	NO_2^-	2
4	2.95	Br^-	2
5	3.20	NO_3^-	10
6	5.38	HPO_4^{2-}	2
7	6.92	SO_4^{2-}	60

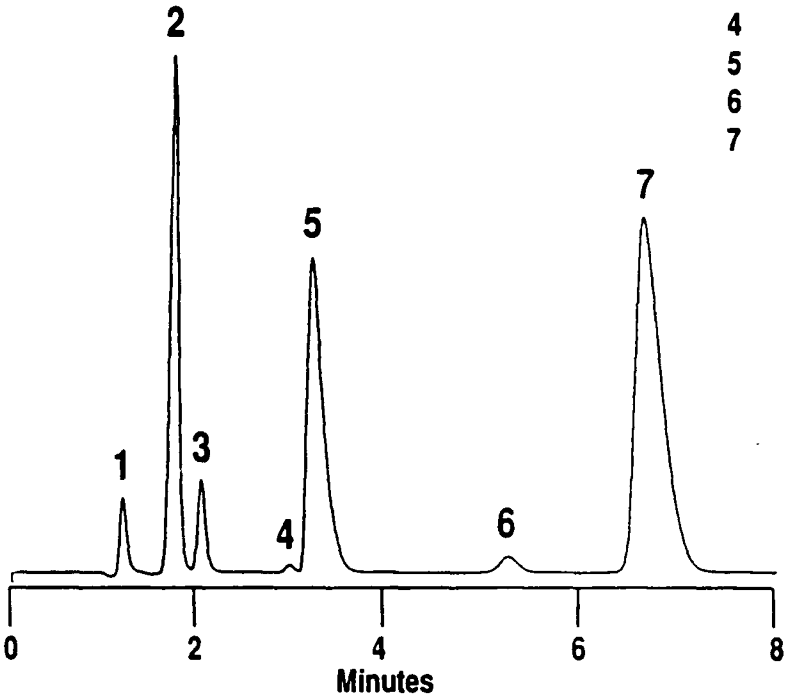

Figure 1. Chromatogram showing separation using the AS4A column

Method B

Peak	Ret. Time	Ion	mg/L
1	2.75	ClO_2^-	0.1
2	3.23	BrO_3^-	0.1
3	3.63	Cl^-	0.1
4	7.08	ClO_3^-	0.1

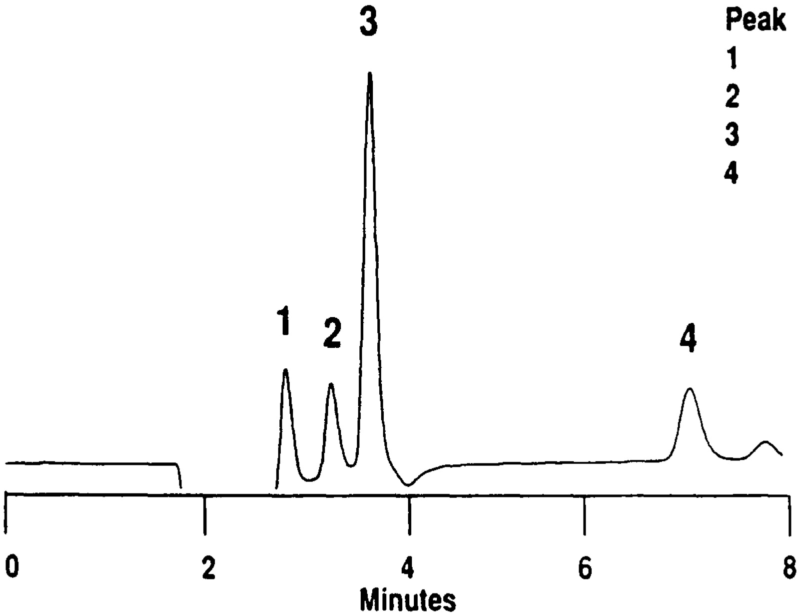

Figure 2. Chromatogram showing separation using the AS9 column

ARAR IDENTIFICATION FORM

McClellan AFB - Soil Vapor Extraction Pilot

AGENCY: SAC. METRO AIR QUALITY MANAGEMENT DISTRICT

CONTACT PERSON & PHONE NUMBER:
JORGE DeGUZMAN PHONE: (916) 386-7027

AIR EMISSIONS

1) Action-specific ARARs:

SMAQMD Rule 202, Section 301 - BACT requirements
SMAQMD Rule 401 - Ringelman Chart (20% opacity limit)
SMAQMD Rule 403 - Fugitive Dust

2) Chemical-specific ARARs:

SMAQMD Rule 202, Section 301 - BACT requirements
SMAQMD Rule 202, Section 302 - Offsets
SMAQMD Rule 402 - Nuisance/Health Risk Assessments

3) Site-specific ARARs:

SMAQMD Rule 202, Section 301 - BACT requirements
SMAQMD Rule 202, Section 302 - Offsets
SMAQMD Rule 402 - Nuisance/Health Risk Assessments

RETURN TO: Mark Malinowski
DTSC - SITE MITIGATION
10151 CROYDON WAY, SUITE 3
SACRAMENTO, CA 95827

ARAR IDENTIFICATION FORM

McClellan AFB - Soil Vapor Extraction Pilot

AGENCY:

DTSC - Region 1 - Facility Permitting Branch

CONTACT PERSON & PHONE NUMBER:

Eric Hong, (916) 855-7726

~~AIR EMISSIONS~~

1) Action-specific ARARs:

Miscellaneous Treatment Unit Performance Standards: 22CCR 66264.601
HW Management Process Vents: 40CFR 264 Subpart AA(264.1030)
Incinerator Performance Standards: 22CCR 66264.343, 66264.345

2) Chemical-specific ARARs:

Characteristics of Toxicity: 22CCR 66261.24
RCRA Listing of Waste: 22CCR Chapter 11, Article 4

3) Site-Specific ARARs:

Facility Location: 22CCR 66270.14(b)(11)
Facility Security: 22CCR 66264.14
Location Standards: 22CCR 66264.18

Return to: Mark Malinowski
DTSC, SITE MITIGATION
10151 Croydon Way, Suite 3
Sacramento, CA 95827

FORM 311
EMERGENCY TELEPHONE NUMBERS

Police Department	Address:	2852nd SPS McClellan AFB	Phone: 916/643-6168 112 911 (off-base)
Fire Department	Address:	2852nd DEF/ABG McClellan AFB	Phone: 916/643-5622 117 911 (off-base)
Paramedic	Address:		Phone: 116 911 (off-base)
Fire Report	Address:		Phone: 117 911 (off-base)
Ambulance Service	Address:		Phone: 116 911 (off-base)
Water Department	Address:		Phone: 916/643-4875 366-2000 (off-base)
Gas Utility	Address:		Phone: 916/643-4875 383-2323 (off-base)
Electric Utility	Address:		Phone: 916/643-4875 383-2323 (off-base)
Telephone Utility	Address:		Phone: 916/643-4875 811-9000 (off-base)
Hospital	Address:	American River Hosp. 4747 Engle Road Carmichael, CA (off-base)	Phone: 916/643-5420 848-2100 (off-base)
Owner	Address:		Phone: Contact:

This notice is located at :____________________________

FORM 533

RECORD OF HAZARDOUS WASTE FIELD ACTIVITY

Site Name: McClellan Air Force Base; California
Site Safety Coordinator: Barry Collom/CVO
Project Number: SAC28722.38
Record of Activities For (Dates):

Empl. Number	Employee Name	Total Days Onsite	Days at the Site in			or	Number of Days as SSC			Activities Employees Performed While Onsite
			Level B	Level C	Level D		Level B	Level C	Level D	

Signature of SSC: ______________________

Material Safety Data Sheet
Required under USDL Safety and Health Regulations for Shipyard Employment (29 CFR 1915)

U.S. Department of Labor
Occupational Safety and Health Administration

OMB No. 1218-0072
Expiration Date 05/31/86

PREPARED 1/10/86

tion I

Manufacturer's Name: [illegible]CONOX, INC.
Emergency Telephone Number: (212) 473-1300
Address (Number, Street, City, State, and ZIP Code): 215 PARK AVENUE SOUTH
NEW YORK, N.Y. 10003
Chemical Name and Synonyms: N.A.
Trade Name and Synonyms: ALCONOX
C6300-1, C6301-1, C6301-2,-3,-4,-5
Chemical Family: ANIONIC DETERGENT
Formula: N.A.

Section II - Hazardous Ingredients

A-DS1-S02

Paints, Preservatives, and Solvents	%	TLV (Units)	Alloys and Metallic Coatings	%	TLV (Units)
Pigments NONE			Base Metal NONE		
Catalyst NONE			Alloys NONE		
Vehicle NONE			Metallic Coatings NONE		
Solvents NONE			Filler Metal Plus Coating or Core Flux NONE		
Additives NONE			Others NONE		
Others NONE					

azardous Mixtures of Other Liquids, Solids or Gases	%	TLV (Units)
NONE		

Section III - Physical Data

Boiling Point (°F)	N.A.	Specific Gravity (H_2O=1)	N.A.
Vapor Pressure (mm Hg.)	N.A.	Percent Volatile by Volume (%)	N.A.
Vapor Density (AIR=1)	N.A.	Evaporation Rate ________ =1)	N.A.

Solubility in Water: APPRECIABLE
Appearance and Odor: WHITE POWDER INTERSPERSED WITH CREAM COLORED FLAKES - ODORLESS

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used) NONE	Flammable Limits N.A.	Lel N.A.	Uel N.A.

Extinguishing Media: WATER, CO_2, DRY CHEMICAL, FOAM, SAND/EARTH
Special Fire Fighting Procedures: FOR FIRES INVOLVING THIS MATERIAL, DO NOT ENTER WITHOUT PROTECTIVE EQUIPMENT AND SELF CONTAINED BREATHING APPARATUS
l Fire and Explosion Hazards: NONE

Form OSHA-20
Rev. 5/84

Section V - Health Hazard Data

Threshold Limit Value
NO DATA AVAILABLE - TREAT AS NUISANCE DUST

Effects of Overexposure
PROLONGED EXPOSURE TO DUST MAY IRRITATE MUCOUS MEMBRANES

Emergency First Aid Procedures
EYES - FLUSH WITH PLENTY OF WATER FOR 15 MINUTES, SKIN-FLUSH WITH PLENTY OF WATER. INGESTION - DRINK LARGE QUANTITIES OF WATER TO DILUTE MATERIAL. GET MEDICAL ATTENTION FOR DISCOMFORT.

Section VI - Reactivity Data

Stability	Unstable		Conditions to Avoid NONE
	Stable X		

Incompatability (Materials to Avoid)
AVOID STRONG ACIDS

Hazardous Decomposition Products
MAY RELEASE CO_2 GAS ON BURNING

Hazardous Polymerization	May Occur		Conditions to Avoid NONE
	Will Not Occur X		

Section VII - Spill or Leak Procedures

Steps to be Taken in Case Material is Released or Spilled
MATERIAL FOAMS PROFUSELY, SHOVEL AND RECOVER AS MUCH AS POSSIBLE. RINSE REMAINDER TO SEWER. MATERIAL IS COMPLETELY BIODEGRADABLE.

