COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN I)
Northern and Central California, Nevada, and Utah
Contract Number N62474-88-D-5086
Contract Task Order 0235

Prepared for

DEPARTMENT OF THE NAVY
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Engineering Field Activity West
Naval Facilities Engineering Command
San Bruno, California

MOFFETT FEDERAL AIRFIELD CALIFORNIA (Formerly Naval Air Station Moffett Field)

DRAFT SITE 5 PHASE I CORRECTIVE ACTIONS TECHNICAL MEMORANDUM

August 15, 1996

Prepared By

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August 19, 1996

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CLEAN Contract Number N62474-88-D-5086
Contract Task Order 0235

Subject: Draft Site 5 Phase I Corrective Actions Technical Memorandum, Moffett Federal Airfield

Dear Messrs. Chao and Chan:

Enclosed are two copies of the above-referenced document. PRC Environmental Management, Inc. (PRC) prepared this technical memorandum to document the results of biovent and biosparge pilot testing at Site 5. Additional copies are being forwarded to the regulatory agencies, project personnel, and other interested parties.

If you have any questions, please call me at (303) 312-8886 or Mike Young at (303) 312-8857.

Sincerely,

Stephen D. Annecone
Environmental Engineer

Michael N. Young
Project Manager

SDA/jem

Enclosures

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Draft Site 5 Phase I Corrective Actions Technical Memorandum
Moffett Federal Airfield

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ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, and xylene
CO_2	Carbon dioxide
CAP	Petroleum Sites Corrective Action Plan
CFU/mL	Colony forming units per milliliter
CLEAN	Comprehensive Long-term Environmental Action Navy
DO	Dissolved oxygen
fpm	Feet per minute
FS	Feasibility Study
ft/day	Feet per day
IT	International Technology Corporation
µg/L	Micrograms per liter
MFA	Moffett Federal Airfield
mg/kg	Milligrams per kilograms
mg/L	Milligrams per liter
msl	Mean sea level
MW	Montgomery Watson
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
O_2	Oxygen
ORC	Oxygen Releasing Compound
OU	Operable unit
PCBs	Polychlorinated biphenyls
PID	Photoionization detector
ppm	Parts per million
ppmv	Parts per million by volume
PRC	PRC Environmental Management, Inc.
psi	Pounds per square inch
PVC	Polyvinyl chloride
ROI	Radius of influence
scfh	Standard cubic feet per hour
scfm	Standard cubic feet per minute
TDS	Total dissolved solids
TKN	Total Kjeldhal nitrogen
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TPH-e	Total petroleum hydrocarbons extractable
USTs	Underground storage tanks

EXECUTIVE SUMMARY

PRC Environmental Management, Inc. (PRC) conducted a bioventing and biosparging study at Moffett Federal Airfield (MFA) Site 5 as part of Phase I Corrective Actions. The pilot testing was conducted to evaluate potentially useful remedial technologies for the cleanup of soils and groundwater contaminated by petroleum hydrocarbons at Site 5. Both soils and groundwater at Site 5 have been contaminated by releases of JP-5 jet fuel during operation of fuel storage tanks at the fuel farm.

A remedial system consisting of a biovent trench, biosparge air injection points, monitoring wells, and related equipment was designed by PRC in 1994 and constructed by International Technologies Corporation (IT) in 1995. PRC initiated bioventing and biosparging tests in August 1995, and a long-term biovent test (approximately 6 months) was completed in May 1996. Activities included collecting soil and groundwater samples, and testing air permeability, in situ respiration, biosparge feasibility, and long-term effects on the potential for biodegradation of the petroleum contaminants.

Results from the long-term test indicate that the bioventing operation significantly reduced total petroleum hydrocarbon (TPH) concentrations in soil in the pilot test area. Based on analytical results of soil samples collected before and after the 6-month test, the average soil TPH concentrations were reduced approximately 1,150 milligrams per kilogram (mg/kg), or 82 percent. However, the radius of influence (ROI) of the bioventing system was small due to the low permeability of Site 5 soils. Reductions in groundwater TPH concentrations were not quantified, although dissolved oxygen (DO) concentrations in groundwater increased in nearby wells after biosparge testing. The ROI of the biosparge system was also small due to the relatively low permeability of the saturated soils in the test area. Data collected during the pilot test and in prior investigations indicate that previous and ongoing natural attenuation of TPH contaminants has occurred in both soils and groundwater at Site 5.

Based on findings that the biovent and biosparge operations have small ROIs and would require numerous trenches and biosparge points to remediate the Site 5 area, bioventing and biosparging would not likely be cost-effective remedial options. On the other hand, data suggest that an intrinsic remediation program would be capable of effectively addressing petroleum contaminants at Site 5.

1.0 INTRODUCTION

PRC Environmental Management, Inc. (PRC) investigated the potential effectiveness of bioventing and biosparging technologies for remediating petroleum-contaminated soils and groundwater at Moffett Federal Airfield (MFA) as part of Phase I corrective actions at Site 5. Test activities and system operation were conducted from August 1995 through May 1996 under contract task order 0235. This corrective action study was part of the Comprehensive Long-term Environmental Action Navy (CLEAN) program for the environmental restoration of Navy facilities.

Three primary conclusions can be drawn from results collected during pilot testing:

(1) Bioventing operation appeared to result in significant reductions in soil contamination in the pilot test area.

(2) Both bioventing and biosparging affected only relatively small areas around air injection points, suggesting that these technologies may not be cost-effective.

(3) Significant evidence of ongoing intrinsic bioremediation was found at Site 5, indicating that a program of intrinsic remediation would likely be successful in remediating petroleum contamination.

This technical memorandum describes testing and field activities, reports and evaluates test results, and presents options and recommendations for full-scale remediation of soil and groundwater. This introductory section discusses project purpose and site background, and provides an assessment of the potential effectiveness of bioremediation at Site 5. Section 2.0 summarizes field activities associated with the test, including system construction, soil sampling and lithologic characterization, and biovent and biosparge testing. Section 3.0 presents chemical and geotechnical soil data. Section 4.0 presents groundwater analytical results. Section 5.0 presents results of the biovent and biosparge tests. Section 6.0 presents conclusions, describes potential remedial alternatives considered for implementation at Site 5, and presents recommendations for full-scale remediation. Finally, references are listed in Section 7.0.

1.1 SITE BACKGROUND

This subsection briefly discusses the history, physical setting, and hydrogeology of MFA and Site 5, and describes previous investigations conducted at Site 5. Much of the information presented here was obtained from the Additional Petroleum Sites Investigation Technical Memorandum (PRC 1995a) and the Petroleum Sites Corrective Action Plan (CAP) (PRC 1994a).

1.1.1 Physical Setting

MFA is located near the southwestern edge of San Francisco Bay in Santa Clara County, California (Figure 1). It bordered by salt evaporation ponds on the north, Lockheed Missile and Space Company's Lockheed Aerospace Center on the east, U.S. Highway 101 on the south, and Stevens Creek on the west. MFA also borders the cities of Mountain View and Sunnyvale, California. Sunnyvale is located east of Mountain View, and both cities are adjacent to the southern portion of MFA. The National Aeronautics and Space Administration (NASA) Ames Research Center is located west and north of MFA.

Historically, tidal salt marsh and mud flats covered extensive areas of the southern portion of San Francisco Bay near MFA; most of these areas, however, have been eliminated or greatly altered by fill material. The large area north and northeast of MFA was diked and is now used as commercial salt water evaporation ponds. Coyote Creek and Guadalupe Slough drain into San Francisco Bay east of MFA, and Stevens Creek drains into the bay to the west. About 40 acres of wetlands located along the northern portion of MFA are the only natural surface water features at MFA. Another wetland area consisting of approximately 80 acres lies north of the Ames Research Center. These areas provide habitat for various mammals, birds, and other species.

1.1.2 Installation History

MFA was continuously operated by the U.S. military since it was commissioned in April 1933 to support the West Coast dirigible program. In October 1935, the station was transferred to the Army Air Corps for use as a training base. Ames Aeronautical Laboratory was granted a permit in 1939 to use part of the station.

In April 1942, the base was returned to Navy control and was renamed Naval Air Station (NAS) Moffett Field. In 1949, the station became home to the Military Air Transport Service Squadron. By 1950, NAS Moffett Field was the largest naval air transport base on the West Coast and became the first all-weather naval air station. In 1953, the station became home to all Navy fixed-wing, land-based antisubmarine aircraft. A weapons department was formed on the base in 1954. In February 1966, the base activated its high-speed refueling facilities. During reorganization of the station in 1973, it became the headquarters of the Commander Patrol Wings, U.S. Pacific Fleet.

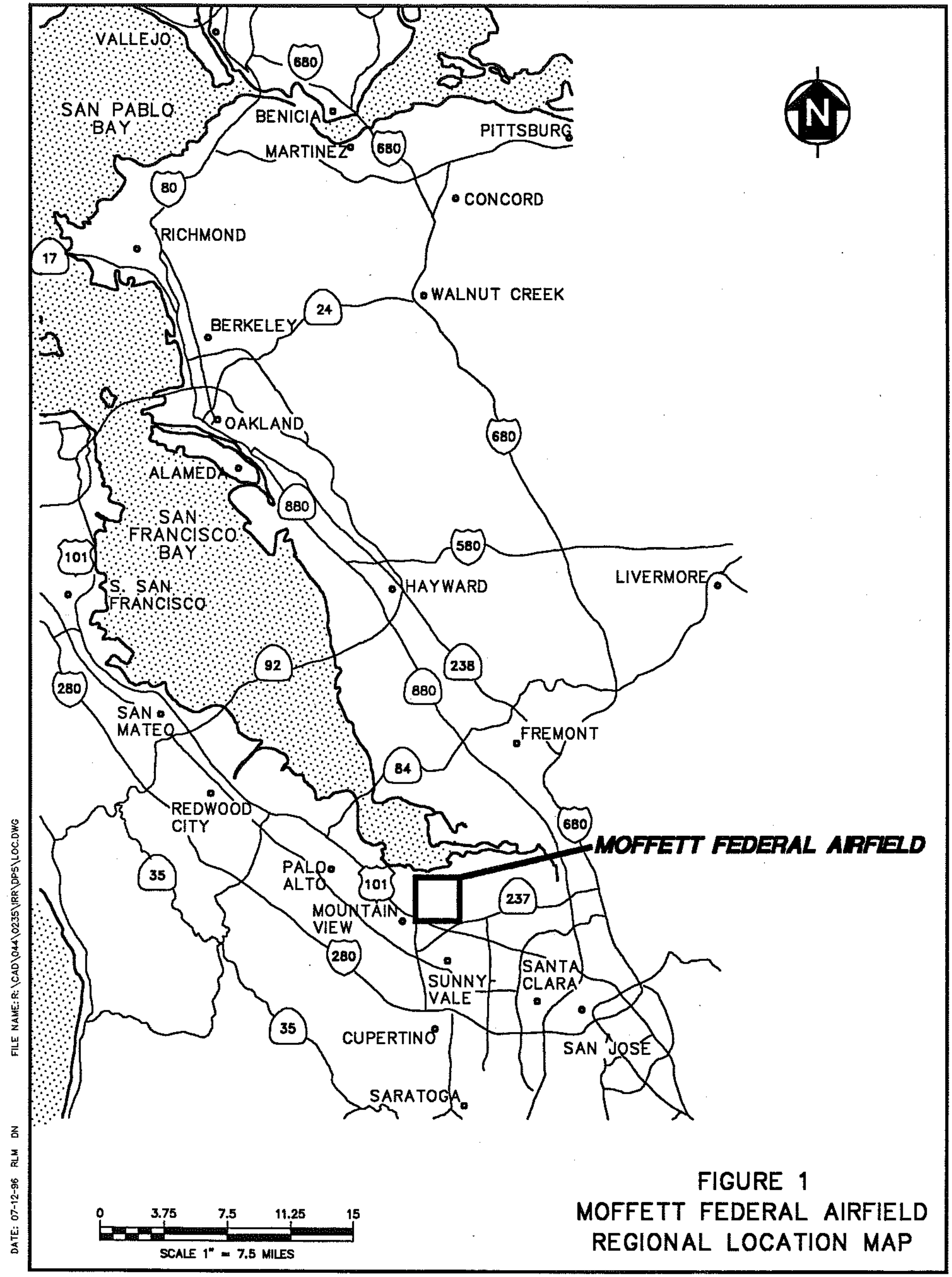


FIGURE 1
MOFFETT FEDERAL AIRFIELD
REGIONAL LOCATION MAP

During the 1980s and early 1990s, the mission of NAS Moffett Field was to support antisubmarine warfare training and patrol squadrons. The station supported more than 70 tenant units, including the Commander Patrol Wings, U.S. Pacific Fleet, and the California Air National Guard. At one point, NAS Moffett Field was the largest P-3 base in the world, with nearly 100 P-3C Orion patrol aircraft. These aircraft were assigned to nine squadrons supported by 5,500 military, 1,500 civilian, and 1,000 reservist personnel. No heavy manufacturing or major aircraft maintenance was conducted at NAS Moffett Field, but a significant amount of unit- and intermediate-level maintenance occurred. In April 1991, the station was designated for closure as an active military base under the Department of Defense Base Realignment and Closure program. NAS Moffett Field was closed as an active military base and transferred to NASA in July 1994. At that time, NAS Moffett Field was renamed Moffett Federal Airfield. The Navy will continue environmental restoration activities and remain responsible for remediating contamination caused by Navy operations in accordance with a memorandum of understanding between the Navy and NASA.

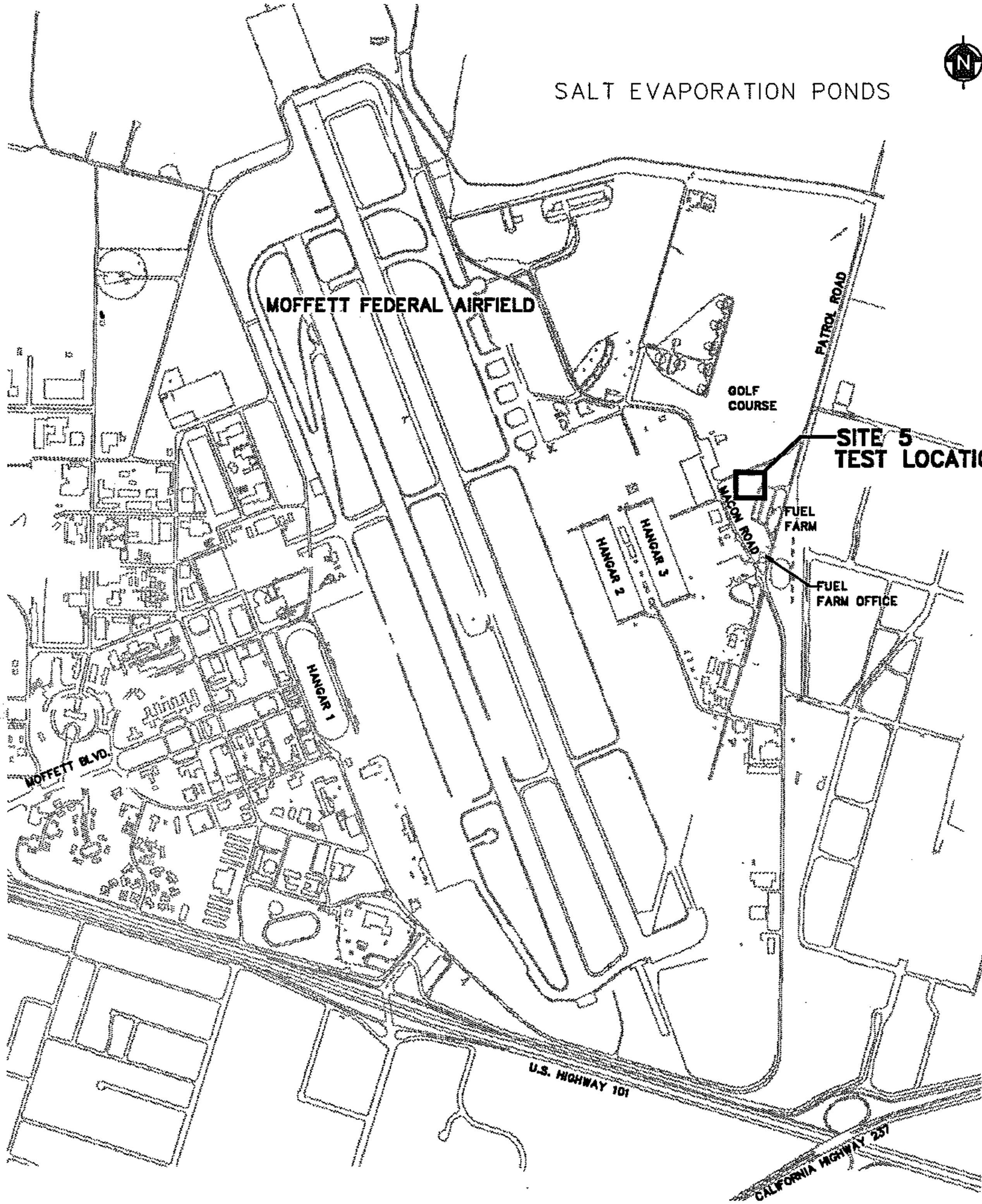
1.1.3 Nature and Extent of Contamination

The following information regarding the nature and extent of contamination at Site 5 has been adapted from the Additional Petroleum Sites Investigation Technical Memorandum (PRC 1995a).

<u>Soils</u>

Site 5 encompasses the areas adjacent to and including the active fuel farm on the eastern side of MFA (see Figure 2). The majority of fuel-contaminated soils are adjacent to four large underground storage tanks (USTs) in the northern portion of Site 5. These 567,000 gallon tanks have historically contained JP-5 jet fuel, though they now (since June 1995) contain JP-8 fuel. Subsurface soils and groundwater at Site 5 have been contaminated by fuel/water mixtures disposed of in dry wells (also known as french drains) and possibly from fuel spills and leaking pipes and USTs. (Recent pressure tests and other leak detection tests indicate that all remaining pipes and tanks are intact and free of leaks.) Contamination primarily resides in the capillary fringe zone at depths of about 6 to 10 feet below ground surface (bgs). Figure 3 shows the estimated extent of soil contamination above cleanup levels at Site 5.

As indicated in Figure 3, most contaminated soils at Site 5 lie just north and northwest of Tanks 10 through 13. Numerous soil samples in this vicinity exhibit total petroleum hydrocarbon (TPH) concentrations in excess of 1,000 milligrams per kilogram (mg/kg), including a sample containing 2,000 mg/kg total petroleum hydrocarbons as extractables (TPH-e) at boring SB5-35 and 1,970 mg/kg



SITE LOCATION MAP

FIGURE 2
MOFFETT FEDERAL AIRFIELD
SITE 5 PHASE I
TEST LOCATION

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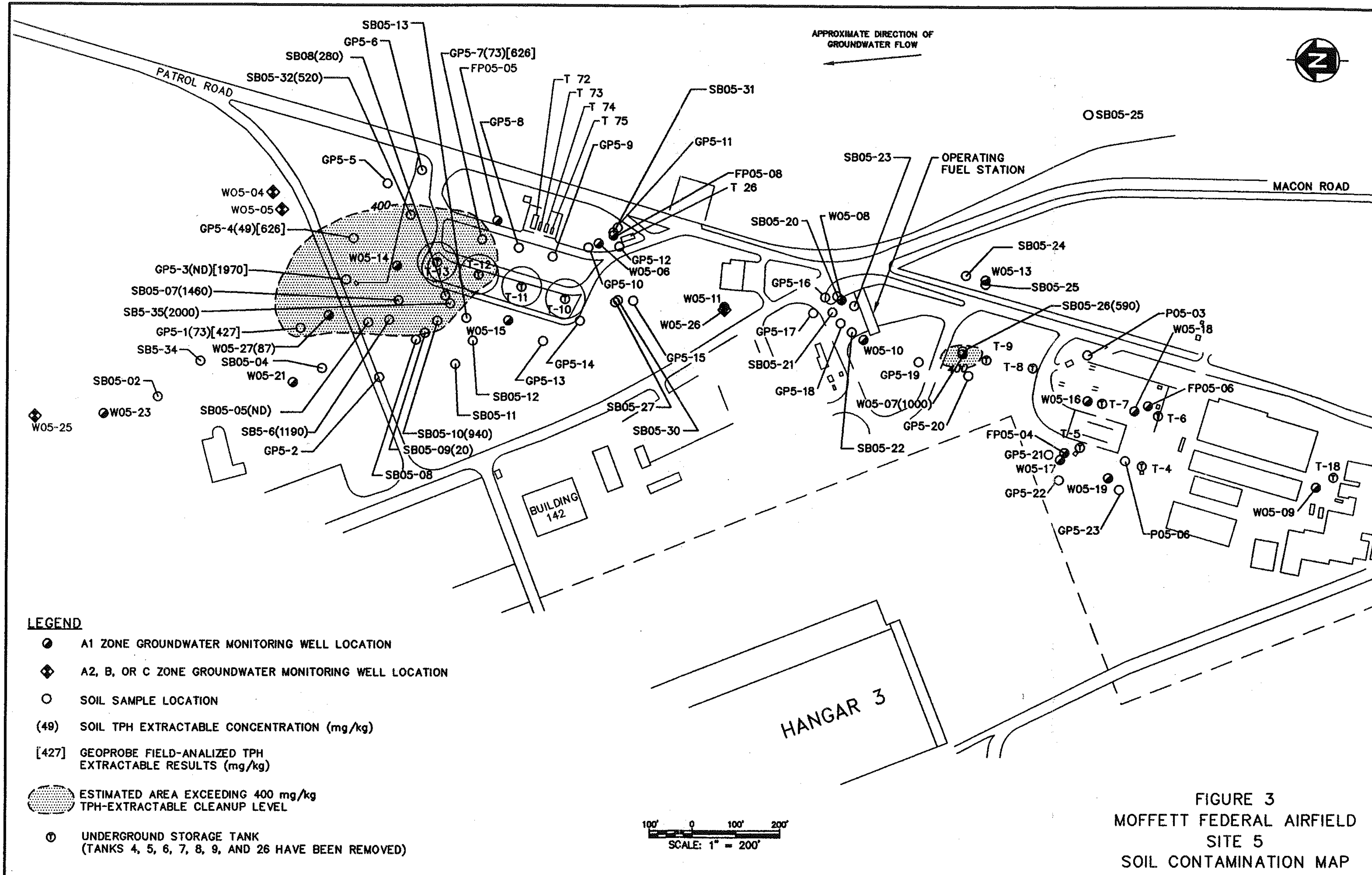


FIGURE 3
MOFFETT FEDERAL AIRFIELD
SITE 5
SOIL CONTAMINATION MAP

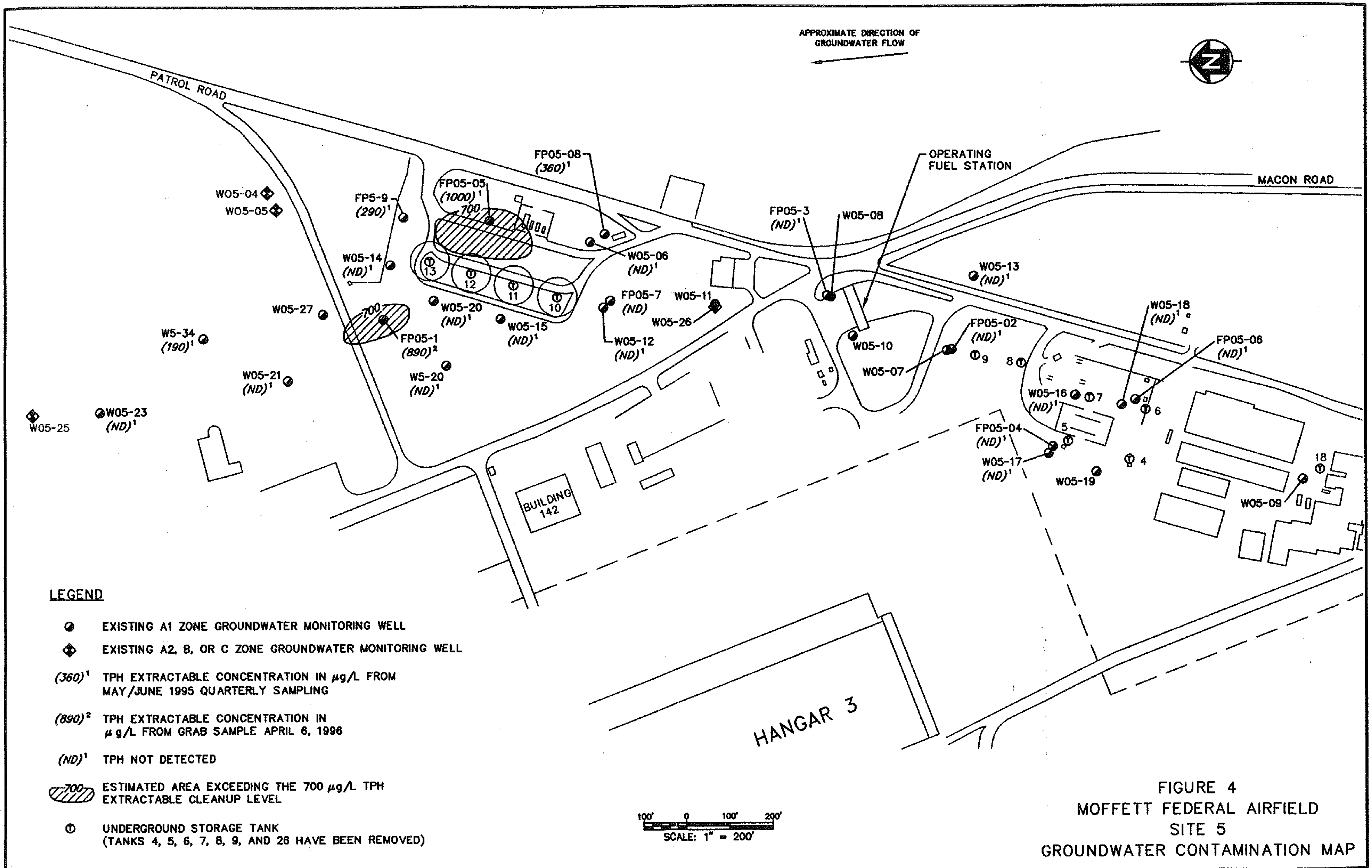


FIGURE 4
MOFFETT FEDERAL AIRFIELD
SITE 5
GROUNDWATER CONTAMINATION MAP

1.1.5 Hydrogeology

Hydrogeologic information provided below has been adapted from the Petroleum Sites CAP (PRC 1994a), which was compiled from the Geology and Hydrogeology Technical Memorandum (PRC and MW 1992a), the Operable Unit 4 (OU4) Feasibility Study (FS) report (PRC 1992b), and the OU5 FS report (PRC 1995b). These documents provide additional information regarding MFA hydrogeology.

The hydrogeologic setting at MFA consists of alluvial sand and gravel aquifers separated by low permeability silt and clay aquitards. In the interior part of the Santa Clara Valley, the numerous aquifers have been divided into two broad zones or sequences: the upper-aquifer sequence (A and B aquifers) and the lower-aquifer sequence (C aquifer). The upper aquifer sequence is generally unconfined, although it is semiconfined locally. The lower aquifer sequence is confined under a laterally extensive clay aquitard at depths of 140 to 200 feet bgs. Water bearing materials in the upper zone are generally thin and discontinuous. Aquifer materials range from silty to fine sand to coarse gravel.

The A aquifer has been divided into two zones: a shallow 5- to 35-foot-deep zone referred to as the A1-aquifer zone, and the deeper 35- to 65-foot-deep zone referred to as the A2-aquifer zone. Predominant lithologies include fine-grained silt and clay within these zones. Permeable units that comprise the productive parts of these aquifer zones are thin (3 to 20 feet thick), discontinuous channels and lenses of sand and gravel. These sediments were deposited by a branching fluvial channel system that traversed alluvial plain and marsh environments, creating discontinuous, lenticular sand bodies surrounded by finer-grained deposits.

Groundwater in the A and B aquifers generally flows northward toward San Francisco Bay. The horizontal groundwater flow gradient averages about 0.004 to 0.005 feet per foot in the A and B aquifers (PRC 1992a). Hydraulic conductivity values estimated from aquifer tests (PRC 1995b) are greater in the A aquifer (ranging from 5.7 to 240 feet per day [ft/day]) than in the B aquifer (0.35 to 36 ft/day). This is consistent with the overall coarsening upward of sediment grain size observed from the B aquifer to the A aquifer. The vertical gradients between the B and overlying A aquifers are variable but are generally upward.

Site 5 hydrogeology is consistent with general hydraulic conditions observed at MFA. However, sediments of the A1-aquifer zone considered "permeable" were not encountered during Phase I corrective action activities. Petroleum contamination at Site 5 appears to be limited to the A1-aquifer zone; therefore, all monitoring wells and sparge wells at Site 5 were installed in the A1-aquifer zone.

1.2 TECHNOLOGY ASSESSMENT

This section assesses the potential effectiveness of bioventing and biosparging technologies for remediating petroleum-contaminated soils and groundwater at Site 5. This information provides a framework for the discussion of the pilot test presented in the remainder of the report. Several criteria, which include contaminant properties, soil matrix characteristics, and site characteristics, are discussed below in relation to remediation of Site 5 soils and groundwater. The Final Petroleum Sites CAP (PRC 1994a) contains details regarding technology screening conducted before Phase I testing began.

1.2.1 Contaminant Properties

The potential effectiveness of bioremediation technologies, including bioventing and biosparging, depends largely on the biodegradability of the contaminant. Some contaminants, such as chlorinated hydrocarbons or polychlorinated biphenyls (PCBs), are not readily amenable to aerobic degradation due to toxicity effects or other biorefractory characteristics such as a complex, tightly-bonded molecular structure. However, most petroleum products and wastes are readily biodegradable aerobically and provide an excellent substrate (food source) for microorganisms under the proper conditions.

The primary contaminant of concern at Site 5 is JP-5 jet fuel. JP-5 fuel generally consists of middle and heavier range petroleum compounds, including branched and straight-chain hydrocarbons. Most aliphatic hydrocarbons in JP-5 fall within the 10 (C10) to 16 (C16) carbon range. Unlike gasoline, JP-5 is relatively low in volatility, very low in benzene, toluene, ethylbenzene, and xylene (BTEX) content, and appears to be relatively nontoxic to microbes. JP-5, as well as other heavier fuels such as kerosene and diesel, has been shown to be readily biodegradable in soils and groundwater (Hinchee and Ong 1992; AFCEE 1992; Anderson 1995) when adequate nutrients are available.

1.2.2 Soil Matrix Characteristics

Permeability, porosity, and moisture content are among the soil matrix characteristics that can strongly influence the effectiveness of bioventing and biosparging technologies. Homogeneous, permeable soils are most amenable to remediation using bioventing and biosparging. In this discussion, permeability describes the ability of air to flow through a soil matrix and transport oxygen to soil microbes. Previous investigations at Site 5 indicate that the soil is of relatively low permeability, although some coarser, more permeable regions exist at the site. Soil heterogeneities, or areas of differing permeabilities, can result in preferential air flow to the more permeable zones at a bioventing or biosparging site. Although remediation of more permeable soils is generally quicker than remediation of less permeable soils, bioventing may still be effective in treating low-permeability soils by diffusion of oxygen from air flow in coarser sediments adjacent to the less permeable material.

Soil porosity affects the ability of a bioventing system to deliver oxygen to contaminated soil regions. In general, the higher the effective (interconnected) porosity, the greater the potential for air to flow through subsurface soils. Since soil moisture occupies a percentage of the soil pores, increased soil moisture typical of the capillary fringe acts to decrease air flow near the water table. For air to flow through the saturated zone, high-porosity soils with large pore spaces are ideal. In general, the smaller the pore spaces in the soil medium, the higher the pressures required for injecting air into the vadose and saturated zones.

1.2.3 Site Characteristics

Site-specific factors that influence the effectiveness and implementability of bioventing and biosparging include the presence and location of surface and subsurface features and the distribution of contamination relative to these features. The contaminated soil and groundwater regions of Site 5 are primarily overlain by unpaved, grassy areas with relatively few buildings and aboveground structures. However, the most contaminated region is adjacent to four 567,000 gallon active fuel tanks and a network of fuel transfer pipes. Other subsurface utilities, including water and electrical power lines, exist in the contaminated regions of Site 5. Because of the presence of active USTs and subsurface utilities, much of the contaminated soils would not be easily excavated for removal or ex situ treatment. Furthermore, since most shallow groundwater at Site 5 resides in relatively impermeable lithologies, groundwater extraction rates would be very low in most regions, making pump and treat options expensive and time consuming. Therefore, use of in situ treatment methods such as bioventing and biosparging or natural attenuation is preferred over ex situ methods.

Implementation of full-scale in situ remedial systems could be achieved with minimal or no impact to existing fuel operations, and with less impact to potentially sensitive birds and mammals than ex situ methods. Because of these factors, in situ bioremediation technologies were deemed viable and bioventing and biosparging were pilot tested. A horizontal vent well was used for the bioventing pilot test to improve the potential to intersect coarser grained soils and sand stringers, thereby improving air distribution into the formation during testing. Since contaminated soils are relatively shallow at Site 5, construction of a horizontal vent well was technically and economically feasible.

2.0 FIELD ACTIVITIES SUMMARY

This section describes field activities associated with test system construction, soil sampling and lithologic characterization, groundwater sampling, and biovent and biosparge testing. Initial test activities were conducted from August 13 to 24, 1995; additional testing was conducted on September 11 and 12, 1995; and long-term biovent testing was completed on May 16, 1996. Analytical and other test results are presented in Sections 3.0, 4.0, and 5.0.

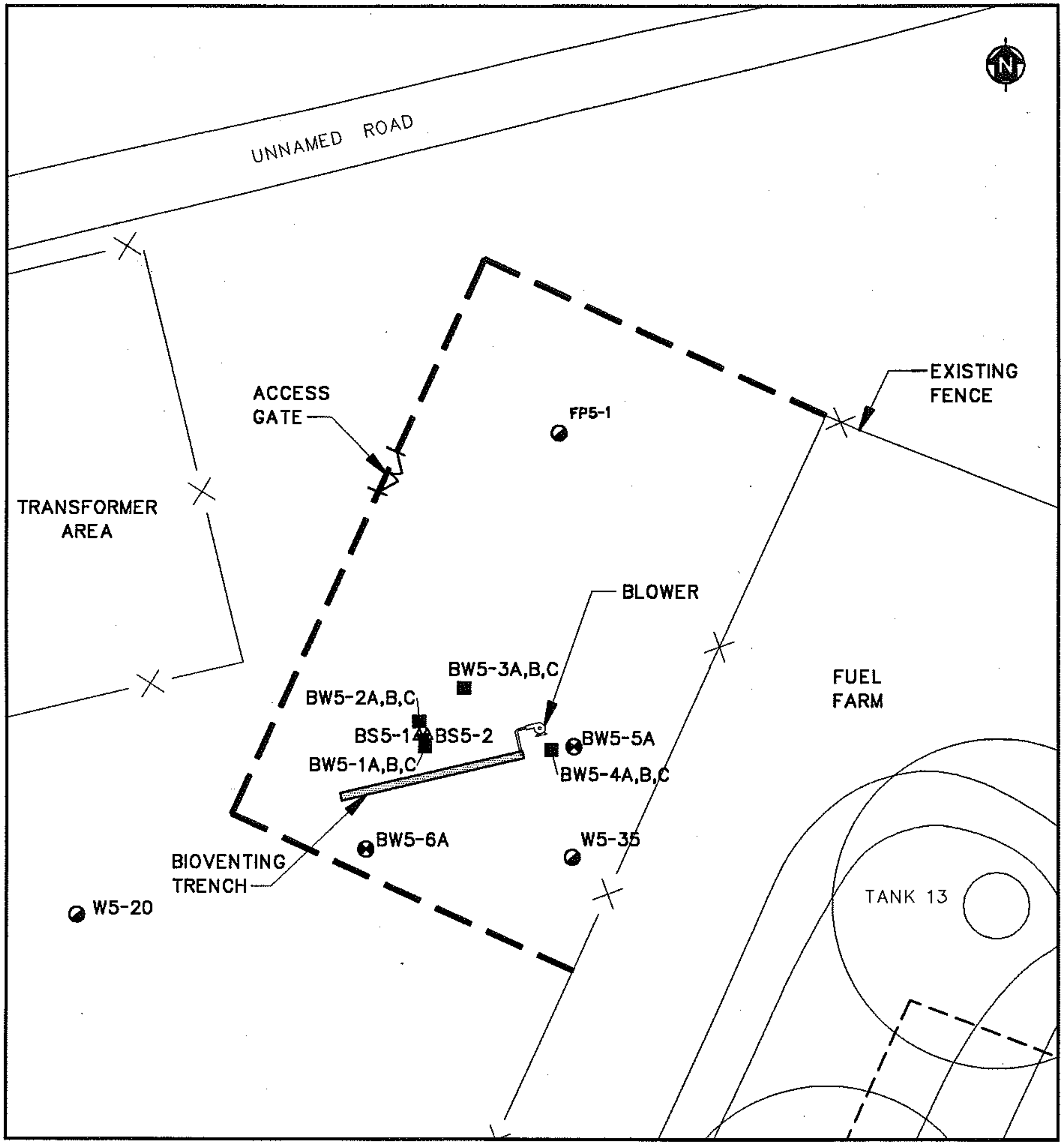
2.1 SYSTEM CONSTRUCTION

International Technology Corporation (IT) constructed the bioventing and biosparging test system in accordance with design drawings and specifications prepared by PRC for the Navy in September 1994. IT submitted a work plan for construction activities to the Navy in November 1994 (IT 1994), and began system construction in December 1994. Figure 5 presents a layout of the test site area.

2.1.1 Field Activities

Construction activities involved installation of a horizontal biovent injection trench, two biosparge injection wells, four monitoring well clusters, two vadose-zone monitoring wells, and temporary chain-link fencing around the area. Test equipment included a positive displacement blower and associated piping and instrumentation.

A trench was excavated to approximately 7 feet bgs for installation of the 50-foot-long horizontal biovent injection well. The trench was excavated with vertical side walls. A permeable geotextile fabric was then placed in the bottom of the trench and covered by approximately 1 foot of gravel. The injection well, which consisted of 4-inch-diameter schedule 40 polyvinyl chloride (PVC) pipe with 0.040-inch slotted screen, was placed horizontally in the trench at approximately 6 feet bgs and extended to the surface with a vertical section of 4-inch schedule 40 PVC pipe. Additional gravel fill



LEGEND

- TEMPORARY CHAIN-LINK FENCE 6 FEET HIGH
- CLUSTER MONITORING WELLS (A-, B-, AND C-LEVEL WELLS)
- SINGLE MONITORING WELL
- SPARGE INJECTION POINTS
- EXISTING GROUNDWATER MONITORING WELL

20' 0 20' 40'
SCALE: 1" = 40'

FIGURE 5
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
SYSTEM CONFIGURATION

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The air injection system consisted of a positive displacement blower connected with piping to the vent, an air filter, a silencer, a pressure gauge, and an in-line globe valve and bleed line with globe valve to enable regulation of air flow into the trench.

Four monitoring well clusters (BW5-1, BW5-2, BW5-3, and BW5-4) were constructed for observation of subsurface pressure. Each cluster consisted of three monitoring wells, one each screened from 5 to 7 feet bgs, 9 to 11 feet bgs, and 13 to 15 feet bgs. Boreholes for the wells were drilled using a 6-inch-diameter hollow-stem auger to depths of approximately 7.5, 11.5, and 15.5 feet bgs. Each well was constructed of 2-inch-diameter schedule 40 PVC casing. Screened well sections consisted of 0.020-inch slot schedule 40 PVC in 2-foot lengths. Filter material surrounding the screened portions of the wells was composed of 8-12 mesh silica sand placed to approximately 6 inches above the top of the screen. A 2-foot bentonite seal, using 1/4-inch-diameter bentonite pellets, was placed over the filter pack. The remaining annular space of the borehole was filled with cement-bentonite grout 24 hours after the bentonite was hydrated, and a concrete well box was installed at grade over each well. Two single vadose-zone monitoring wells (BW5-5A and BW5-6A) were also installed and screened from 5 to 7 feet bgs and were also completed as described above. Appendix A contains the well construction logs for all monitoring wells.

The three discrete wells in each cluster were designated as "A" for the shallowest (5 to 7 feet bgs) screened well, "B" for the intermediate (9 to 11 feet bgs) screened well, and "C" for the deepest (13 to 15 feet bgs) screened well. The A-level wells were screened across vadose zone soils, while the B- and C-level wells were screened entirely in the saturated zone. The screened intervals of the A-level wells were intended to correspond to the depth of the horizontal trench pipe, and those of the B- and C-level wells were intended to correspond to the same lithologic unit as sparge wells BS5-1 and BS5-2 (described below).

The two biosparge wells (BS5-1 and BS5-2) used during testing were each constructed of 1-inch-diameter schedule 80 PVC casing with a top-threaded tee connection. Boreholes for the wells were drilled using a 6-inch-diameter hollow-stem auger to depths of approximately 11.5 and 15.5 feet. Spargepoint Microporous fine bubble diffusers were installed in the bottom 30 inches of each well. Filter material surrounding the bubble diffusers was composed of 20-40 mesh silica sand placed to approximately 6 inches above the diffuser. A 2-foot bentonite seal was placed over the filter pack, and the remaining annular space of the borehole was filled with cement-bentonite grout. A concrete well box common to both sparge wells was installed at grade.

Some problems were encountered during system construction prior to pilot testing. Due to unusually heavy precipitation during December 1994 and January 1995, some excavated soils became saturated and had to be mixed with dry, off-site soils to achieve 85 percent compaction during backfilling. Furthermore, although the water table had risen to above the vent pipe, the blower was turned on during system startup testing with the pressure bleed valve fully closed. This resulted in a surge of high pressure air up through trench backfill materials (as evidenced by air bubbles near the riser pipe), a torn liner near the surface, and possibly vertical soil fractures in and adjacent to the trench excavation. Because the ground surface was covered with water and surficial soils appeared saturated, the extent of damage was difficult to assess. Therefore, the system was not repaired until May 1995 when the water table level had receded to below the vent pipe and surface soils were dry. The repair consisted of removing some soil near the riser pipe, adding grout to a cardboard annular tube placed around the riser pipe, reconnecting the impermeable liner, and backfilling soils by hand.

2.2 SOIL SAMPLING AND LITHOLOGIC CHARACTERIZATION

Soil samples were collected during test site construction for geotechnical and chemical analyses. Characterization of test site soils assists in interpreting test results and assessing the effectiveness of bioventing and biosparging technology at Site 5.

2.2.1 Construction Sampling

Five soil samples were collected from the biovent trench sidewall at the anticipated depth of the horizontal vent pipe and analyzed at an off-site laboratory for grain size distribution. Lithologic characteristics of the trench were also observed and logged by a field geologist.

Split-spoon samples collected during monitoring well and air sparge well construction were logged for lithologic characteristics in accordance with the Unified Soil Classification System. Contents of each split spoon were screened with a photoionization detector (PID) to assess relative contaminant concentrations along the entire length of the borehole. Appendix B contains soil borehole logs.

One sample from each of five selected soil borings was sent off site for laboratory geotechnical analysis including grain-size distribution, porosity, and moisture content. Borehole geotechnical sample collection depths of approximately 7, 11, and 15 feet bgs were selected to coincide with the three proposed monitoring well screened intervals. Two of the five samples were also analyzed for nutrients (orthophosphate, ammonia, nitrate, and total organic carbon [TOC]), and heterotrophic and hydrocarbon-utilizing microbe plate counts.

All soil samples were collected in accordance with procedures specified in the basewide quality assurance project plan (PRC and MW 1992b). Appendix C contains soil chemical analytical results, soil geotechnical analysis results are contained in Appendix D, and soil sample results are presented in Section 3.0.

Figures 6 and 7 are cross-sections derived from borehole logs and trench observations, and depict the relationship among subsurface stratigraphy, monitoring well and sparge well screened intervals, and horizontal biovent placement. Layering of soil shown in the figures is generalized and based on the dominant lithology of the ranges shown. Minor lithologic variations present in the layers are not shown.

2.2.1.1 Work Plan Deviations

No significant deviations from the work plan were noted during soil sampling and lithologic characterization activities. The alignment of the biovent trench and monitoring well system differed slightly from design drawings. The original design intended the system to be aligned around an east-west-trending trench. Final alignment of the trench and monitoring well system was in the northeast-southwest direction approximately 10 degrees from directly east-west.

2.2.2 Baseline Sampling

Twenty soil samples were collected to evaluate pretest contaminant concentrations within the system's estimated maximum zone of aeration and to serve as a comparative baseline. All baseline samples were analyzed for the presence of TPH-e. Confirmation samples were collected and analyzed at the end of the Phase I test as discussed in Section 2.2.3. Analytical results from confirmation samples are compared with the baseline results in Section 3.0 to assess system effectiveness.

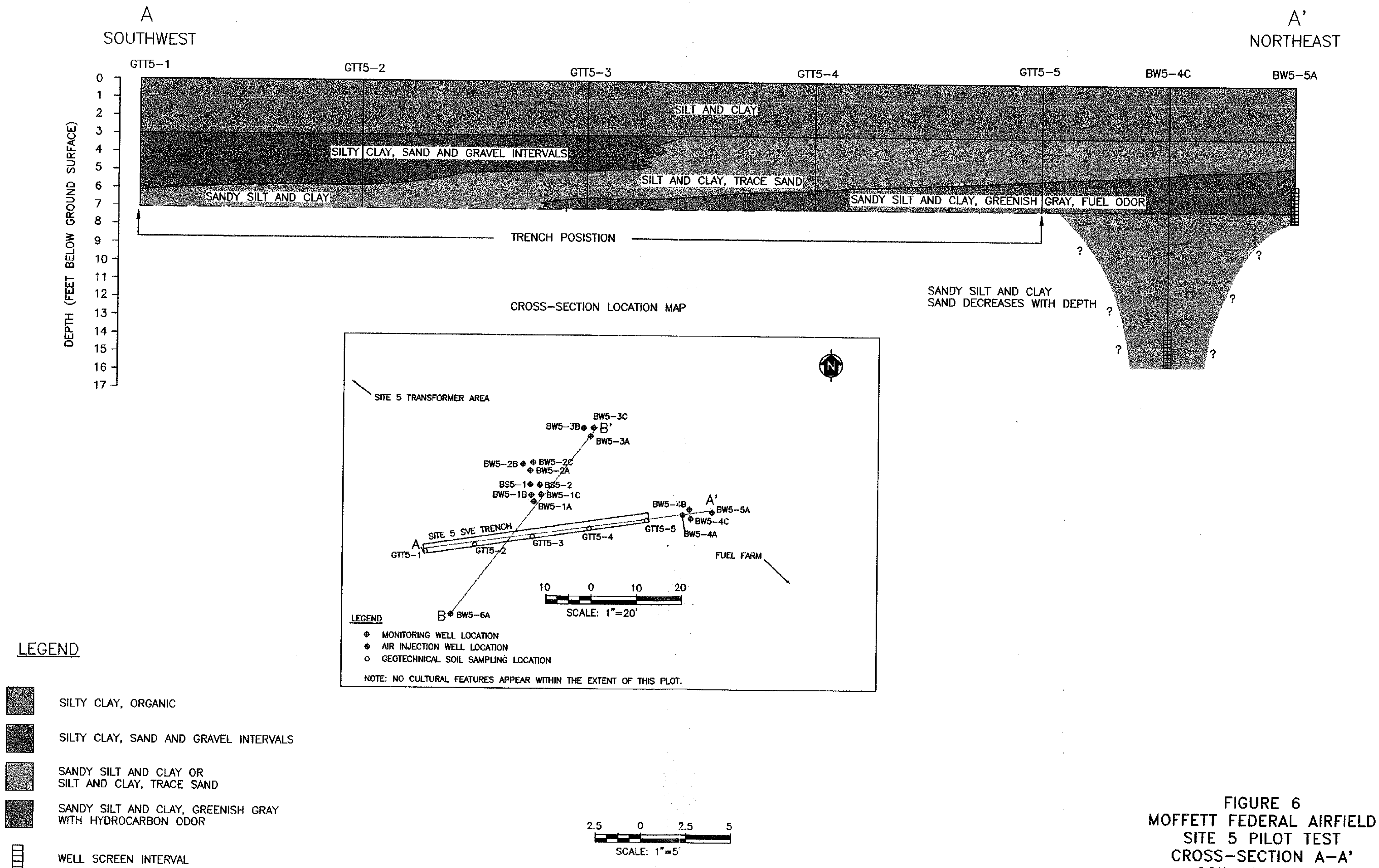

FIGURE 6
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
CROSS-SECTION A-A'
SOIL LITHOLOGY

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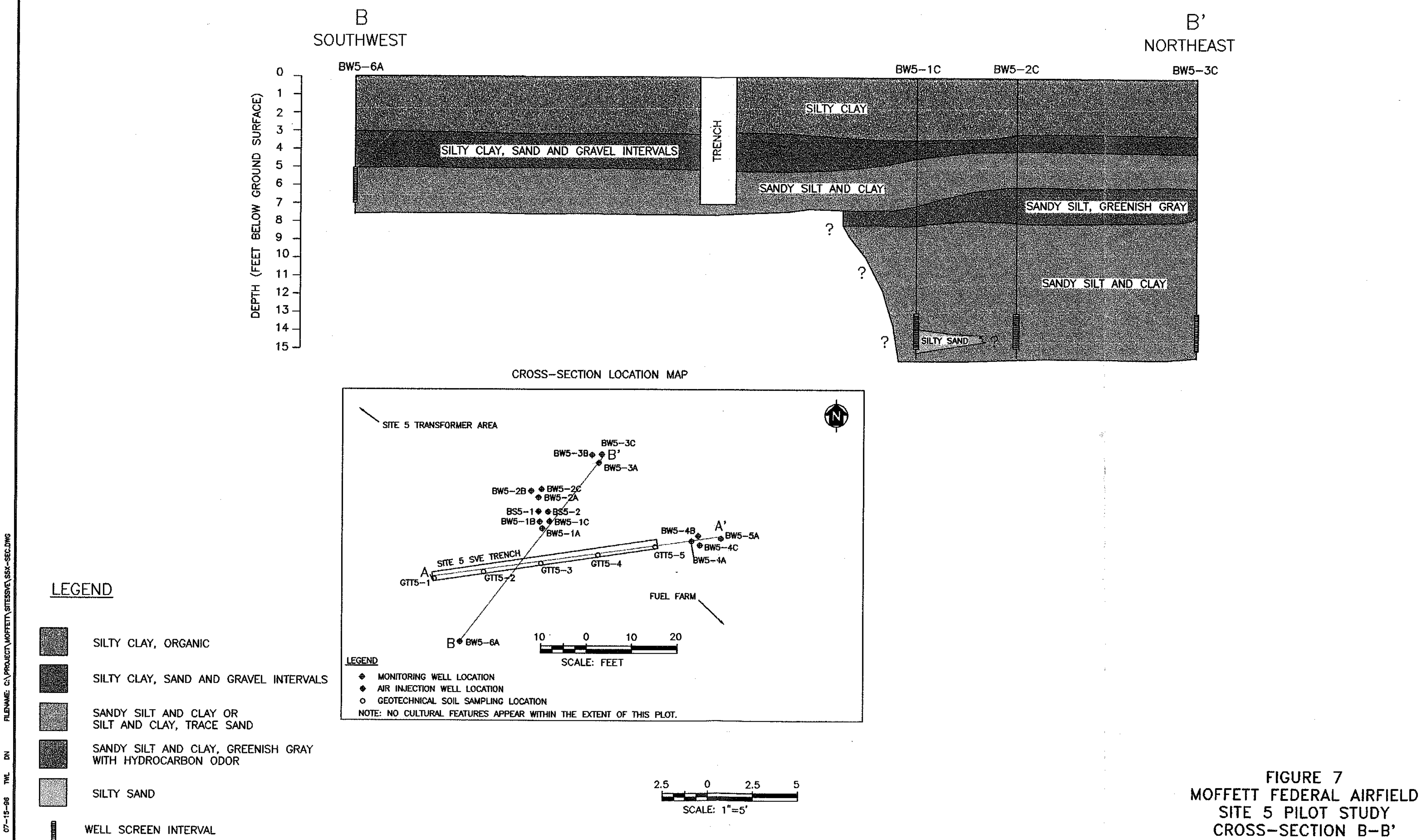

FIGURE 7
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT STUDY
CROSS-SECTION B-B'
SOIL LITHOLOGY

Baseline samples were collected from locations along four lines parallel to the centerline of the trench. Two lines were on each side of the trench approximately 4 feet and 10 feet from the centerline. Figure 8 shows the locations of the baseline samples. Samples were collected from the zone of highest apparent contamination, approximately 6 to 7 feet bgs, using a Geoprobe sampling system. Lithologic descriptions of the sampled intervals are consistent with those presented in the borehole logs (Appendix B).

2.2.2.1 Work Plan Deviations

The work plan states that baseline samples will be collected based on a radius of influence (ROI) calculated after the air permeability test is completed. However, conditions in the subsurface precluded an accurate estimation of the effective ROI after the air permeability test was performed. Anticipating that a ROI could be calculated after further testing, baseline sampling was postponed until after the biosparge test.

The work plan states that baseline samples will be collected based on visual observation and headspace analysis of portions of each sample core. Because of strong fuel odor and obvious staining in the sampling zone, headspace analysis was not necessary.

2.2.3 Confirmation Sampling

Confirmation samples were collected at the conclusion of the Phase I test (May 15 to 16, 1996) to evaluate the performance of the bioventing system. Samples were collected near the baseline sample locations, offset approximately 6 inches, and at the same approximate depth using the same collection methodology as used for the baseline samples. Analytical results from these samples are compared to baseline sample analyses to evaluate any decrease in TPH concentrations due to system operation, and these results are presented in Section 3.0.

2.2.3.1 Work Plan Deviations

No work plan deviations occurred during confirmation soil sampling.

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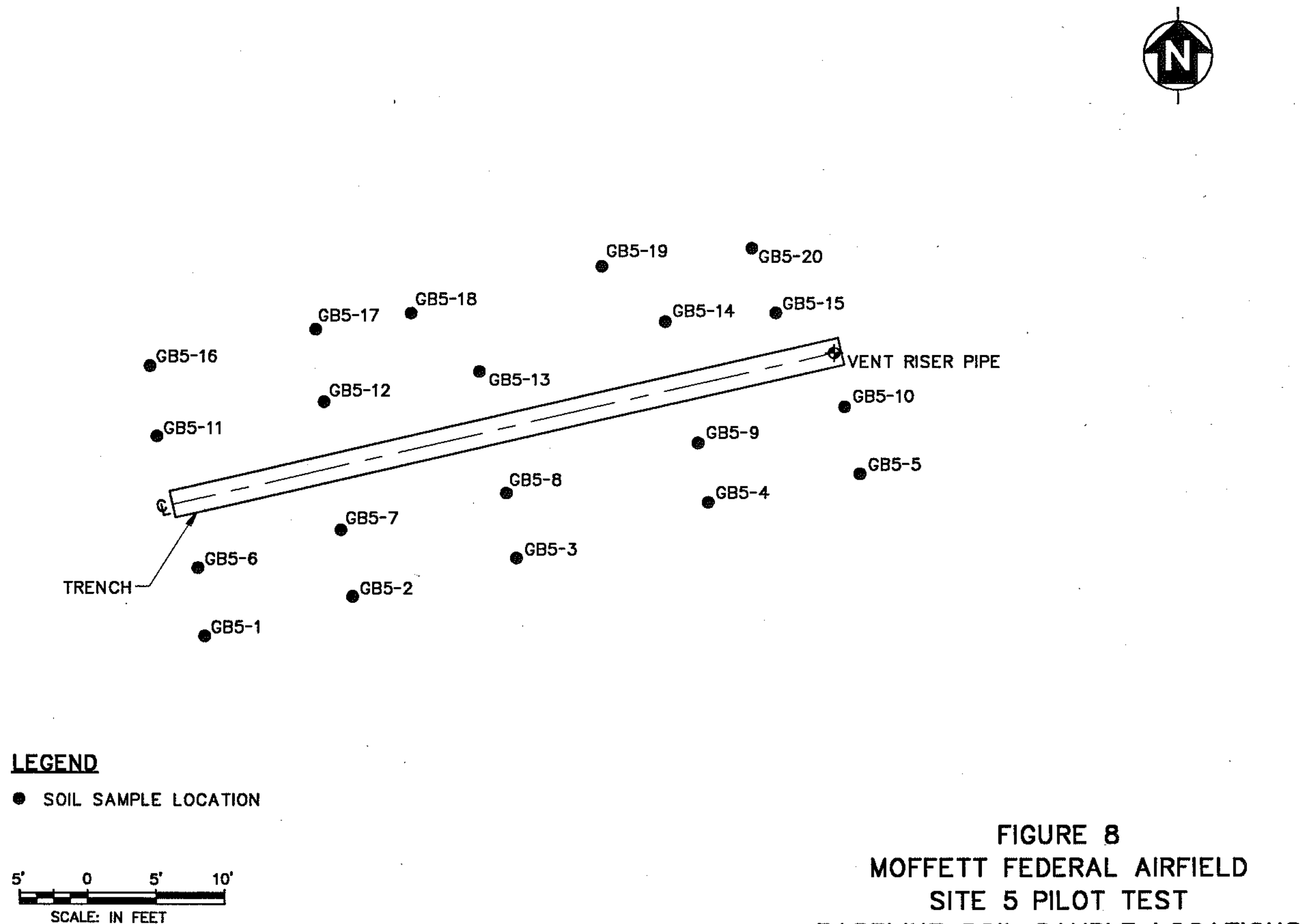

FIGURE 8
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
BASELINE SOIL SAMPLE LOCATIONS

2.3 GROUNDWATER SAMPLING

Though not indicated in the field work plan, groundwater samples were collected for chemical and biological analysis to better evaluate biosparging feasibility.

2.3.1 Field Activities

Groundwater samples were collected from each of the shallow B-level wells to better assess the feasibility of groundwater bioremediation at Site 5. Samples were collected on August 14, 1995 and analyzed for TPH-e, total Kjeldahl nitrogen (TKN), nitrate, phosphate, and hydrocarbon-utilizing plate counts. All quality control procedures specified in the Draft Phase I Corrective Action Field Work Plan (PRC 1994b) and the basewide quality assurance project plan (PRC and MW 1992b) were followed during groundwater sampling.

Nitrogen and phosphate are nutrients required for microbial metabolism and are useful indicators of general nutrient status for bioremediation. The hydrocarbon-utilizing plate count analysis yields an indication of indigenous microorganisms that are capable of degrading hydrocarbons. These data, in conjunction with the sparge test data, are useful in evaluating the potential for successful bioremediation of Site 5 groundwater.

2.3.2 Work Plan Deviations

Since groundwater sampling was not specifically indicated in the work plan, all groundwater sampling activities are considered work plan deviations. As indicated in Section 2.3.1 above, the purpose of this additional field work was to better evaluate the feasibility of biosparging.

2.4 AIR PERMEABILITY TESTING

This section discusses activities that were conducted to evaluate the air permeability of subsurface soils at the pilot test area. Collection of air permeability test data was also intended to assess the feasibility of injecting air into subsurface soils and to evaluate the ROI of the biovent system. The air permeability tests were conducted on August 14, 21, and 22, and September 11 to 12, 1995.

2.4.1 Field Activities

Initial field activities included installation of barbed brass fittings in monitoring well caps and the connection of tubes and Magnehelic gauges to these fittings for pressure measurement. A thermometer was also installed in the biovent riser pipe for blower monitoring and temperature corrections to flowrate calculations. To assess depth to groundwater, water level measurements were taken at all B- and C-level wells prior to testing.

A system check was then conducted to verify proper system operation. The blower was turned on with the bleed valve fully open and pressure and flowrate were measured while air flow was slowly increased to the biovent trench. Pressure at A-zone monitoring wells was monitored for a few different flowrates. Although the biovent system equipment appeared to be in proper working order, only a slight increase in pressure was detected at any A-zone monitoring wells during the system check.

On August 14, 1995, air permeability testing was initiated using a flowrate of approximately 11 standard cubic feet per minute (scfm). Eight different flowrates were used for run times of up to approximately 30 minutes each. Pressure was monitored at A-zone wells and at the biovent inlet pipe during each run. Only slight increases in pressure were detected in any monitoring wells, and pressure at the biovent inlet pipe appeared to be very low considering the relatively low permeability of soils at the injection depths. Leaks or short-circuiting of injected air to the ground surface was suspected, and this initial phase of air permeability testing was discontinued after approximately 2 1/2 hours. Testing conducted to evaluate potential vertical soil fractures or other system leaks is discussed in Section 2.5.

Since creation of vertical fractures at the biovent trench (which could result in short-circuiting of injected air toward the ground surface) during system construction was suspected, a decision was made to use a vertical A-zone monitoring well as a biovent injection point for further air permeability testing. Based on its location relative to other A-zone monitoring points, biovent monitoring well BW5-2A was selected as a biovent air injection well.

Before initiating testing at well BW5-2A, three additional vadose-zone monitoring points were installed for better evaluation of ROI. These temporary monitoring points (T1, T2, and T3) were installed using a Geoprobe at locations as shown in Figure 9. The 3/4-inch diameter PVC casings

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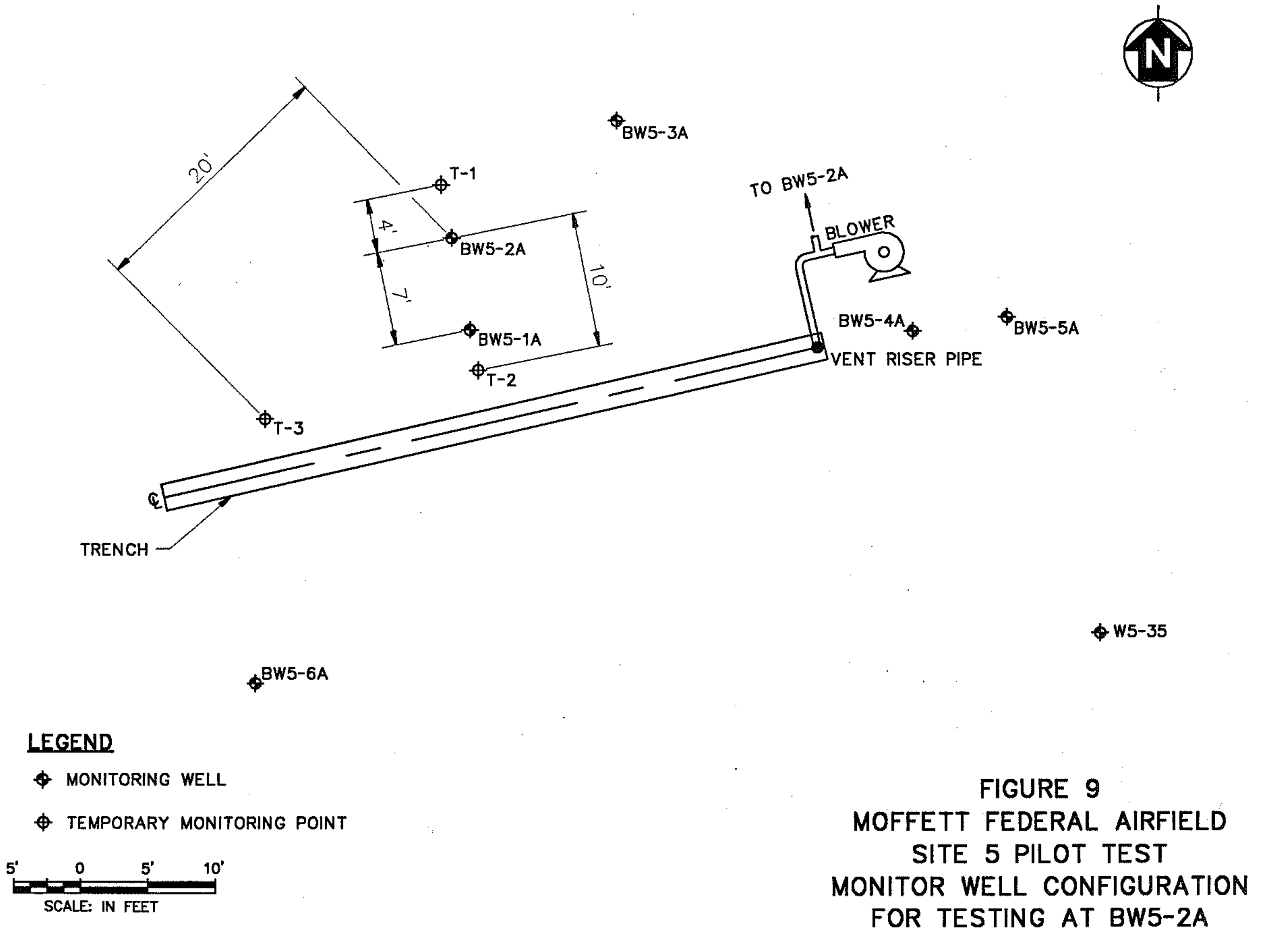

FIGURE 9
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
MONITOR WELL CONFIGURATION
FOR TESTING AT BW5-2A

(screened at 5 to 7 feet bgs) were inserted into 2 1/2-inch diameter holes cored with a Geoprobe. Sand was then backfilled into the annular space to approximately 5 feet bgs, and the remainder of the corehole was backfilled with cement grout to ground surface. Casings were then fitted with air-tight PVC caps and barbed brass fittings for subsequent pressure monitoring. These temporary points were located to be used as monitoring points for air permeability testing at BW5-2A as well as for further testing at the biovent trench.

Air injection into well BW5-2A was initiated on August 21, 1995 using an air compressor. Numerous air flow rates up to approximately 4.5 scfm were used while monitoring pressures at nearby A-zone wells and at the wellhead. Since the compressor was not capable of supplying more than approximately 4.5 scfm, the blower was then set up for use as an air injection source. The globe valve on the biovent line was completely shut off, the original bleed line was fully opened and connected to well BW5-2A, and an additional bleed valve was installed in this line to regulate flow to the new injection well (see Figure 10). The system blower was used to inject air at numerous flowrates into the well while recording pressures at nearby monitoring wells and at the wellhead. This temporary test system was then disconnected and the system was restored to its original configuration.

On August 22, 1995, additional pressure data were collected from temporary points T2 and T3 during blower operation. Although these points were sampled during leak testing field activities (see Section 2.5), these data are also useful in evaluating air permeability.

Based on test results at the biovent trench, IT was mobilized to complete additional modifications to the biovent trench system in an attempt to reduce or eliminate potential vertical air flow to ground surface. Soils were excavated from an area approximately 4 feet in diameter around the riser pipe to 5 feet bgs (top of gravel pack). The riser pipe was checked, and the hole was backfilled to surface with cement grout. Topsoils were removed to a 3-foot depth over an area of approximately 8 by 56 feet centered over the trench. Soils were then backfilled and compacted to 1 foot bgs, and a 12 by 60 foot liner was reinstalled and reconnected to the riser pipe. Finally, the remaining 12 inches of soil was backfilled and compacted to grade. This repair work was conducted from September 5 to 11, 1995.

Further air permeability testing was conducted on September 11 and 12, 1995 to evaluate subsurface air flow after the modifications had been completed. As before, the blower was turned on and testing was conducted using numerous flowrates and injection pressures. Pressures were recorded at the vent and at A-zone monitoring wells, and temperature and flow velocities were also recorded. The results of all air permeability testing are presented in Section 5.1.

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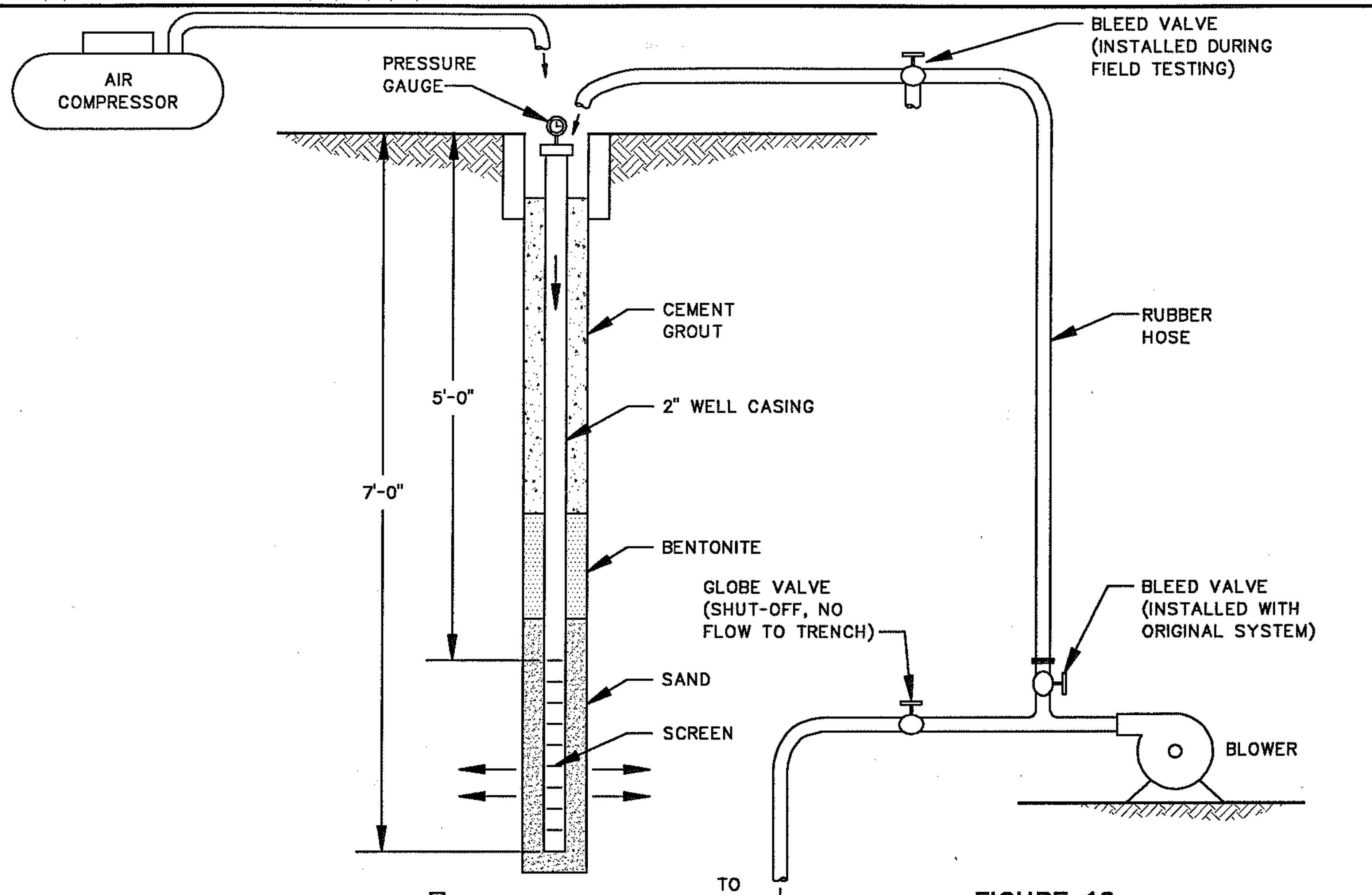

NOTE:

AIR COMPRESSOR USED FOR LOWER FLOW RATES (≤4.5 SCFM); BLOWER USED FOR HIGHER FLOW RATES (>4.5 SCFM).