Waste Disposal Method
SMALL QUANTITIES MAY BE DISPOSED OF IN SEWER. LARGE QUANTITIES SHOULD BE DISPOSED OF ACCORDING TO LOCAL REQUIREMENTS FOR NON-HAZARDOUS DETERGENT

Section VIII - Special Protection Information

Respiratory Protection (Specify Type)
DUST MASK

Ventilation	Local Exhaust NORMAL	Special N.A.
	Mechanical (General) N.A.	Other N.A.

Protective Gloves USEFUL - NOT REQUIRED	Eye Protection USEFUL - NOT REQUIRED

Other Protective Equipment
NOT REQUIRED

Section IX - Special Precautions

Precautions to be Taken in Handling and Storing
SHOULD BE STORED IN A DRY AREA TO PREVENT CAKING

Other Precautions
NO SPECIAL REQUIREMENTS OTHER THAN THE GOOD INDUSTRIAL HYGIENE AND SAFETY PRACTICES EMPLOYED WITH ANY INDUSTRIAL CHEMICAL.

LIQUID AIR CORPORATION
INDUSTRIAL GASES DIVISION

Material Safety Data Sheet

PRODUCT NAME
Hydrogen

TELEPHONE (415) 977-6500
EMERGENCY RESPONSE INFORMATION ON PAGE 2

LIQUID AIR CORPORATION **INDUSTRIAL GASES DIVISION** One California Plaza, Suite 350 2121 N. California Blvd. Walnut Creek, California 94596	**TRADE NAME AND SYNONYMS** Hydrogen, Normal Hydrogen, Water Gas	**CAS NUMBER** 1333-74-0
	CHEMICAL NAME AND SYNONYMS Hydrogen	
ISSUE DATE AND REVISIONS OCTOBER 1, 1985 CORPORATE SAFETY DEPT.	**FORMULA** H_2 **MOLECULAR WEIGHT** 2.016	**CHEMICAL FAMILY** Inorganic flammable gas

HEALTH HAZARD DATA

TIME WEIGHTED AVERAGE EXPOSURE LIMIT Hydrogen is defined as a simple asphyxiant. Oxygen levels should be maintained at greater than 18 molar percent at normal atmospheric pressure which is equivalent to a partial pressure of 135 mm Hg. (ACGIH, 1984-85)

SYMPTOMS OF EXPOSURE

Inhalation: High concentrations of hydrogen so as to exclude an adequate supply of oxygen to the lungs causes dizziness, deeper breathing due to air hunger, possible nausea and eventual unconsciousness.

TOXICOLOGICAL PROPERTIES

Hydrogen is inactive biologically and essentially nontoxic; therefore, the major property is the exclusion of an adequate supply of oxygen to the lungs.

Listed as Carcinogen or Potential Carcinogen	National Toxicology Program	Yes ☐ No ☒	I.A.R.C. Monographs	Yes ☐ No ☒	OSHA	Yes ☐ No ☒

RECOMMENDED FIRST AID TREATMENT

PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO HYDROGEN. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS AND BE COGNIZANT OF EXTREME FIRE AND EXPLOSION HAZARD.

Inhalation: Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. Unconscious persons should be moved to an uncontaminated area, given mouth-to-mouth resuscitation and supplemental oxygen. Medical assistance should be sought immediately.

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES

Hydrogen is flammable over a very wide range in air.

PHYSICAL DATA

BOILING POINT -422.98°F (-252.77°C)	**LIQUID DENSITY AT BOILING POINT** 4.4307 lb/ft^3 (70.973 kg/m^3)
VAPOR PRESSURE @ 70°F (21.1°C) above the critical temp. of -399.84°F (-239.91°C)	**GAS DENSITY AT 70°F 1 atm** .005209 lb/ft^3 (.08344 kg/m^3)
SOLUBILITY IN WATER @ 68°F (20°C) Bunsen coefficient = .0178	**FREEZING POINT** -434.565°F (-259.203°C)

APPEARANCE AND ODOR

Colorless, odorless gas. Specific gravity @70°F (Air = 1.0) is .07.

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED) Gas	**AUTO IGNITION TEMPERATURE** 1058°F (570°C)	**FLAMMABLE LIMITS % BY VOLUME** LEL = 4; UEL = 74.5

EXTINGUISHING MEDIA Water, carbon dioxide, dry chemical	**ELECTRICAL CLASSIFICATION** Class 1, Group B

SPECIAL FIRE FIGHTING PROCEDURES

If possible, stop the flow of hydrogen. Cool surrounding containers with water spray. Hydrogen burns with an almost invisible flame of relatively low thermal radiation.

UNUSUAL FIRE AND EXPLOSION HAZARDS

drogen is very light and rises very rapidly in air. Should a hydrogen fire be extinguished and the flow of gas continue, increase ventilation to prevent an

(Continued on last page.)

REACTIVITY DATA

STABILITY		**CONDITIONS TO AVOID**
Unstable		
Stable	X	

INCOMPATIBILITY (Materials to avoid)

Oxidizers

HAZARDOUS DECOMPOSITION PRODUCTS

None

HAZARDOUS POLYMERIZATION		**CONDITIONS TO AVOID**
May Occur		
Will Not Occur	X	

SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Evacuate all personnel from affected area. Use appropriate protective equipment. If leak is in user's equipment, be certain to purge piping with an inert gas prior to attempting repairs. If leak is in container or container valve, contact the closest Liquid Air Corporation location.

WASTE DISPOSAL METHOD

not attempt to dispose of waste or unused quantities. Return in the shipping container properly labeled, with any valve outlet plugs or caps secured and valve protection cap in place to Liquid Air Corporation for proper disposal. For emergency disposal, contact the closest Liquid Air Corporation location.

EMERGENCY RESPONSE INFORMATION

IN CASE OF EMERGENCY INVOLVING THIS MATERIAL, CALL DAY OR NIGHT (800) 231-1366

OR CALL CHEMTREC AT (800) 424-9300

SPECIAL PROTECTION INFORMATION

ORY PROTECTION (Specify type) Positive pressure air line with mask or self-contained thing apparatus should be available for emergency use.

NTILATION Hood with forced entilation	**LOCAL EXHAUST** To prevent accumulation above the LEL.	**SPECIAL**
	MECHANICAL (Gen.) In accordance with electrical codes.	**OTHER**

PROTECTIVE GLOVES

Plastic or rubber

EYE PROTECTION

Safety goggles or glasses

OTHER PROTECTIVE EQUIPMENT

Safety shoes, safety shower

SPECIAL PRECAUTIONS*

SPECIAL LABELING INFORMATION

DOT Shipping Name: Hydrogen or Hydrogren, compressed I.D. No.: UN 1049
DOT Shipping Label: Flammable Gas DOT Hazard Class: Flammable Gas

SPECIAL HANDLING RECOMMENDATIONS

Use only in well-ventilated areas. Valve protection caps must remain in place unless container is secured with valve outlet piped to use point. Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting cylinder to lower pressure (<3,000 psig) piping or systems. Do not heat cylinder by any means to increase the discharge rate of product from the cylinder. Use a check valve or trap in the discharge line to prevent hazardous back flow into the cylinder.

For additional handling recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1

SPECIAL STORAGE RECOMMENDATIONS

otect cylinders from physical damage. Store in cool, dry, well-ventilated area of on-combustible construction away from heavily trafficked areas and emergency exits. Do not allow the temperature where cylinders are stored to exceed 130F (54C). Cylinders should be stored upright and firmly secured to prevent falling or being knocked over. Full and empty cylinders should be segregated. Use a "first in-first out" inventory system to prevent full cylinders being stored for excessive periods of time. Post "No Smoking or Open Flames" signs in the storage or use area. There should be no sources of ignition in the storage or use area.

For additional storage recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1.

SPECIAL PACKAGING RECOMMENDATIONS

Hydrogen is noncorrosive and may be used with any common structural material.

OTHER RECOMMENDATIONS OR PRECAUTIONS

Earth-ground and bond all lines and equipment associated with the hydrogen system. Electrical equipment should be non-sparking or explosion proof. Compressed gas cylinders should not be refilled except by qualified producers of compressed gases. Shipment of a compressed gas cylinder which has not been filled by the owner or with (written) consent is a violation of Federal Law (49CFR).

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*Various Government agencies (i.e., Department of Transportation, Occupational Safety and Health Administration, Food and Drug Administration and others) may have specific regulations concerning the transportation, handling, storage or use of this product which may not be contained herein. The customer or user of this product should

ADDITIONAL DATA

UNUSUAL FIRE AND EXPLOSION HAZARDS: (Continued)

explosion hazard, particularly in the upper portions of buildings or sheds where the gas might "collect".

Specialty Gas Material Safety Data Sheet

Air Products

BYRNE SPECIALTY GASES

pure and mixed gases • gas handling equipment • cryogenics

Byrne Specialty Gases, Inc.
514 S. River Street
Seattle, Washington 98108 (206) 764-4633

PRODUCT NAME	ISOBUTYLENE
EMERGENCY PHONE	(800) 523-9374; IN PENNSYLVANIA (800) 322-9092

AIR PRODUCTS AND CHEMICALS, INC.
BOX 538
ALLENTOWN, PA 18105
(215) 398-8257

ISSUE DATE AND REVISIONS 1 June 1978	**TRADE NAME AND SYNONYMS** Isobutylene	
	CHEMICAL NAME AND SYNONYMS Isobutylene, Isobutene, 2-Methylpropene	
	FORMULA (iso) C_4H_8	**CHEMICAL FAMILY** Aliphatic Hydrocarbon

HEALTH HAZARD DATA

TIME WEIGHTED AVERAGE EXPOSURE LIMIT

Nontoxic but may act as a simple asphyxiant.

SYMPTOMS OF EXPOSURE

Symptoms of exposure to isobutylene depending on concentration and duration of exposure, may include rapid respiration, air hunger, incoordination, fatigue, nausea, vomiting, convulsions, loss of consciousness, and death. Contact of liquid isobutylene with the skin may cause frostbite. Symptoms of frostbite are skin color change to gray or white, cold feeling and numbness.

TOXICOLOGICAL PROPERTIES

Isobutylene acts as a simple asphyxiant through the exclusion of oxygen from breathing atmospheres. Anesthetic properties may be evident at very high concentrations. There exists an immediate fire and explosion hazard when the concentration of isobutylene in the atmosphere exceeds the lower flammable limit (1.8% by volume).

RECOMMENDED FIRST AID TREATMENT

RESCUE PERSONNEL SHOULD AVOID UNNECESSARY EXPOSURE. SELF-CONTAINED BREATHING APPARATUS MAY BE REQUIRED.

Inhalation: Extreme hazard of fire or explosion may result from static electrical discharge or other ignition sources. Do not enter explosive atmospheres except in clearly life saving situations. Move the affected person to an uncontaminated atmosphere. If breathing has stopped or is labored, give artificial respiration (e.g. mouth-to-mouth). Supplemental oxygen should be administered. Keep victim warm and quiet. Seek medical assistance promptly.

Skin Contact: In the event of freezing of the skin, frozen tissues should be flooded

(Continued on last page)

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES

Isobutylene reacts vigorously with oxidizing materials.

PHYSICAL DATA

BOILING POINT 19.6°F (-6.9°C)	**LIQUID DENSITY AT BOILING POINT** 39.1 lb/ft^3 (626.3 kg/m^3)
VAPOR PRESSURE at 70°F (21.1°C) 39.05 psia (269.24 kPa)	**GAS DENSITY AT 70°F, 1 atm** 0.1493 lb/ft^3 (2.3916 kg/m^3)
SOLUBILITY IN WATER Insoluble	**FREEZING POINT** -220.7°F (-140.4°C)
APPEARANCE AND ODOR Colorless gas with a sweet, gasoline-like odor. Isobutylene is stored as a liquid under its own vapor pressure.	

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used) Gas	**AUTO IGNITION TEMPERATURE** 869°F (465°C)	**FLAMMABLE LIMITS % BY VOLUME** LEL 1.8 UEL 9.6
EXTINGUISHING MEDIA Carbon dioxide or dry chemical for small fires		**ELECTRICAL CLASSIFICATION** Class I, Group not specified

SPECIAL FIRE FIGHTING PROCEDURES

Stop flow of gas. Keep fire-exposed containers cool with water spray from a distance. Allow the fire to burn itself out.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area.

REACTIVITY DATA

STABILITY Unstable		**CONDITIONS TO AVOID** Sources of heat and ignition
Stable	X	

INCOMPATIBILITY (Materials to avoid) Oxygen and strong oxidizers

HAZARDOUS DECOMPOSITION PRODUCTS None

HAZARDOUS POLYMERIZATION May Occur		**CONDITIONS TO AVOID**
Will Not Occur	X	

SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Eliminate all sources of ignition. Detect leaks with a soap water solution, never use a flame. Ventilate enclosed areas.

WASTE DISPOSAL METHOD

Do not attempt to dispose of waste or surplus isobutylene. Return all unused quantities to Air Products and Chemicals, Inc. for proper disposal.

SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type)	Positive pressure self-contained breathing apparatus should be available for emergency use.	
VENTILATION	**LOCAL EXHAUST**	**SPECIAL**
	MECHANICAL (Gen.) X	**OTHER**
PROTECTIVE GLOVES	Rubber	
EYE PROTECTION	Safety goggles or glasses	
OTHER PROTECTIVE EQUIPMENT	Safety showers, eyebath	

SPECIAL PRECAUTIONS*

SPECIAL LABELING INFORMATION

D.O.T. Red Label, "Flammable Gas"

SPECIAL HANDLING RECOMMENDATIONS

Use only in a well-ventilated area. Never drop cylinders or allow them to strike each other violently. Avoid dragging or sliding cylinders, even for short distances. They should be moved by a suitable hand truck. Keep the valve protection cap in place until cylinder is secured and ready for use. Always insert a trap or check-valve in the line to prevent hazardous back-flow into the cylinder. Use a pressure-reducing regulator when connecting to lower pressure piping systems. Never use a flame to detect leaks, use a soap water solution.

For additional handling recommendations consult the Air Products Specialty Gas Catalog Safety and Technical Information Section or Compressed Gas Association Pamphlet P-1.

SPECIAL STORAGE RECOMMENDATIONS

Protect against physical damage. Store cylinders in a cool, dry, well-ventilated area of noncombustible construction. Protect cylinders from excessive temperature rise by storing away from sources of heat. No part of a cylinder should be subjected to a temperature above 125°F (52°C). Store cylinders in an upright position and firmly secured. Segregate full and empty cylinders. Isolate from oxidizing materials.

For additional storage recommendations consult the Air Products Specialty Gas Catalog Safety and Technical Information Section or Compressed Gas Association Pamphlet P-1.

SPECIAL PACKAGING RECOMMENDATIONS

Isobutylene is noncorrosive to common structural materials. Systems employing isobutylene must be designed to handle the pressures involved.

OTHER RECOMMENDATIONS OR PRECAUTIONS

Ground and bond all lines and equipment. Do not use around sparking motors or other nonexplosion-proof equipment. Vapor is heavier than air and may collect in low areas.

HEALTH HAZARD DATA

RECOMMENDED FIRST AID TREATMENT (Continued)

or soaked with tepid water (105—115°F, 41—46°C). DO NOT USE HOT WATER. If freezing is superficial and to minor extent, medical assistance may not be necessary; however, all other cases should be referred to a physician.

LIQUID AIR CORPORATION
ALPHAGAZ DIVISION

ALPHAGAZ

Specialty Gas

Material Safety Data Sheet

	PRODUCT NAME [redacted]	
	TELEPHONE (415) 977-6500 EMERGENCY RESPONSE INFORMATION ON PAGE 2	
LIQUID AIR CORPORATION ALPHAGAZ DIVISION One California Plaza, Suite 350 2121 N. California Blvd. Walnut Creek, California 94596	TRADE NAME AND SYNONYMS Methane	CAS NUMBER 74-82-8
	CHEMICAL NAME AND SYNONYMS Methane, Methyl Hydride, Marsh Gas	
ISSUE DATE AND REVISIONS OCTOBER 1, 1985 CORPORATE SAFETY DEPT.	FORMULA CH_4 MOLECULAR WEIGHT 16.01	CHEMICAL FAMILY Aliphatic Hydrocarbon

HEALTH HAZARD DATA

TIME WEIGHTED AVERAGE EXPOSURE LIMIT Methane is defined as a simple asphyxiant. Oxygen levels should be maintained at greater than 18 molar percent at normal atmospheric pressure which is equivalent to a partial pressure of 135 mm Hg. (ACGIH, 1984-85)

SYMPTOMS OF EXPOSURE

Inhalation: High concentrations of methane so as to exclude an adequate supply of oxygen to the lungs causes dizziness, deeper breathing due to air hunger, possible nausea and eventual unconsciousness.

Skin Contact: Contact with cryogenic liquid methane causes cryogenic "burns" or frostbite of dermal tissue.

TOXICOLOGICAL PROPERTIES

Methane is inactive biologically and essentially nontoxic; therefore, the major property is the exclusion of an adequate supply of oxygen to the lungs.

Frostbite effects are a change in color of the skin to gray or white possibly followed by blistering.

Listed as Carcinogen or Potential Carcinogen	National Toxicology Program		I.A.R.C. Monographs		OSHA	
	Yes	☐	Yes	☐	Yes	☐
	No	☒	No	☒	No	☒

RECOMMENDED FIRST AID TREATMENT

PROMPT MEDICAL ATTENTION IS MANDATORY IN ALL CASES OF OVEREXPOSURE TO METHANE. RESCUE PERSONNEL SHOULD BE EQUIPPED WITH SELF-CONTAINED BREATHING APPARATUS AND BE COGNIZANT OF EXTREME FIRE AND EXPLOSION HAZARD.

Inhalation: Conscious persons should be assisted to an uncontaminated area and inhale fresh air. Quick removal from the contaminated area is most important. Unconscious persons should be moved to an uncontaminated area, given mouth-to-mouth resuscitation and supplemental oxygen. Medical assistance should be sought immediately.

Dermal Contact or Frostbite: Remove contaminated clothing and flush affected areas with lukewarm water. DO NOT USE HOT WATER.

(Continued on last page.)

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES

Forms explosive or flammable mixtures with most oxidizers (oxygen, chlorine, fluorine, etc.)

Is flammable over a wide range in air.

PHYSICAL DATA

BOILING POINT -258.74°F (-161.52°C)	**LIQUID DENSITY AT BOILING POINT** 26.383 lb/ft^3 (422.62 kg/m^3)
VAPOR PRESSURE @ 70°F (21.1°C) Above the critical temperature of -116.7°F (-82.62°C)	**GAS DENSITY AT 70°F 1 atm** .041 lb/ft^3 (.657 kg/m^3)
SOLUBILITY IN WATER @ 68°F (20°C) Bunsen Coefficient = .035	**FREEZING POINT** -296.45°F (-182.47°C)
APPEARANCE AND ODOR Colorless, odorless gas, liquid is water white.	Specific gravity @70°F (Air = 1.0) is .55.

FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED)-306°F (-188°C) Closed Cup	**AUTO IGNITION TEMPERATURE** 1076°F (580°C)	**FLAMMABLE LIMITS % BY VOLUME** LEL=5 UEL=15

EXTINGUISHING MEDIA Water, carbon dioxide, dry chemical	**ELECTRICAL CLASSIFICATION** Class 1, Group D

SPECIAL FIRE FIGHTING PROCEDURES

If possible, stop the flow of methane. Use water spray to cool surrounding containers.

UNUSUAL FIRE AND EXPLOSION HAZARDS

Should flame be extinguished and flow of gas continue, increase ventilation to prevent flammable or explosible mixture formation.

REACTIVITY DATA

STABILITY **Unstable**		**CONDITIONS TO AVOID**
Stable	X	

INCOMPATIBILITY (Materials to avoid)

Oxidizers

HAZARDOUS DECOMPOSITION PRODUCTS

None

HAZARDOUS POLYMERIZATION **May Occur**		**CONDITIONS TO AVOID**
Will Not Occur	X	

SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

Evacuate all personnel from affected area. Use approopriate protective equipment. If leak is in user's equipment, be certain to purge piping with an inert gas prior to attempting repairs. If leak is in container or container valve, contact the closest Liquid Air Corporation location.

WASTE DISPOSAL METHOD

Do not attempt to dispose of waste or unused quantities. Return in the shipping container properly labeled, with any valve outlet plugs or caps secured and valve protection cap in place to Liquid Air Corporation for proper disposal. For emergency disposal, contact the closest Liquid Air Corporation location.

EMERGENCY RESPONSE INFORMATION
IN CASE OF EMERGENCY INVOLVING THIS MATERIAL, CALL DAY OR NIGHT (800) 231-1366
OR CALL CHEMTREC AT (800) 424-9300

SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type) Positive pressure air line with mask or self-contained breathing apparatus should be available for emergency use.

VENTILATION Hood with forced ventilation	**LOCAL EXHAUST** To prevent accumulation above the LEL.	**SPECIAL**
	MECHANICAL (Gen.) In accordance with electrical codes.	**OTHER**

PROTECTIVE GLOVES
Plastic or rubber

EYE PROTECTION
Safety goggles or glasses

OTHER PROTECTIVE EQUIPMENT
Safety shoes, safety shower, eyewash "fountain"

SPECIAL PRECAUTIONS*

SPECIAL LABELING INFORMATION (Note: For cryogenic liquid methane, see last page.)

DOT Shipping Name:	Methane	DOT Hazard Class:	Flammable Gas
DOT Shipping Label:	Flammable Gas	ID No.:	UN 1971

SPECIAL HANDLING RECOMMENDATIONS

Use only in well-ventilated areas. Valve protection caps must remain in place unless container is secured with valve outlet piped to use point. Do not drag, slide or roll cylinders. Use a suitable hand truck for cylinder movement. Use a pressure reducing regulator when connecting cylinder to lower pressure (<3,000 psig) piping or systems. Do not heat cylinder by any means to increase the discharge rate of product from the cylinder. Use a check valve or trap in the discharge line to prevent hazardous back flow into the cylinder.