NOT TO SCALE

FIGURE 10
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
AIR PERMEABILITY TEST SYSTEM AT BW5-2A

2.4.2 Work Plan Deviations

Several deviations from the field work plan occurred during air permeability testing. In general, the deviations were due to suspected system leaks and attempts to continue to gather useful data for system evaluation.

None of the air permeability tests were continued for the 4- to 8-hour periods originally intended. However, the system stability criterion (no more than 10 percent pressure change at BW5-3A over 1 hour) to stop testing was met as specified in the field work plan, since no pressure increase was ever observed at well BW5-3A. Pressure versus time data were not plotted during testing since change in pressure over time was insignificant at the wells where pressure was detected.

All test activities at well BW5-2A are considered deviations from the field work plan since this testing was not planned. These activities included the installation of temporary monitoring points. This impromptu testing at a vertical well was done to compensate for lack of complete data due to biovent trench system leakage.

2.5 LEAK TESTING

Because of suspected leaks of biovented air upward toward the ground surface, leak testing was conducted in an attempt to locate potential leak areas. Leak tests were conducted on August 16 and 22, and on September 12, 1995.

2.5.1 Field Activities

Initial leak testing involved the use of puddled water on surface soils above the biovent trench area. On August 16, small berms were made with shovels to enclose areas of approximately 10 square feet, and these areas were then filled with water. With the biovent system running, puddles were closely watched for the presence of air bubbles that would indicate the location of a vertical leak. Numerous bermed puddles were made and observed along the length of the trench area.

Since observation of puddles appeared to be useful only for detection of the largest leaks, helium gas was then used for finer resolution leak detection. On August 22, a compressed helium gas tank was connected to the biovent inlet pipe and flow was regulated to achieve an approximate 5 percent mixture by volume of helium to air. The system was run for about 2 1/2 hours while numerous surface areas were scanned (within about 2 inches of ground surface) with a Marks 9821 helium detector. This helium detector is capable of measuring down to 0.01 percent helium. Helium concentration data and corresponding location information were recorded.

Leak testing using helium was also conducted after trench system repair. On September 12, 1995, compressed helium gas was connected to the biovent inlet and numerous surface areas were scanned as before using a helium detector. All helium concentration data and location information were recorded over a 1 1/2 hour testing timeframe. Results of all leak tests are presented in Section 5.2.

2.5.2 Work Plan Deviations

Since system leak testing was not anticipated, leak testing was not specified in the field work plan. Therefore, all leak testing activities are work plan deviations. This additional testing was necessary to evaluate the nature of vertical components of the bioventing air flow through subsurface soils.

2.6 RESPIRATION TESTING

This section discusses testing activities conducted to evaluate the presence and degree of microbial degradation of petroleum hydrocarbons at Site 5. Microorganisms use oxygen as an electron acceptor to metabolize or biodegrade organic contaminants (reduced carbon source), producing carbon dioxide (CO_2) (oxidized carbon byproduct) in the process. Since the biodegradation rate is directly related to oxygen consumption and CO_2 production rates, in situ biodegradation rates can be estimated based on concentration changes in oxygen and CO_2 levels (respiration) observed in the field.

Respiration results are useful for assessing the presence of naturally occurring microbes capable of degrading petroleum contaminants, evaluating the feasibility of bioremediation of soils, assessing nutrient status, and estimating the time in situ biodegradation would require to achieve cleanup goals. Respiration test activities were conducted from August 15 to 23, 1995.

2.6.1 Field Activities

On August 13, 1995, before respiration and biovent testing began, background gas samples were collected and field analyzed for oxygen and CO_2 concentrations. These background concentrations serve as baseline values representing pretesting soil respiration conditions.

On August 15, an air/helium injection system was set up using an air compressor, compressed helium tanks, regulators, flow gauges, and tubing, as seen in Figure 11. The intent of the system was to supply equal amounts of oxygen to a vadose-zone well with soil contamination (BW5-5A) and a background, "clean" well (W5-20) to increase oxygen concentrations in the subsurface and stimulate biodegradation for respiration testing. This background well, screened partially in the vadose zone, was used to measure any respiration in clean soils caused by naturally occurring soil organic matter or oxygen depletion due to chemical oxidation of naturally occurring minerals. An approximate 2 percent mixture of helium in air was used as a tracer gas to evaluate potential loss of injected gases (including oxygen) from the wells via advection or diffusion.

Injection of the air/helium mixture began on August 16 into wells BW5-5A and W5-20. Flowrates varied from approximately 60 to 75 standard cubic feet per hour (scfh) with helium concentrations ranging between 1.9 and 2.8 percent. The air compressor malfunctioned twice during the first 2 days of injection, requiring field repairs, although total system downtime was minimized (1 hour 45 minutes on August 16, 1995, 2 hours 40 minutes on August 17, 1995) and relatively continual air injection conditions were maintained over the injection period. On August 18, air and helium injection into the two wells was stopped after a total of approximately 43 hours.

Within 5 minutes of shutting off the air compressor and helium tanks, respiration measurements were initiated by sampling the two wells for oxygen and CO_2. Measurements were made every 2 hours for the first 8 hours, every 8 hours for the next 2 days, then twice a day. Data were collected until the morning of August 23, for a total monitoring period of 5 days. These respiration results are presented and discussed in Section 5.3.

2.6.2 Work Plan Deviations

Only minor deviations from the work plan occurred during respiration testing. The total injection time (43 hours) was slightly less than the 48-hour injection time specified in the work plan, partially

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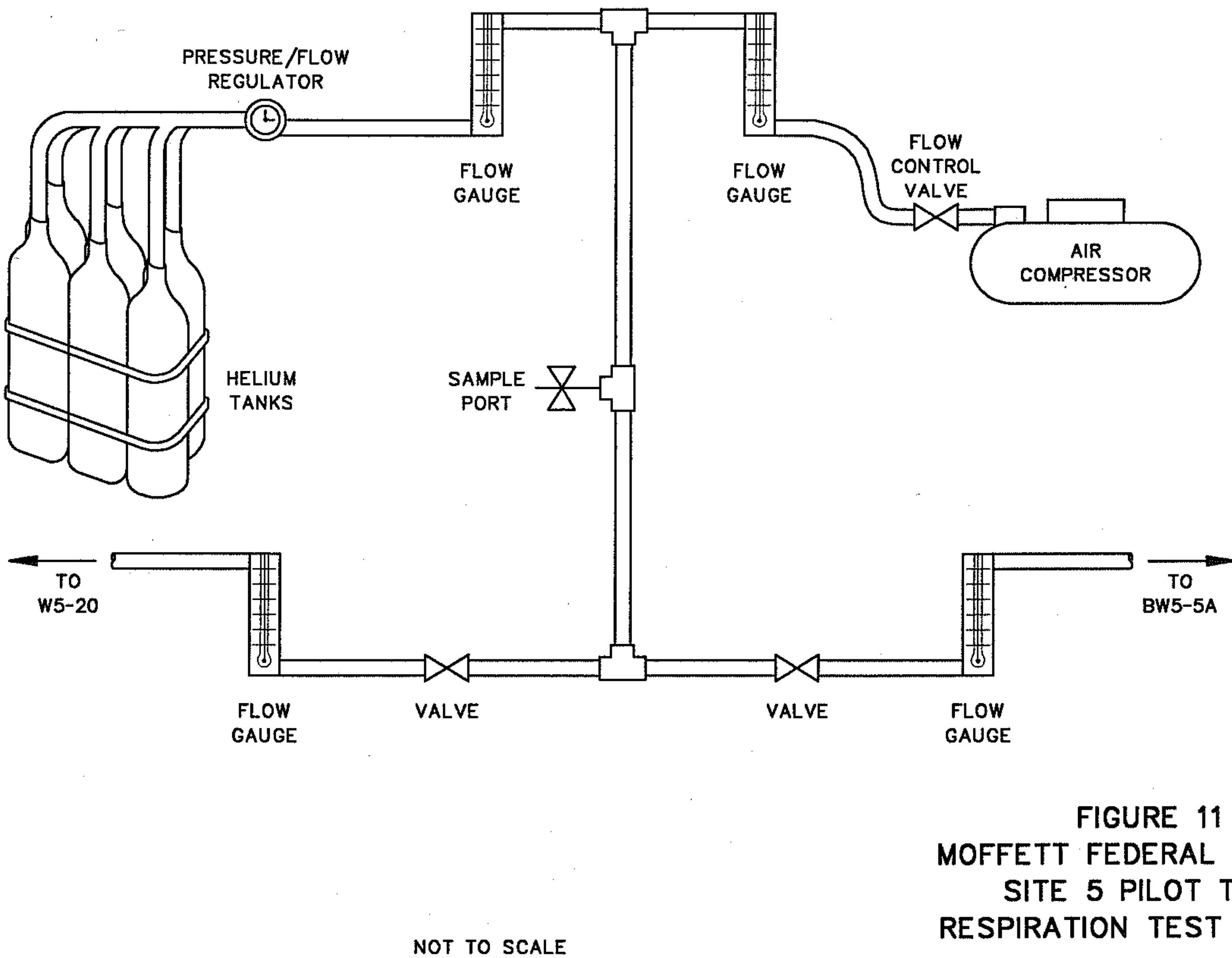

FIGURE 11
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
RESPIRATION TEST SYSTEM

due to equipment problems. However, as evidenced by respiration data (Section 5.3), the period of injection time was sufficient to obtain good results and meet the objectives of testing. Furthermore, the injection time used exceeded time periods reported at other successful biovent pilot test sites (AFCEE 1992).

Monitoring well BW5-5A was used for air injection during respiration testing rather than well BW5-1A as indicated in the field work plan. This change was made because monitoring well BW5-5A appeared to be located in a soil area more contaminated with TPH-e than the area around well BW5-1A, possibly enabling more readily quantifiable respiration rate estimates.

Another minor work plan deviation relates to sampling frequency. Since a relatively steady decline in oxygen and increase in CO_2 were observed at well BW5-5A during the first 3 days, sampling frequency was reduced to once every 12 hours for the last 2 days rather than once every 8 hours as specified in the plan. The data obtained were fully satisfactory and sufficient for meeting all test objectives.

2.7 BIOSPARGE TESTING

This section discusses testing used to assess the feasibility of using biosparging for groundwater remediation at Site 5. This testing consisted primarily of air injection at two sparge wells (BS5-1 and BS5-2) screened at different intervals and measurement of pressures at nearby monitoring wells. Biosparge testing was conducted on August 22 and 23, 1995.

2.7.1 Field Activities

Before air was injected, groundwater levels were measured to compare with later changes in the static water table elevation due to sparging activities. Water level data were collected at both sparge wells and at all B- and C-level monitoring wells.

Air injection into biosparge well BS5-1 (screened 9 to 11 feet bgs) was initiated on August 22, 1995 using an air compressor. No measurable air flow was obtained until pressure was applied at approximately 4.5 pounds per square inch (psi). Injection pressures were increased up to 12 psi with corresponding flow rates up to 4.6 scfm, while response pressures were monitored at A- and B-level wells. Water levels at nearby wells were also recorded during air injection, and helium gas was also injected for approximately 35 minutes to evaluate air flow including potential vertical flow. Biosparge testing at BS5-1 was concluded on August 23 after a total of approximately 3 1/2 hours of air injection.

Air injection into biosparge well BS5-2 (screened 13 to 15 feet) was initiated on August 23, 1995 using the air compressor. Pressures exceeding 7 psi were required to obtain any measurable air flow. Injection pressures up to 12.5 psi were used at flowrates up to 13.0 scfm; pressures above 8.0 psi were obtained by using the blower as an air injection source. As with testing at sparge well BS5-1, data collected included response pressures, water levels, and helium concentrations at nearby monitoring wells. Biosparge testing at BS5-2 was stopped on August 23 after approximately 1 1/2 hours.

Dissolved oxygen (DO) concentrations were then measured and recorded from groundwater samples taken from monitoring wells BW5-1B, -1C, -2B, and -2C to compare with pre-sparge testing DO data. Field DO measurements were made using a Hach test kit model OX-2P. All biosparge test results are presented in Section 5.4.

2.7.2 Work Plan Deviations

Some deviations from the field work plan occurred during biosparge testing. Injection pressures used at both sparge wells were higher than indicated in the work plan due to the need to overcome formation resistance and achieve air flow. In addition, sparge tests at both injection wells were run for less time than indicated in the work plan. The test times were shortened because measured ROIs were low (less than 5 feet) for both sparge wells even at relatively high injection pressures, likely due to very low soil permeability. Final DO concentrations were not measured at wells BW5-3C and -4C because both of these wells were far outside the sparging ROI. Finally, a combined biovent/biosparge system test was not run because independent system ROIs did not overlap, most likely due to the relatively impermeable saturated and vadose zone lithologies of the test area.

2.8 LONG-TERM BIOVENT TESTING

2.8.1 Field Activities

The long-term biovent test was initiated on September 12, 1995, after the last stage of air permeability testing was completed. The biovent system was left running with a flowrate of approximately 30 scfm at 3.5 inches of water pressure. Except for a 2-day shutdown for respiration testing in November 1995, the blower was running continuously from September 12, 1995 to about January 14, 1996. Sometime between January 12 and 14, the blower malfunctioned and stopped injecting air into the biovent trench. The blower was removed, inspected, and then replaced, and the system was restarted on February 16, 1996 with a flowrate of 29 scfm at 11 inches of water pressure. One month later, the blower again malfunctioned and a decision was made to discontinue system operation and conclude the long-term test. The total system run time was approximately 5 1/2 months, and long-term test results are presented in Section 5.5. To complete the biovent system evaluation, 20 confirmation soil samples were collected and analyzed as discussed in Section 2.2. Soil sampling results are presented in Section 3.0.

2.8.2 Work Plan Deviations

Because of scheduling and equipment problems, monitoring well oxygen data were collected roughly every 8 weeks throughout the long term test, rather than every 6 weeks as stated in the field work plan. Hydrocarbon data were not collected throughout long-term testing since PID readings were zero for all wells except BW5-5A (22.9 parts per million [ppm]) during baseline soil gas sampling. The final in situ respiration test was not conducted since no monitoring wells appeared to indicate significant increases in oxygen during long-term testing and therefore would likely not be subject to significant microbial acclimation and respiration improvements during the 5 1/2-month period.

3.0 SOIL ANALYTICAL RESULTS

This section presents soil chemical and geotechnical analytical results for samples collected from the Site 5 biovent trench and monitoring well boreholes.

3.1 SOIL NUTRIENTS

Two of the five samples collected from biovent monitoring wells were analyzed for nutrients and microbial plate counts. Specific nutrient analyses included ortho-phosphate (phosphate as phosphorus), ammonia, nitrate (nitrate as nitrogen), and TOC. Microbial plate count analyses consisted of a heterotrophic plate count and a hydrocarbon-utilizing plate count using diesel as a fuel substrate. These analyses were conducted to assist in evaluating the biodegradation potential for the bioventing system at Site 5. Table 1 summarizes the soil nutrient analytical results. Complete laboratory analytical results are contained in Appendix C.

TABLE 1

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
SOIL NUTRIENT ANALYTICAL RESULTS

Sample Analysis	Sample Number (Depth)	
	BW5-2A (6.5-7.5)	BW5-4A (6.0-7.5)
Total Organic Carbon (mg/kg)	1,210	<122
Total Solids (percent by weight)	82.5	81.9
Heterotrophic Plate Count (CFU/gram)	125,000	30,000
Diesel-Utilizing Plate Count (CFU/gram)	29,000	3,000
Nitrate as N (mg/kg)	0.55	0.41
Phosphate as P (mg/kg)	1.1	1.2
Ammonia (mg/kg)	ND[1]	ND[1]

Notes:

[1] Detection limit was 1.0 mg/kg

mg/kg	Milligrams per kilogram
CFU	Colony forming units
N	Nitrogen
P	Phosphorus
ND	Not Detected

As seen in Table 1, significant concentrations of both heterotrophic and hydrocarbon-utilizing microorganisms were present in both soil samples, indicating that biodegradation of fuel contaminants may already be occurring. Nitrogen sources, as measured by nitrate and ammonia, appear to be in relatively low concentrations in the two soil samples collected (up to 0.55 mg/kg nitrate). Phosphate concentrations were 1.1 and 1.2 mg/kg as phosphorus for the two samples. Since nitrogen is estimated to be used by microbes for degradation at a ratio on the order of 10:1 nitrogen to phosphorus (Baker and Herson 1994), it appears that, in addition to oxygen, nitrogen may be a limiting nutrient for biodegradation of hydrocarbons in Site 5 soils, based on the two soil samples. However, some research indicates that microbes may be able to utilize other sources of nitrogen through processes such as nitrogen fixation of atmospheric nitrogen into ammonia (Anderson 1995). Therefore, supplemental nitrogen may not necessarily be required for successful implementation of a bioventing system.

TOC values were 1,210 mg/kg in one sample and less than 122 mg/kg in the other sample. It is likely that some portion of the carbon constituting these TOC values is derived from petroleum contamination. These TOC concentrations are relatively low for robust biodegradation, as they do not represent significant food sources for microbes. However, higher concentrations of TPH in soils were present in the pilot test area, with levels up to 3,500 mg/kg TPH-e detected in baseline soil samples (see Section 3.3).

Based on the soil nutrient and microbiological results presented here, conditions appear to be favorable for biodegradation in soils at Site 5 provided that there is an adequate supply of oxygen to support microbial activity. It is possible that supplemental nitrogen would enhance biodegradation rates, and this addition should be considered if a full-scale bioventing system is implemented.

3.2 GEOTECHNICAL RESULTS

Samples collected from the biovent trench sidewall were analyzed for grain size distribution to confirm the observed lithologic description of the trench. Samples were also collected from selected borings and analyzed for the geotechnical properties of grain size distribution, porosity, and moisture content. Table 2 summarizes results of geotechnical analyses of samples collected from the trench and boreholes. Complete geotechnical analytical results are presented in Appendix D.

Results presented on Table 2 indicate that the majority of soil samples were characterized as sandy clayey silts or clayey sandy silts. Figures 6 and 7 provide cross-sections that depict lithologic characteristics of the pilot test area based on field observations. Visual observation of soils indicate that the trace sands or gravels present were discontinuous and that individual grains were separated by

TABLE 2

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
SOIL GEOTECHNICAL ANALYTICAL RESULTS

Sample	Sample Source	Sample Depth (feet bgs)	Soil Description	Porosity (percent)	Moisture Content (percent)
GTT5-1	Trench	(5.5-6.5)	Silty gravelly sand	NA	NA
GTT5-2	Trench	(5.5-6.5)	Silty sand	NA	NA
GTT5-3	Trench	(4.5-5.5)	Silt with sand	NA	NA
GTT5-4	Trench	(4.5-5.5)	Sandy clayey silt	NA	NA
GTT5-5	Trench	(5.0-5.5)	Clayey silt	NA	NA
GTB5-1B	BW5-1B	(10.5-11.0)	Clayey silt with sand	NA	NA
GTB5-1C	BW5-1C	(14.5-15.0)	Clayey silt with sand	NA	NA
GTB5-2A	BW5-2A	(6.5-7.0)	Sandy clayey silt	40.7	25.1
GTB5-4A	BW5-4A	(6.5-7.0)	Clayey sandy silt	39.6	24.0
GTB5-6A	BW5-6A	(6.5-7.0)	Clayey sandy silt	37.7	22.2

Notes:

NA Not Analyzed
bgs Below ground surface

relatively large intervals of less permeable materials. In general, visual characterization and geotechnical analyses indicate that both vadose zone and saturated zone soils in the pilot test area exhibit a relatively low permeability and are not conducive to air flow. Analysis of other Site 5 borehole logs outside of the pilot area also indicates that, in general, Site 5 soils are relatively fine grained and likely have a low air permeability. Therefore, in situ remedial actions for soils or groundwater at Site 5 may require fracturing or other permeability enhancements for successful implementation.

3.3 BASELINE CHEMICAL DATA

Twenty soil samples were collected from boreholes aligned in a grid established along four lines parallel to the biovent trench, as shown in Figure 8. Two lines were positioned on each side of the trench approximately 4 and 10 feet from its centerline. Samples were collected from the zone of highest apparent contamination in each borehole. Field observations and analytical results show that this zone lies between 6 and 7 feet bgs, coinciding with the approximate high level of groundwater in the area. Analytical results also show that, in general, the highest TPH-e concentrations are found in the eastern portion of the pilot test area. TPH concentrations in baseline samples ranged from not detected in three western samples to 3,500 mg/kg TPH-e in sample GB5-15 (eastern region of the sample grid). Figure 12 shows the locations and detected concentrations of TPH for all baseline samples. Table 3 summarizes analytical results from baseline soil samples. Complete analytical results for baseline samples are presented in Appendix C.

3.4 CONFIRMATION DATA

Confirmation soil sampling was performed at the end of the Phase I bioventing test in May 1996 as described in Section 2.2. As with the baseline samples, all 20 confirmation samples were collected in a grid pattern offset approximately 6 inches from the original baseline sample locations. The intention of this confirmation sampling was to compare soil sample TPH-e concentrations before and after long-term biovent testing to assess any changes due to bioventing operations. All attempts were made to collect the confirmation samples using the same sampling equipment, sample depths, collection methodologies, and analytical procedures as were used for the baseline samples. To reduce chances for any analytical differences between laboratories, the same laboratory (Anametrix) was used to analyze both sets of samples. Results of TPH-e analysis of confirmation soil samples are shown in Table 4. For comparison purposes, analytical results of baseline samples are shown adjacent to the corresponding confirmation sample result in Table 4, as well as the percent reductions in TPH-e concentrations from baseline to confirmation samples.

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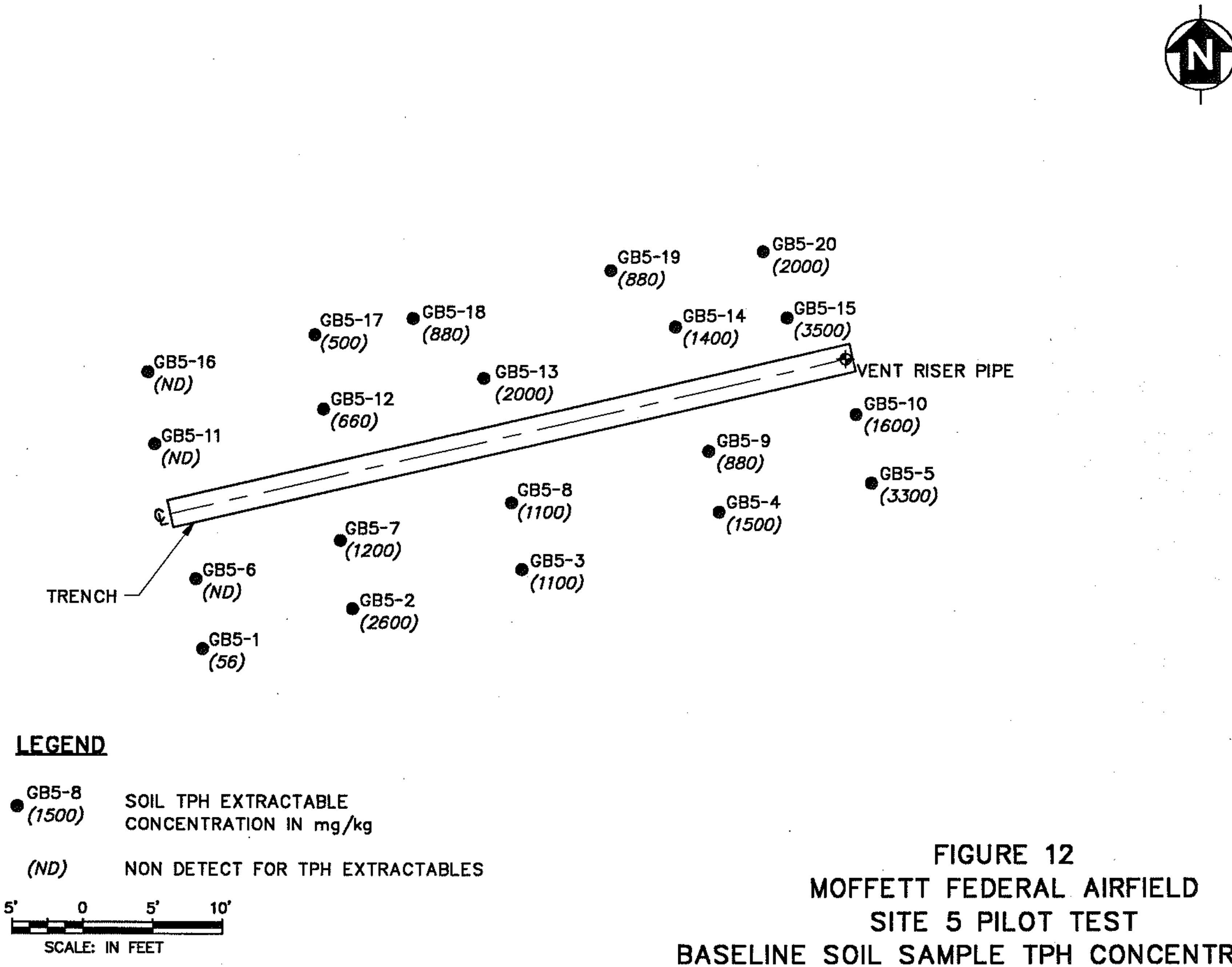

FIGURE 12
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
BASELINE SOIL SAMPLE TPH CONCENTRATIONS

TABLE 3

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
BASELINE SOIL SAMPLE ANALYTICAL RESULTS
TOTAL EXTRACTABLE PETROLEUM HYDROCARBONS
(mg/kg)

Sample Number	Depth Interval (feet bgs)	Baseline JP-5
GB5-1	(6.0-7.0)	56[1]
GB5-2	(6.8-7.0)	2,600
GB5-3	(6.1-6.5)	1,100
GB5-4	(6.4-7.0)	1,500
GB5-5	(5.3-5.6)	3,300
GB5-6	(6.5-7.0)	ND
GB5-7	(6.4-7.0)	1,200
GB5-8	(6.6-7.0)	1,100
GB5-9	(6.0-6.8)	880
GB5-10	(6.0-7.0)	1,600
GB5-11	(6.0-7.0)	ND
GB5-12	(6.6-7.0)	660
GB5-13	(6.5-7.0)	2,000
GB5-14	(6.5-7.0)	1,400
GB5-15	(6.4-6.7)	3,500
GB5-16	(6.5-7.0)	ND
GB5-17	(6.7-7.0)	500
GB5-18	(6.4-6.7)	880
GB5-19	(6.4-6.8)	880
GB5-20	(6.0-7.0)	2,000

Notes:

1 This sample was non-detect for TPH extractable as JP-5, but had a detection quantified as 56 mg/kg TPH extractable as motor oil.

mg/kg	Milligrams per kilogram
bgs	Below ground surface
ND	Not detected, detection limits ranged from 11 to 12 mg/kg

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TABLE 4

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
CONFIRMATION SOIL SAMPLE ANALYTICAL RESULTS
TOTAL EXTRACTABLE PETROLEUM HYDROCARBONS
(mg/kg)

Sample Number	Depth Interval (feet bgs)	Confirmation Result	Baseline Result	Percent Reduction[1]
GCB5-1	(6.0-7.0)	ND	56[2]	78.6[3]
GCB5-2	(6.8-7.0)	260	2,600	90.0
GCB5-3	(6.1-6.5)	110	1,100	90.0
GCB5-4	(6.4-7.0)	230	1,500	84.7
GCB5-5	(5.3-5.6)	1,500	3,300	54.5
GCB5-6	(6.5-7.0)	ND	ND	NA
GCB5-7	(6.4-7.0)	73	1,200	93.9
GCB5-8	(6.6-7.0)	480	1,100	56.4
GCB5-9	(6.0-6.8)	100	880	88.6
GBC5-10	(6.0-7.0)	140	1,600	91.3
GCB5-11	(6.0-7.0)	ND	ND	NA
GCB5-12	(6.6-7.0)	170	660	74.2
GCB5-13	(6.5-7.0)	170	2,000	91.5
GCB5-14	(6.5-7.0)	290	1,400	79.3
GCB5-15	(6.4-6.7)	300	3,500	91.4
GCB5-16	(6.5-7.0)	25	ND	Increase[4]
GCB5-17	(6.7-7.0)	7.6 J	500	98.5
GCB5-18	(6.4-6.7)	300	880	65.9
GCB5-19	(6.4-6.8)	210	880	76.1
GCB5-20	(6.0-7.0)	140	2,000	93.0

Notes:

1 Percent reduction = [(baseline-confirmation)/baseline] x 100
2 This sample was non-detect for TPH extractable as JP-5, but had a detection quantified as 56 mg/kg TPH extractable as motor oil.
3 This percent reduction was calculated assuming that the confirmation value was at the detection limit of 12 mg/kg; actual reduction is probably greater than 78.6 percent.
4 Confirmation sample TPH value was higher than the corresponding baseline sample (detection limit was 11 mg/kg)

bgs Below ground surface

TABLE 4 (continued)

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
CONFIRMATION SOIL SAMPLE ANALYTICAL RESULTS
TOTAL EXTRACTABLE PETROLEUM HYDROCARBONS
(mg/kg)

ND	Not detected, detection limits ranged from 11 to 12 mg/kg
NA	Not available
J	Estimated value
mg/kg	Milligrams per kilogram
TPH	Total petroleum hydrocarbons

As seen in Table 4, nearly all sets of samples showed significant reductions in TPH-e concentrations when comparing confirmation to baseline results. Percent reductions in TPH-e concentrations ranged from 54.5 to 98.5 percent, with an average reduction of 82.2 percent. Two sample pairs indicated no detections of TPH-e in soil samples analyzed before and after the bioventing study. Only one sample pair (GB5-16 and GCB5-16) of the 20 sample pairs showed an increase, from not detected in the baseline sample to 25 mg/kg TPH-e in the confirmation sample. This increase could be due to soil heterogeneities and resulting local differences in contaminant distribution. Although variations in contaminant distribution between nearby soil sample pairs could account for some of the lower concentrations in confirmation samples, there appears to be a significant overall trend in contaminant reduction after the long-term biovent test. Based on these results, it is likely that the injection of air into contaminated soils by the bioventing system resulted in significant biodegradation of TPH contaminants in test area soils.

4.0 GROUNDWATER ANALYTICAL RESULTS

This section presents groundwater analytical results and discusses their implications for the feasibility of successful bioremediation. All groundwater samples were collected on August 14, 1995 from the B-level wells screened from 9.0 to 11.0 feet bgs.

Table 5 presents analytical results for nutrients and TPH-e. Nitrate concentrations ranged from 3.0 to 4.9 milligrams per liter (mg/L), with the highest concentration measured in a sample collected from monitoring well BW5-3B. TKN concentrations, which sum organic and ammonia nitrogen forms, were all approximately 0.4 mg/L. These TKN and nitrate analytical results indicate that sufficient dissolved nitrogen is available to degrade significant amounts of TPH contamination in groundwater (greater than 10 mg/L TPH), assuming that other conditions are favorable for biodegradation.

Phosphate was not detected in any groundwater samples at detection limits ranging from 0.05 to 0.25 mg/L. Phosphate is an essential nutrient and the lack of detections may be indicative of phosphate-limited conditions for biodegradation. However, if other conditions are favorable for degradation, microbes may be capable of utilizing or making bioavailable other sources of phosphorus including sorbed or precipitated forms in the soil or groundwater matrix. Phosphate was present in both soil samples collected just above the water table (see Section 3.1), and phosphorus was also detected in the 0.1 to 0.2 mg/L range in four groundwater samples collected approximately 80 feet downgradient at the oxygen-releasing compound (ORC) pilot test study (PRC 1996).

TABLE 5

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
GROUNDWATER ANALYTICAL RESULTS
(Sampled August 14, 1995)

Sample Location	Nitrate (mg/L)	Phosphate (mg/L)	TPH-e (mg/L)[3]	TKN (mg/L)	Hydrocarbon-Utilizing Plate Count (CFU/mL)
BW5-1B	4.3	ND[1]	ND	0.41	1680
BW5-2B	4.0	ND[2]	ND	0.41	20
BW5-3B	4.9	ND[1]	ND	0.41	10
BW5-4B	3.0	ND[1]	ND	0.40	510

Notes:

[1] Detection limit was 0.05 mg/L
[2] Detection limit was 0.25 mg/L
[3] Detection limit was 0.1 or 0.11 mg/L

mg/L	Milligrams per liter
TPH-e	Total petroleum hydrocarbons as extractables
TKN	Total Kjeldahl nitrogen (organic nitrogen plus ammonia)
CFU/mL	Colony forming units per milliliter
ND	Not detected

All four water samples were analyzed for TPH-e, although no TPH-e contaminants were detected in any samples at detection limits of approximately 0.1 mg/L. Hydrocarbon-utilizing plate counts ranged from 10 to 1,680 colony forming units per milliliter (CFU/mL), with the highest concentration in the sample collected from monitoring well BW5-1B. While these concentrations are relatively low, the presence of hydrocarbon utilizers is an indication that microbial biodegradation is possible given adequate nutrients and contaminant substrates (organic food sources). Furthermore, the low plate counts are likely due to an insufficient food source for metabolism (TPH-e was not detected in any groundwater samples) and low dissolved oxygen. Laboratory groundwater analytical results are presented in Appendix E.

Dissolved oxygen was measured in groundwater samples as a part of biosparge testing (see Section 5.0). However, DO results are also summarized in this section to aid in the evaluation of nutrient status of groundwater in the pilot test area. Table 6 presents DO values of groundwater samples collected from B- and C-level wells screened at 9 to 11 and 13 to 15 feet bgs, respectively.

DO values ranged from 1.6 to 2.2 mg/L and 0.6 to 1.6 mg/L in samples collected from the B- and C-level wells, respectively. These relatively low DO levels are indicative of oxygen limitation relative to biodegradation, as DO levels less than 2.0 mg/L are not conducive to significant biodegradation of contaminants (Brown 1994, Salanitro 1993). In the pilot test area, both oxygen and fuel (TPH-e) are present in concentrations that appear to be too low for significant biodegradation. However, based on the groundwater analytical results presented above, it appears likely that biodegradation of petroleum contaminants in groundwater would occur at Site 5 given adequate oxygen supply and sufficient fuel contamination for microbial metabolism.

5.0 BIOVENTING AND BIOSPARGING TEST RESULTS

This section presents and discusses results of all bioventing and biosparging test activities conducted during Phase I pilot testing at Site 5. These tests, conducted from August 13, 1995 to May 16, 1996, included air permeability testing, leak testing, respiration testing, biosparge testing, and long-term biovent testing.