For additional handling recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1

SPECIAL STORAGE RECOMMENDATIONS

Protect cylinders from physical damage. Store in cool, dry, well-ventilated area of non-combustible construction away from heavily trafficked areas and emergency exits. Do not allow the temperature where cylinders are stored to exceed 130F (54C). Cylinders should be stored upright and firmly secured to prevent falling or being knocked over. Full and empty cylinders should be segregated. Use a "first in-first out" inventory system to prevent full cylinders being stored for excessive periods of time. Post "No Smoking or Open Flames" signs in the storage or use area. There should be no sources of ignition in the storage or use area.

For additional storage recommendations consult L'Air Liquide's Encyclopedia de Gaz or Compressed Gas Association Pamphlet P-1

SPECIAL PACKAGING RECOMMENDATIONS

Methane is noncorrosive and may be used with any common structural material.

OTHER RECOMMENDATIONS OR PRECAUTIONS

Earth-ground and bond all lines and equipment associated with the methane system. Electrical equipment should be non-sparking or explosion proof. Compressed gas cylinders should not be refilled except by qualified producers of compressed gases. Shipment of a compressed gas cylinder which has not been filled by the owner or with his (written) consent is a violation of Federal Law (49CFR).

*Various Government agencies (i.e. Department of Transportation, Occupational Safety and Health Administration, Food and Drug Administration and others) may have specific [illegible] on the transportation, handling, storage or use of this product which may not be contained herein. The customer or user of this product should

ADDITIONAL DATA

RECOMMENDED FIRST AID TREATMENT: (Continued)

A physician should see the patient promptly if the cryogenic "burn" has resulted in blisterning of the dermal surface or deep tissue freezing.

SPECIAL LABELING INFORMATION: (Continued)

For cryogenic liquid methane:

DOT Shipping Name: Methane, refrigerated liquid
DOT Shipping Label: Flammable gas
DOT Hazard Class: Flammable gas
I.D. No.: UN 1972

American Burdick & Jackson
Material Safety Data Sheet

MATERIAL SAFETY
DATA SHEET

METHANOL

emergency telephone no. 312/973-3600 (American Scientific Products)
chemtrec telephone no. 800/424-9300
information telephone no. 616/726-3171 (American Burdick & Jackson)

I. Identification

chemical name Methanol
molecular weight 32.04
chemical family Alcohol
formula CH_4O
synonyms Carbinol, Methyl Alcohol, Wood Alcohol
DOT proper shipping name Methyl Alcohol or Methanol
DOT hazard class Flammable Liquid
DOT identification no. UN1230
CAS no. 67-56-1

II. Physical and Chemical Data

boiling point, 760mm Hg. 64.7°C
freezing point -97.7°C
evaporation rate (BuAc=1) ca 5
vapor pressure at 20°C 97 mm Hg
vapor density (air = 1) 1.11
solubility in water @ 20°C complete
% volatiles by volume ca 100
specific gravity (H_2O = 1) @ 20°C 0.792
stability Stable
hazardous polymerization Not expected to occur.
appearance and odor A clear, colorless liquid with a slight alcoholic odor.
conditions to avoid Heat, sparks, open flame, open containers, and poor ventilation.
materials to avoid Strong oxidizing agents and reactive metals which will displace hydrogen.
hazardous decomposition products Incomplete combustion can generate carbon monoxide and other toxic vapors such as formaldehyde.

III. Fire and Explosion Hazard Data

flash point, (test method) 12°C (Tag closed cup)
auto ignition temperature 385°C
flammable limits in air % by volume: lower limit 6.0
upper limit 36.5
unusual fire and explosion hazards May burn with an invisible flame. Mixtures with water as low as 21% by volume are still flammable (flash point below 37.8°C). Under some circumstances can corrode certain metals, including aluminum and zinc, and generate hydrogen gas.
extinguishing media Carbon dioxide, dry chemical, alcohol foam, water mist or fog.
special fire fighting procedures Wear full protective clothing and self-contained breathing apparatus. Heat will build pressure and may rupture closed storage containers. Keep fire-exposed containers cool with water spray.

IV. Hazardous Components

Methanol	% ca 100	TLV 200 ppm	CAS no. 67-56-1

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Subsidiary of American
Hospital Supply Corporation
1953 South Harvey Street
Muskegon, MI 49442

V. Health Hazards

Occupational Exposure Limits

OSHA	8-hour PEL	-	200 ppm
	Ceiling	-	not listed
	Peak	-	not listed
ACGIH	TLV-TWA	-	200 ppm
	TLV-STEL (15-min)	-	250 ppm
NIOSH	TLV-TWA	-	200 ppm
	TLV-C	-	800 ppm

Concentration Immediately Dangerous to Health

OSHA/NIOSH	25,000 ppm

Odor Threshold

NSC & OHS	10 ppm
NIOSH	2000 ppm

Carcinogenic, Mutagenic, Teratogenic Data

Positive mutagen (RTEC)

Primary Routes of Entry

Methanol may exert its effects through inhalation, skin absorption, and ingestion.

Industrial Exposure: Route of Exposure/Signs and Symptoms

Inhalation:	Exposure can cause drowsiness and intoxication, headache, visual disturbance leading to blindness, coughing and shortness of breath, collapse and death at high concentrations.
Eye Contact:	Liquid can cause moderate burning, watering, swelling, and redness; high vapor concentration (greater than 2000 ppm) may cause same symptoms.
Skin Contact:	This substance may be absorbed through intact skin and produce toxic effects. Extensive, repeated and/or prolonged skin contact can cause burning, itching, redness, or blisters.
Ingestion:	Causes burning of the gastrointestinal tract and toxic effects. Swallowing more than 2 ounces of methanol can cause death.

Effects of Overexposure

Mild poisoning is characterized by fatigue, nausea, headache, and delayed visual blurring. Moderate intoxication results in severe depression. Temporary or permanent blindness may follow in 2-6 days. In severe poisoning, symptoms progress to rapid, shallow respiration, cyanosis, coma, hypotension, dilated pupils, and visual disturbance. Death may result from respiratory failure.

Medical Condition Aggravated by Exposure

Preclude from exposure those individuals with diseases of eyes, liver, kidneys, and lungs.

Emergency First Aid

Inhalation: Immediately remove to fresh air. If not breathing, administer mouth-to-mouth rescue breathing. If there is no pulse administer cardiopulmonary resuscitation (CPR). Contact physician immediately.

Eye Contact: Rinse with copious amounts of water for at least 15 minutes. Get emergency medical assistance.

Skin Contact: Flush thoroughly for at least 15 minutes. Wash affected skin with soap and water. Remove contaminated clothing and shoes. Wash clothing before re-use, and discard contaminated shoes. Get emergency medical assistance.

Ingestion: Call local Poison Control Center for assistance. Contact physician immediately. Never induce vomiting or give anything by mouth to a victim unconscious or having convulsions.

Note to Physician

In case of ingestion or massive inhalation, observe victim as an inpatient because slow metabolism causes a latent period of 24 hours between exposure and acidosis and blindness.

VI. Safety Measures and Equipment

Ventilation: Adequate ventilation is required to protect personnel from exposure to chemical vapors exceeding the PEL and to minimize fire hazards. The choice of ventilation equipment, either local or general, will depend on the conditions of use, quantity of material, and other operating parameters.

Respiratory: Use approved respirator equipment. Follow NIOSH and equipment manufacturer's recommendations to determine appropriate equipment (air-purifying, air-supplied, or self-contained breathing apparatus).

Eyes: Safety glasses are considered minimum protection. Goggles or face shield may be necessary depending on quantity of material and conditions of use.

Skin: Protective gloves and clothing are recommended. The choice of material must be based on chemical resistance and other user requirements. Generally, neoprene or rubber offers acceptable chemical resistance. Individuals who are acutely and specifically sensitive to methanol may require additional protective equipment.

Storage: Methanol should be protected from temperature extremes and direct sunlight. Proper storage of methanol must be determined based on other materials stored and their hazards and potential chemical incompatibility. In general, methanol should be stored in an acceptably protected and secure flammable liquid storage room.

Other: Emergency eye wash fountains and safety showers should be available in the vicinity of any potential exposure. Ground and bond metal containers to minimize static sparks.

VII. Spill and Disposal Data

Spill Control: Protect from ignition. Wear protective clothing and use approved respirator equipment. Absorb spilled material in an absorbent recommended for solvent spills and remove to a safe location for disposal by approved methods. If released to the environment, comply with all regulatory notification requirements.

Waste Disposal: Dispose of methanol as an EPA hazardous waste. Hazardous waste numbers: U154 (Ignitable); D001 (Ignitable).

Revision Date: 1/85

KEY

ca	Approximately	STEL	Short Term Exposure Level
na	Not applicable	TLV	Threshold Limit Value
C	Ceiling	TWA	Time Weighted Average
PEL	Permissable Exposure Level	BuAc	Butyl Acetate

NSC	National Safety Council ("Fundamentals of Industrial Hygiene", 1983)
OHS	Occupational Health Services ("Hazardline")

EM SCIENCE
111 Woodcrest Road, P.O. Box 5018, Cherry Hill, N.J. 08034-0395, Phone (609) 354-9200

MATERIAL SAFETY DATA SHEET

Essentially Similar to U.S. Department of Labor Form OSHA-20

SECTION 1 NAME & PRODUCT

Chemical Name: Pentane	Catalog Number: PX0166, 0167, 0170, 0175
Trade Name & Synonyms: CAS #109-66-0	Chemical Family: Hydrocarbon
Formula: C_5H_{12}	Formula Weight: 75.15

SECTION 2 PHYSICAL DATA

Boiling Point, 760 mm Hg (°C)	36.1°C	Specific Gravity (H_2O = 1)	0.626
Melting Point (°C)	-129.7°C	Solubility in H_2O, % by wt. at 20°C	Insoluble
Vapor Pressure at 20°C	426 mm Hg	Appearance and Odor	Clear liquid gasoline odor
Vapor Density (air = 1)	2.5		
Percent Volatiles by Volume		Evaporation Rate (Butyl Acetate = 1)	

SECTION 3 FIRE AND EXPLOSION HAZARD DATA

Flash Point (test method) - 57°F (cc)	Flammable Limits	Lel 1.5%	Uel 7.8%

Extinguishing Media CO_2, dry chemical, foam
Water spray to cool fire-exposed containers
Water spray to disperse vapors

Special Hazards and Procedures Extremely flammable

Unusual Fire and Explosion Hazards

SECTION 4 REACTIVITY DATA

Stable X	Conditions to Avoid Heat, sparks, open flame
Unstable	

Materials to Avoid
( ) Water ( ) Acids ( ) Bases ( ) Corrosives (✓) Oxidizers
( ) Other (specify)

Hazardous Decomposition Products Emits highly toxic gases including CO_x

SECTION 5 SPILL OR LEAK PROCEDURES AND DISPOSAL

Steps to be Taken in Case Material is Released or Spilled Eliminate ignition sources. Collect spill on vermiculite or other absorbent

Waste Disposal Method To be performed in compliance with all current local, state and federal regulations

PX0166, 0167, 0170, 0175

SECTION 6 HEALTH HAZARD DATA

Threshold Limit Value OSHA std-air: TWA 1000 ppm TXDS: ihl-hmn LCLo: 130,000 ppm

Occupational exposure to Alkanes recm std-air: TWA 350 mg/m^3

Effects of Overexposure Irritating to eyes, nose and skin, causing dermatitis. Highly narcotic at high concentrations. Causes drowsiness and chemical pneumonia. Exposure to levels of 5000 ppm is immediately dangerous to life and health!

First Aid Procedures

Skin: wash with soap/water; get medical assistance for persistent dermatitis
Eyes: flush thoroughly with water; get medical assistance
Inhalation: remove to fresh air; get medical assistance
Ingestion: get medical assistance

SECTION 7 SPECIAL PROTECTION INFORMATION

Ventilation, Respiratory Protection, Protective Clothing, Eye Protection

Provide adequate general mechanical and local exhaust ventilation
Protect eyes and skin with safety goggles and gloves
Fill in hood only
Wear protective clothing
Do not breathe fumes; do not get in eyes; avoid prolonged/repeated breathing of vapor

SECTION 8 SPECIAL HANDLING AND STORING PRECAUTIONS

Keep container tightly closed
Store in an explosion-proof refrigerator
Keep in dry, well-ventilated areas away from ignition sources
Wash thoroughly after handling

DOT - Flammable Liquid

SECTION 9 HAZARDOUS INGREDIENTS

(refer to section 3 through 8)

SECTION 10 OTHER INFORMATION

NFPA 704:	1	4	0
	Health	Flammability	Reactivity

EMERGENCY PHONE NUMBER (609) 423-6300

AUTHORIZED SIGNATURE ____________________

DATE ISSUED: 1/82

DATE REVISED: 10/83

HEALTH AND SAFETY SITE MEETING

We the undersigned have read Section 8: Health and Safety, and fully understand its contents and will adhere to procedures set forth in this document.

Name	Affiliation	Title	Date

SAFETY AND HEALTH PLAN
MCCLELLAN AIR FORCE BASE
PILOT TEST STUDY
SACRAMENTO, CA

1.0 INTRODUCTION

This Safety and Health plan has been prepared for the implementation of remedial actions at the McClellan Air Force Base in Sacramento, CA. All site activities will be performed under the direction of the CH2M Hill McClellan Air Force Base (McAFB) Personnel. Activities covered by this Safety and Health plan include:

* installation of process piping and vacuum extraction equipment
* operation of the vacuum extraction equipment
* system monitoring and optimization
* scheduled sampling activities

1.1 SITE DESCRIPTION

Mc AFB is located north of Sacramento, CA. Site activities for this pilot test refer to Area "S" on this active Air Force Base. Figure 1 is an area map of the McClellan Hill Air Force Base. Figure 2 is a site plot plan disclosing well locations and equipment layout.

2.0 ORGANIZATION

Figure 3 details the organizational structure of Terra Vac personnel for Pilot Test Construction/Operation Activities.

A brief description of key personnel and their responsibilities follows:

2.1 PROJECT MANAGER

The Project Manager, Robert A. Dahl , will coordinate all matters relating to the completion of this project. The Project Manager will be responsible for:

* Ensuring that all personnel and subcontractors understand and abide by the provisions of the SHP,
* Implementing preventative measures that eliminate an unsafe condition from occurring
* Enforcing any disciplinary action necessary when unsafe acts or practices occur,
* Reviewing and approving field reports,
* Confirming an employee's suitability for work based on the physician's recommendations,

- Notifying emergency response personnel in case or emergencies,
- Serving as liaison with public officials and medical personnel, and implement
- Review any updates and changes to SSHP

The Project Manager has the authority to stop work at the site if an unsafe condition exists.

2.2 QUALITY ASSURANCE/QUALITY CONTROL OFFICER

Ann Marie Dockstader will oversee all quality assurance/quality control activities including analytical chemistry and safety and health activities. Additionally, Ms. Dockstader will be responsible for inspecting housekeeping procedures in conjunction with the Safety and Health Officer.

2.3 FIELD ENGINEER/FIELD SUPERVISOR

Michael S. Lynch is responsible for supervising installation of extraction system, and operational and field activities. If Mr. Lynch is unavailable, another duly trained individual will be appointed. Mr. Lynch will serve as CH2M Hill & Air Force personnel contact and on-site manager during construction operations.

2.4 SAFETY AND HEALTH OFFICER

Timothy M. Warner, will serve as site Safety and Health Officer (SHO) during this project. The SHO's responsibilities include but are not limited to the following:

- Implementation and enforcement of the Safety and Health Program,
- Maintenance of safety and health records and preparation of reports,
- Conducting safety and health meetings,
- Controlling site access and work zone entry and maintaining site security,
- Enforcing safety procedures, including the buddy system,
- Reporting any unsafe acts or procedures to the Project Manager,
- Calibrating and maintaining all safety and health equipment,
- Determining levels of personal protective equipment (PPE) through monitoring of the breathing zone VOC concentrations,
- Dispensing PPE and ensuring PPE is available to all employees and visitors,
- Periodic inspection of individuals PPE for proper use and for proper maintenance,

- Providing the proper decontamination and/or disposal facilities for all equipment including PPE,
- Monitoring all on-site hazards and conditions including possible heat/cold stress situations,
- Serving as a liaison with public officials and medical personnel and notifying the proper emergency response personnel in the case of any emergency,
- Updating and changing the SSHP as necessary; changes are to be reviewed by the project manager

The SHO has the authority to stop work at the site if an unsafe condition exists and shall report to the Project Manager.

If Mr. Warner is unavailable to be at the site, another duly trained individual will serve in this capacity.

2.5 TEAM MEMBERS

The team members consist of all personnel involved in the project who will be allowed on the site. All team members will be responsible for understanding and complying with the site safety and health requirements. One member of the project group will be assigned the responsibility of cleaning and maintaining the safety and health equipment and the decontamination area each day. All team members who will work at the site on a particular day must attend the brief daily safety meetings. The Monday morning meeting will also serve as a more comprehensive weekly meeting and will include a review of the activities of the previous week. This weekly Safety meeting will be held at the Terra Vac offices if site activity is not planned until later in the week.

3.0 MEDICAL MONITORING AND PERSONNEL TRAINING REQUIREMENTS

Terra Vac has established a medical surveillance program designed to monitor and reduce health risks for its employees who have potential to be exposed to hazardous materials. This program is based on the Occupational Safety and Health Administration (OSHA) requirements under the U.S. Department of Labor (29 CFR 1910.120). The medical examinations are administered prior to employment and on an annual basis. The medical examination includes the following:

A) Occupational History Evaluation
B) Complete Physical Examination
C) Pulmonary Function Test for Respirator Certification
    1) Exhale Force Test
    2) Exhale Recovery Test
D) Complete Blood Count
E) SMA 24 Multiplasic Blood Chemistry (incl. metals)
F) Urinalysis
G) Chest X-ray (biannually)

H) Electrocardiogram (6-12 electrode)
I) Vision Test
J) Audiogram

Each employee is issued a certificate to certify him for respirator use upon completion of all requirements. The SHO will keep a record of the monitoring results of all employees and subcontractors.

All Terra Vac activities will be performed in accordance to OSHA Standards and with properly trained employees who have passed all medical requirements of 29 CFR 1910.120. In addition, site specific training prior to the start-up of any activity will be required for those individuals performing the activity. Training will address any potential hazards and associated risks, site operating procedures, and emergency response procedures, including a review of the site SHP.

The SSO will monitor the breathing zone during site activities and at the beginning of each new activity to determine which level of PPE is needed. Based on the established action levels, the SSO shall determine if exposure to hazards has occurred and if exposed, take appropriate action. The criteria for determining exposure to potential hazards can be found in Section 4.0, On-site Hazards.

Only two subcontractors (a licensed electrician and a licensed plumber) will be used during this project. These subcontractors will not be required to comply with the OSHA requirements outlined in 29 CFR 1910.120. While performing their work, electricians and plumbers will not be exposed to hazardous materials and/or chemicals and will not be working within the exclusion zone. During monitoring of the breathing zone, if for some unforeseen reason the action level is exceeded, Terra Vac subcontractors will evacuate the area until the health hazard no longer exists.

3.1 HEALTH PHYSICIANS

All Terra Vac employees from the Northern California region have their annual physical examinations performed by board-certified occupational health physicians employed by Readicare located at 7817 Oakport Street in Oakland, California.

3.2 TRAINED PERSONNEL IN FIRST AID/CPR

Terra Vac employees receive first aid/CPR training (Red Cross or its equivalent) during Terra Vac's annual in-house safety and health training sessions.

4.0 ON-SITE HAZARDS

4.1 CHEMICAL HAZARDS

The primary hazard on-site is the possible release of potentially hazardous levels of volatile organic compounds from soils as the result of soil disturbance activities. In general, the soil contaminants have been shown to consist of various volatile and semi-volatile organic compounds. A complete list of expected compounds with exposure limits is detailed in Table 1. Any activity at the site which causes physical disturbance of the soil could possibly allow the release of contaminants into the air, such an occurrence may be recognized by noticeable chemical odors. Common symptoms of overexposure to compounds at the site of drowsiness, headache, dizziness, loss of coordination, fatigue, tremors or irritation of the eyes, nose or throat. Since the site is covered with an impermeable, multi-layered cap, the contaminated soil is not expected to present a hazard during operation of the vacuum extraction system.

The site SHO will have available on-site toxicity data (i.e., Material Safety Data Sheets) for the hazardous materials identified on the site. Prior to the start of site activities covered by this plan, all site personnel will be briefed as to the nature of the chemical hazards present and will review the SHP.

4.2 PHYSICAL HAZARDS

Hazards typically encountered at construction sites will be a concern at this site. These include slippery ground surfaces, uneven terrain, holes/trenches, and operation of heavy equipment. The basic safety apparel such as steel-toed shoes, hard hats, and safety glasses will be worn during all construction activities by all employees involved.

Venomous snakes and spiders may be found at this site. These cold-blooded animals are likely to be found in sunny locations during cold weather. During warm days they will most likely be found in shadow. Employees will be advised to take precautions.

4.3 ENVIRONMENTAL HAZARDS

Environmental hazards may exist at the project site, such as exposure to heat, cold, wind, rain, and lightning.