5.1 AIR PERMEABILITY TESTING

Air permeability testing using air injection was conducted using two different injection locations: the biovent trench pipe and vadose zone monitoring well BW5-2A. The additional, unanticipated testing at well BW5-2A was done to gather more air permeability data for evaluating bioventing at Site 5

TABLE 6

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
BACKGROUND DISSOLVED OXYGEN RESULTS

Sample Location	DO Concentration (mg/L)
BW5-1B	2.0
BW5-1C	0.8
BW5-2B	2.2
BW5-2C	0.6
BW5-3B	1.8
BW5-3C	1.6
BW5-4B	1.6
BW5-4C	0.8

Notes:

1. All water samples were collected with bailers and field analyzed for DO using a Hach OX-2P test kit.

2. All B-level wells screened at 9.0 to 11.0 feet bgs and sampled on August 14, 1995.

3. All C-level wells screened at 13.0 to 15.0 feet bgs and sampled on August 20, 1995.

mg/L Milligrams per liter
DO Dissolved oxygen

since biovent trench data were limited by suspected vertical flow leakage from the biovent trench. Sections 5.1.1 and 5.1.2 present biovent and monitoring well air permeability test results. Section 5.1.3 summarizes these results and discusses the potential for successful bioventing at Site 5 based on these results.

5.1.1 Biovent Trench Permeability Testing

Prior to biovent system operation, water level data were collected to verify that the water table was below the targeted zone of injection (which corresponds to the biovent trench gravel pack at 5 to 7 feet bgs). Table 7 presents the results of water level measurements taken on August 13, 1995 at all B- and C-level monitoring wells.

As seen in Table 7, depths to groundwater ranged from 6.95 to 7.23 feet bgs, which is at or below the bottom of the bioventing trench gravel pack. Therefore, conditions were deemed acceptable for bioventing operation.

A brief system check was run on August 14, 1995 to verify system operation. The blower was turned on and air flow into the trench was set at approximately 5 scfm. This combination resulted in an injection pressure of 0.4" water (inches of water pressure) and an air temperature of approximately 110° F. The system was run at this flowrate for about 20 minutes. No pressure response was detected at any monitoring wells except for a slight response at well BW5-4A. The system appeared to be in working order and ready for biovent testing.

The biovent air permeability testing was initiated on August 14, 1995 immediately following the system check. Flowrates, temperatures, injection pressures, and pressure responses at vadose zone monitoring wells were measured every few minutes as flowrates were gradually increased. Table 8 presents these biovent air permeability results.

As seen in Table 8, injected air flowrates were increased from 10.9 to 83.4 scfm. Biovent injection pressures also increased from 1.1" to 6.8" water. Pressure responses at all A-level vadose zone monitoring wells were slight to none, with small responses only detected at well BW5-1A in the 0.1" to 0.15" water range. The low vent pressures and low pressure responses at monitoring wells corresponding to the relatively high flowrates indicate system leaks or vertical air flow rising relatively unimpeded from the biovent pipe to the ground surface. Although it is possible that large,

TABLE 7

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
PRE-PERMEABILITY TESTING WATER LEVEL RESULTS
August 13, 1995

Monitoring Well	Depth to Groundwater (feet bgs)
BW5-1B	7.09
BW5-1C	7.10
BW5-2B	7.23
BW5-2C	7.23
BW5-3B	6.95
BW5-3C	6.95
BW5-4B	7.19
BW5-4C	7.17

bgs Below ground surface

TABLE 8

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
INITIAL BIOVENT AIR PERMEABILITY TEST RESULTS
August 14, 1995

Time	Air Velocity (fpm)	Flowrate (scfm)[1]	Vent Pressure (inches water)	Well Pressure Response[2] (inches water)
1606	150	10.9	1.1	None
1622	220	16.0	1.8	None
1643	300	21.9	2.45	None
1709	400	29.2	3.25	None
1729	500	36.6	4.55	None
1753	600	44.0	5.0	0.1 at BW5-1A
1800	1,000	73.6	6.5	0.14 at BW5-1A
1807	1,200	83.4	6.8	0.15 at BW5-1A

Notes:

1 Flowrate is corrected to standard conditions (14.7 psi pressure and 20°C temperature) using recorded vent pressures and temperature (approximately 43.3°C throughout this test).

2 Only pressure responses of at least 0.1 inches water were recorded because of instrument sensitivities to wind and motion when using the 0 to 1 inch water Magnehelic pressure gauges.

fpm Feet per minute (actual)
scfm Standard cubic feet per minute
psi Pounds per square inch
°C Degrees celsius

highly permeable channels intersecting the trench area may be capable of diverting injected air flows with similar pressure responses measured during testing, no such channels or any other highly permeable lithologic units were observed during construction.

Since no aboveground system leaks were detected, it was assumed that the majority of the injected air was flowing vertically through soil fractures with a relatively lower component of horizontal air flow into the formation. During leak testing on August 22, 1995, pressure responses were detected at temporary monitoring points T2 (0.25" water) and T3 (1.5" water), both located about 3 feet away from the trench. Since instruments at well BW5-1A did detect a slight pressure increase and this well is situated approximately 7 feet away from the biovent pipe, it is estimated that the ROI was approximately 7 feet in the general direction of well BW5-1A. In the areas near wells BW5-4A (east of the trench) and BW5-6A (southwest end of trench), little to no pressure increase was detected and ROIs in these areas were assumed to be less than 7 feet. While some soil zones near the trench may have higher local permeabilities and therefore correspondingly higher localized ROIs due to bioventing, it is unlikely that ROIs extended more than 15 feet in any direction based on test results and observed lithology in the test area.

Because it was suspected that vertical soil cracks (either naturally occurring or created during system construction) were contributing to system short-circuiting (nonhorizontal flow), the system was modified as described in Section 2.4.1 in an attempt to improve system performance. Following the modifications, further biovent air permeability testing was conducted on September 11 and 12, 1995. Water levels were measured in B-level wells and results are presented in Table 9. All water levels were lower than measured in August 1995 before initial permeability testing began. Table 10 presents the biovent air permeability test results collected after the system was modified.

Injected air flows ranged from 5.5 to 79.2 scfm, with injection pressures in the 1.0" to 9.75" water range. A review of results presented in Table 10 indicates that pressure responses at wells and injection pressures were not significantly different after system modifications than before. More air appeared to be flowing toward well BW5-4A after the system modifications, and at one point small pressure responses were noted at wells BW5-1A, -4A, and -6A simultaneously. In general, pressure responses appeared to be slightly stronger after system modifications than before, indicating that horizontal air flow was somewhat improved due to the modifications. However, the resulting ROI was still estimated to be no greater than 7 to 10 feet.

TABLE 9

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
POST-MODIFICATION WATER LEVEL RESULTS
September 11, 1995

Monitoring Well	Depth to Groundwater (feet bgs)
BW5-1B	7.27
BW5-2B	7.40
BW5-3B	7.15
BW5-4B	7.36

Note:

bgs Below ground surface

TABLE 10

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
POST-MODIFICATION BIOVENT AIR PERMEABILITY TEST RESULTS
September 11 and 12, 1995

Time	Air Velocity (fpm)	Flowrate (scfm)[1]	Temperature (°F)	Vent Pressure (inches water)	Well Pressure Response[2] (inches water)
1543	75	5.5	100	1.0	None
1629	150	11.1	100	1.3	0.1 at BW5-4A
1705[3]	220	16.4	100	2.5	Slight response at BW5-4A
0817	250	18.8	65	2.25	None
0825	400	31.5	70-80	4.5	0.1 at BW5-4A
1054	500	38.5	85	7.0	0.2 at BW5-4A
1125[4]	1,000	76.3	90-96	9.0	0.36 at BW5-4A, slight responses at BW5-1A and -6A
1330	600	45.1	96	5.0	0.14 at BW5-4A
1500	600	44.8	100	5.25	0.9 at BW5-4A, slight response at BW5-1A
1506	1,050	79.2	100	9.75	Slight response at BW5-1A, slight vacuum at BW5-4A
1521[5]	400	29.6	102	3.5	0.24 vacuum at BW5-4A

Notes:

1 Flowrate is corrected to standard conditions (14.7 psi pressure and 20°C temperature) using recorded vent pressures and temperature (approximately 43.3°C throughout this test).

2 Only pressure responses of at least 0.1" water were recorded because of instrument sensitivities to wind and motion when using the 0 to 1" water Magnehelic pressure gauges.

3 This run was continued until 1812.

4 This run was continued until 1235.

5 The system was left running at these conditions for the long-term biovent test.

* The first three table entries listed above describe test conditions on September 11, 1995. All remaining data presented in this table were collected on September 12, 1995.

fpm Feet per minute (actual)
scfm Standard cubic feet per minute
psi Pounds per square inch
°F Degrees Fahrenheit
°C Degrees Celcius

5.1.2 Monitoring Well BW5-2A Air Permeability Testing

Air permeability testing at vadose zone monitoring well BW5-2A was conducted on August 21, 1995 using the test configuration shown in Figure 10. An air compressor was used initially as an injection air source and pressure responses were measured at three temporary monitoring points (T1, T2, and T3) and monitoring wells BW5-1A, -3A, and -4A. Test results are presented in Table 11.

As can be seen from results presented in Table 11, high injection air pressures were required to obtain relatively small air flows. Flowrates tested using the air compressor ranged from 1 to 4.6 scfm at pressures of 3.5 to 7.2 psi. Pressure responses were detected only at temporary monitoring point T1 (up to 0.44" water) located approximately 4.2 feet away from injection well BW5-2A (see Figure 9).

Because the air compressor was incapable of supplying higher air flows and pressures, the system blower was then connected and used as an air injection source at well BW5-2A as shown in Figure 10. Table 12 presents the air permeability test results collected at BW5-2A using the blower.

Flows ranged from 12 to 26 scfm at injection pressures of 7.7 to 9.0 psi. Pressure responses were detected and measured at monitoring wells BW5-1A, T1, and T2, with up to 2.5" water recorded at T1. Pressures at BW5-1A (7 feet away) and T2 (11 feet away) were of very similar magnitude, with up to 0.2" water at both wells. No measurable responses were observed at wells BW5-3A, -4A, or T3.

5.1.3 Summary

Based on air permeability test results presented above and the soil analytical results presented in Section 3.0, it is clear that contaminated subsurface soils in the pilot test area are fine-grained and have a relatively low permeability to air flow. This low permeability is partially due to the high degree of soil saturation in the targeted zone (5 to 7 feet bgs) which reduces the effective (air-filled) porosity of these soils. This high degree of saturation is a natural condition of soils residing in the capillary fringe just at and above the water table.

Measured ROIs appeared to be somewhat larger at well BW5-2A (likely due to more permeable soils and less vertical air flow) than at the biovent trench, but much higher pressures and flowrates per length of vent screen were required at BW5-2A. However, ROIs at both injection sources did not appear to exceed 10 feet in the directions measured.

TABLE 11

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
MONITORING WELL BW5-2A
AIR PERMEABILITY TEST RESULTS
(Using an air compressor injection source)

Time	Flow (scfm)	Injection Pressure (psi)	Well T1 Pressure (inches water)
1017	1	3.5	None
1027	1	3.5	None
1035	2	5.5	0.13
1049	2.1	5.0	0.12
1100	2	5.0	0.11
1110	2	4.9	0.11
1120	2.1	5.0	0.16
1130	2.1	4.8	0.12
1145	3.1	7.0	0.26
1155	3.3	6.0	0.28
1200	4.4	7.2	0.41
1210	4.5	6.5	0.41
1215	4.6	6.5	0.44
1226	4.5	6.5	0.44

Notes:

1. No pressure responses greater than 0.1" water were measured at monitoring wells T2 and T3 and BW5-1A, -3A, and -4A.

2. Testing was conducted on August 21, 1995 using an air compressor to inject air into monitoring well BW5-2A.

scfm Standard cubic feet per minute
psi Pounds per square inch

TABLE 12

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
MONITORING WELL BW5-2A
AIR PERMEABILITY TEST RESULTS
(Using the system blower as an injection source)

Time	Flow (scfm)	Injection Pressure (psi)	Well T1 Pressure (" water)	BW5-1A Pressure (" water)	Well T2 Pressure (" water)
1445	12.0	8.0	1.05	0.10	None
1446	12.5	7.8	1.05	0.10	None
1450	12.8	7.7	NA	NA	NA
1455	14.0	8.2	1.24	0.11	0.10
1457	14.2	8.1	1.23	0.11	0.10
1501	14.6	8.0	1.25	0.11	0.10
1505	15.0	7.9	1.30	0.11	0.12
1515	15.2	7.9	1.32	0.12	0.10
1523	19.0	8.5	1.70	0.14	0.14
1533	19.2	8.4	1.72	0.14	0.14
1543	20.5	8.5	1.82	0.15	0.16
1553	22.0	9.0	2.0	0.17	0.18
1603	23.0	8.5	2.1	0.17	0.17
1615	26.0	9.0	2.4	0.19	0.19
1630	26.0	8.3	2.5	0.20	0.20

Notes:

1. No pressure responses greater than 0.1" water were measured at monitoring wells T3, BW5-3A, and -4A.

2. Testing was conducted on August 21, 1995 using the system blower to inject air into monitoring well BW5-2A.

scfm Standard cubic feet per minute
psi Pounds per square inch
" water Inches of water pressure
NA Not available

To successfully remediate contaminated soils at Site 5 using in situ bioventing, it appears based on these test results that relatively close vent well spacings or soil permeability improvements would be required. Two potential methods for permeability improvement are soil fracturing (pneumatic or hydraulic) and in situ soil warming. While both of these methods have been shown to improve ROI at other sites, implementation of these technologies would significantly increase the overall cost of remediation. Installation of closely spaced vent wells also increases the cost relative to wider vent spacings typical at sites with more permeable soils.

5.2 LEAK TESTING

Leak testing was conducted at three different times during pilot testing. Initially, potential leaks were evaluated using water puddled into bermed soil areas, and these results are presented in Section 5.2.1. Later, leaks were evaluated using helium as a flow tracer gas, and these results are presented in Section 5.2.2. Finally, leak testing was conducted after the biovent system was modified and these results are presented in Section 5.2.3. Section 5.2.4 summarizes all leak test results.

5.2.1 Water Puddle Testing

On August 16, 1995, leak testing was conducted by pouring water into small bermed areas at numerous surface locations near the trench. The biovent system was turned on and puddles were watched closely for the presence of water bubbles at 10 bermed locations, including along the edges of the trench liner and at the vertical riser pipe. Significant bubbling was observed at two locations: large, continuous bubbles at the south and east edges of the riser pipe, and smaller bubbles every 2 to 3 seconds at a point along the south edge of the trench about 10 feet west of the vent pipe. No other significant bubbling was observed at other test locations.

5.2.2 Helium Tracer Testing

On August 22, 1995, leak testing was conducted by turning on the blower system with an approximate 5 percent mixture of helium to air and measuring helium concentrations at numerous surface locations around the bioventing trench. Roughly 60 locations were sampled over an area encompassing a 15 to 20 foot radius around the trench. Helium concentrations ranged from 0.1 percent (the lower detection limit of the Marks 9821 helium detector) to 1.8 percent, with the highest detection measured at the ground surface adjacent to the vent riser pipe. The majority of the points measured had low helium detections greater than 0.01 percent. The helium concentration at the point farthest from the trench where helium was detected was 0.14 percent. This point was located about 22 feet southwest of the southwest corner of the trench. There appeared to be no patterns in concentration distributions other than a general trend toward higher helium detections closer to the trench edges and higher detections over large, visible cracks at the soil surface.

5.2.3 Post-Modification Helium Tracer Testing

On September 12, 1995, after system modifications had been completed and additional air permeability testing had been performed, another helium tracer leak test was conducted. As before, a helium tracer was connected to the biovent pipe and the mixture was set at approximately 7 percent helium to air. Roughly 50 surface locations were sampled throughout the test area, with helium detected at the majority of locations. Helium concentrations ranged from 0.01 to 7.4 percent at a large 1/2 inch wide crack approximately 10 feet west of the west end of the trench. Two other helium detections greater than 6 percent were measured 20 feet west and 10 feet north of the west end of the trench, both directly over visible cracks. Numerous detections greater than 1.0 percent were measured at the bases of concrete pads around monitoring wells BW5-1A, -4A, and -6A, and a large detection (6.8 percent) was also measured at the base of the biovent riser pipe. The farthest location where helium was detected (0.08 percent) was at a point approximately 28 feet south of the west end of the trench.

In general, helium detections were measured significantly farther from the trench than during testing prior to system modifications, with many detections 6 to 10 feet away from the trench. Very few helium detections were made immediately above the trench, contrary to the many detections measured above the trench prior to system modifications. As before, the highest helium detections were measured at points just above visible surface cracks.

5.2.4 Summary

Based on the leak test results presented above, it appears likely that significant portions of the injected biovent air were short-circuiting (via cracks or other pathways) vertically toward the ground surface. It is not clear from the data collected how much of the vertical flow can be attributed to naturally occurring soil cracks versus potential fractures created during system construction, although it is possible that both pathways are present. Shallow vertical soil cracks and fractures, extending down to 3 to 5 feet bgs or more, are not uncommon in fine-grained soils.

The system modifications made in September 1995 (described in Section 2.4.1) appear to have improved the ratio of horizontal to vertical flow components, as higher helium concentrations were measured farther out from the trench afterward. This should result in a larger supply of air flowing horizontally outward. However, vertical leaks appeared to be occurring along the side of the riser pipe both before and after system modifications. Although alternative designs or construction methods may reduce vertical air flow, it is likely that there would always be some vertical air flow or system leakage when applying bioventing to a site with such shallow soil contamination.

5.3 RESPIRATION TESTING

This section presents results collected from in situ respiration testing conducted during August 1995. Section 5.3.1 presents background oxygen and CO_2 soil gas data collected from wells prior to respiration testing. Section 5.3.2 presents respiration test results at background (uncontaminated) well W5-20 and from monitoring well BW5-5A (installed in contaminated soils). Finally, Section 5.3.3 summarizes respiration results and discusses the implications for successful bioremediation.

5.3.1 Background Soil Gas

On August 13, 1995, before system operation and respiration testing began, background soil gas samples were collected and field analyzed for oxygen, CO_2, and hydrocarbons. Table 13 presents the results of this background soil gas sampling.

At sea level, the ambient concentrations of oxygen and CO_2 in air are roughly 21 percent and 0.035 percent, respectively. As seen in Table 13, oxygen levels are significantly lower and CO_2 levels are significantly higher than ambient levels in most sampling locations. The two wells installed in the areas of highest apparent contamination (BW5-4A and -5A) yielded soil gas samples with the lowest oxygen and highest CO_2 values. These baseline results strongly suggest that microbial respiration of hydrocarbons is already occurring without intervention at Site 5.

5.3.2 Respiration Testing

Following 2 days of air injection, respiration data were collected over a 5-day period from August 18 to 23, 1995. The respiration data included field measurements of oxygen, CO_2, and helium from wells W5-20 and BW5-5A. Table 14 presents these in situ respiration test results. Figure 13 shows a plot of oxygen concentrations over time for both wells and Figure 14 shows a plot of CO_2 concentrations over time at both wells.

TABLE 13

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
BASELINE SOIL GAS SAMPLE RESULTS
August 13, 1995

Sample Location	Oxygen (percent)	Carbon Dioxide (percent)	PID (ppm)
Trench	8.5	6.5	11.6
BW5-1A	15.0	5.5	0.0
BW5-2A	18.2	7.0	0.0
BW5-3A	18.7	6.5	0.0
BW5-4A	7.7	9.0	0.0
BW5-5A	8.8	12.2	22.9
BW5-6A	19.8	1.2	0.0
W5-20	19.5	7.5	0.0
FP5-1	19.3	1.8	0.0

Notes:

1. Samples collected and analyzed on August 13, 1995 using a Gastech 3252 OX for O_2/CO_2 and a MicroTip PID for hydrocarbons.

2. Gas samples were collected from the 5 to 7 foot bgs depth using 1/4 inch diameter Tygon tubes suspended in the screened interval.

PID Photoionization detector
ppm Hydrocarbon concentration, parts per million

TABLE 14

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
IN SITU RESPIRATION TEST RESULTS

Time (hours)	BW5-5A			W5-20		
	Percent Oxygen	Percent CO_2	Percent Helium	Percent Oxygen	Percent CO_2	Percent Helium
0.0	20.6	0.10	0.54	20.5	0.10	1.70
2.0	20.1	0.15	0.41	20.4	0.08	1.70
4.0	20.1	0.20	0.11	20.1	0.05	1.50
6.0	20.4	0.25	0.00	20.4	0.09	1.40
8.0	20.4	0.25	1.30	20.1	0.09	1.40
19.0	20.1	0.80	0	20.2	0.10	1.40
24.0	19.9	0.90	0.01	20.4	0.08	1.20
32.0	19.5	1.40	0.28	20.3	0.10	1.10
40.0	19.5	1.30	0.01	20.5	0.10	0.91
48.0	19.5	1.50	0.01	20.4	0.10	0.85
56.0	19.1	1.70	0	20.3	0.10	0.65
64.0	19.1	1.80	0	20.4	0.10	0.52
72.5	18.8	2.00	0	20.5	0.11	0.42
82.0	18.8	2.20	0	20.3	0.11	0.33
96.5	18.9	2.10	0	20.1	0.11	0.21
106.0	18.2	2.80	0.02	20.2	0.20	0.18
120.5	18.1	2.90	0	20.3	0.20	0.11

Notes:

1. Start time (0.0) was 0726 on August 18, 1995; finish time (120.5) was 0812 on August 23, 1995.
2. Oxygen and CO_2 measurements were taken with a Gastech 3252 OX analyzer.
3. Helium measurements were taken using a Marks 9821 helium detector.

CO_2 Carbon dioxide

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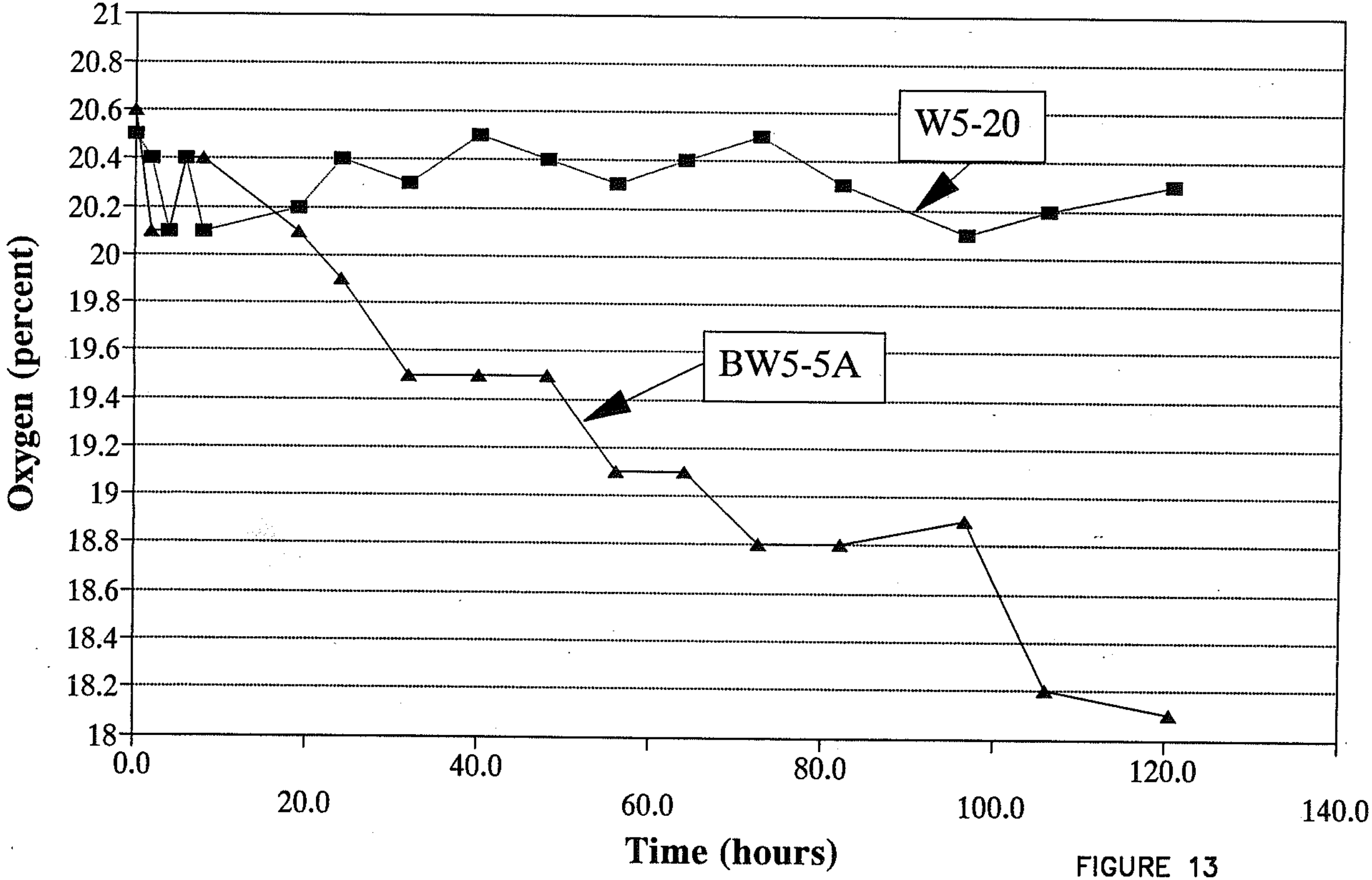

FIGURE 13
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
IN SITU RESPIRATION RESULTS
OXYGEN VERSUS TIME

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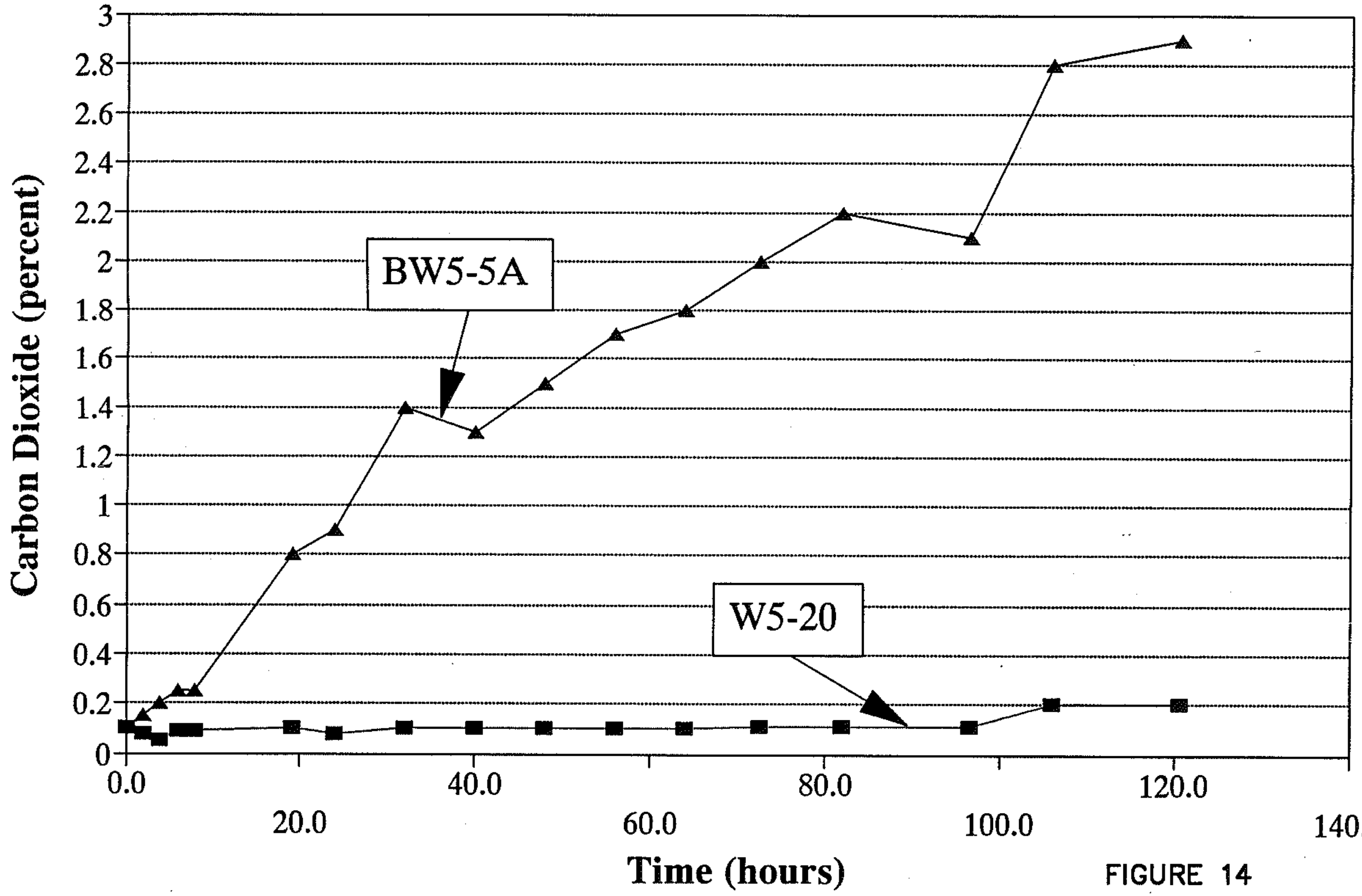

FIGURE 14
MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
IN SITU RESPIRATION RESULTS
CARBON DIOXIDE VERSUS TIME

As seen in the table and figures, both oxygen (20.1 to 20.5 percent) and CO_2 (0.05 to 0.2 percent) concentrations were fairly consistent and unchanged at the background well throughout the 5-day test period. This is indicative of little to no natural, background respiration or oxygen consumption in soils near the background well at the depth measured. However, data collected from well BW5-5A show significant trends in steady oxygen depletion and CO_2 production. Oxygen concentrations at well BW5-5A started at 20.6 percent and decreased to 18.1 percent during the test period. CO_2 concentrations at well BW5-5A started at 0.10 percent and increased to 2.9 percent over the same period. With these respiration results, biodegradation rates were estimated using formulas based on oxygen consumption and CO_2 production rates (AFCEE 1992). Using (by common convention) hexane as the representative hydrocarbon, calculated biodegradation rates at the test wells were 0.22 mg/kg/day (milligrams per kilogram per day) and 0.52 mg/kg/day based on oxygen consumption and CO_2 production, respectively. While these biodegradation rates are somewhat low, they are within ranges reported at other bioventing sites (Hinchee and Ong 1992).

Helium data are also reported in Table 14. Helium declined steadily and rapidly in samples from the background well, from 1.7 to 0.11 percent during the test. As seen in Table 14, helium concentrations were more erratic for well BW5-5A. Concentrations varied from high to low values three times before finally becoming not detected after 56 hours. Although initially intended as a way to estimate gaseous diffusion, the variable results at well BW5-5A and rapid losses at well W5-20 were inconclusive and not used to factor out an overall diffusion or system leak rate. Due to helium's smaller molecular weight, it is conceivable that system leaks of helium occurred that did not necessarily indicate similar leaks of oxygen and CO_2.

5.3.3 Summary

Based on these respiration results and data presented in Section 3.1, two conclusions can be made. First, microbial respiration is already occurring naturally at Site 5, which results in some degradation of petroleum hydrocarbons. Second, injection of air into contaminated soils at Site 5 appeared to result in significant, measurable degradation of petroleum hydrocarbons. Although respiration rates appeared to be low relative to other bioventing sites (Hinchee and Ong 1992), this may be attributable to lower soil TPH concentrations at Site 5 relative to other sites, as higher concentrations provide more food substrate and allow higher microbial respiration and activity. In addition, the more "weathered" character of the TPH suggests that the remaining hydrocarbons require more metabolic energy to reduce their presence. Low nutrient status and relatively impermeable soils may be other contributing factors. However, these respiration results suggest that bioremediation of hydrocarbons will occur at Site 5 when oxygen is supplied to contaminated soils, and that some degradation (albeit at a lower rate) may also occur naturally without the addition of air.

5.4 BIOSPARGE TESTING

Biosparge testing was conducted on August 22 and 23, 1995 using sparge injection wells BS5-1 (screened 9.0 to 11.0 feet bgs) and BS5-2 (screened 13.0 to 15.0 feet bgs). Before sparge testing began, water levels in the injection wells and all B- and C-level wells were measured to evaluate potential changes in water levels due to sparging. Table 15 presents the data collected prior to sparge testing.

Background DO results prior to sparging were also recorded and these data are presented in Table 6 in Section 4.0. Section 5.4.1 presents sparge test results at injection well BS5-1, and Section 5.4.2 presents results at well BS5-2.

5.4.1 Injection Well BS5-1 Results

Biosparge testing at well BS5-1 was conducted by using an air compressor as an injection air source and measuring pressure responses at nearby A- and B-level wells. Table 16 presents these test results.

As can be seen from the results presented in Table 16, pressure responses were detected at monitoring points T1 and BW5-2A (both A-level) during testing. However, no responses were detected in any of the B-level wells, including wells BW5-1B and BW5-2B (located about 3 feet and 5 feet away from BS5-1, respectively). Helium was mixed into the injection air during sparging (5 percent), and was detected at the ground surface at the outside edge of the well box around well BS5-1 (1.9 percent). Slight detections were also noted inside the well box, at the injection piping threads, and at some surface points within 3 feet of well BS5-1. It appears that air flow was directed somewhat vertically with some horizontal flow components in the vadose zone, with minimal horizontal flow at the depth of injection through groundwater. Groundwater levels did not appear to change in any monitoring wells due to sparging.

TABLE 15

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
PRE-SPARGING WATER LEVEL RESULTS
August 22, 1995

Sample Location	Depth to Water (feet bgs)
BS5-1	6.92
BS5-2	6.99
BW5-1B	7.19
BW5-1C	7.21
BW5-2B	7.34
BW5-2C	7.34
BW5-3B	7.06
BW5-3C	7.06
BW5-4B	7.30
BW5-4C	7.28

Note

bgs Below ground surface

TABLE 16

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
BIOSPARGE TEST RESULTS AT INJECTION WELL BS5-1

Date	Time	Injection Pressure (psi)	Flow (scfm)	Pressure at BW5-2A (inches water)	Pressure at T1 (inches water)
8-22-95	1554	4.5	1.4	NA	NA
	1645	5.0	2.2	NA	NA
	1718	7.5	NA	None	None
	1720	8.9	3.2	None	None
	1740	9.0	3.7	None	None
	1755	10.2	4.1	None	None
	1805	11.0	4.7	None	None
8-23-95	0820	9.0 - 10.0	2.1	0.36	0.1
	0857	12.0	3.0	Slight	Slight
	0910	12.0	4.0	NA	NA
	0917	12.0	4.6	1.0	Slight

Notes:

1. Testing was conducted on August 22 and 23, 1995 using an air compressor as an injection source.
2. No pressure responses were detected at any B-level wells or at any other A-level wells other than those listed above.
3. "Slight" listed in the table above refers to an apparent pressure increase though less than 0.1" water.

psi Pounds per square inch
scfm Standard cubic feet per minute
NA Not available

5.4.2 Injection Well BS5-2 Results

Biosparge testing at injection well BS5-2 was conducted on August 23, 1995 using both an air compressor and the system blower as air injection sources. Table 17 presents the results of this testing.

As seen in Table 17, relatively large pressures (up to 12.5 psi) and flowrates (up to 13 scfm) were used with relatively small pressure responses at monitoring wells. C-level wells BW5-1C and -2C exhibited small responses, although they were located only 2 feet and 5 feet away, respectively. As with sparge well BS5-1, air flow appeared to be moving up and laterally, with minimal horizontal movement at the injection depth. The sparge ROI appeared to be greater for injection well BS5-2 at the flows tested than for well BS5-1. As with testing at well BS5-1, helium tracer measurements indicate that some vertical leakage occurred at the outside edge of the well box, at the sparge pipe threads, in the well box, and at nearby surface locations. Just before air injection was stopped, water levels were measured to check for signs of mounding. The water level at well BW5-1B increased significantly to 5.35 feet bgs, an increase of approximately 1.8 feet, although no other wells showed measurable level increases. DO was also measured in the nearby groundwater monitoring wells that showed pressure responses during testing. As seen in Table 18, DO did increase significantly in wells BW5-1B and BW5-2C due to biosparging. These data, in conjunction with the pressure data presented above, are an indication that sparged air traveled at least 5 feet in the saturated zone.

5.4.3 Summary

In general, relatively high pressures were required to achieve small flowrates and ROIs at both sparge injection wells. Results at well BS5-2 (deeper well) were somewhat more favorable to sparging than at well BS5-1, based on pressure response and water table data. During both tests, there appeared to be a significant vertical component of flow, indicating that soils at the zone of sparge injection were less permeable to flow than overlying soils (or that cracks and pathways existed within the overlying soils). These sparge test results, along with soil borehole log data, indicate that saturated soils in the test area, similar to the unsaturated zone, are relatively impermeable to air flow.

Although more permeable saturated soils and channels exist at Site 5, the soils in the pilot test are fairly representative of the majority of Site 5 soils. To apply biosparging at Site 5 for the remediation

TABLE 17

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
BIOSPARGE TEST RESULTS AT INJECTION WELL BS5-2
(August 23, 1995)

Time	Injection Pressure (psi)	Flow (scfm)	Pressure Response (inches water)					
			BW5-1C	BW5-2C	BW5-1B	BW5-2A	T1	T2
1005	7.2	1.7	Slight	None	None	None	None	None
1015	7.0	3.4	Slight	Slight	None	None	None	None
1030	6.1	3.5	None	None	None	None	None	None
1034	8.0	4.9	0.5	Slight	None	0.54	None	None
1112	12.5	9.5	Slight	Slight	1.5	Slight	0.58	None
1117	11.6	11.0	None	None	1.5	None	None	None
1127	10.5	13.0	None	None	1.5	None	None	0.3

Notes:

1. Testing was conducted on August 23, 1995 initially using an air compressor as an injection source. The air compressor was shut off at 1052; the blower was turned on starting at 1112 and shut off at 1142.

2. No pressure responses were detected at wells BW5-2B, -3B, -3C, -4B, -4C, nor point T3.

3. "Slight" listed in the table above refers to an apparent pressure increase though less than 0.1" water.

psi Pounds per square inch
scfm Standard cubic feet per minute

TABLE 18

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
POST-SPARGING DISSOLVED OXYGEN RESULTS
August 23, 1995

Sample Location	Pre-Sparge DO Concentration (mg/L)	Post-Sparge DO Concentration (mg/L)
BW5-1B	2.0	>7.0
BW5-1C	0.8	0.8
BW5-2B	2.2	1.8
BW5-2C	0.6	1.7

Notes:

1. All water samples were collected with bailers and field analyzed for DO using a Hach OX-2P test kit.

mg/L Milligrams per liter
DO Dissolved oxygen

of groundwater, it would likely be necessary to implement in situ soil fracturing (either hydraulic or pneumatic) to improve horizontal air flow and make the remedial system more effective. Otherwise, high injection pressures and a large number of closely spaced sparge wells would be required for remediation based on these pilot test results.

5.5 LONG-TERM BIOVENT TESTING

Long-term biovent testing was conducted from September 1995 to May 1996. During this test period, soil gas oxygen concentrations were measured periodically at A-zone monitoring wells and these data are presented in Table 19. Initial background soil gas results are also shown in the table for comparison. Confirmation soil samples were collected and analyzed after the long-term biovent test was completed, and these results are presented in Section 3.4.

As seen in Table 19, wells BW5-1A, BW5-5A, and the trench showed increased oxygen levels relative to background levels, presumably due to bioventing operation. Significant air flow did not appear to be occurring in the vicinity of wells BW5-2A, -3A, -4A, and -6A based on these results. However, these oxygen data are not the only indicators of system performance, and results from air permeability testing and soil sampling were also used to evaluate performance. All oxygen results collected in January 1996 appear to be lower than during other periods, possibly due to a higher water table and therefore less air flow into the targeted zone.

6.0 RECOMMENDATIONS

This section discusses potential full-scale remedial alternatives for TPH contamination in both soil and groundwater at Site 5, describes the rationale for selection of the recommended alternative, and presents recommendations for full-scale implementation.

After data obtained during Phase I testing was analyzed, bioventing and biosparging technologies were assessed in comparison to other viable remedial options for site soils and groundwater to determine an optimum approach to achieving cleanup of JP-5 contamination at Site 5. Technologies evaluated for soil remediation include bioventing, excavation, and intrinsic remediation, and these alternatives are discussed in Section 6.1. Technologies evaluated for groundwater remediation include biosparging, bioremediation using ORC, and intrinsic remediation, and these are discussed in Section 6.2. Considerations involved in determining the recommended alternative included effectiveness in meeting cleanup levels, capital and operating costs, ease of implementation, and required cleanup time. The recommended remedial alternative is presented in Section 6.3.

TABLE 19

MOFFETT FEDERAL AIRFIELD
SITE 5 PILOT TEST
LONG-TERM BIOVENT TEST OXYGEN RESULTS
(ppmv)

Well	November 1995	January 1996	May 1996	Background
BW5-1A	19.3	15.3	19.2	15.0
BW5-2A	NA	13.9	14.9	18.2
BW5-3A	NA	15.3	15.8	18.7
BW5-4A	2.5	0.4	2.6	7.7
BW5-5A	13.5	1.8	13.2	8.8
BW5-6A	20.1	18.6	19.4	19.8
Trench	21.2	20.7	14.6	8.5

Notes:

1. Background oxygen samples were collected on August 13, 1995 prior to any biovent air injection.

ppmv Parts per million by volume
NA Not analyzed

6.1 SOIL REMEDIATION ALTERNATIVES

This section provides a discussion of bioventing, excavation, and intrinsic remediation as potential remedial alternatives for Site 5 soils.

6.1.1 Bioventing

The Phase I test results indicate that bioventing should be effective in reducing JP-5 contamination in vadose-zone soils at Site 5. However, due to the relatively low permeability of soils typically found throughout Site 5, this site does not represent ideal conditions for implementation of a bioventing system. To remediate soils in an effective manner using bioventing, additional engineering methods such as soil fracturing and surface sealing would likely be required. If soil fracturing or other permeability enhancements were not used, then relatively close vent well spacings (approximately 20 to 30 feet apart based on the area studied) would be required to supply oxygen to the majority of contaminated soils, resulting in large construction costs. With a large number of trench or well points, expected operation and maintenance costs would be relatively high. Therefore, overall costs to achieve cleanup using bioventing would also be relatively high.

The time required to meet soil cleanup levels using bioventing is variable and depends on factors such as lithology, system performance, soil nutrient status, and contaminant distribution relative to the bioventing system configuration. Using in situ respiration results presented in Section 5.3, biodegradation rates during testing were estimated to be roughly 0.5 mg TPH/kg/day. Using the before and after test data obtained during soil sampling, the average TPH reduction was approximately 1,150 mg/kg (see Table 4) over the 266-day period between sampling events, yielding an average TPH reduction of approximately 4.3 mg/kg/day. Assuming that these estimates represent an approximate range of degradation rates to be expected during full-scale remediation, cleanup (to less than the 400 mg/kg cleanup level) of Site 5 soils using bioventing would require from about 1.1 to 9.3 years to complete. Soil fracturing would likely improve bioventing system performance and result in shorter overall cleanup times.

6.1.2 Excavation

Soil excavation and ex situ treatment or disposal were considered as an alternative for Site 5 soils. Advantages of excavation include the fast removal of soils potentially contaminating groundwater and the complete removal of contaminants that otherwise may be difficult or time consuming to degrade in situ. Disadvantages are the relatively high cost, increased potential risks due to worker exposure and soil transport, possible destruction of burrowing owl habitat, and the difficulty of removing contaminated soils located below the water table. In addition, the fact that Site 5 is an active fuel farm with remaining USTs and fuel lines would further complicate the removal of soils, since the soil with the highest TPH contamination is located adjacent to these structures and care would be required to avoid damaging existing utilities.

Once soils are excavated, they could be treated on site using ex situ bioventing or other forms of bioremediation (such as compost piles), chemical oxidation, or thermal desorption. However, due to the current demand at California landfills for fill material, off-site disposal of TPH-contaminated soils at Class II and III landfills is relatively inexpensive and would likely be the preferred alternative for excavated soils disposal. Excavation and off-site disposal, though relatively expensive, would likely be the fastest method to remove or reduce contaminated soils from Site 5.

6.1.3 Intrinsic Remediation

Intrinsic remediation, also known as natural attenuation, entails the ongoing reduction of soil contamination that occurs naturally without any human intervention. A recent report by Lawrence Livermore National Laboratory (LLNL 1995) indicates that the majority of leaking USTs in California result in stable soil and groundwater plumes that are subjected to significant biodegradation by indigeous soil microbes. While intrinsic remediation is largely due to bioremediation in petroleum-contaminated soils, other attenuation factors such as volatilization, diffusion, and chemical oxidation also occur naturally in soils and also result in reduced soil contaminant levels over time. Proper implementation of intrinsic remediation entails use of monitoring programs to ensure that contamination is not migrating, or posing risks to human or ecosystem receptors, and to confirm contaminant reductions over time.

Data collected from Site 5 indicate that significant intrinsic biodegradation of contaminated soils has been and is currently occurring. Initial respiration data presented in Section 5.3 indicate background conditions of low oxygen and high CO_2 in vadose zone soil gas, which is typical of hydrocarbon contamination in soils undergoing biodegradation. Soil microbial population data (presented in Section 3.1) show that heterotrophic microbes capable of hydrocarbon degradation are present in soils, indicating that biodegradation is likely in progress. Furthermore, review of gas chromatograms produced during laboratory soil sample analyses indicates that JP-5 fuels are significantly degraded, most likely due to naturally occurring microbial degradation.

Chromatograms of biodegraded fuel in soil samples can generally be characterized by fewer resolved component peaks and larger unresolved hydrocarbon humps than for fresh fuel standards. Furthermore, the increased molecular weight (due to oxidation of the alkanes) of the degraded fuel will cause JP-5 to elute later than the undegraded standard. Figure 15 shows gas chromatograms for two JP-5-contaminated soil samples (GP5-1 and GP5-5) and compares them with a fresh, unweathered JP-5 fuel standard. These chromatograms were considered typical and representative of other Site 5 soil samples. As seen in Figure 15, missing alkane peaks in the soil sample chromatograms indicate that the JP-5 has been significantly degraded. Additionally, the large unresolved hydrocarbon humps are displaced about 2 minutes later than the corresponding envelope in the JP-5 standard. This 2-minute displacement is roughly equal to the increase in mass expected by oxidation of the alkanes. These results and the nearly complete loss of the lower molecular weight fraction of the fuel in the soil samples suggest the fuel has been substantially biodegraded.

Recent guidance from the San Francisco Bay RWQCB suggests that source removal and passive remediation are recommended for "low-risk" fuel sites. RWQCB defines "low risk" soil sites as having the following characteristics: "1) The leak has been stopped and ongoing sources, including free product, removed or remediated; 2) The site has been adequately characterized; 3) Little or no groundwater impact currently exists and no contaminants are found at levels above established MCLs or other applicable water quality objectives; 4) No water wells, deeper drinking water aquifers, surface water, or other sensitive receptors are likely to be impacted; 5) The site presents no significant risk to human health; 6) The site presents no significant risk to the environment" (RWQCB 1996).

Site 5 soils meet all of the characteristics outlined above for low risk soil sites, with the possible exception of point 3. However, MCLs have not been established for the relatively low toxicity fuel constituents found in JP-5, and only a single well at Site 5 (1,000 μg/L TPH other heavy components from FP5-5) currently exhibited contaminants in a groundwater sample above the 700 μg/L TPH cleanup level. Most recent analyses of groundwater samples from all other wells at Site 5 indicate TPH constituents were not detected or were detected below the cleanup level.

Although significant data exist to indicate that intrinsic bioremediation is occurring at Site 5, no data are available to accurately estimate the time required to meet cleanup goals using intrinsic remediation. However, since soil contamination is stable and not migrating, groundwater contamination is stable and attenuating over time, and no apparent risks to humans or environmental receptors are present, rapid cleanup of soils at Site 5 should not be required.

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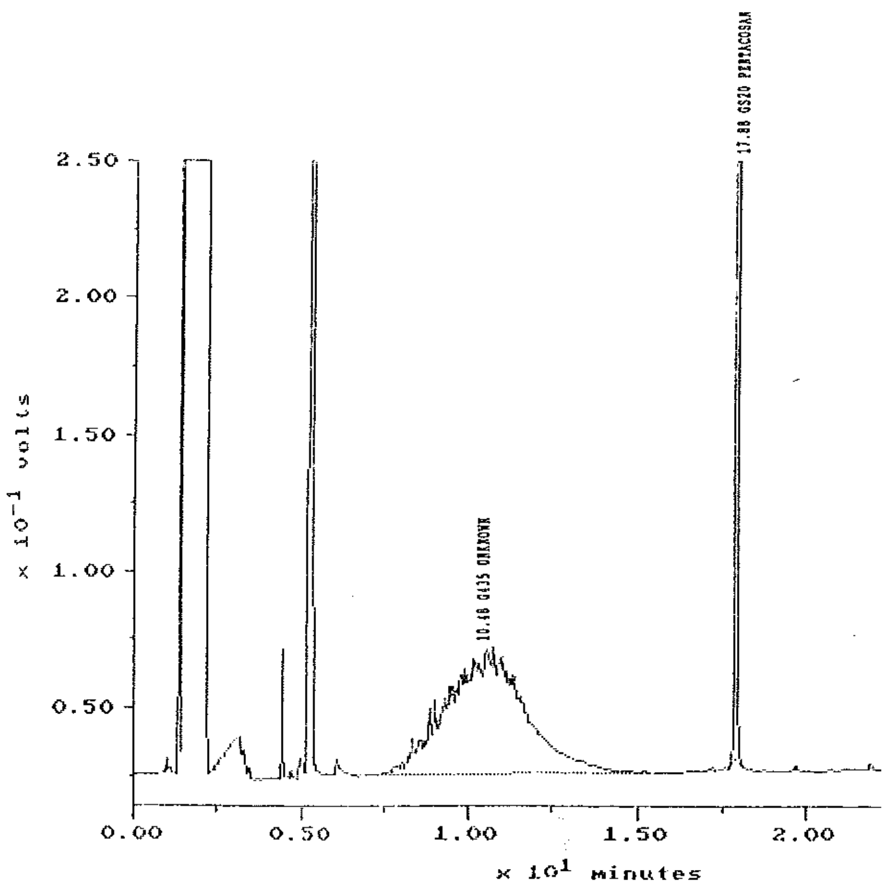
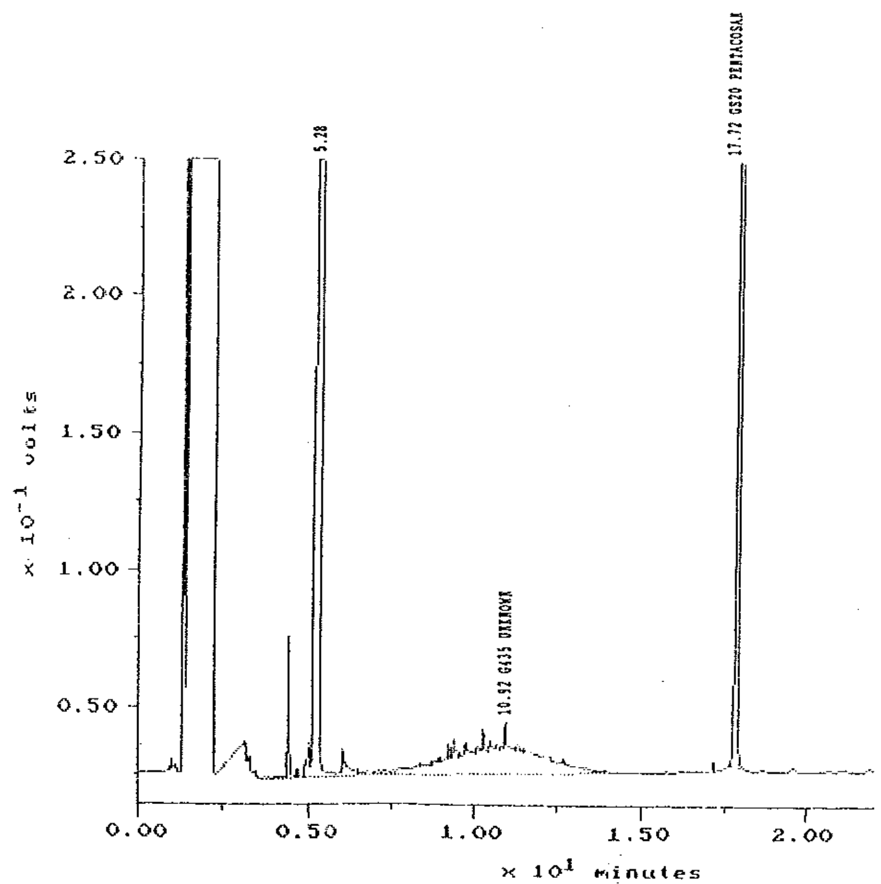
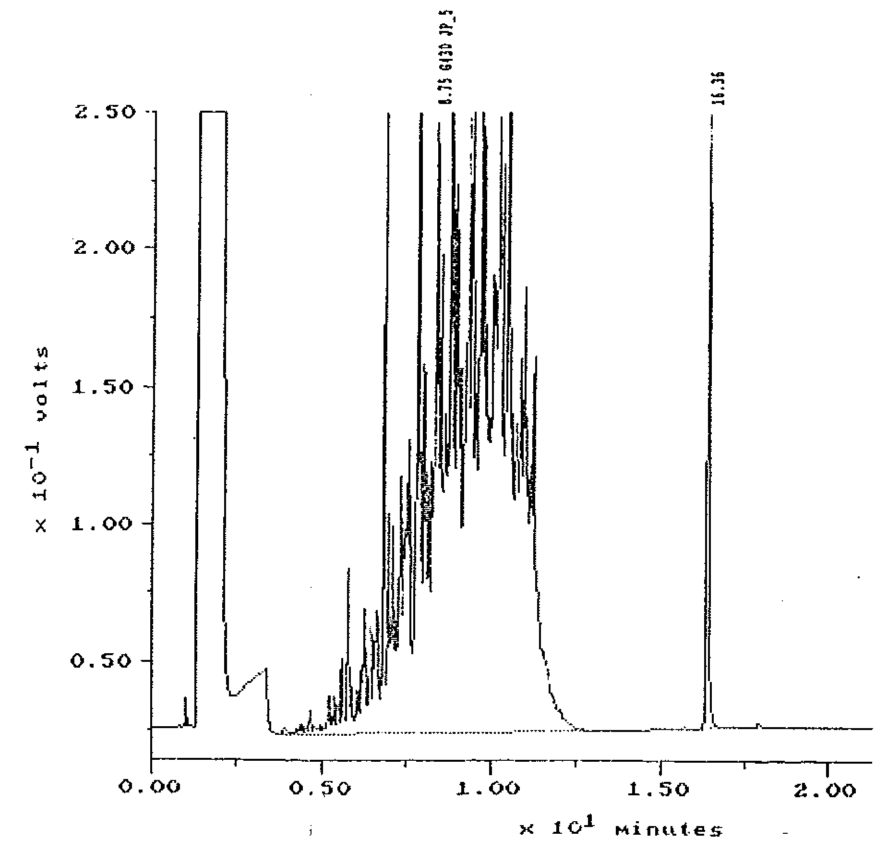


GP5-1 SOIL SAMPLE



GP5-5 SOIL SAMPLE



JP-5 STANDARD

FIGURE 15
MOFFETT FEDERAL AIRFIELD
CHROMATOGRAPHIC COMPARISON OF DEGRADED
JP-5 IN SOILS WITH STANDARD

6.2.2 Bioremediation Using ORC

A treatability study using ORC as an oxygen source for bioremediation was recently conducted at Site 5, and results have been reported in a treatability study technical memorandum (PRC 1996). The treatability study was conducted at and just downgradient of monitoring well FP5-1 located approximately 90 feet north of the biosparging pilot test area.

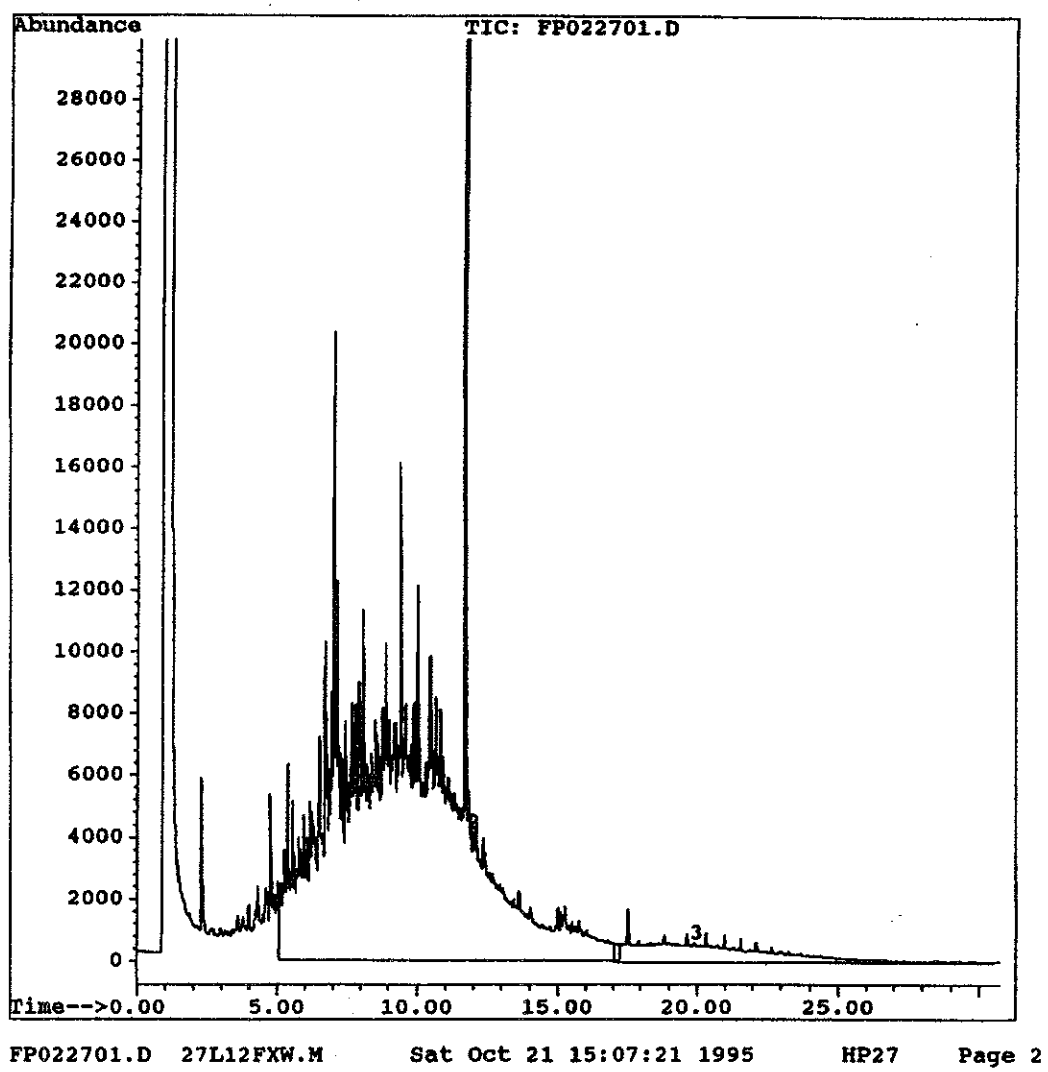
Results from the treatability study indicate that while DO in excess of levels required for bioremediation was supplied by ORC in the source well (FP5-1), DO in wells 5 feet downgradient was elevated only about 1 mg/L. Furthermore, both bromide tracer test results and DO results from monitoring wells indicate that only slight lateral dispersion of solutes (bromide and oxygen) was occurring in groundwater near well FP5-1. This small lateral dispersion of solutes has implications for use of ORC in bioremediation, since relatively close source well spacings would likely be required to effectively increase DO concentrations throughout regions of contaminated groundwater.

Groundwater samples were collected from source and monitoring wells before, during, and after ORC testing and analyzed for TPH-e. No significant trends or reductions in TPH concentrations were evident based on analytical data. Based on the results summarized in this section, it does not appear likely that ORC would result in successful bioremediation of groundwater at Site 5.

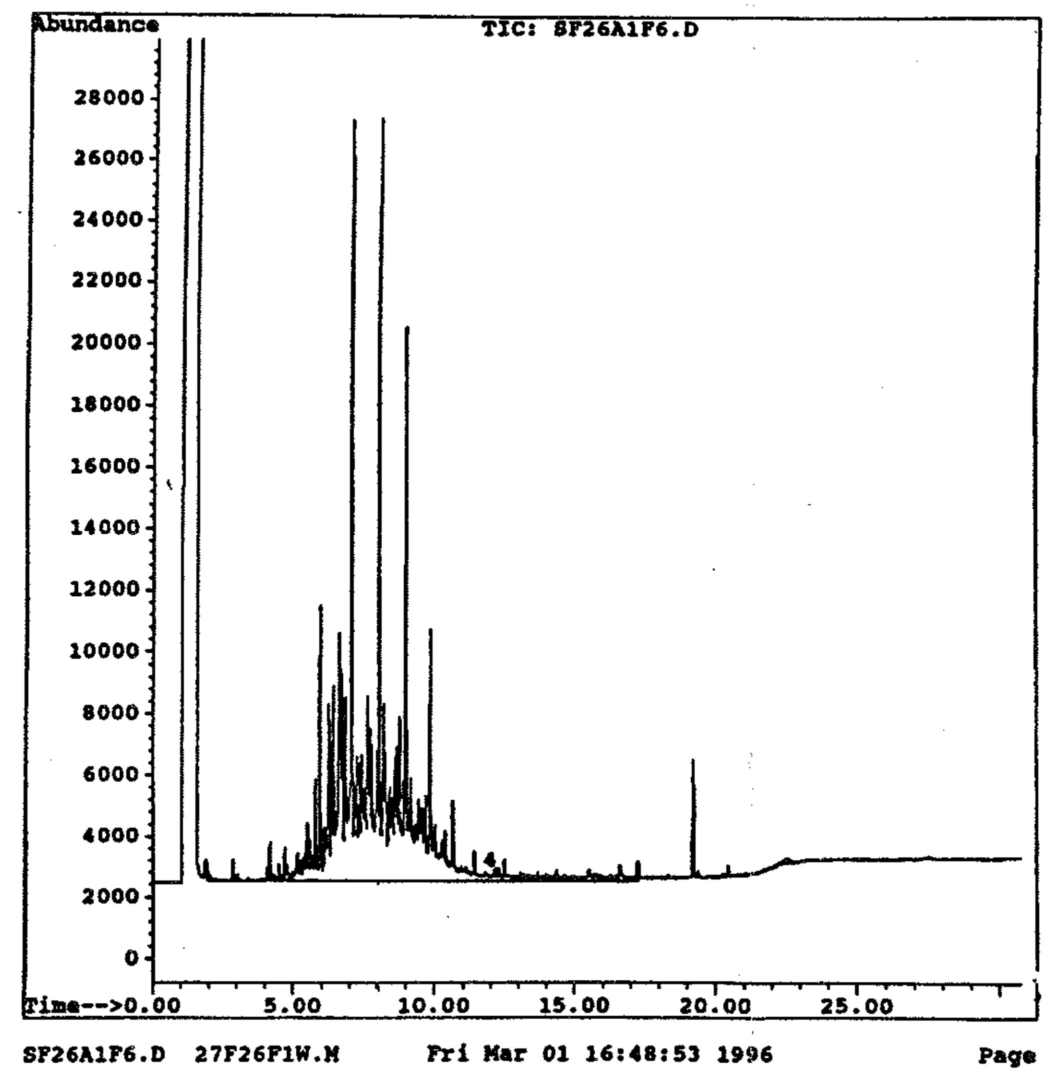
6.2.3 Intrinsic Remediation

Data collected from Site 5 during pilot testing and during routine quarterly sampling indicate that significant natural attenuation of JP-5 in groundwater is already occurring at Site 5. Analysis of groundwater sample chromatograms indicates that JP-5 is being degraded in situ. Furthermore, TPH concentrations in groundwater samples collected from Site 5 monitoring wells have been stable or decreasing over time, indicative of natural attenuation. As discussed in Section 6.1.3, groundwater at most petroleum UST sites in California is undergoing significant biodegradation by naturally occurring microbes (LLNL 1995) and it appears that Site 5 groundwater is no exception.

Figure 16 shows a chromatographic comparison of degraded JP-5 in a groundwater sample (FP5-1) versus a fresh JP-5 standard. A close comparison of these two chromatograms shows the FP5-1 chromatogram contains few equally spaced resolved peaks that are present in the laboratory standard, indicating that the alkanes have been removed or altered in the degraded fuel. Additionally, the water

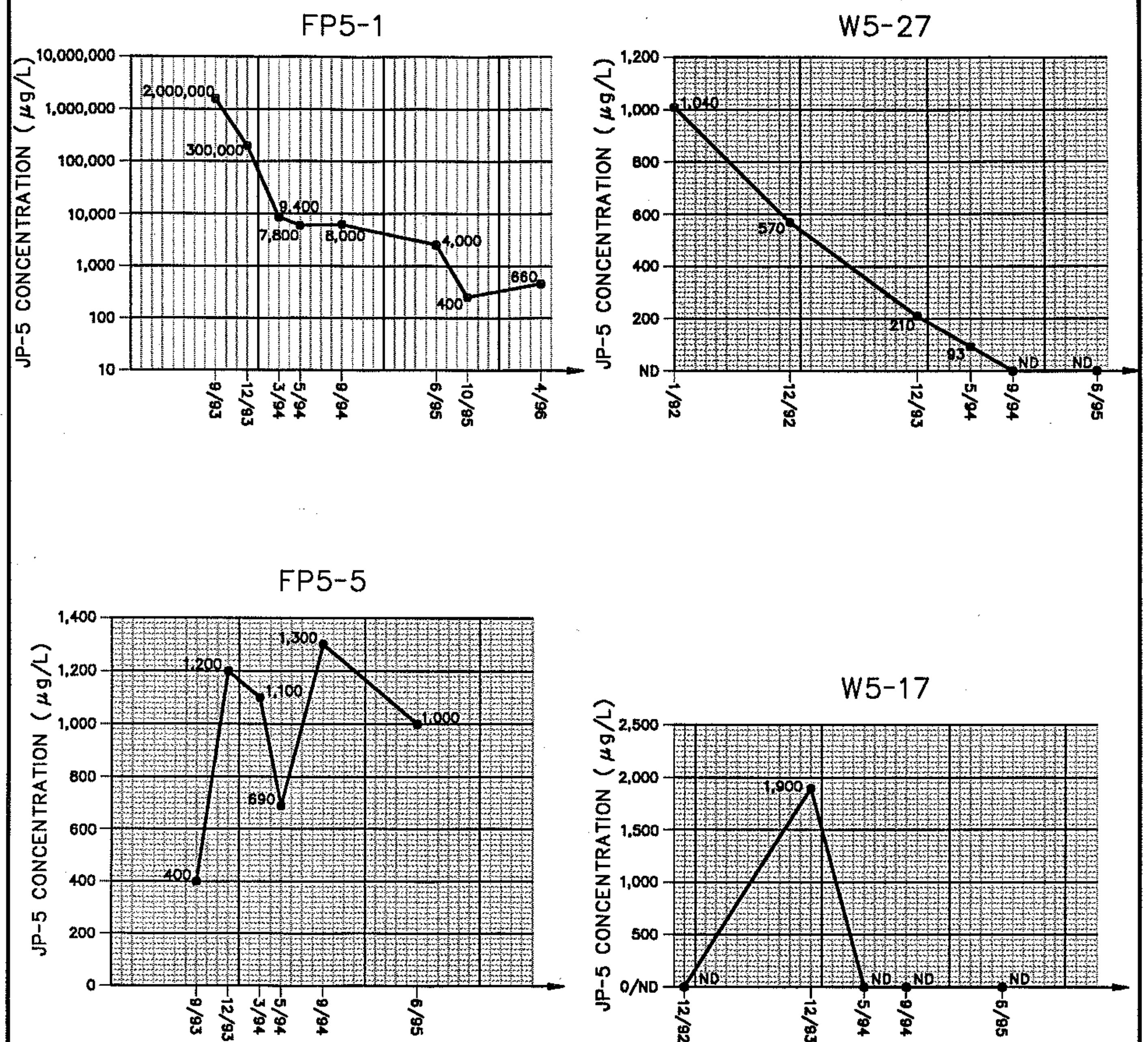


Chromatogram of water Sample
from FP5-1 (October 21, 1995)



Chromatogram of JP- Laboratory
Standard - 300 mg

FIGURE 16
MOFFETT FEDERAL AIRFIELD
CHROMATOGRAPHIC COMPARISON OF
DEGRADED JP-5 IN GROUNDWATER
WITH STANDARD



FILE NAME: R:\CAD\044\0235\RR\DP5\TPH.DWG

DATE: 08-01-96 RLM DN

NOTE

1. SAMPLES ANALYZED FROM FP5-1 FOR 10/95 AND 4/96 WERE COLLECTED DURING ORC PILOT TESTING USING A PERISTALTIC PUMP. ALL OTHER SAMPLES AT FP5-1 AND OTHER WELLS WERE COLLECTED DURING QUARTERLY SAMPLING USING BAILERS.

FIGURE 17
MOFFETT FEDERAL AIRFIELD
SITE 5 GROUNDWATER
TPH TRENDS

6.3 RECOMMENDED ALTERNATIVE

Intrinsic remediation of both soils and groundwater is considered to be the best remedial alternative for Site 5 for the reasons presented in Sections 6.1.3 and 6.2.3. Current risks to human and ecosystem receptors are very low since the A1-aquifer zone is not being used as a drinking water source, groundwater does not exfiltrate into any surface waters at or near Site 5, contaminated soils are predominantly found at 6 to 10 feet bgs, and groundwater velocities are very low (less than 0.5 feet/day in an area near FP5-1 with higher permeability soils for Site 5). Furthermore, due to naturally high total dissolved solids (TDS) and metals content and the very low pumping extraction rates attainable, it is highly unlikely that Site 5 groundwater will ever be used as a drinking water source. Guidance from RWQCB also supports this remedial action, as a recent memorandum states, "Passive bioremediation should be the preferred remedial alternative unless there is a compelling reason to do otherwise" (RWQCB 1996).

Use of intrinsic remediation should entail regular monitoring, particularly in the downgradient areas, to ensure that JP-5 contamination continues to attenuate over time. Monitoring wells should be sampled until all TPH levels meet cleanup levels or until stability is demonstrated beyond any reasonable doubt.