To avoid the possibility of heat stress the following work regime has been established:

SUGGESTED FREQUENCY OF REST PERIODS

Temperature*	Normal Work Ensemble	Impermeable Ensemble
90°F or above	Break after each 45 minutes of work	Break after each 15 minutes of work
87.5°-90°F	Break after each 60 minutes of work	Break after each 30 minutes of work
82.5°-87.5°F	Break after each 90 minutes of work	Break after each 60 minutes of work
77.5o-82.5oF	Break after each 120 minutes of work	Break after each 90 minutes of work
72.5°-77.5°F	Break after each 150 minutes of work	Break after each 120 minutes of work

The above work/rest regime shall be used along with pulse rate monitoring. The pulse rate of workers will be determined at the beginning of each rest period. If pulse rates are above 110 beats per minute, the length of the next work period shall be shortened by 1/3.

Although the possibility of injury due to cold stress is unlikely, if the ambient temperature falls below 40° F, workers will be allowed a ten minute break to warm themselves every two hours. Appropriate clothing and a warm shelter will be provided for rest periods.

When weather conditions change, the Project Manager and the SHO will be responsible for determining if work procedures can be performed safely. If engineering controls are required to continue work, the procedures must be approved by the Quality Assurance/Quality Control Officer.

4.4 NOISE STRESS

Noise is defined as any undesirable sound. Excessive noise can destroy the ability to hear and may put stress on other parts of the body including the heart. Prevention from excessive exposure is the only way to avoid the health hazards of noise.

Terra Vac will provide hearing protection to employees who:

1. Are required to work in areas containing sound levels of between 85 - 90 decibels or higher as determined by sound level monitoring (dB A).
2. Work in or around operating vacuum extraction units.
3. Request the use of hearing protection.

Each employee is ultimately responsible to have available and wear the hearing protection provided to them in all operating, posted areas and when instructed by the SHO or their supervisor. Essentially, employees should have access to their hearing protection at all times while working at a job site.

Supervisors will identify and post areas where hearing protection is required based on sound level monitoring results. In addition, supervisors will document that all personnel, including subcontractors, have been informed of the specific areas which require hearing protection and ensure that personnel have access to hearing protection. The SHO should be informed of problem areas and/or consulted for additional information.

Whenever the possibility exists of an employee being exposed to potentially loud noises, supervisors must either require hearing protection or measure sound levels with instrumentation. If a sound level indicator is used, it will be calibrated before and after use, and all information will be noted in the project safety and health log book.

PERMISSIBLE NOISE EXPOSURES

Section (b)(1) of 29 CFR 1910.95 outlines the following permissible noise exposure limits based upon an eight hour work day:

DURATION PER DAY HOURS	SOUND LEVEL dB A SLOW RESPONSE
8.0	85 and above
6.0	92
4.0	95
3.0	97
2.0	100
1.5	102
1.0	105
0.5	110
0.25 (or less)	115

Note: When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect.

5.0 WORK ACTIVITIES

5.1 PROCESS PIPING INSTALLATION

The eight vacuum extraction wells will be connected to the vacuum extraction equipment via process piping. Wells will be completed above grade and surrounded by a security fence.

Distribution piping servicing the wells will be connected to a second fenced area containing the process equipment.

5.2 VACUUM EXTRACTION EQUIPMENT AND TREATMENT SYSTEM

Terra Vac will install five extraction units (positive displacement blower) and vapor-liquid separators. The extraction unit is equipped with noise suppression devices and explosion-proof motor and motor controls. The extraction unit is operated on 240/480-Volt, 3-phase service.

Extracted vapors will be treated by passing the contaminated vapor stream through fluidizied bed catalytic oxidizer prior to emission to the atmosphere. Abatement efficiency will be administered under limitations imposed by the Sacramento Municipal Air Quality Management District and the Air Force. A process flow diagram is included as Figure 4.

A more detailed description of Equipment and operating procedures is provided in the operating manual:

5.3 SYSTEM OPERATIONS

Once all equipment has been installed and tested, system start-up and operation will occur. Tasks during this phase include: system optimization, system monitoring (including vapor sampling), and continued operations.

5.4 HOT AIR INJECTION

Halfway through the project additional wells will be drilled and modified for hot air injection. Effects on rate of contaminant removal will be documented.

5.5 FINAL REPORT

Once the six month pilot test is complete, a final report will be written and the demobilization of the vacuum extraction equipment will occur.

6.0 RISK MITIGATION

Phase specific risks for the pilot test project are tabulated as follows:

Activity	Physical/Chemical Risks	Assessment
Construction	heavy lifting, traffic,	low - moderate
	heat/cold stress	moderate - high
Start-up/ operations	heat/cold stress	moderate - high

Demobilization	heavy lifting, rotating equipment,	low - moderate
	heat/cold stress	moderate - high

6.1 SITE MONITORING/ACTION LEVELS

Field activities associated with the installation and/or operation of the vacuum extraction system may create potential hazardous conditions such as the release of hazardous substances, especially during construction. Monitoring of these substances by the SSO will be performed to ensure appropriate personal protective measures are employed during site activities.

Monitoring with a hand-held photoionization detector (PID) will be conducted in the work zone during sampling activities and during system operation. The PID will monitor total VOC levels and will be calibrated using 100 ppm Isobutylene. The ionization potential of the PID lamp is 11.7 eV.

Total atmospheric breathing space vapor/gas concentrations will be monitored to determine appropriate action levels to protect the safety and health of workers. During this sampling survey, it is likely that the instrument readings will reflect a mixture of contaminants. The PID readings will be recorded for each intrusive activity in the daily log. All monitoring instruments will be calibrated according to the manufacturers specifications at least on a daily basis.

During the course of any activity, if PID readings of <1ppm (above background) are encountered in the breathing zone of the exclusion area, modified level D protection shall be used. If concentrations are between 1 - 5 ppm (above background) the level of protection shall be upgraded to level C. If concentrations in the work zone exceed 5 ppm (above background) for a period of 5 minutes or longer, work will immediately be terminated by the Project Manager and/or the site SHO. The area will then be monitored until the concentration drops below 5 ppm.

The following are general guidelines associated with air monitoring readings:

LEVELS OF PROTECTION	**PID READINGS OR VINYL CHLORIDE COLORIMETRIC READINGS**
Level D	< 1 ppm**
Level C (1/2 face mask)	1 - 5 ppm**
Work terminated, area evacuated	> 5 ppm**

** Readings taken in the breathing zone for 5 minutes, above background.

6.2 PERSONAL PROTECTIVE EQUIPMENT

Based on an evaluation of the hazards at the site, PPE will be required for all personnel and visitors entering the controlled portion (exclusion zone) of the site. Protective clothing and respiratory protection for each level of protection are as follows:

Level C

- -Full or half face, air purifying, organic vapor cartridge equipped respirator,
- -Disposable chemical resistant one-piece suit (polyethylene coated Tyveks),
- -Chemical resistant safety boots with chemical resistant overboot (polyethylene coated),
- -Inner and outer chemical resistant gloves (neoprene rubber),
- -Hard hat,
- -Safety glasses.

Level D

- -Disposable chemical resistant one-piece suit (polyethylene coated Tyveks), (optional, unless handling wet materials, contaminated soil, or steam cleaning),
- -Long sleeve shirt and long trousers
- -Protective gloves,
- -Chemical resistant safety boots or shoes,
- -Hard hat,
- -Safety glasses.

The following levels are anticipated for the following site activities:

1.	Installation of process piping	D
2.	Vacuum system operations	D
3.	Vacuum system sampling	D
4.	Secured zone area access	D

6.3 EMERGENCY PROCEDURES

Emergency communications at the site will be conducted by means of a telephone. Emergency phone numbers, found in Table 2, will be clearly posted above the phone. The Project Manager and Field Supervisor will notify all field personnel and evacuate the area if necessary if an emergency occurs.. A designated evacuation area will be identified on the first day of operations.

The Project Manager or Field Supervisor will perform a head count to ensure that all personnel are safely away from danger. Terra Vac will provide emergency responders with copies of the material safety data sheets (see Appendix 7) and any other requested information.

The COE will be notified immediately by telephone if any significant event occurs on site and a written report explaining the event shall be prepared within one day. A significant event is defined to include events in which a personnel injury occurs, a property loss of substance occurs, or where the events posed a significant threat of loss or personnel injury as described in federal, state, and local requirements.

6.4 CONFINED SPACE ENTRY PROCEDURES

Upon review of the site and the tasks required to remediate the site, it has been determined that there will be no confined spaces that Terra Vac employees, subcontractors or visitors must enter, therefore no confined space entry procedures are recorded here.

7.0 RESPIRATORY PROTECTION PROGRAM

Respiratory protective equipment shall be used whenever effective engineering control measures are not feasible. Only National Institute of Occupational Safety and Health (NIOSH) approved respiratory protection equipment will be used. To ensure an effective respiratory protection program, the SHO, or Field Supervisor will monitor and evaluate various operations to assure all facets of this plan are being followed.

7.1 EMPLOYEE RESPONSIBILITY

1. Employees shall use the protective equipment in accordance with instructions and training received.
2. Employees shall guard against damage to safety equipment.
3. Employees who use respiratory protective equipment shall clean, inspect, maintain, and properly store the equipment.

7.2 SELECTION OF RESPIRATORY PROTECTIVE EQUIPMENT

Selection of the appropriate respiratory equipment will be based on the chemical and physical properties, toxicity and concentrations of the hazardous materials encountered.

7.3 USE OF RESPIRATORY PROTECTIVE EQUIPMENT

I. General

A. Respiratory protective equipment shall not be worn when conditions prevent a good face seal.

B. To assure proper protection, the face piece fit shall be checked by the user each time the equipment is used. This will be done by performing a positive/negative pressure test.

The procedure for a negative pressure test is:

1. Close off the inlet opening of the canister by covering with the palm of the hand.
2. Inhale gently so that the face piece collapses slightly and hold breath for approximately 10 seconds.
3. If the face piece remains in its slightly collapsed condition and no inward leakage of air is detected, a satisfactory respirator fit exists. If not, the respirator will not be used until a satisfactory fit is attained.

The procedure for a positive pressure test is:

1. Close off or cover the exhalation valve.
2. Exhale gently into the face piece.
3. A correct fit will provide a slight positive pressure inside the face piece without any evidence of leakage around the face piece.

C. Employees and subcontractors will not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and handle the equipment.

D. Terra Vac employees will each be issued a respirator and are responsible for its care and maintenance.

E. Smoking will be prohibited on any Terra Vac job site offices, vehicles, or facilities.

II. TRAINING

A. Each respirator wearer shall be given training including:

1. An explanation of respiratory hazards and consequences if the respirator is not used properly.

2. An explanation of why a particular type of respirator has been selected.

3. A discussion of the function, capabilities and limitations of the selected respirator.

4. Instruction in how to don the respirator and to check its fit and operation.

5. Instruction in the proper wearing of the respirator.

6. Instruction in respirator maintenance.

B. Each employee shall be fit tested for each respirator they are expected to use.

C. After initial training in the use of respiratory protective equipment, periodic evaluations of each employee's ability to use the equipment will be performed by Terra Vac Health and Safety Officers.

9.0 SITE CONTROL PLAN

In order to have authorized entry into the controlled portion of the site:

1. Examination by a licensed physician within the previous twelve months, having been determined to be capable of performing the work, and have a respirator certification.

2. All required training requirements outlined in 29 CFR 1910.120 (OSHA regulations for hazardous waste site workers) have been satisfied.