Since the bioventing trench is installed in an area with soil contamination above cleanup levels, it is recommended that the vent pipe be opened to atmosphere to serve as a passive air inlet well. The vent opening could be modified to prevent the introduction of surface water, rain water, or animals into the trench via the pipe. Selected vadose zone wells and groundwater monitoring wells screened partially across the vadose zone could also be used as passive air inlet wells. Recent experiments at other bioventing sites suggest that diurnal fluctuations in atmospheric pressure can result in significant air flow into and out of passive wells (Foor et al. 1995). Use of passive inlet wells in this manner would likely accelerate natural attenuation processes due to enhanced oxygen supply to microorganisms.

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APPENDIX A

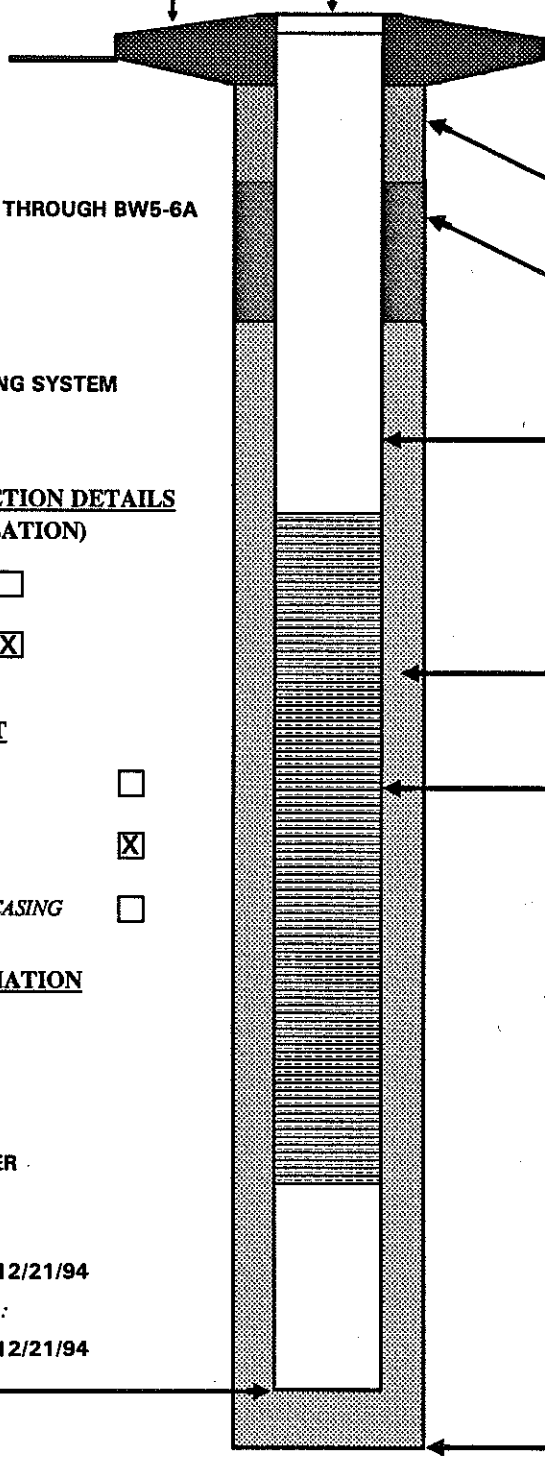
MONITORING WELL CONSTRUCTION DIAGRAMS

PRC Environmental Management Inc.

MONITORING WELL COMPLETION DIAGRAM

CONCRETE PAD

FLUSH-MOUNTED PROTECTIVE CASING



BOREHOLE

WELL

WELL NO.: BW5-1A THROUGH BW5-6A

BOREHOLE NO.:

SITE: Site 5

SUBSITE: BIOVENTING SYSTEM

DATE: 07-17-96

SURFACE COMPLETION DETAILS (TYPE OF INSTALLATION)

ABOVE GROUND ☐

FLUSH MOUNT ☒

MEASURING POINT

TOP OF CASING ☐

GROUND SURFACE ☒

TOP OF PROTECTIVE CASING ☐

DRILLING INFORMATION

DRILLING COMPANY:

IT CORP.

DRILLING METHOD:

HOLLOW STEM AUGER

DRILLING DATE(S):

12/19/94 THROUGH 12/21/94

INSTALLATION DATE(S):

12/19/94 THROUGH 12/21/94

BOTTOM OF WELL

7.0 FEET:

CEMENT/BENTONITE GROUT

FROM 0.0 *TO* 2.5 *FT. BELOW GROUND*

BENTONITE SLURRY

FROM 2.5 *TO* 4.5 *FT. BELOW GROUND*

PVC RISER CASING

FROM 0.0 *TO* 5.0 *FT. BELOW GROUND*

2-INCH SCHEDULE 40 PVC

#8/12 **SAND PACK**

FROM 4.5 *TO* 7.5 *FT. BELOW GROUND*

0.02 **SLOT PVC SCREEN**

FROM 5.0 *TO* 7.0 *FT. BELOW GROUND*

2-INCH SCHEDULE 40 PVC

WATER ADDED DURING DRILLING

YES ☐ GALLONS:

NO ☒

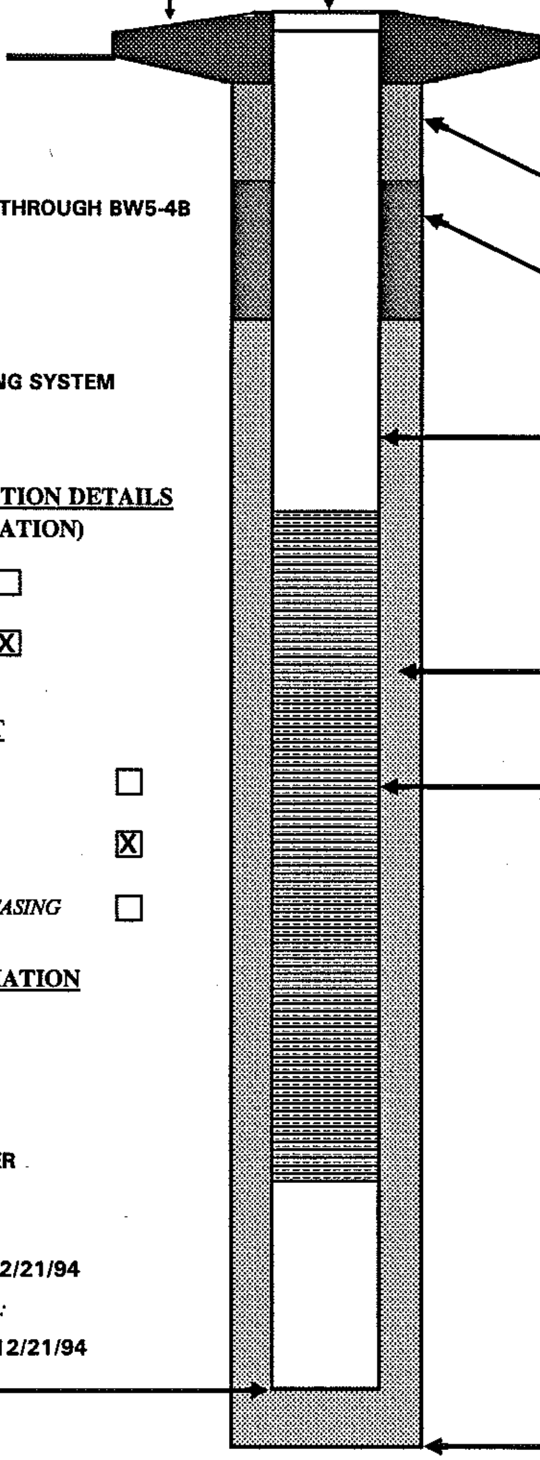
TOTAL DEPTH OF BOREHOLE : 7.5 **FT.**

PRC Environmental Management Inc.

MONITORING WELL COMPLETION DIAGRAM

CONCRETE PAD

FLUSH-MOUNTED PROTECTIVE CASING



WELL

WELL NO.: BW5-1B THROUGH BW5-4B

BOREHOLE NO.:

SITE: SITE 5

SUBSITE: BIOVENTING SYSTEM

DATE: 07-17-96

SURFACE COMPLETION DETAILS (TYPE OF INSTALLATION)

ABOVE GROUND ☐

FLUSH MOUNT ☒

MEASURING POINT

TOP OF CASING ☐

GROUND SURFACE ☒

TOP OF PROTECTIVE CASING ☐

DRILLING INFORMATION

DRILLING COMPANY:

IT CORP.

DRILLING METHOD:

HOLLOW STEM AUGER

DRILLING DATE(S):

1219/94 THROUGH 12/21/94

INSTALLATION DATE(S):

12/19/94 THROUGH 12/21/94

BOTTOM OF WELL

11.0 FEET:

CEMENT/BENTONITE GROUT

FROM 0.0 *TO* 6.5 *FT. BELOW GROUND*

BENTONITE SLURRY

FROM 6.5 *TO* 8.5 *FT. BELOW GROUND*

PVC RISER CASING

FROM 9.0 *TO* 11.0 *FT. BELOW GROUND*

2-INCH SCHEDULE 40 PVC

#8/12 **SAND PACK**

FROM 8.5 *TO* 11.5 *FT. BELOW GROUND*

0.02 **SLOT PVC SCREEN**

FROM 9.0 *TO* 11.0 *FT. BELOW GROUND*

2-INCH SCHEDULE 40 PVC

WATER ADDED DURING DRILLING

YES ☐ GALLONS:

NO ☒

TOTAL DEPTH OF BOREHOLE : 11.5 **FT.**

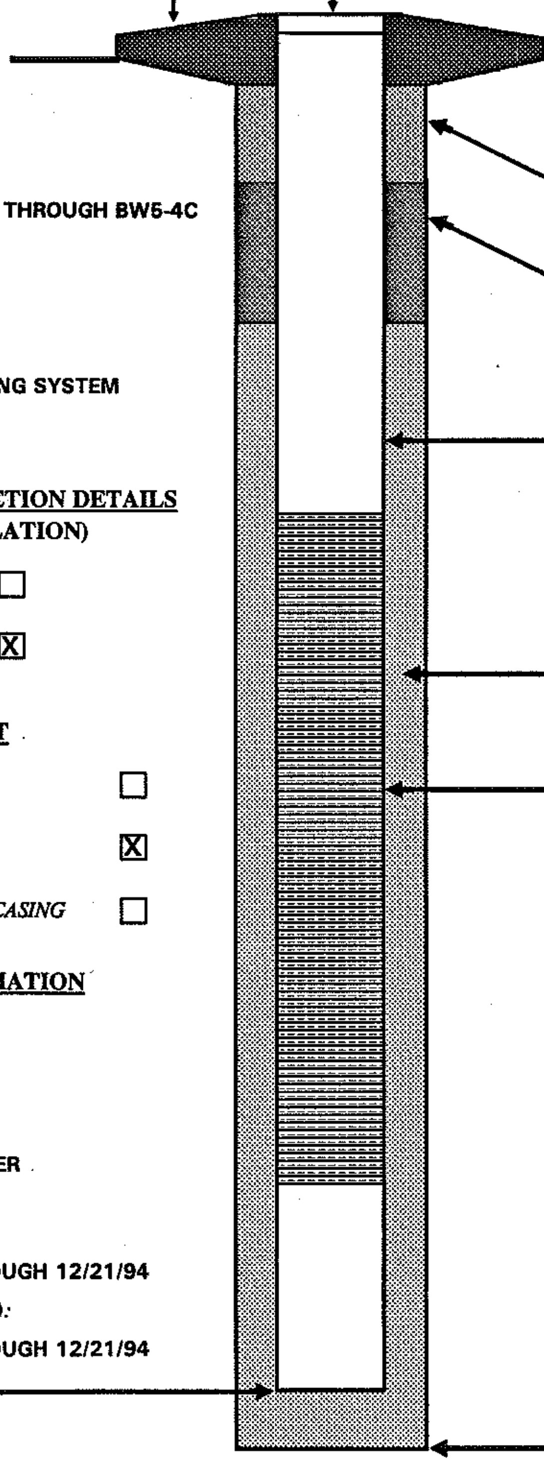
BOREHOLE

PRC Environmental Management Inc.

MONITORING WELL COMPLETION DIAGRAM

CONCRETE PAD

FLUSH-MOUNTED PROTECTIVE CASING



WELL

WELL NO.: BW5-1C THROUGH BW5-4C

BOREHOLE NO.:

SITE: SITE 5

SUBSITE: BIOVENTING SYSTEM

DATE: 07-17-96

SURFACE COMPLETION DETAILS (TYPE OF INSTALLATION)

ABOVE GROUND ☐

FLUSH MOUNT ☒

MEASURING POINT

TOP OF CASING ☐

GROUND SURFACE ☒

TOP OF PROTECTIVE CASING ☐

DRILLING INFORMATION

DRILLING COMPANY:

IT CORP

DRILLING METHOD:

HOLLOW STEM AUGER

DRILLING DATE(S):

12/12 & 12/19 THROUGH 12/21/94

INSTALLATION DATE(S):

12/12 & 12/19 THROUGH 12/21/94

BOTTOM OF WELL

15.0 FEET:

CEMENT/BENTONITE GROUT

FROM 0.0 *TO* 11.0 *FT. BELOW GROUND*

BENTONITE SLURRY

FROM 11.0 *TO* 13.0 *FT. BELOW GROUND*

PVC RISER CASING

FROM 0.0 *TO* 13.0 *FT. BELOW GROUND*

2-INCH SCHEDULE 40 PVC

#8/12 **SAND PACK**

FROM 13.0 *TO* 15.0 *FT. BELOW GROUND*

0.02 **SLOT PVC SCREEN**

FROM 13.0 *TO* 15.0 *FT. BELOW GROUND*

2-INCH SCHEDULE 40 PVC

WATER ADDED DURING DRILLING

YES ☐ GALLONS:

NO ☒

TOTAL DEPTH OF BOREHOLE : 15.5 **FT.**

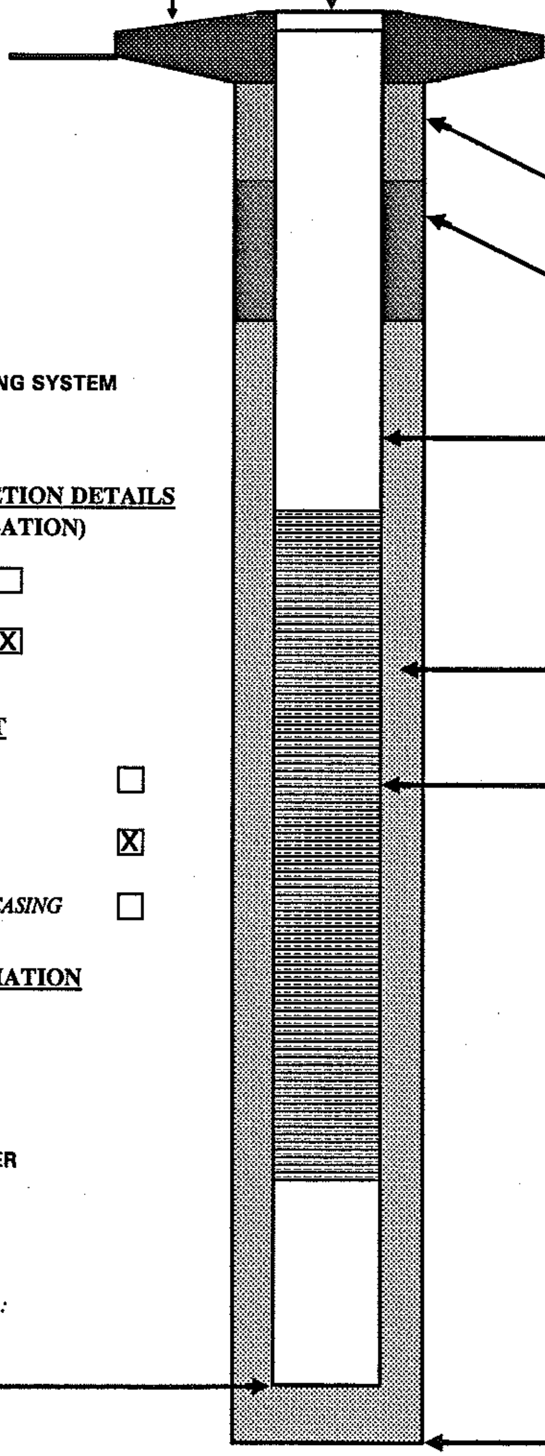
BOREHOLE

PRC Environmental Management Inc.

SPARGE INJECTION COMPLETION DIAGRAM

CONCRETE PAD

FLUSH-MOUNTED PROTECTIVE CASING



WELL

WELL NO.: BS5-1

BOREHOLE NO.:

SITE: SITE 5

SUBSITE: BIOVENTING SYSTEM

DATE: 07-18-96

SURFACE COMPLETION DETAILS (TYPE OF INSTALLATION)

ABOVE GROUND ☐

FLUSH MOUNT ☒

MEASURING POINT

TOP OF CASING ☐

GROUND SURFACE ☒

TOP OF PROTECTIVE CASING ☐

DRILLING INFORMATION

DRILLING COMPANY:
IT CORP.

DRILLING METHOD:
HOLLOW STEM AUGER

DRILLING DATE(S):
12/21/94

INSTALLATION DATE(S):
12/21/94

BOTTOM OF WELL
11.0 FEET:

CEMENT/BENTONITE GROUT
FROM 0 *TO* 6.0 *FT. BELOW GROUND*

BENTONITE SLURRY
FROM 6.0 *TO* 8.0 *FT. BELOW GROUND*

PVC RISER CASING
FROM 0.0 *TO* 8.5 *FT. BELOW GROUND*
1-INCH SCHEDULE 80 PVC

#20/40 **SAND PACK**
FROM 8.0 *TO* 11.5 *FT. BELOW GROUND*

FINE BUBBLE DIFFUSER
FROM 8.5 *TO* 11.0 *FT. BELOW GROUND*

WATER ADDED DURING DRILLING
YES ☐ GALLONS:
NO ☒

TOTAL DEPTH OF BOREHOLE : 11.5 **FT.**

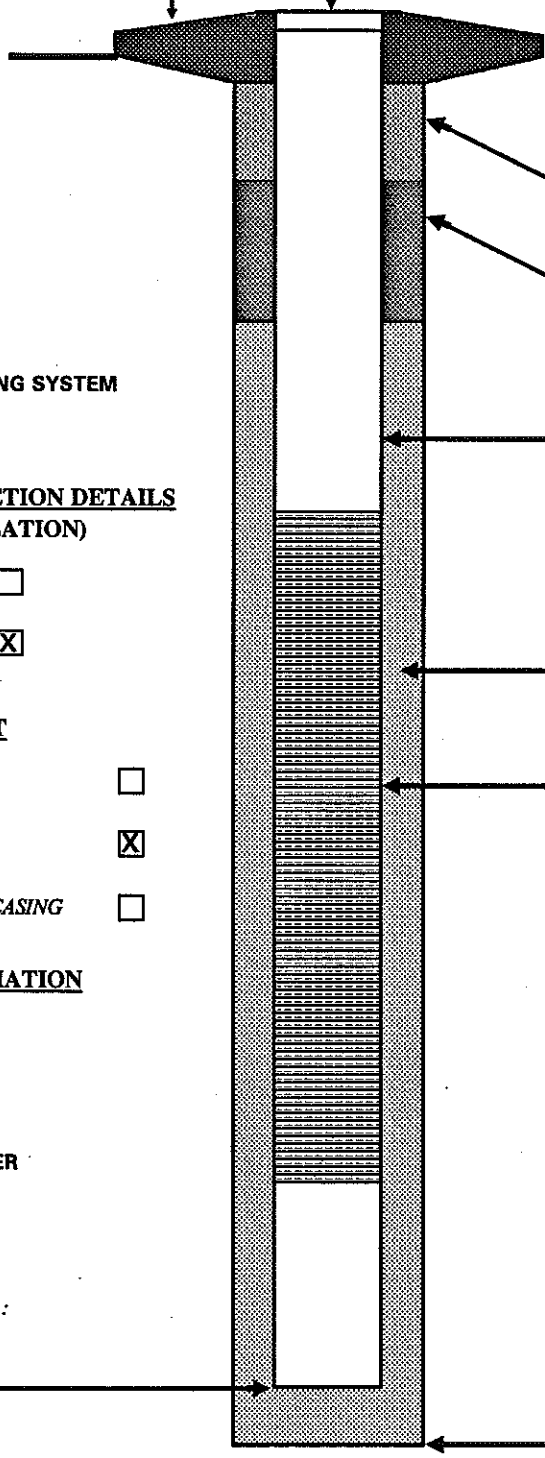
BOREHOLE

PRC Environmental Management Inc.

SPARGE INJECTION COMPLETION DIAGRAM

CONCRETE PAD

FLUSH-MOUNTED PROTECTIVE CASING



WELL

WELL NO.: BS5-2

BOREHOLE NO.:

SITE: SITE 5

SUBSITE: BIOVENTING SYSTEM

DATE: 07-18-94

SURFACE COMPLETION DETAILS (TYPE OF INSTALLATION)

ABOVE GROUND ☐

FLUSH MOUNT [X]

MEASURING POINT

TOP OF CASING ☐

GROUND SURFACE [X]

TOP OF PROTECTIVE CASING ☐

DRILLING INFORMATION

DRILLING COMPANY:
IT CORP.

DRILLING METHOD:
HOLLOW STEM AUGER

DRILLING DATE(S):
12/21/94

INSTALLATION DATE(S):
12/21/94

BOTTOM OF WELL
15.0 FEET:

CEMENT/BENTONITE GROUT
FROM 0.0 *TO* 10.0 *FT. BELOW GROUND*

BENTONITE SLURRY
FROM 10.0 *TO* 12.0 *FT. BELOW GROUND*

PVC RISER CASING
FROM 0.0 *TO* 12.5 *FT. BELOW GROUND*

1-INCH SCHEDULE 80 PVC

#20/40 **SAND PACK**
FROM 12.0 *TO* 15.5 *FT. BELOW GROUND*

FINE BUBBLE DIFFUSER
FROM 12.5 *TO* 15.0 *FT. BELOW GROUND*

WATER ADDED DURING DRILLING

YES ☐ GALLONS:

NO [X]

TOTAL DEPTH OF BOREHOLE : 15.5 **FT.**

BOREHOLE

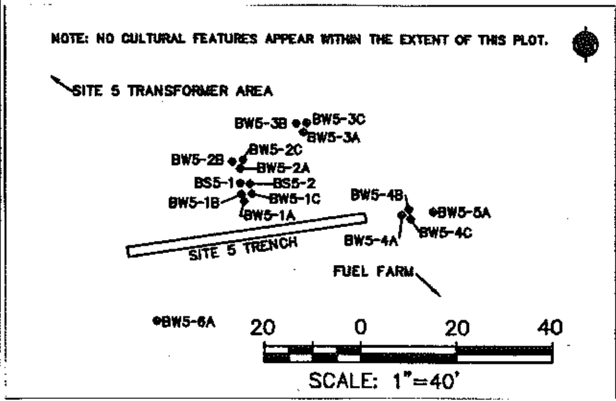
APPENDIX B

SOIL BOREHOLE LOGS

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.

SHEET 1 OF 1



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-1A
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-20-94

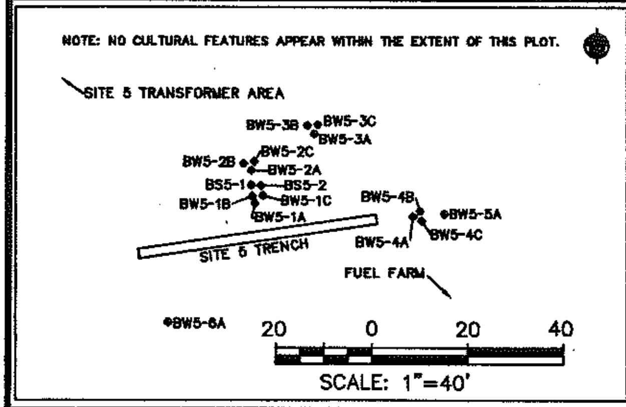
DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED / DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5'/5'	0856	5 ppm						(0.0-3.0)
										1		SILTY CLAY. Slightly moist, roots, organic matter, black.
										2		
										3		(3.0-4.5)
						16 ppm						SILT AND CLAY, trace very fine sand. Slightly moist, mottled olive brown and black.
										4		(4.5-5.0)
		5.0										SANDY SILT, trace gravel. Slightly moist, soft, light yellowish brown.
										5		(5.0-6.5)
	5.0					13 ppm						AS ABOVE. Silt and clay increase with depth.
										6		(6.5-7.5)
				2.5/2.5	0903	1.2 ppm						VERY FINE TO FINE SANDY SILT AND CLAY. Very moist, slightly plastic, hydrocarbon odor, greenish gray (5 9Y 5/1)
						184 ppm				7		
		7.5								8		
										9		
										10		Total Drilled Depth = 7.5 feet
										1		
										2		
										3		
										4		
										5		
										6		
										7		
										8		
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-1B
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-20-94

DRILLING PERSONNEL/METHOD:

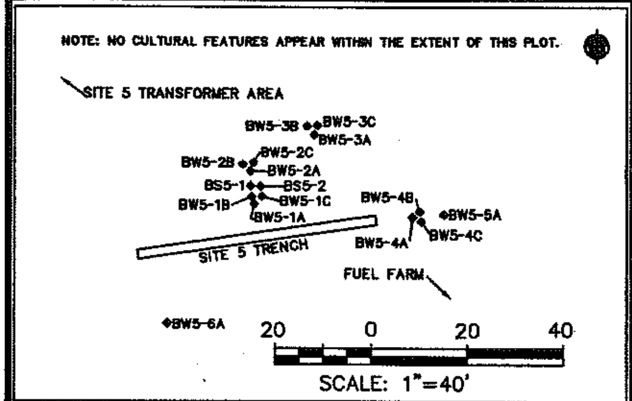
6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED / DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5'/5'	0758	0 ppm				1		(0.0-3.0) SILTY CLAY. Slightly moist, roots, organic matter, black.
						0.5 ppm				2		
										3		(3.0-4.5) SILT AND CLAY, trace very fine sand. Slightly moist, mottled olive brown and black.
										4		(4.5-5.0) SANDY SILT, trace gravel, trace cobbles. Slightly moist, soft, light yellowish brown.
		5.0				1.0 ppm				5		
	5.0									6		(5.0-6.5) AS ABOVE. Silt and clay increase with depth.
				4.5/5.0	0805	195 ppm						(6.5-7.5) VERY FINE TO FINE SANDY SILT AND CLAY. Very moist, soft, hydrocarbon odor, greenish gray (5GY 5/1)
										7		(7.5-10.0) SILT AND CLAY, trace very fine to fine sand. Moist, slightly plastic, stiff, mottled light and dark olive brown.
										8		
										9		
						37 ppm						
										10		(10.0-11.5) AS ABOVE with some calcareous nodules. Increasing sand content from 10.5-11.0 feet.
	10.0	10.0		1.5/1.5	0810	1.6 ppm				1		
		11.5				2.4 ppm						
										2		
										3		Total Drilled Depth = 11.5 feet
										4		
										5		
										6		
										7		
										8		
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.

SHEET 1 OF 1



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-1C
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-19-94

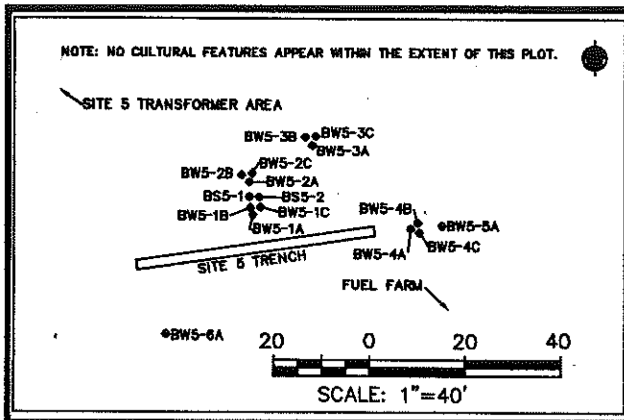
DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED/DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5.0/5.0	1400	0 ppm				1		(0.0-4.5) SILTY CLAY, trace sand and gravel. Slightly moist, tight, roots,organic matter, black. Color change at 3.2 feet to mottled olive brown and black.
										2		
						0 ppm				3		
										4		(4.5-5.0) SANDY SILT AND CLAY. Moist.
		5.0				0 ppm				5		(5.0-7.0) AS ABOVE.
	5.0					12.7 ppm				6		
				4.0/5.0	1409					7		(7.0-8.2) VERY FINE TO FINE SANDY SILT AND CLAY. Very moist, olive brown and greenish gray, fuel odor.
						147 ppm				8		(8.2-10.0) SILT AND CLAY, trace very fine sand and calcareous nodules. Tight, mottled light olive brown and brownish gray, slight fuel odor.
										9		
		10.0				25 ppm				10		(10.0-14.5) VERY FINE TO FINE SANDY SILT AND CLAY, occasional calcareous nodules. Very moist, mottled light olive brown and brownish gray.
	10.0			5.0/5.0	1418					1		
						5.4 ppm				2		
										3		
										4		
		15.0				3.1 ppm				5		(14.5-15.0) AS ABOVE except more sand.
										6		
										7		
										8		Total Drilled Depth = 15.5 feet
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.

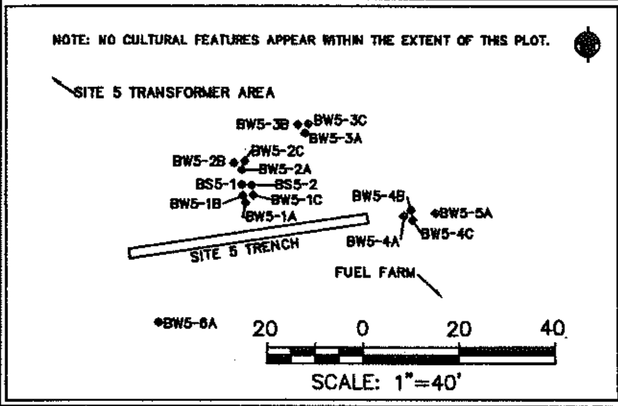


JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-2A
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-19-94
DRILLING PERSONNEL/METHOD: 6" O.D. HSA/ 5 ft. continuous coring	

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED / DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5'/5'	1254	1.3 ppm						(0.0-3.0)
										1		SILTY CLAY, trace sand, trace gravel. Slightly moist, roots, organic matter, hard, black. Color change at 3.0 feet.
										2		
										3		(3.0-5.0) AS ABOVE except trace sand, trace gravel. Stiff, mottled olive.
										4		
		5.0								5		(5.0-6.0)
	5.0					0 ppm						SILTY, CLAYEY, VERY FINE TO MEDIUM SAND, some loose gravel. Moist, light olive brown with light greenish gray mottling. Bottom 3 inches SANDY SILT AND CLAY. Moist, light olive brown with olive brown mottling.
		6.0								6		
	6.0							X				
							X	X		7		(6.0-7.5)
						75 ppm		X				SILT AND CLAY with VERY FINE TO FINE SAND. Very moist, mottled olive brown with greenish gray, hydrocarbon odor.
		7.5								8		
										9		
										10		
										1		Total Drilled Depth = 7.5 feet
										2		
										3		
										4		
										5		
										6		
										7		
										8		
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-2B
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-19-94

DRILLING PERSONNEL/METHOD:

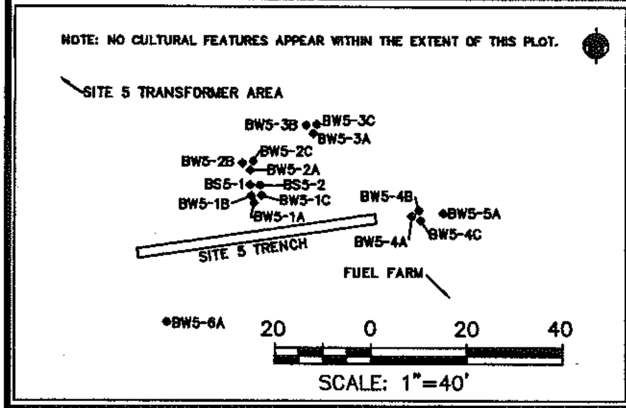
6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT.	BLOWS/ 6 IN. SAMPLE	RECOVERED/DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5'/5'	1129	6.9 ppm				1		(0.0-2.5) SILTY CLAY. Slightly moist, roots, organic matter, black.
						13 ppm				2		(2.5-4.0) SILTY CLAY, trace very fine to fine sand, occasional gravel and cobbles. Moist, tight, mottled olive brown with black.
										3		(4.0-5.0) VERY FINE TO FINE SANDY SILT AND CLAY. Moist, soft, light olive brown.
										4		
		5.0				17 ppm				5		(5.0-6.0) SILTY, CLAYEY SAND, some gravel and cobbles. Sand is very fine to medium grained. Moist, light olive brown.
	5.0					1 ppm				6		(6.0-7.0) SANDY SILT AND CLAY. Moist, mottled light olive brown.
				4.5/5.0	1140	124 ppm				7		(7.0-8.0) SANDY SILT AND CLAY. Abrupt color change to dark greenish gray. Hydrocarbon odor.
						0 ppm				8		(8.0 10.0) SILTY CLAY, some very fine sand. Moist, tight, hard, light olive brown with gray sand stringers.
										9		
		10.0								10		(10.0-11.5) SANDY SILT AND CLAY, occasional gravel and hard gypsum clasts. Very moist, light olive brown.
	10.0			1.5/1.5	1150	0 ppm				1		
		11.5								2		
										3		Total Drilled Depth = 11.5 feet
										4		
										5		
										6		
										7		
										8		
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.

SHEET 1 OF 1



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-2C
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-19-94

DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED/ DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	USCS SOIL TYPE GRAPHIC LOG
5' SS	0	3.0		3.0/3.0	0959					
	3.0	8.0		3.0/5.0	1005	25 ppm				
	8.0	13.0		5.0/5.0	1015	1.0 ppm				
	13.0	15.5		2.5/2.5	1025	0 ppm				

DEPTH in Ft: 1 2 3 4 5 6 7 8 9 10 1 2 3 4 5 6 7 8 9 0

SOIL DESCRIPTION

(0.0-2.5)
SILTY CLAY, trace very fine sand, gravel, and cobbles. Slightly moist, tight, stiff, roots, organic matter, black.

(2.5 3.0)
AS ABOVE except color change to mottled olive (5Y 4/3) and black.

(3.0-4.0)
AS ABOVE. except slightly more silt.

(4.0-6.0)
Poor recovery.

(6.0-7.0)
SILTY VERY FINE TO FINE SAND, occasional hard clasts. Moist, light olive brown (2.5Y 5/4)

(7.0-7.5)
SILTY VERY FINE TO MEDIUM SAND AND GRAVEL, Very moist to wet, light olive brown mottled with greenish gray.

(7.5-8.0)
VERY FINE SANDY SILT, some clay. Moist to wet, light olive brown mottled with greenish gray, fuel odor.

(8.0-13.0)
VERY FINE TO FINE SANDY SILT, some clay, gypsum clasts. Wet, light olive brown with greenish gray mottling, slight fuel odor.

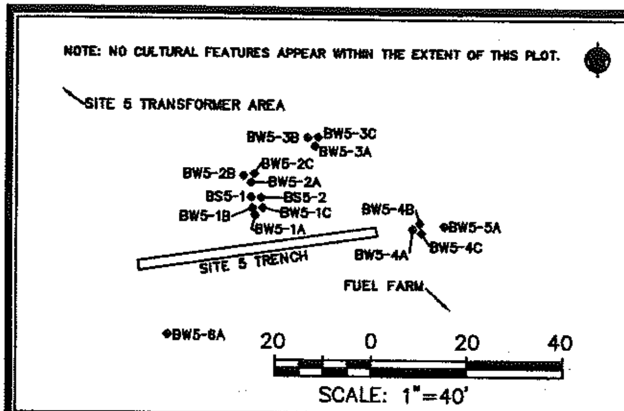
(13.0-15.5)
SANDY SILT, some clay and gravel, very fine to fine sand stringers. Wet, light olive brown, mottled with dark brown and greenish gray. No fuel odor.

Total Drilled Depth = 15.5 feet

BOREHOLE LOG

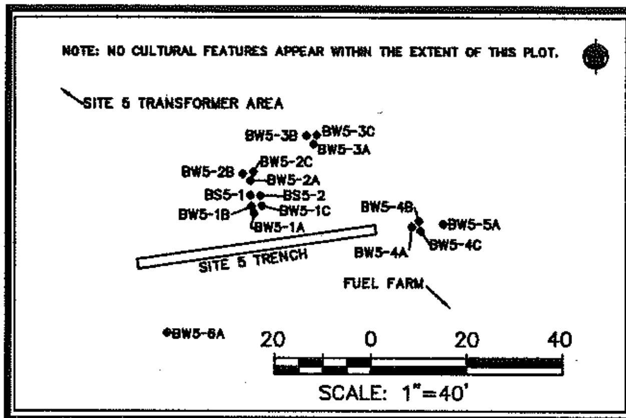
PRC ENVIRONMENTAL MANAGEMENT, INC.

SHEET 1 OF 1



BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.



JOB NO.: 044-0236

BOREHOLE DESIGNATION: BW5-3B

CLIENT: U.S. Navy

SURFACE ELEVATION:

SITE: Moffett Federal Air Field

DEPTH TO WATER: ~6.5 feet bls

SUBSITE: Site 5

LOGGED BY: Tom Lackman

DRILLING CO.: HEW Drilling Co.

DRILLING DATE(S): 12-21-94

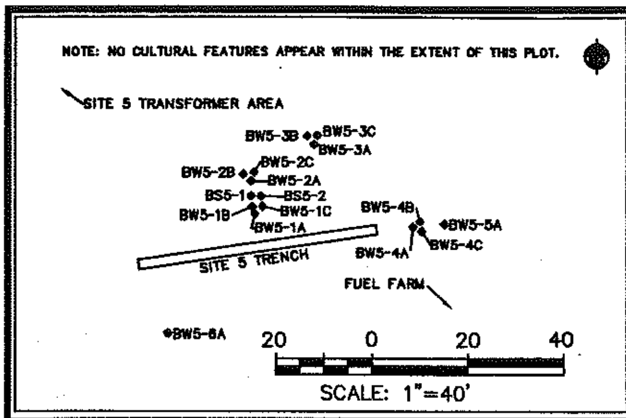
DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN SAMPLE	RECOVERED/ DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5.0/5.0	1433	0 ppm				1		(0.0-3.0) SILTY CLAY. Slightly moist, stiff, roots, organic matter, black.
										2		(3.0-4.0) AS ABOVE except mottled olive brown and black.
						0 ppm				3		
										4		(4.0-5.0) SILT AND CLAY, some very fine to fine sand. Slightly moist, slightly plastic, soft.
		5.0				0 ppm				5		(5.0-6.0) AS ABOVE.
	5.0					0 ppm				6		(6.0-7.5) SILT AND CLAY, some very fine to fine sand. Very moist, slightly plastic, mottled greenish gray and olive brown with greenish gray streaks, fuel odor.
				5.0/5.0	1440							
						576 ppm				7		(7.5-10.0) AS ABOVE except no greenish gray streaks.
										8		
										9		
										10		
		10.0				49 ppm						(10.0-11.5) SILT AND CLAY, trace very fine to fine sand, hard precipitate inclusions. Moist, hard, slightly plastic, mottled olive brown and grayish brown, fuel odor.
	10.0			1.5/1.5	1449					1		
		11.5				38 ppm						
										2		
										3		
										4		Total Drilled Depth = 11.5 feet
										5		
										6		
										7		
										8		
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-3C
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-21-94

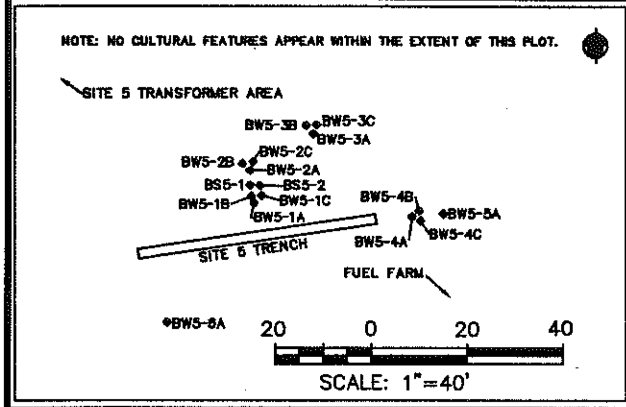
DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED/DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			3.0/5.0	1330	0 ppm						(0.0-3.0) SILTY CLAY. Moist, roots, organic matter, black. Crumbly from 1.0-2.0 feet.
										1		
										2		
						0 ppm				3		(3.0-5.0) Poor recovery
										4		
		5.0				3.1 ppm				5		(5.0-6.5) SIlLT AND CLAY, trace/some fine to very fine sand. Moist. Slightly plastic. Mottled light olive to grayish brown.
	5.0			5.0/5.0	1340	177 ppm				6		(6.5-7.5) AS ABOVE except slightly more sand. Moist to wet. Greenish gray streaking to 8.5 feet. Fuel odor.
										7		(7.5-10.0) SILT AND CLAY, trace sand . Hard precipitate inclusions. Moist to wet. Light olive brown with greenish gray streaking in sandy zones.
										8		
						27 ppm				9		
		10.0		5.0/5.0	1349	3.9 ppm				10		(10.0-15.0) SILT AND CLAY. Trace very fine sand. Moist to wet. Olive brown and grayish brown. Sticky. Hard inclusions throughout.
	10.0									1		
						1.7 ppm				2		
										3		Total Drilled Depth = 15.5 feet
										4		
		15.0								5		
						0.4 ppm				6		
										7		
										8		
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-4A
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-20-94

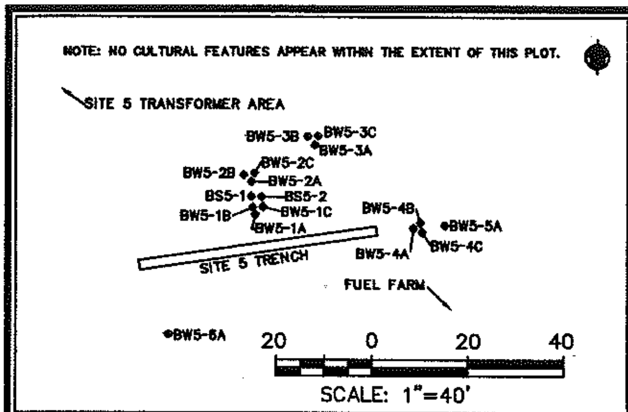
DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED	DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH In Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5'/5'		1255	0 ppm						(0.0-3.0)
											1		SILTY CLAY. Slightly moist, roots, organic matter, tight, black.
											2		
											3		(3.0-4.5)
							0 ppm						SILT AND CLAY with VERY FINE TO FINE SAND. Slightly moist, mottled olive brown with black.
											4		(4.5-5.0)
		5.0											AS ABOVE except light olive brown, calcareous nodules, softer.
											5		(5.0-6.0)
	5.0			1.0/1.0		1305	0 ppm						SANDY SILT AND CLAY, sand is very fine to fine. Moist to very
		6.0					78 ppm						moist, soft, cohesive, greenish gray, hydrocarbon odor.
											6		(6.0-7.5)
	6.0								X				AS ABOVE except brown and greenish gray mottling. Decreasing
								X	X				sand content at 7.0 feet.
											7		
						1310	81 ppm		X				
		7.5											
											8		
											9		
											10		Total Drilled Depth = 7.5 feet
											1		
											2		
											3		
											4		
											5		
											6		
											7		
											8		
											9		
											0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-4B
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-20-94

DRILLING PERSONNEL/METHOD:

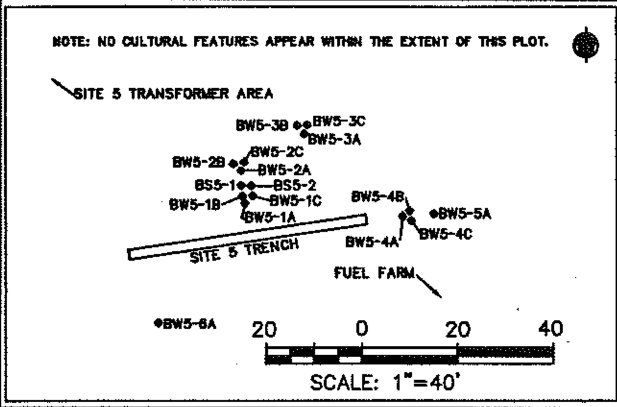
6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED / DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH In Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5.0/5.0	1047	0 ppm						(0.0-3.0)
										1		SILTY CLAY. Slightly moist, tight, roots, organic matter, black.
										2		(3.0-4.5) SILT AND CLAY, trace very fine sand. Slightly moist, black with olive brown mottling.
						0 ppm						
										3		
										4		(4.5-5.0) AS ABOVE except more sand, softer.
		5.0				0 ppm						(5.0-7.5)
										5		
	5.0											VERY FINE TO FINE SANDY SILT AND CLAY, Very moist, greenish gray, fuel odor.
						92 ppm						
										6		
				5.0/5.0	1055							
										7		(7.5-10.0)
						38 ppm						VERY FINE TO FINE SANDY SILT AND CLAY, some sand stringers and calcareous nodules. Slightly moist, stiff, mottled yellowish brown and grayish brown with dark brown spots.
										8		
										9		
										10		(10.0-11.5)
		10.0				35 ppm						VERY FINE TO FINE SANDY SILT AND CLAY, some calcareous nodules. Wet, mottled yellowish brown and grayish brown.
	10.0			1.5/1.5	1103							
										1		
		11.5				5 ppm						
										2		
												Total Drilled Depth = 11.5 feet
										3		
										4		
										5		
										6		
										7		
										8		
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.

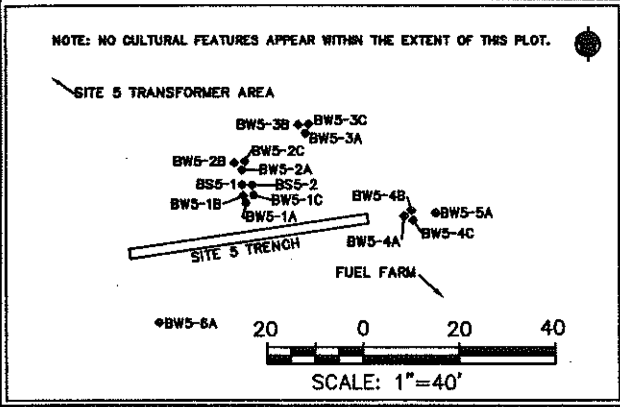
SHEET 1 OF 1



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-4C
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-20-94
DRILLING PERSONNEL/METHOD: 6" O.D. HSA/ 5 ft. continuous coring	

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED / DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5.0/5.0	0940	0 ppm				1		(0.0-3.0) SILTY CLAY. Slightly moist, tight, roots, organic matter, black.
										2		(3.0-4.5) SILT AND CLAY, trace very fine sand. Slightly moist, mottled olive brown with black.
						0 ppm				3		(4.5-5.0) AS ABOVE except slightly more sand.
										4		
	5.0	5.0				0 ppm				5		(5.0-6.0) Poor recovery.
				4.0/5.0	0949	125 ppm				6		(6.0-8.0) VERY FINE TO FINE SANDY SILT AND CLAY. Moist to wet, greenish gray, fuel odor.
										7		
										8		(8.0-9.0) AS ABOVE except mottled greenish gray and yellowish brown.
						49 ppm				9		(9.0-10.0) SILT AND CLAY, some fine to very fine sand stringers. Slightly moist, stiff, mottled yellowish brown and grayish brown with dark brown spots.
	10.0	10.0		5.0/5.0	0958	13 ppm				10		(10.0-15.0) SANDY SILT AND CLAY. Sand decreases slightly with depth. Mottled as above.
						0 ppm				1		
										2		
						0 ppm				3		Total Drilled Depth = 15.5 feet
										4		
		15.0				0.2 ppm				5		
										6		
										7		
										8		
										9		
										0		

BOREHOLE LOG



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-5A
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-20-94

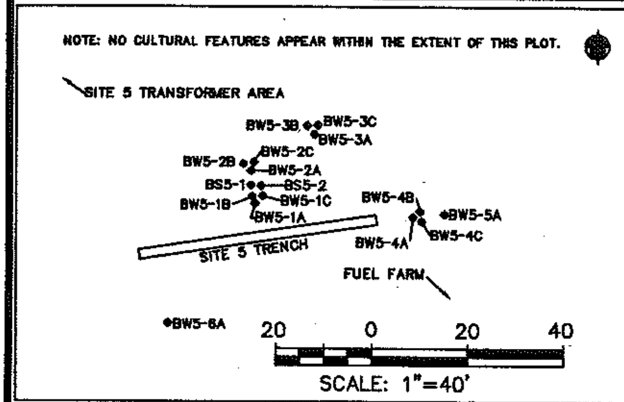
DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED	DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH In Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5'/5'		1341	0 ppm						(0.0-3.0)
											1		SILTY CLAY. Slightly moist, tight, roots, organic matter, black.
											2		
											3		(3.0-4.5)
							0 ppm						SILT AND CLAY, trace very fine to fine sand. Slightly moist, mottled olive brown with black.
											4		(4.5-5.0)
		5.0											AS ABOVE except increased very fine sand. Light olive brown.
											5		(5.0-7.0)
	5.0						0 ppm						AS ABOVE except mottled greenish gray and olive brown.
											6		
				2.5/2.5			81 ppm						
											7		(7.0-7.5)
							467 ppm						SILTY VERY FINE TO MEDIUM, trace clay. Wet, strong fuel odor.
		7.5											
											8		
											9		
													Total Drilled Depth = 7.5 feet
											10		
											1		
											2		
											3		
											4		
											5		
											6		
											7		
											8		
											9		
											0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BW5-6A
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-21-94

DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN SAMPLE	RECOVERED/DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	USCS SOIL TYPE GRAPHIC LOG
5' SS	0	5.0		5'/5'	0830	13.8 ppm				
	5.0	6.0		1.0/1.0	0834	2.0 ppm				
	6.0	7.5		1.5/1.5		0.5 ppm / 6.2 ppm	X			

SOIL DESCRIPTION

(0.0-5.0)
SILTY CLAY. Slightly moist, stiff, roots, organic matter, black.

(3.0-4.0)
SILTY CLAY, some very fine sand. Slightly moist, mottled olive brown with black.

(4.0-5.0)
VERY FINE TO FINE SANDY SILT, some clay, some hard clasts. Soft, light olive brown.

(5.0-6.0)
SILT AND CLAY, some sand, calcareous nodules. Moist, mottled light and dark olive brown.

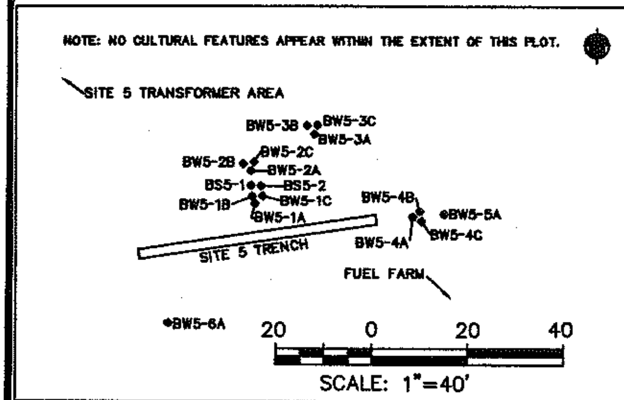
(6.0-7.5)
AS ABOVE.

Total Drilled Depth = 7.5 feet

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.

SHEET 1 OF 1



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BS5-1
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-21-94

DRILLING PERSONNEL/METHOD:

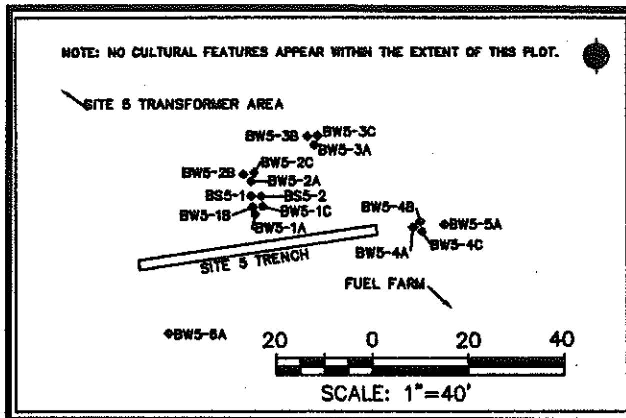
6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED / DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5'/5'	1021	0 ppm						(0.0-5.0) See borelog for BS5-2
										1		
										2		
						0 ppm				3		
										4		
		5.0								5		(5.0-10.0) See borelog for BS5-2
	5.0					0 ppm				6		
				4.0/5.0		242 ppm				7		
										8		
										9		
		10.0				46 ppm				10		(10.0-11.5) SILT AND CLAY, some very fine sand. Moist, slightly plastic, mottled light olive brown and olive brown.
	10.0			1.5/1.5								
		11.5				8 ppm				1		
										2		Total Drilled Depth = 11.5 feet
										3		
										4		
						0 ppm				5		
										6		
										7		
										8		
										9		
										0		

BOREHOLE LOG

PRC ENVIRONMENTAL MANAGEMENT, INC.

SHEET 1 OF 1



JOB NO.: 044-0236	**BOREHOLE DESIGNATION:** BS5-2
CLIENT: U.S. Navy	**SURFACE ELEVATION:**
SITE: Moffett Federal Air Field	**DEPTH TO WATER:** ~6.5 feet bls
SUBSITE: Site 5	**LOGGED BY:** Tom Lackman
DRILLING CO.: HEW Drilling Co.	**DRILLING DATE(S):** 12-21-94

DRILLING PERSONNEL/METHOD:

6" O.D. HSA/ 5 ft. continuous coring

SAMPLER TYPE	SAMPLE DEPTH TOP	SAMPLE DEPTH BOT	BLOWS/ 6 IN. SAMPLE	RECOVERED / DRIVEN	TIME	PID Rdg.	ANLYS PHYS	ANLYS CHEM	WELL Info.	DEPTH in Ft.	USCS SOIL TYPE GRAPHIC LOG	SOIL DESCRIPTION
5' SS	0			5'/5'	0920	0 ppm				1		(0.0-3.0) SILTY CLAY. Slightly moist, roots, organic matter, stiff, black.
										2		
						3 ppm				3		(3.0-4.0) CLAYEY SILT, trace sand, trace cobbles. Slightly moist, olive brown with black streaks.
										4		(4.0-5.0) CLAYEY SILT with very fine to fine sand, occasional gravel. Light olive brown.
		5.0								5		
	5.0					1.5 ppm						(5.0-6.0) Poor recovery.
						13.6 ppm				6		(6.0-7.0) AS IN (4.0-5.0) ABOVE.
				4.0/5.0		312 ppm				7		(7.0-8.0) SANDY SILT AND CLAY. Moist to wet, soft, greenish gray, fuel odor.
										8		(8.0-10.0) SILTY CLAY, some very fine sand. Moist, stiff, mottled light and dark yellowish brown, with grayish brown, slight fuel odor
										9		
		10.0				42 ppm				10		(10.0-15.0) AS ABOVE. Decreasing moisture. Dark brown spots from 14.5-15.0.
	10.0											
						1 ppm				1		
						1.2 ppm				2		
										3		
										4		
		15.0										
						0 ppm				5		(15.0-16.5) AS ABOVE.
										6		
										7		
										8		
										9		Total Drilled Depth = 16.5 feet
										0		

APPENDIX C

SOIL ANALYTICAL RESULTS

FORM 1 135229
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-1 (6.0-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268941

Sample wt/vol: 30.3 (g/mL) G Lab File ID: 22SE951729-I311

% Moisture: 17 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/23/95

Injection Volume: 1.0 (uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: 8.2 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	12	U
39-40-2	Motor Oil	56	
21274-30-0	JP-5	12	U
8008-20-6	Kerosene	12	U

FORM 1 135230

TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-2 (6.8-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268942

Sample wt/vol: 30.1 (g/mL) G Lab File ID: 22SE951729-I321

% Moisture: 18 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/23/95

Injection Volume: 1.0 (uL) Dilution Factor: 100.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	1200	U
39-40-2	Motor Oil	1200	U
21274-30-0	JP-5	2600	
8008-20-6	Kerosene	1200	U

FORM 1 135231

TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-3 (6.1-6.5)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268943

Sample wt/vol: 30.3 (g/mL) G Lab File ID: 22SE951729-I331

% Moisture: 18 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/23/95

Injection Volume: 1.0 (uL) Dilution Factor: 50.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	600	U
39-40-2	Motor Oil	600	U
21274-30-0	JP-5	1100	
8008-20-6	Kerosene	600	U

FORM I TPH

135232

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-4 (6.4-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268944

Sample wt/vol: 30.2 (g/mL) G Lab File ID: 22SE951729-I341

% Moisture: 18 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/23/95

Injection Volume: 1.0 (uL) Dilution Factor: 50.0

GPC Cleanup: (Y/N) N pH: 8.5 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	600	U
39-40-2	Motor Oil	600	U
21274-30-0	JP-5	1500	
8008-20-6	Kerosene	600	U

135233

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-5 (5.3-5.6)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268945

Sample wt/vol: 30.3 (g/mL) G Lab File ID: 22SE951729-I351

% Moisture: 19 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/23/95

Injection Volume: 1.0 (uL) Dilution Factor: 100.0

GPC Cleanup: (Y/N) N pH: 8.3 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	1200	U
39-40-2	Motor Oil	1200	U
21274-30-0	JP-5	3300	
8008-20-6	Kerosene	1200	U

133234

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-6 (6.5-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268946

Sample wt/vol: 31.1 (g/mL) G Lab File ID: 23SE951245-I331

% Moisture: 19 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/24/95

Injection Volume: 1.0 (uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: 8.5 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	12	U
39-40-2	Motor Oil	12	U
21274-30-0	JP-5	12	U
8008-20-6	Kerosene	12	U

FORM 1 135237
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-7 (64-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268947

Sample wt/vol: 30.6 (g/mL) G Lab File ID: 22SE951729-I361

% Moisture: 17 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/23/95

Injection Volume: 1.0 (uL) Dilution Factor: 50.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	590	U
39-40-2	Motor Oil	590	U
21274-30-0	JP-5	1200	
8008-20-6	Kerosene	590	U

FORM I TPH

135238

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-8 (6.5-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268948

Sample wt/vol: 30.0 (g/mL) G Lab File ID: 22SE951729-I371

% Moisture: 18 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/23/95

Injection Volume: 1.0 (uL) Dilution Factor: 50.0

GPC Cleanup: (Y/N) N pH: 8.3 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	610	U
39-40-2	Motor Oil	610	U
21274-30-0	JP-5	1100	
8008-20-6	Kerosene	610	U

135239

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-9 (6.0-6.5)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268949

Sample wt/vol: 30.6 (g/mL) G Lab File ID: 26SE951318-I041

% Moisture: 19 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted:09/06/95

Concentrated Extract Volume: 2(mL) Date Analyzed: 09/26/95

Injection Volume: 1.0(uL) Dilution Factor: 10.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	120	U
39-40-2	Motor Oil	120	U
21274-30-0	JP-5	880	
8008-20-6	Kerosene	120	U

133240

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-10 (6.0-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268950

Sample wt/vol: 30.1 (g/mL) G Lab File ID: 26SE951318-I051

% Moisture: 20 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted:09/06/95

Concentrated Extract Volume: 2(mL) Date Analyzed: 09/26/95

Injection Volume: 1.0(uL) Dilution Factor: 20.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	250	U
39-40-2	Motor Oil	250	U
21274-30-0	JP-5	1600	
8008-20-6	Kerosene	250	U

FORM 1 135243

TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-11 (6.0-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268951

Sample wt/vol: 30.6 (g/mL) G Lab File ID: 23SE951245-I201

% Moisture: 17 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/24/95

Injection Volume: 1.0 (uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	12	U
39-40-2	Motor Oil	12	U
21274-30-0	JP-5	12	U
8008-20-6	Kerosene	12	U

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-12 (6.6-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268952

Sample wt/vol: 30.2 (g/mL) G Lab File ID: 23SE951245-I211

% Moisture: 17 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted:09/06/95

Concentrated Extract Volume: 2(mL) Date Analyzed: 09/24/95

Injection Volume: 1.0(uL) Dilution Factor: 10.0

GPC Cleanup: (Y/N) N pH: 8.3 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	120	U
39-40-2	Motor Oil	120	U
21274-30-0	JP-5	660	
8008-20-6	Kerosene	120	U

FORM 1 135245

TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-13 (6.5-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268953

Sample wt/vol: 30.1 (g/mL) G Lab File ID: 23SE951245-I221

% Moisture: 19 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted:09/06/95

Concentrated Extract Volume: 2(mL) Date Analyzed: 09/24/95

Injection Volume: 1.0(uL) Dilution Factor: 50.0

GPC Cleanup: (Y/N) N pH: 8.2 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	620	U
39-40-2	Motor Oil	620	U
21274-30-0	JP-5	2000	
8008-20-6	Kerosene	620	U

100248

FORM 1

TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-14 (6.5-7.-)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268954

Sample wt/vol: 30.6 (g/mL) G Lab File ID: 26SE951318-I081

% Moisture: 19 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/26/95

Injection Volume: 1.0 (uL) Dilution Factor: 20.0

GPC Cleanup: (Y/N) N pH: 8.3 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	240	U
39-40-2	Motor Oil	240	U
21274-30-0	JP-5	1400	
8008-20-6	Kerosene	240	U

135249

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-15(6.4-6.7)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268955

Sample wt/vol: 30.4 (g/mL) G Lab File ID: 23SE951245-I261

% Moisture: 20 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/24/95

Injection Volume: 1.0 (uL) Dilution Factor: 100.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	1200	U
39-40-2	Motor Oil	1200	U
21274-30-0	JP-5	3500	
8008-20-6	Kerosene	1200	U

FORM 1 135250

TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-16 (6.5-7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268956

Sample wt/vol: 30.2 (g/mL) G Lab File ID: 23SE951245-I271

% Moisture: 11 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/24/95

Injection Volume: 1.0 (uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: 8.8 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	11	U
39-40-2	Motor Oil	11	U
21274-30-0	JP-5	11	U
8008-20-6	Kerosene	11	U

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-17 (6.7 - 7.0)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268957

Sample wt/vol: 30.3 (g/mL) G Lab File ID: 23SE951245-I281

% Moisture: 18 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/24/95

Injection Volume: 1.0 (uL) Dilution Factor: 5.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	60	U
39-40-2	Motor Oil	60	U
21274-30-0	JP-5	500	
8008-20-6	Kerosene	60	U

FORM 1 135254

TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-18 (6.4-6.7)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268958

Sample wt/vol: 30.4 (g/mL) G Lab File ID: 23SE951245-I291

% Moisture: 17 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/24/95

Injection Volume: 1.0 (uL) Dilution Factor: 20.0

GPC Cleanup: (Y/N) N pH: 8.2 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	240	U
39-40-2	Motor Oil	240	U
21274-30-0	JP-5	880	
8008-20-6	Kerosene	240	U

135255

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-19 (6.4-6.8)

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF015

Matrix: (soil/water) SOIL Lab Sample ID: 268959

Sample wt/vol: 30.2 (g/mL) G Lab File ID: 23SE951245-I301

% Moisture: 19 decanted: (Y/N) N Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL) Date Analyzed: 09/24/95

Injection Volume: 1.0 (uL) Dilution Factor: 10.0

GPC Cleanup: (Y/N) N pH: 8.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	120	U
39-40-2	Motor Oil	120	U
21274-30-0	JP-5	880	
8008-20-6	Kerosene	120	U

135256

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

GB5-20 (6.0-7.0)

Lab Name: AQUATEC, INC.   Contract: 93228

Lab Code: AQUAI   Case No.: 044   SAS No.:   SDG No.: MF015

Matrix: (soil/water) SOIL   Lab Sample ID: 268960

Sample wt/vol: 30.2 (g/mL) G   Lab File ID: 23SE951245-I311

% Moisture: 18   decanted: (Y/N) N   Date Received: 08/26/95

Extraction: (SepF/Cont/Sonc) SONC   Date Extracted: 09/06/95

Concentrated Extract Volume: 2 (mL)   Date Analyzed: 09/24/95

Injection Volume: 1.0 (uL)   Dilution Factor: 100.0

GPC Cleanup: (Y/N) N   pH: 8.5   Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/KG	Q
39-40-0	Diesel Fuel	1200	U
39-40-2	Motor Oil	1200	U
21274-30-0	JP-5	2000	
8008-20-6	Kerosene	1200	U

ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138249

Project ID : 235
Sample ID : ~~GCB51~~ GCBS-K(6.0-7.0)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/22/96
Instrument ID : HP23

Anametrix ID : 9605161-01
Lab File ID : FPY16101
% Moisture : 18.

Dilution Factor : 1.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	ND	U

GC/TPH - PAGE

JLB
6/24/96

ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138250

Project ID : 235
Sample ID : ~~GCB52~~ GCB5-2(68.7-0)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/22/96
Instrument ID : HP23

Anametrix ID : 9605161-02
Lab File ID : FPY16102
% Moisture : 17.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	260000.	

GC/TPH - PAGE

JLB 6/26/96

ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138251

Project ID : 235
Sample ID : ~~GCB53~~ GCB5-3(6.1-6.5)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/22/96
Instrument ID : HP23

Anametrix ID : 9605161-03
Lab File ID : FPY16103
% Moisture : 18.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	110000.	

GC/TPH - PAGE

SMB 6/26/96

ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138252

C

Project ID : 235
Sample ID : ~~GCB54~~ GCBS-4(6.4-7.0)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/22/96
Instrument ID : HP23

Anametrix ID : 9605161-04
Lab File ID : FPY16104
% Moisture : 16.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	230000.	

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JLB 6/24/96

04

ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138253

Project ID : 235
Sample ID : ~~GCB55~~ GCB5-5(53-56)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/22/96
Instrument ID : HP23

Anametrix ID : 9605161-05
Lab File ID : FPY16105
% Moisture : 19.

Dilution Factor : 10.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	62000.	ND	U
4444-44-4	MOTOR OIL	62000.	ND	U
3333-33-3	JP-5	62000.	1500000.	

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138254

Project ID	: 235	Anametrix ID	: 9605161-06
Sample ID	: ~~GCB56~~ GCB5-6(6.5-7.0)	Lab File ID	: FRY16106
Matrix	: SOIL	% Moisture	: 17.
Date Sampled	: 5/15/96		
Date Extracted	: 5/21/96		
Amount Extracted	: 20.0 g		
Date Analyzed	: 5/23/96	Dilution Factor	: 1.0
Instrument ID	: HP23	Conc. Units	: ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	ND	U

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138255

Project ID : 235
Sample ID : ~~GCB57~~ GCB5-7(6.6-7.0)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-07
Lab File ID : FRY16107
% Moisture : 17.

Dilution Factor : 1.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	73000.	

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138256

Project ID : 235
Sample ID : ~~GCB58~~ GC135-8(6.5-7.0)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-08
Lab File ID : FRY16108
% Moisture : 17.

Dilution Factor : 5.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	30000.	ND	U
4444-44-4	MOTOR OIL	30000.	ND	U
3333-33-3	JP-5	30000.	480000.	

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JLB 6/24/96

026

ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138257

Project ID : 235
Sample ID : ~~GCB59~~ GCBS-9 (6.0-6.8)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-09
Lab File ID : FPY16109
% Moisture : 19.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	100000.	

JLB
6/24/96

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138258

Project ID	: 235		Anametrix ID	: 9605161-10
Sample ID	: ~~CB510~~ GCB5-10(6.0-7.0)		Lab File ID	: FPY16110
Matrix	: SOIL		% Moisture	: 16.
Date Sampled	: 5/15/96			
Date Extracted	: 5/21/96			
Amount Extracted	: 20.0 g			
Date Analyzed	: 5/23/96		Dilution Factor	: 2.0
Instrument ID	: HP23		Conc. Units	: ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	140000.	

JWB
6/26/96

ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138259

Project ID : 235
Sample ID : ~~CB511~~ GCB5-11(6.0-7.0)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-11
Lab File ID : FRY16111
% Moisture : 17.

Dilution Factor : 1.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	ND	U

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6/26/96

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138260

Project ID : 235
Sample ID : ~~CB512~~ GCB5-12(6.6-7.0)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-12
Lab File ID : FPY16112
% Moisture : 16.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	170000.	

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138261

010

Project ID : 235
Sample ID : ~~CB513~~ GCB5-13(6.5-7.0)
Matrix : SOIL
Date Sampled : 5/16/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-13
Lab File ID : FPY16113
% Moisture : 19.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	170000.	

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138262

011

Project ID : 235
Sample ID : ~~GB514~~ GCB5-14(6.5-7.0)
Matrix : SOIL
Date Sampled : 5/16/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-14
Lab File ID : FPY16114
% Moisture : 17.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	290000.	

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138263 010

Project ID : 235
Sample ID : ~~CB515~~ GCB5-15(6.4-6.7)
Matrix : SOIL
Date Sampled : 5/16/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-15
Lab File ID : FPY16115
% Moisture : 19.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	300000.	

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138264

Project ID	: 235
Sample ID	: ~~CB516~~ GCBS-16 (6.5-7.0)
Matrix	: SOIL
Date Sampled	: 5/15/96
Date Extracted	: 5/21/96
Amount Extracted	: 20.0 g
Date Analyzed	: 5/23/96
Instrument ID	: HP23
Anametrix ID	: 9605161-16
Lab File ID	: FRY16116
% Moisture	: 18.
Dilution Factor	: 1.0
Conc. Units	: ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	25000.	

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138265

Project ID : 235
Sample ID : ~~CB517~~ GCBS-17(6.7-7.0)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-17
Lab File ID : FRY16117
% Moisture : 18.

Dilution Factor : 1.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	7600.	J

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138266

Project ID : 235
Sample ID : ~~CB518~~ GCBS-18(6.4-6.7)
Matrix : SOIL
Date Sampled : 5/16/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-18
Lab File ID : FPY16118
% Moisture : 17.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	300000.	

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JLB
6/26/96

016

ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138267

Project ID : 235
Sample ID : ~~CB519~~ GCBS-19(6.4-6.8)
Matrix : SOIL
Date Sampled : 5/15/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-19
Lab File ID : FRY16119
% Moisture : 18.