3. The details of this SHP reviewed, understood and signed off by the individual.

All personnel must attend daily safety and health meetings held prior to the beginning of each day's activities or when necessary to assure compliance with the site SHP and to discuss and solve any new problems that may have arisen from previous activities.

9.1 CONTROL ZONES

Control boundaries will be established within the areas of site activities (See Figure 5). Examples of boundary zones include: exclusion zone, decontamination zone and support zone. All boundaries will be dynamic and determined by the planned activities for the day. The Project Manager and/or site Safety and Health Officer will be responsible for personnel passing through these zones and for ensuring the proper decontamination of equipment and personnel.

Anyone entering the controlled area will be required to sign in on the Terra Vac Safety and Health log located on-site at an easily accessible location.

9.2 EXCLUSION ZONE

The controlled portion of the site will be delineated to identify the exclusion zone, wherein a higher level of personal protective equipment may be required for entry. An exclusion zone will be designated in any areas in which site activities have the potential for exposure. The limits of the exclusion zone will be defined by caution tape. The "buddy" system will be implemented for any work within the exclusion zone. While working in the "buddy" system, at least one individual will have completed an 8-hour supervisory training for hazardous waste operations supervisors.

All personnel entering the exclusion zone will be required to wear the level of protection (D or C) which has been selected by the Project Manager or the site SHO. No smoking, eating, chewing gum, tobacco, or drinking will be allowed within the exclusion zone.

9.3 DECONTAMINATION ZONE

Upon leaving the exclusion zone, all personnel and equipment must follow appropriate decontamination procedures. The decontamination requirements will depend on the level of protection used within the exclusion zone and the degree of contamination.

The personnel decontamination zone will be located immediately outside the access of the exclusion zone, and will be delineated by temporary chain-link fencing. This zone will contain the necessary decontamination materials for personnel decontamination.

9.4 SUPPORT ZONE

The support zone will be located so there is little or no potential of exposure to hazardous materials while working within this zone. All personnel conducting work within the support zone will be required to wear level D PPE. All of the vacuum extraction equipment will be located within the support zone.

9.5 SITE COMMUNICATIONS

Communication with on-site personnel shall be by means of voice communication, hand signals, and a whistle. Hand signals will be discussed at each mornings safety and health briefing. The site SHO will have a whistle which he will blow if evacuation of the site is necessary. A "buddy" system will be used during all on-site activities. No single individual will be on site by himself during site activities.

For off-site communication, a telephone will be installed in the on-site office trailer. Emergency telephone numbers (Table 2), and the fastest/safest route to the nearest hospital (Figure 6) will be placed on the wall above the telephone.

9.6 STANDARD SAFE OPERATING PROCEDURES

The following is a list of standard safe operating procedures for Terra Vac sites. These procedures may vary from site to site depending upon specific circumstances.

- Prior to site entry, all personnel shall have reviewed and understood the site Safety and Health Plan,
- Personnel shall sign "in" and "out" in the daily log,
- Daily/weekly safety and health meetings will be held to address site activities and any concerns or problems that may have arisen from previous activities,
- Monitoring of on-site personnel for signs of heat/cold stress or fatigue,
- Monitoring of the breathing zone for VOCs and for explosive gas mixtures,
- Site inspection for any physical hazards
- Use of the "buddy" system to ensure that there will be a second person available non-emergency should the need arise.

10.0 DECONTAMINATION

Decontamination is the process of removing or neutralizing hazardous materials that workers and/or equipment have come into contact with as a result of working in a controlled environment. Decontamination is crucial to health and safety at hazardous work sites. Decontamination procedures protect:

1. Workers against exposure to dangerous materials,
2. Equipment, vehicles and testing equipment for future use.

In addition, decontamination is the only protection against transport of contaminants from the site. Proper decontamination procedures, when followed with care, will protect employees and the general public from the effects of hazardous materials and help provide a safe working environment.

10.1 PERSONNEL DECONTAMINATION

Upon leaving the exclusion zone, all personnel must follow appropriate decontamination procedures. The decontamination requirements will depend on the level of protection used within the exclusion zone and the degree of contamination.

A decontamination zone will be established immediately outside the access opening of the exclusion zone. This zone will contain the necessary decontamination materials for personnel decontamination. This area will contain a tub of wash water, a tub of rinse water, a plastic-lined drum for disposal of expendable clothing and a first aid kit.

Wash solutions will consist of water and detergent such as Alconox or sodium phosphate, and rinse solution shall consist of clean water. Any contaminated wash solutions shall be collected in drums for disposal. All other safety and health equipment will be decontaminated and disposed of as non-hazardous waste.

10.2 EQUIPMENT DECONTAMINATION

The equipment decontamination area will be staged in an area to be determined by site specifics. It will consist of long-handled scrub brushes, detergent solution, water, a plastic-lined disposal drum and plastic sheeting.

All equipment, including heavy equipment and soil sampling equipment, will be cleaned of any excess material (soil, etc.) prior to leaving the exclusion zone. Soiled equipment will be washed with brushes, detergent solution, rinse water, and steam as deemed necessary. All material collected on the plastic sheeting will be drummed and disposed of properly according to regulations.

Because of the sensitivity of certain monitoring equipment (i.e. photoionization detector, and the LEL meter), decontamination of such equipment shall consist of wiping the exterior down with a damp disposable cloth and air dried before leaving the decontamination area.

11.0 SITE LOGS, REPORTS AND RECORD KEEPING

Terra Vac shall keep and maintain logs and reports covering the implementation of the Safety and Health Plan. A separate training log, and daily safety and health log, will be kept on site at all times.

Site safety and health logs are listed below:

1. Training log

   - date and place of training site
   - employee or visitor's name
   - amount of time allotted for training
   - topics covered in training session

2. Daily Safety and Health Log

   - date and time of site entry/exit
   - work zone location
   - workers in a particular zone
   - air monitoring data
   - equipment being used in each zone
   - personal protective equipment being worn by workers

3. Operating Log

   - operating data
   - system adjustments
   - sample collection

12.0 HAZARD COMMUNICATION PROGRAM

A hazardous chemical is broadly defined as a chemical that is either a health hazard, a physical hazard, or both. To insure that all employees and subcontractors receive the necessary information regarding the safe handling of chemicals, and other substances that are normally required in the execution of Terra Vac projects, a Hazard Communication Program has been established.

A list of hazardous chemicals will be maintained by the Project Manager or site SHO. The master list will consist of all hazardous chemicals used or stored at the project site and will be updated weekly. The Project Manager or SHO must be notified of any chemical substance being ordered for the first time or not on the master list to assure the new chemical will be added to the master list.

12.1 MATERIAL SAFETY DATA SHEETS

Material Safety Data Sheets (MSDS), for each chemical used or stored at the job site shall be kept in a notebook located in a central location and accessible to all employees whose jobs may involve handling of these materials. The MSDS notebook will be reviewed and updated weekly to ensure a current MSDS is available for all chemicals used or stored on site.

12.2 LABELS

All containers on site holding hazardous chemicals must be appropriately labeled, tagged, or marked with the identity of the material and appropriate hazard warnings. Labels may identify by using the common trade name or the chemical name. The hazard warning is a brief statement of the hazardous effect of the chemical. It is the responsibility of the SHO to ensure all containers are properly labeled.

13.0 STANDARD OPERATING PROCEDURES, ENGINEERING CONTROLS, WORK PRACTICES

On all Terra Vac job sites safe work and operating practices are required. Where possible, engineering controls will be used to provide a safer work place.

13.1 SITE RULES/PROHIBITIONS

The following is a list of rules and prohibitions required for Terra Vac job sites.

1. Proper levels of protection will be required for all on-site personnel (Level D is required if no other level is specified).
2. The "buddy" system will be implemented during work within the exclusion zone.
3. Operating logs and safety and health logs to be on-site for review and daily entries.
4. Safety and health monitoring for chemical, physical, and environmental risks will be performed as needed and by qualified personnel.
5. Workers will be properly trained for the various tasks performed during this project.
6. Personnel and equipment will be properly decontaminated prior to breaks (meals, rest, etc.) and leaving the site.
7. All on-site personnel will review and understand the site safety and health plan.
8. All work will be performed in a professional and safe manner.
9. No smoking will be permitted in Terra Vac vehicles, offices, or at job sites.
10. No Terra Vac employee will be under the influence of alcohol or controlled substances while conducting Terra Vac business.

13.2 HEAVY EQUIPMENT OPERATION

The procedures for the operation of heavy construction equipment shall be in compliance with 29 CFR 1926. Every employee who will operate a specific piece of equipment shall receive the proper training in the operation and maintenance of that equipment. If any heavy equipment is expected to be used at a job site, all workers will be informed of the presence of heavy equipment and of the safe work practices involved when working around heavy equipment.

13.3 MACHINERY/MECHANIZED EQUIPMENT

Terra Vac remediation equipment must be inspected and maintained to insure proper performance and minimal safety and health risks to the equipment operators. The following is a list of some of the items that need to be checked and/or inspected on most mechanized equipment:

1. Check for any bare or exposed wires.
2. Check all belts for proper tightness and alignment.
3. Check oil (change oil if necessary) and water levels of equipment when applicable.
4. Ensure all protective covers and guards are in place.
5. Ensure any rotating equipment if turning in the proper direction.
6. Report any infractions to the site SHO and/or the Field Supervisor.
7. Site SHO and/or the Field Supervisor shall make proper entries into the site Safety and Health log book.

13.4 FALL PROTECTION

During the course of this remediation project, minimal overhead work will be performed where a ladder or other method of raising a worker above the ground will be needed. When overhead work is performed, the proper safety equipment (i.e. safety belt or cage) will be used.

13.5 SAFE CLEARANCE

Safe clearance procedures shall be used when any maintenance work may be performed on electrical systems, machinery, pressure systems, and rotating equipment. Power (electrical and mechanical) will be turned off, tagged and locked in an open position at the master switch or main breaker and mechanical transmissions shall be physically locked out or disconnected prior to starting any work on the system.

Lockout/Tagout procedures can be found in Appendix A. The procedures of the Lockout/Tagout Plan can be applied to all types of systems that require safe clearance policies.

13.6 ELECTRICAL HAZARDS

The remediation equipment at this site will be powered by 480 Volt, 3-phase power. Terra Vac policy states that Electrical Lock-out/Tag-out procedures (see Appendix A) are to be used whenever inspection, maintenance or other work on electrical equipment of 400 Volts or above occurs and on lower voltage equipment if it is physically possible to do so. It is the responsibility of the Project Manager, SHO, or the Field Supervisor to ensure employees are trained in these procedures, and that the procedures are followed.

Initial electrical installation shall be performed by a qualified subcontractor who will be informed of Terra Vac policies on electrical procedures and will be required to adhere to these policies. Electrical connections, wiring, and equipment shall conform to all codes and regulations.

13.7 UTILITY CLEARANCES

An underground locator service shall be employed to locate and mark any underground obstructions. If possible, as built drawings showing underground interferences shall also be obtained. Any overhead utilities can readily be seen and avoided during site activities.

13.8 SPILL CONTAINMENT

After reviewing the necessary tasks for site remediation and finding little or no potential for hazardous liquid storage or spill, it has been determined that no detailed spill containment program is needed. Adsorbent will be kept onsite for minor spills.

13.9 COMMUNICATIONS

On-site communications shall be by verbal communication, designated hand signals (to be demonstrated in the field on the first day of each new activity), and a whistle to be blown in the event that evacuation is necessary.

TABLE 2
EMERGENCY TELEPHONE NUMBERS

POLICE DEPARTMENT	Address:	2852nd SPS McClellan AFB	Phone:	916/643 -6168 112 911 (off-base)
FIRE DEPARTMENT	Address:	2852nd DEF/ABG	Phone:	916/643-5622 117 911 (off-base)
PARAMEDIC	Address:		Phone:	116 911 (off base)
FIRE REPORT	Address:		Phone:	117 911 (off-base)
AMBULANCE SERVICE	Address:		Phone:	116 911 (off-base)
WATER DEPARTMENT	Address:		Phone:	916/643-4875 366-2000 (off-base)
GAS UTILITY	Address:		Phone:	916/643-4875 383-2323 (off-base)
ELECTRIC UTILITY	Address:			916/643-4875 383-2323 (off-base)

TABLE 2
EMERGENCY TELEPHONE NUMBERS
MCCLELLAN AIR FORCE BASE

POLICE DEPARTMENT	**Address:**	2852nd SPS	**Phone:**	916/643-6168 112 911 (off-base)
FIRE DEPARTMENT	**Address:**	2852nd DEF/ABG	**Phone:**	916/643-5622 117 911 (off-base)
PARAMEDIC	**Address:**		**Phone:**	116 911 (off-base)
FIRE REPORT	**Address:**		**Phone:**	117 911 (off-base)
AMBULANCE SERVICE	**Address:**		**Phone:**	116 911 (off-base)
WATER DEPARTMENT	**Address:**		**Phone:**	916/643-4875 366-2000 (off-base)
GAS UTILITY	**Address:**		**Phone:**	916/643-4875 383-2323 (off-base)
ELECTRIC UTILITY	**Address:**		**Phone:**	916/643-4875 383-2323 (off-base)
TELEPHONE UTILITY	**Address:**		**Phone:**	916/643-4875 811-9000 (off-base)
HOSPITAL	**Address:**	American River Hosp. 4747 Engle Road Carmichael, CA (off-base)	**Phone:**	916/643-4875 848-2100 (off-base)

FIGURE 3.
PROJECT ORGANIZATION
SOIL VAPOR EXTRACTION REMEDIATION
TERRA VAC PROJECT 30-0056

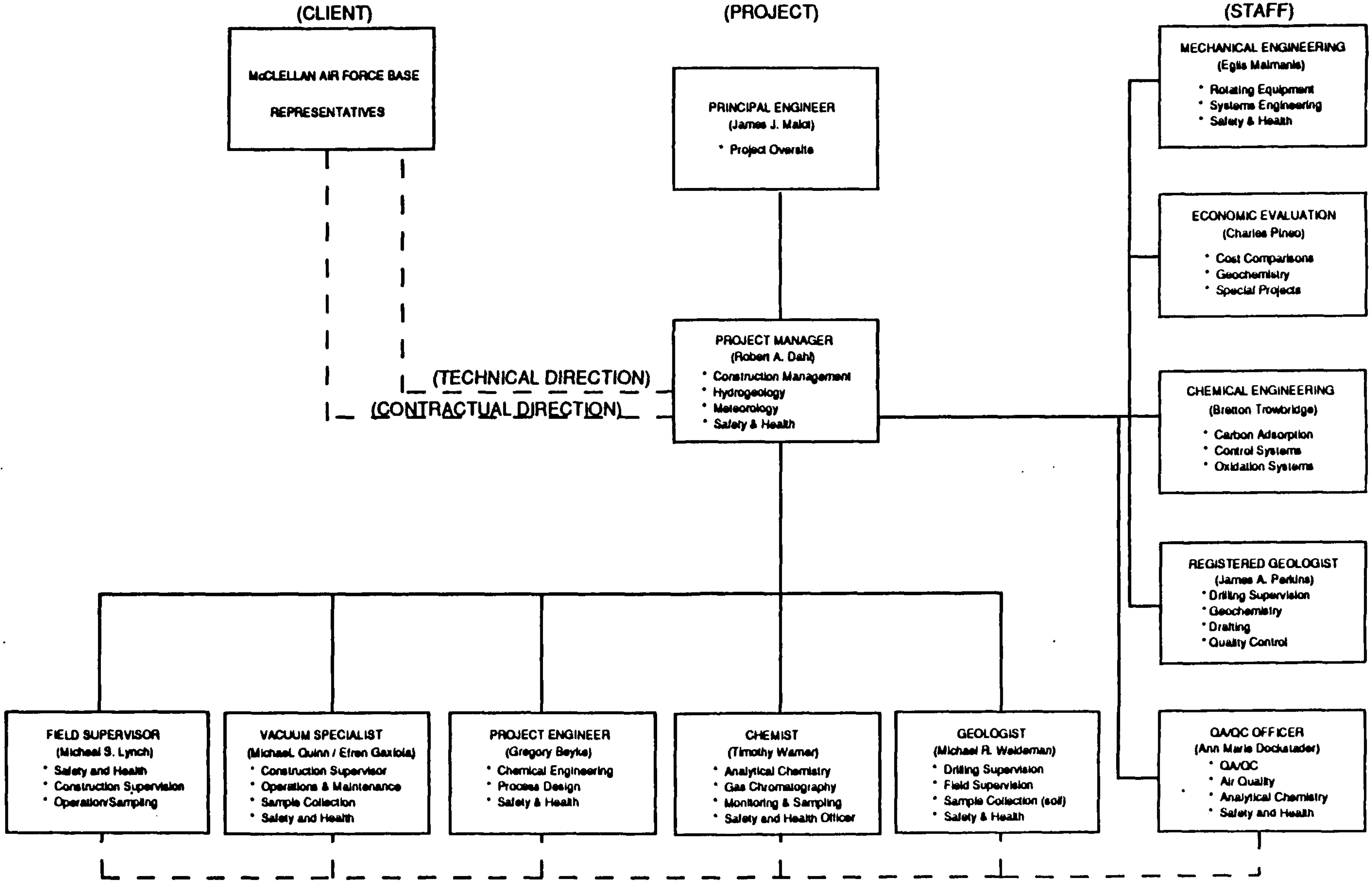

TABLE 1 - McCLELLAN SITE S-OUD TARGET COMPOUNDS

Chemical	Liquid Physical State	Vapor Pressure (mm HG)	Flash Point (in F)	Exposure Limits				Primary Exposure Routes				Symptoms of Exposure Primary Hazards
				PEL* (ppm)*	TLV*	IDLH*	Carcinogen	Inhalation	Skin Absorption	Ingestion	Skin or Eye Contact	
Benzene	x	75	12	1		3000	yes	x	x	x	x	Irrit eyes, nose resp sys; gidd; head, nau, staggered gait, ftg, anor, lass; derm; bone marrow depress. Blood, CNS, skin, bone marrow, eyes, resp sys.
Chlorobenzene	x	77	85	75		2400	no	x		x	x	Irrit skin, eyes, nose; drow, inco Resp sys, eyes, skin, CNS, liver
1,2-Dichlorobenzene DCB	x	1.2	151		50	1000	no	x	x	x	x	Irritated nose, eyes; skin blisters, headache, anorexia, vomiting Liver, kidneys, skin, eyes, respiratory system
Dichlorodifluoromethane Freon 12		<1 atm	NC*	1000		50000	no	x			x	Dizz, tremors, unconsciousness, card arrhy, ca arrest CVS, PNS
1,1-Dichloroethane DCA	x	182	17	100		4000	no	x		x	x	Central nervous system depression, skin irritation, unconsciousness Skin, liver, kidneys
1,1-Dichloroethylene DCE Vinylidene Chloride	x	500	-9	1		N/A	yes	x	x	x		Nose, skin irritation; injury to liver, and kidneys *Skin, liver, kidneys*
1,2-Dichloroethylene	x	180-264	36	200		4000	no	x		x		Irrit eyes, resp sys; CNS depress Resp sys, eyes, CNS
Ethylbenzene ETH	x	7.1	59	100		2000	no	x		x	x	Irritated eyes, mucus membrane, headache, narcotic, coma, dermatitis Eyes, upper respiratory system, skin, CNS
Methylene Chloride	x	350	7	500		5000	yes	x		x	x	Ftg, weak, sleepiness, li-head; limbs numb, ti nau; irrit eyes, skin Skin, CVS, eyes, CNS
Toluene	x	65	40	100		2000		x	x	x	x	Fatgue, weak; conf, euph, dizz, head; dilated pupils,lac; ner, musc ftg, insom; pares; derm CNS, liver, kidneys, skin
1,1,1-Trichloroethane TCA	x	100	NC*	350	350	N/A	yes					Dizziness, dullness, nausea, headache, fatigue,irritation of eyes and skin Liver, kidney, heart, eye, & skin damage
Trichloroethylene TCE	x	58	90	50	200	N/A	yes	x		x	x	Headache, nausea, visual disturbance, vomiting, irritated eyes, dermatitis Respiratory system, heart, liver, kidneys, central nervous system, skin
Trichlorotrifluoroethane Freon 113	x	285	7	1000		4500	no	x		x		Irrit throat, drow, derm; in animals: card arr Skin, heart
1,2,4-Trimethylbenzene	x	<10	130	25		N/A	?	x			x	eye, nose irritation Eye, nose

TABLE 1 - McCLELLAN SITE S-OUD TARGET COMPOUNDS

Chemical	Liquid Physical State	Vapor Pressure (mm HG)	Flash Point (in F)	Exposure Limits				Primary Exposure Routes				Symptoms of Exposure Primary Hazards
				PEL* (ppm)*	TLV*	IDLH*	Carcinogen	Inhalation	Skin Absorption	Ingestion	Skin or Eye Contact	
Vinyl Chloride	x	>1 atm	N/A	1		1	yes	x				Weak; abdom pain, GI bleeding, hepatomegaly; pallor or cyan of extremities
												Liver, CNS, blood, resp sys, lymphatic sys
Xylenes XYL (ortho, meta, and para isomers)	x	7/9/09	63/84/81	100	100	1000	no	x	x	x	x	Dizziness, excitement, drowsiness, irritated eyes, nose, throat, nausea, vomiting, abdominal pain, dermatitis
												Central nervous system, eyes, gastrointestinal, blood, liver, kidneys, skin

mg/kg = milligrams per kilogram

PEL = Permissable Exposure Limit (The lower of NIOSH or ACGIH 8 or 10 hour Time Weighted Average Concentrations)

TLV = Threshold Limit Values (Ceiling Values which shall not be exceeded)

IDLH = Immediately Dangerous to Life and Health

NC = Not Combustible

ppm = parts per million

NA = Information not available

*All information based on 1990 NIOSH Standards