Dilution Factor : 5.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	31000.	ND	U
4444-44-4	MOTOR OIL	31000.	ND	U
3333-33-3	JP-5	31000.	210000.	

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6/26/96

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ORGANIC ANALYSIS DATA SHEET -- EPA METHOD TPHd
ANAMETRIX, INC. (408)432-8192

138268

Project ID : 235
Sample ID : ~~CB520~~ GCBS-20(6.0-7.0)
Matrix : SOIL
Date Sampled : 5/16/96
Date Extracted : 5/21/96
Amount Extracted : 20.0 g
Date Analyzed : 5/23/96
Instrument ID : HP23

Anametrix ID : 9605161-20
Lab File ID : FPY16120
% Moisture : 17.

Dilution Factor : 2.0
Conc. Units : ug/Kg

CAS No.	COMPOUND NAME	REPORTING LIMIT	AMOUNT DETECTED	Q
1111-11-1	DIESEL	12000.	ND	U
4444-44-4	MOTOR OIL	12000.	ND	U
3333-33-3	JP-5	12000.	140000.	

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JLB 6/26/96

Inchcape Testing Services
Aquatec Laboratories

Laboratory Locations
55 South Park Drive
Colchester, VT 05446

75 Green Mountain Drive
South Burlington, VT 05403

150 Herman Melville Boulevard
New Bedford, MA 02740

Analytical Report

Anametrix Laboratory, Inc.
1961 Concourse Drive
Suite #E
San Jose, CA 95131

Attention : Su Patel

Date : 01/05/95
ETR Number : 48661
Project No.: 93228
No. Samples: 2
Arrived : 12/23/94
P.O. Number: 9412232

Case:93228 SDG:52A65 CTO:0236

Standard analyses were performed in accordance with Methods for Analysis of Water and Wastes, EPA-600/4/79-020, Test Methods for Evaluating Solid Waste, SW-846, or Standard Methods for the Examination of Water and Wastewater. All results are in mg/l unless otherwise noted.

Lab No./ Method No.	Sample Description/ Parameter	Result
245747	52A65:12/19/94 (Soil)	
BW5-2A(6.5-7.5) IN847	TOC by Lloyd Kahn	1210 f
IN623	Solids, Total	82.5 c
SBIO-AQ	907B Plate Count soil	125,000 w
SBIO-AQ	Diesel-utilizing plate ct	29,000 w
245748	54A60:12/20/94 (Soil)	
BW5-4A(6.0-7.5) IN847	TOC by Lloyd Kahn	<122 f
IN623	Solids, Total	81.9 c
SBIO-AQ	907B Plate Count soil	30,000 w
SBIO-AQ	Diesel-utilizing plate ct	3,000 w

Comments/Notes

f = mg/Kg dry weight
c = %W/W as received
w = CFU/gram dry weight

< Last Page > Submitted By :

Aquatec Inc.

INCHCAPE TESTING SERVICES
ANAMETRIX LABORATORIES
(408) 432-8192

DATA REPORT

Anametrix Sample ID: **9412232-01**
Client Sample ID: **52A65** (BW5-2A)
Client Project Number: **0236**
Matrix: **SOIL**

Date Sampled: **12/19/94**
Analyst: mK
Supervisor: ML

Analyte	Prep. Method	Analytical Method	Instr. ID	Date Prepared	Date Analyzed	Dil. Factor	Units	Reporting Limit	Results	Q
Nitrate as N	300.0	300.0	IC1	04/25/95	04/26/95	1	mg/Kg	0.20	**0.55**	
Phosphate as P	300.0	300.0	IC1	04/25/95	04/26/95	1	mg/Kg	0.50	**1.1**	
Ammonia	350.3	350.3	MET2	01/03/95	01/03/95	1	mg/Kg	1.0	**ND**	

COMMENTS: Sample was prepared at 1:10 dilution using DI water for ammonia and anions analyses.

01

INCHCAPE TESTING SERVICES
ANAMETRIX LABORATORIES
(408) 432-8192
DATA REPORT

Anametrix Sample ID: **9412232-02**
Client Sample ID: **54A60** (BW5-4A)
Client Project Number: **0236**
Matrix: **SOIL**

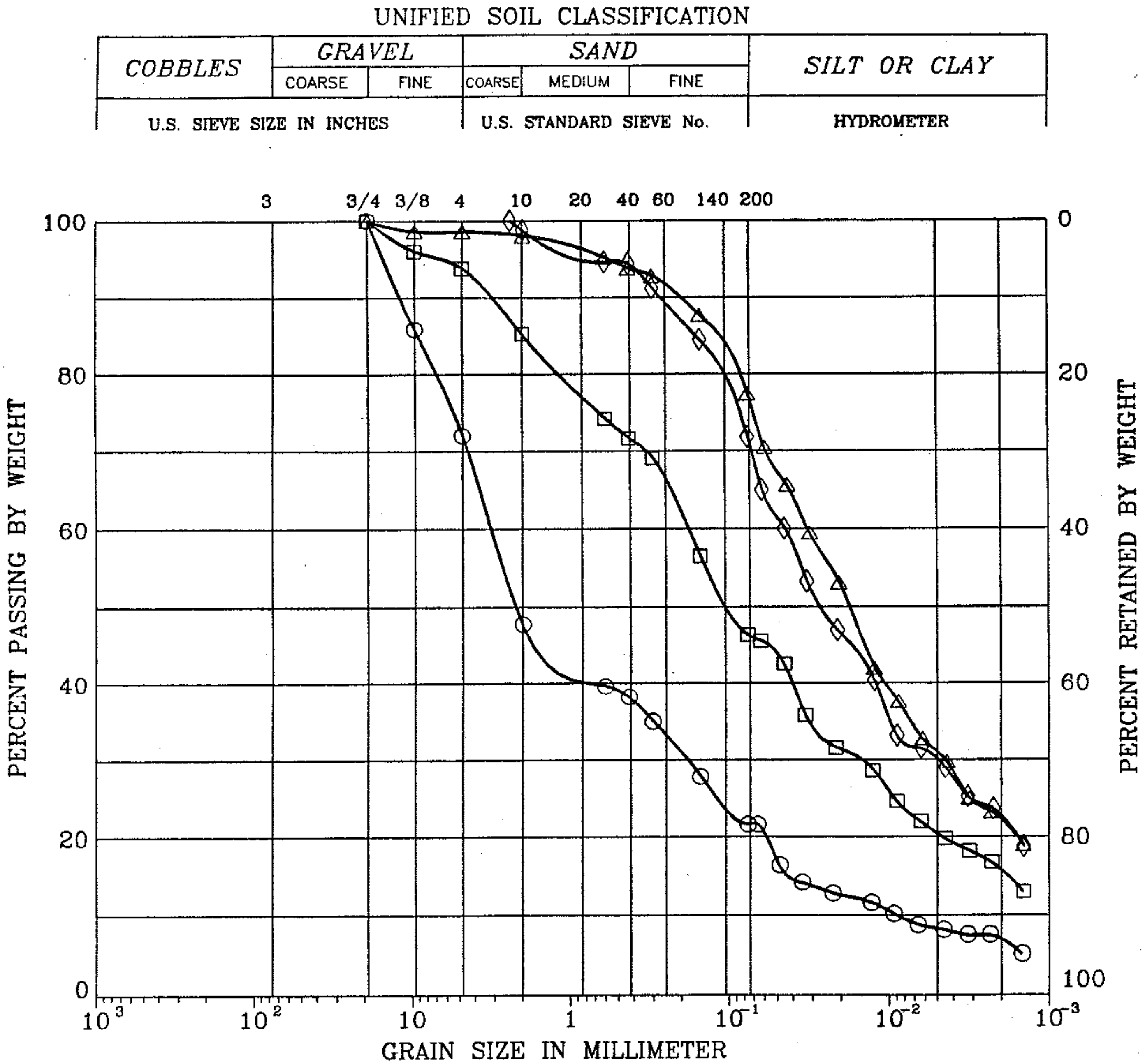
Date Sampled: **12/20/94**
Analyst: CH
Supervisor: MoM

Analyte	Prep. Method	Analytical Method	Instr. ID	Date Prepared	Date Analyzed	Dil. Factor	Units	Reporting Limit	Results	Q
Nitrate as N	300.0	300.0	IC1	04/25/95	04/26/95	1	mg/Kg	0.20	**0.41**	
Phosphate as P	300.0	300.0	IC1	04/25/95	04/26/95	1	mg/Kg	0.50	**1.2**	
Ammonia	350.3	350.3	MET2	01/03/95	01/03/95	1	mg/Kg	1.0	**ND**	

COMMENTS: Sample was prepared at 1:10 dilution using DI water for ammonia.

APPENDIX D

SOIL GEOTECHNICAL RESULTS



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	GTT5-1	5.5-6.5			olive gray silty Gravelly Sand (SM)
□	GTT5-2	5.5-6.5			olive silty Sand (SM)
△	GTT5-3	4.5-5.5			olive clayey Silt w/sand (ML)
◇	GTT5-4	4.5-5.5			olive sandy clayey Silt (ML)

Remark :

Project No.096-019	PRC 044-0236IRPSRP
Cooper Testing Labs Mountain View CA	GRAIN SIZE DISTRIBUTION Figure No.

Cooper Testing Laboratories

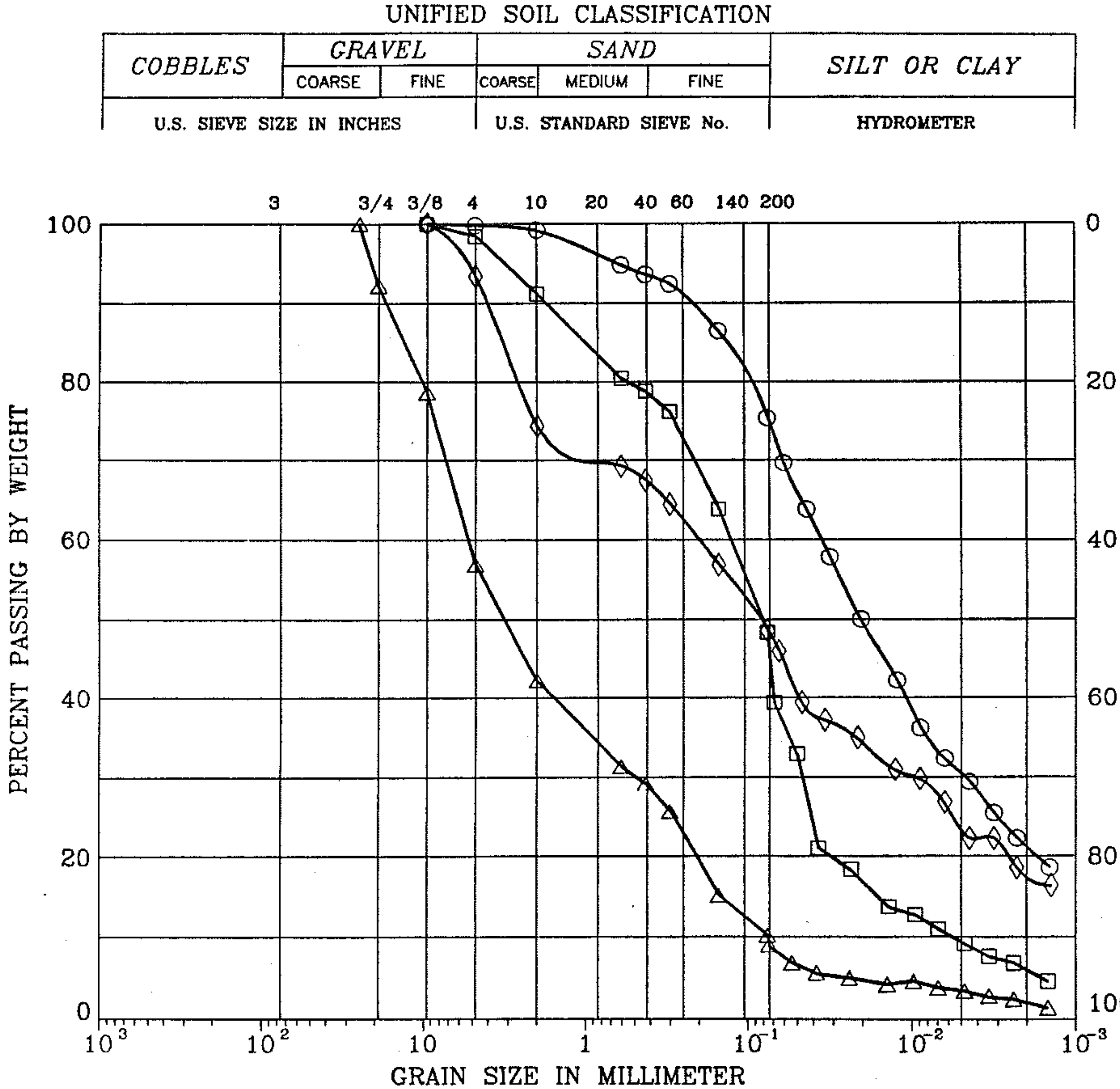
Project No.096-019

PRC 044-0236IRPSRP

Figure No.

BORING	DEPTH	% COBBLES	% GRAVEL	% SAND	% FINE	% SILT	% CLAY	Cu	Cc
GTT5-1	5.5-6.5	0.00	27.99	50.37		13.29	8.36		
GTT5-2	5.5-6.5	0.00	6.16	47.53		25.94	20.37		
GTT5-3	4.5-5.5	0.00	1.43	21.21		46.53	30.84		
GTT5-4	4.5-5.5	0.00	0.00	28.16		42.10	29.73		

GTT5-1 5.5-6.5		GTT5-2 5.5-6.5		GTT5-3 4.5-5.5		GTT5-4 4.5-5.5	
Grain Size (mm)	% Finer	Grain Size (mm)	% Finer	Grain Size (mm)	% Finer	Grain Size (mm)	% Finer
0.0015	5.15	0.0015	12.93	0.0014	18.95	0.0014	18.71
0.0024	7.50	0.0023	16.74	0.0023	23.13	0.0023	23.63
0.0033	7.50	0.0032	18.26	0.0032	25.06	0.0032	25.11
0.0046	8.24	0.0045	19.78	0.0044	29.88	0.0045	29.04
0.0066	8.83	0.0063	21.92	0.0062	32.77	0.0063	31.51
0.0092	10.15	0.0090	24.59	0.0088	37.59	0.0089	33.14
0.0129	11.62	0.0124	28.65	0.0122	42.09	0.0123	40.37
0.0222	12.80	0.0213	31.69	0.0203	53.02	0.0208	46.92
0.0347	14.12	0.0330	35.75	0.0312	59.44	0.0322	53.16
0.0483	16.33	0.0451	42.60	0.0430	65.55	0.0442	60.06
0.0655	21.63	0.0628	45.64	0.0595	70.37	0.0613	64.98
0.0750	21.65	0.0750	46.31	0.0750	77.37	0.0750	71.84
0.1500	27.86	0.1500	56.41	0.1500	87.64	0.1500	84.30
0.3000	35.05	0.3000	69.10	0.3000	92.87	0.3000	91.23
0.4250	38.15	0.4250	71.70	0.4250	93.84	0.4250	94.40
0.6000	39.66	0.6000	74.30	0.6000	95.19	0.6000	94.59
2.0000	47.73	2.0000	85.15	2.0000	98.10	2.0000	98.75
4.7500	72.01	4.7500	93.84	4.7500	98.57	2.3800	100.00
9.5250	85.72	9.5250	96.03	9.5250	98.57		
19.0500	100.00	19.0500	100.00	19.0500	100.00		



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	GTT5-5	5.0-5.5			olive clayey Silt (ML)
~~□~~	~~GTBP-1C~~	~~17-17.5~~		~~-~~	~~gray silty Sand (SM)~~
~~△~~	~~GTB9-2C~~	~~10.5-11~~		~~-~~	~~gray gravelly Sand (SP-SM)~~
~~◇~~	~~GTB9-3c~~	~~7.5-8.0~~			~~gray silty Clayey Sand (SC)~~

Remark :

Project No.096-19	PRC 044-0236IRPSRP
Cooper Testing Labs Mountain View CA	GRAIN SIZE DISTRIBUTION Figure No.

Cooper Testing Laboratories

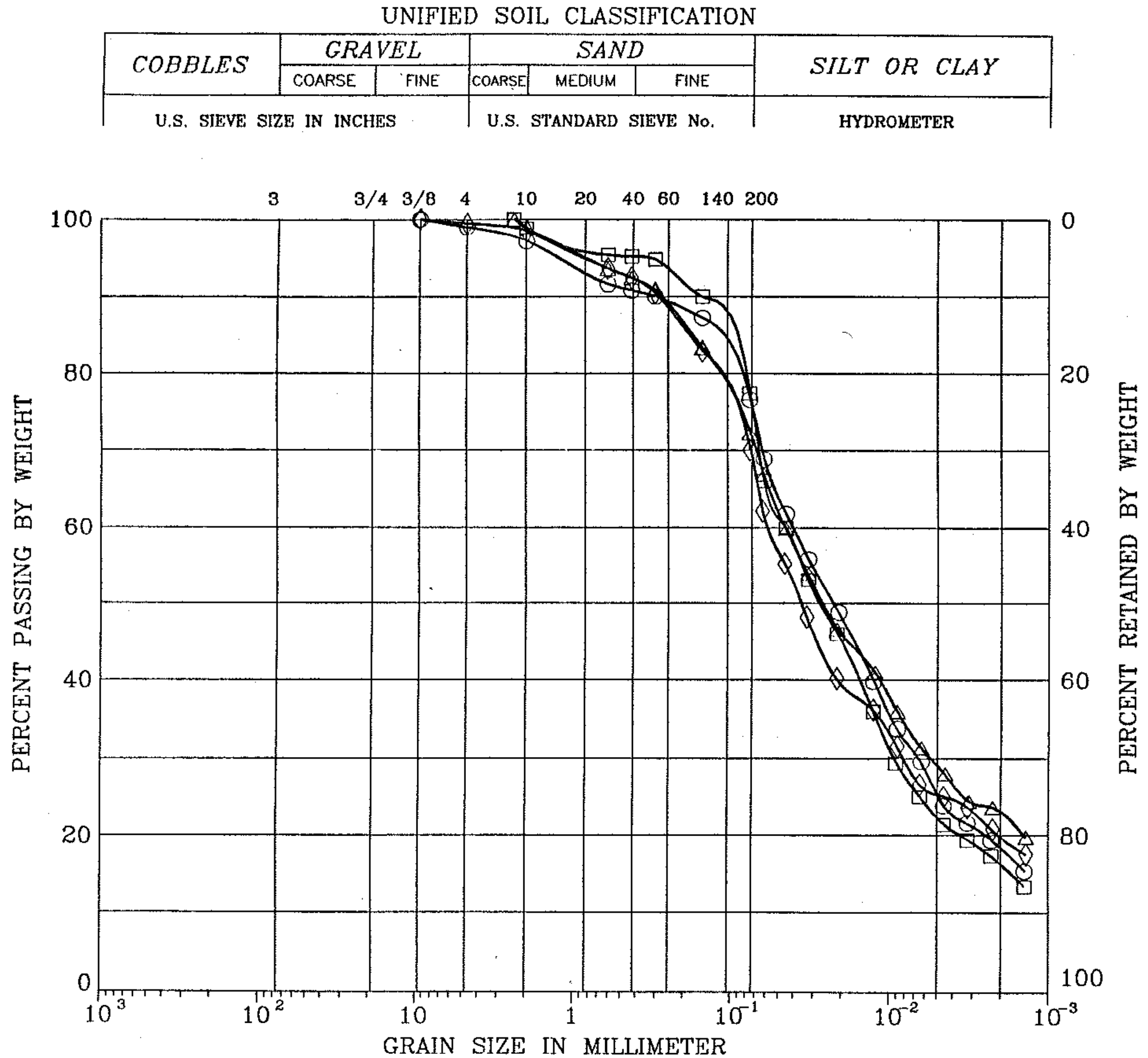
Project No.096-19

PRC 044-0236IRPSRP

Figure No.

BORING	DEPTH	% COBBLES	% GRAVEL	% SAND	% FINE	% SILT	% CLAY	Cu	Cc
GTT5-5	5.0-5.5	0.00	0.21	24.32		45.17	30.30		
~~GTBP-1C~~	~~17-17.5~~	~~0.00~~	~~1.58~~	~~50.07~~		~~39.01~~	~~9.34~~	~~22.4~~	~~3.0~~
~~GTB9-2C~~	~~10.5-11~~	~~0.00~~	~~43.17~~	~~46.68~~		~~6.63~~	~~3.52~~	~~70.2~~	~~0.6~~
~~GTB9-3c~~	~~7.5-8.0~~	~~0.00~~	~~6.66~~	~~44.70~~		~~25.17~~	~~23.46~~		

GTT5-5 5.0-5.5		GTBP-1C 17-17.5		GTB9-2C 10.5-11		GTB9-3c 7.5-8.0	
Grain Size (mm)	% Finer	Grain Size (mm)	% Finer	Grain Size (mm)	% Finer	Grain Size (mm)	% Finer
0.0014	18.63	0.0015	4.58	0.0015	1.42	0.0014	16.35
0.0023	22.21	0.0024	6.87	0.0024	2.45	0.0023	18.58
0.0032	25.49	0.0034	7.62	0.0034	2.71	0.0032	22.29
0.0044	29.41	0.0048	9.16	0.0048	3.49	0.0045	22.29
0.0063	32.35	0.0069	10.99	0.0069	3.87	0.0064	26.75
0.0088	36.27	0.0097	12.83	0.0097	4.65	0.0089	29.72
0.0122	42.15	0.0139	13.74	0.0140	4.26	0.0127	30.96
0.0206	50.00	0.0237	18.32	0.0242	5.04	0.0216	34.93
0.0315	57.84	0.0371	21.07	0.0381	5.55	0.0338	37.16
0.0435	63.72	0.0503	32.98	0.0533	6.84	0.0473	39.38
0.0600	69.60	0.0694	39.39	0.0741	8.91	0.0645	46.07
0.0750	75.47	0.0750	48.36	0.0750	10.15	0.0750	48.63
0.1500	86.31	0.1500	63.82	0.1500	15.21	0.1500	56.85
0.3000	92.41	0.3000	76.16	0.3000	25.65	0.3000	64.47
0.4250	93.60	0.4250	78.74	0.4250	29.15	0.4250	67.45
0.6000	94.78	0.6000	80.40	0.6000	31.41	0.6000	69.25
2.0000	99.11	2.0000	91.26	2.0000	42.23	2.0000	74.47
4.7500	99.79	4.7500	98.42	4.7500	56.83	4.7500	93.34
9.5250	100.00	9.5250	100.00	9.5250	78.66	9.5250	100.00
				19.0500	92.14		
				25.4000	100.00		



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
○	GTB5-1B	10.5-11			brown clayey Silt w/sand (ML)
□	GTB5-1C	14.5-15			brown clayey Silt w/sand (ML)
△	GTB5-2A	6.5-7.0			olive brown sandy clayey Silt, mottled gray (ML)
◇	GTB5-4A	6.5-7.0			olive brown clayey sandy Silt (ML)

Remark :

Project No.096-021	PRC 044-0236IRPSRP
Cooper Testing Labs Mountain View CA	GRAIN SIZE DISTRIBUTION Figure No.

Cooper Testing Laboratories

Project No.096-021

PRC 044-0236IRPSRP

Figure No.

BORING	DEPTH	% COBBLES	% GRAVEL	% SAND	% FINE	% SILT	% CLAY	Cu	Cc
GTB5-1B	10.5-11	0.00	1.03	22.28		51.40	25.29		
GTB5-1C	14.5-15	0.00	0.00	22.63		55.04	22.33		
GTB5-2A	6.5-7.0	0.00	0.00	27.71		43.34	28.95		
GTB5-4A	6.5-7.0	0.00	0.54	29.39		44.62	25.45		

GTB5-1B 10.5-11		GTB5-1C 14.5-15		GTB5-2A 6.5-7.0		GTB5-4A 6.5-7.0	
Grain Size (mm)	% Finer	Grain Size (mm)	% Finer	Grain Size (mm)	% Finer	Grain Size (mm)	% Finer
0.0014	15.44	0.0014	13.50	0.0014	19.76	0.0014	17.56
0.0023	19.42	0.0023	17.32	0.0022	23.63	0.0023	20.74
0.0032	21.57	0.0032	19.50	0.0032	24.48	0.0032	23.59
0.0046	23.90	0.0046	21.50	0.0045	28.03	0.0045	25.09
0.0063	29.54	0.0064	25.00	0.0063	31.41	0.0065	26.60
0.0090	33.86	0.0090	29.50	0.0089	35.97	0.0090	31.62
0.0125	39.83	0.0126	36.00	0.0123	41.04	0.0126	36.13
0.0209	48.79	0.0211	45.99	0.0211	46.61	0.0216	40.15
0.0322	55.77	0.0326	52.99	0.0326	53.70	0.0332	48.18
0.0445	61.74	0.0448	59.99	0.0450	59.78	0.0457	55.20
0.0611	68.71	0.0619	65.99	0.0619	66.87	0.0629	62.23
0.0750	76.69	0.0750	77.37	0.0750	72.29	0.0750	70.07
0.1500	87.17	0.1500	89.91	0.1500	83.16	0.1500	82.86
0.3000	89.99	0.3000	94.77	0.3000	90.75	0.3000	90.37
0.4250	90.80	0.4250	95.17	0.4250	92.39	0.4250	92.41
0.6000	91.60	0.6000	95.37	0.6000	93.62	0.6000	93.62
2.0000	97.24	2.0000	98.81	2.0000	98.95	2.0000	98.50
4.7500	98.97	2.3800	100.00	2.3800	100.00	4.7500	99.46
9.5250	100.00					9.5250	100.00

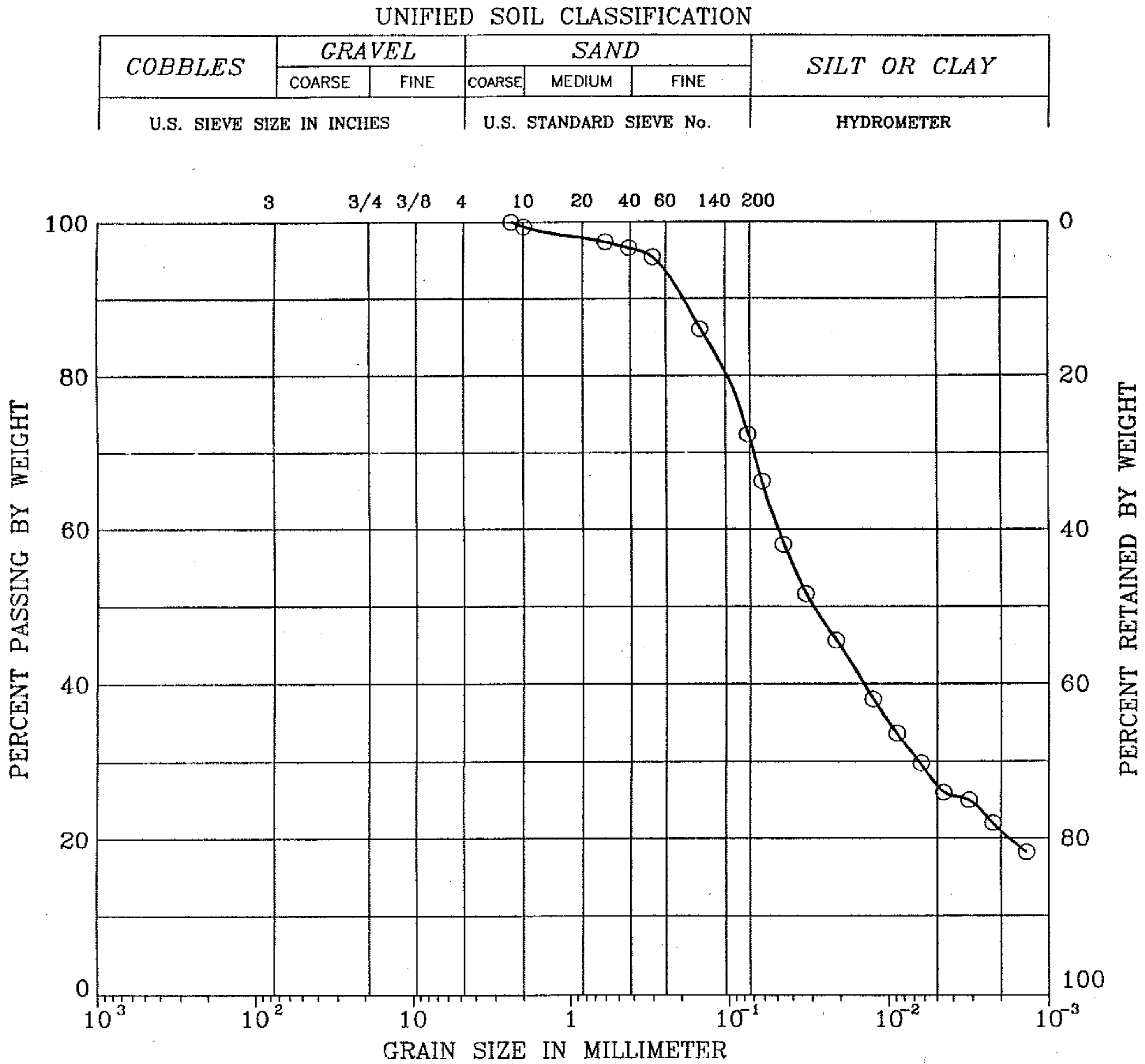
COOPER TESTING LABS

MOISTURE DENSITY - POROSITY DATA SHEET

Job #	096-021
Client	PRC
Project/Location	044-0236IRPSRP
Date	12/28/94

Boring #	GTB5-2A	GTB5-4A	GTB5-6A		
Depth (ft)	6.5-7.0	6.5-7.0	6.5-7.0		
Soil Type	olive brown sandy Clay	olive brown silty Clay	brown Clay		
Specific Gravity	2.73	2.73	2.73		
Volume Total cc	280.869	230.285	230.469		
Volume of Solids	166.665	139.135	143.493		
Volume of Voids	114.204	91.150	86.976		
Void Ratio	0.685	0.655	0.606		
Porosity %	40.7%	39.6%	37.7%		
Saturation %	100.0%	100.0%	100.0%		
Moisture %	25.1%	24.0%	22.2%		
Dry Density (pcf)	101.1	103.0	106.1		

Remarks



SYMBOL	BORING	DEPTH (ft)	LL (%)	PI (%)	DESCRIPTION
O	GTB5-6A	6.5-7.0			brown clayey Sandy Silt (ML)

Remark :

Project No.096-021	PRC 044-0236IRPSRP
Cooper Testing Labs Mountain View CA	GRAIN SIZE DISTRIBUTION Figure No.

Cooper Testing Laboratories

Project No.096-021

PRC 044-0236IRPSRP

Figure No.

BORING	DEPTH	% COBBLES	% GRAVEL	% SAND	% FINE	% SILT	% CLAY	Cu	Cc
GTB5-6A	6.5-7.0	0.00	0.00	27.56		45.44	26.99		

GTB5-6A
6.5-7.0

Grain Size (mm)	% Finer	Grain Size (mm)	% Finer	Grain Size (mm)	% Finer	Grain Size (mm)	% Finer
0.0014	18.19						
0.0023	22.04						
0.0032	25.04						
0.0045	26.04						
0.0063	29.71						
0.0089	33.55						
0.0126	38.06						
0.0212	45.57						
0.0328	51.58						
0.0452	58.09						
0.0619	66.11						
0.0750	72.44						
0.1500	86.01						
0.3000	95.34						
0.4250	96.55						
0.6000	97.36						
2.0000	99.39						
2.3800	100.00						

Specific Gravity
ASTM D-854

Cooper Testing Lab

Job#: 096-021 Date: 12/29/94
Client: PRC By: DC
Project: 044-0236IRPSRP

Boring: Sample: Depth:	GTB5-2A 6.5-7.0	GTB5-4A 6.5-7.0	GTB5-6A 6.5-7.0			
Soil Classification:	olive brown sandy Clay	olive brown silty Clay	brown Clay			
Wt. of Pycnometer Soil & Water, gm:	707.65	717	709.12			
Temp. centigrade:	20	20	20			
Wt. of Pycnometer & Water, gm:	671.96	677.6	675.71			
Wt. Dry Soil, gm:	56.32	62.2	52.7			
Temp. Correction Factor:	1	1	1			
Specific Gravity:	2.73	2.73	2.73	ERR	ERR	ERR

Remarks:

APPENDIX E

GROUNDWATER ANALYTICAL RESULTS

135204

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

BW5-1B ~~BW51B~~

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF013

Matrix: (soil/water) WATER Lab Sample ID: 267344

Sample wt/vol: 945.0 (g/mL) ML Lab File ID: 01SE951415-I181

% Moisture: ______ decanted: (Y/N)___ Date Received: 08/15/95

Extraction: (SepF/Cont/Sonc) SEPF Date Extracted:08/17/95

Concentrated Extract Volume: 1(mL) Date Analyzed: 09/01/95

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ___ Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/L	Q
39-40-0	Diesel Fuel	0.10	U
39-40-2	Motor Oil	0.10	U
21274-30-0	JP-5	0.10	U
8008-20-6	Kerosene	0.10	U

15
REV 10/11/95 GB5

FORM I
TPH ORGANICS ANALYSIS DATA SHEET 135209

CLIENT SAMPLE NO.

~~BW52B~~ BW5-2B

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF013

Matrix: (soil/water) WATER Lab Sample ID: 267345

Sample wt/vol: 971.0 (g/mL) ML Lab File ID: 01SE951415-I191

% Moisture: ______ decanted: (Y/N)___ Date Received: 08/15/95

Extraction: (SepF/Cont/Sonc) SEPF Date Extracted: 08/17/95

Concentrated Extract Volume: 1(mL) Date Analyzed: 09/02/95

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ___ Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/L	Q
39-40-0	Diesel Fuel	0.10	U
39-40-2	Motor Oil	0.10	U
21274-30-0	JP-5	0.10	U
8008-20-6	Kerosene	0.10	U

21
REV
10/11/95
GBS

FORM 1
TPH ORGANICS ANALYSIS DATA SHEET

135214 CLIENT SAMPLE NO.

~~BW53B~~ BW5-3B

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF013

Matrix: (soil/water) WATER Lab Sample ID: 267346

Sample wt/vol: 935.0 (g/mL) ML Lab File ID: 01SE951415-I201

% Moisture: ______ decanted: (Y/N)___ Date Received: 08/15/95

Extraction: (SepF/Cont/Sonc) SEPF Date Extracted:08/17/95

Concentrated Extract Volume: 1(mL) Date Analyzed: 09/02/95

Injection Volume: 1.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ___ Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/L	Q
39-40-0	Diesel Fuel	0.11	U
39-40-2	Motor Oil	0.11	U
21274-30-0	JP-5	0.11	U
8008-20-6	Kerosene	0.11	U

FORM I TPH

26
REV
10/11/95
G35

FORM 1 135219

TPH ORGANICS ANALYSIS DATA SHEET

CLIENT SAMPLE NO.

~~BW54B~~ BW5-4B

Lab Name: AQUATEC, INC. Contract: 93228

Lab Code: AQUAI Case No.: 044 SAS No.: SDG No.: MF013

Matrix: (soil/water) WATER Lab Sample ID: 267347

Sample wt/vol: 1005 (g/mL) ML Lab File ID: 01SE951415-I211

% Moisture: ______ decanted: (Y/N)___ Date Received: 08/15/95

Extraction: (SepF/Cont/Sonc) SEPF Date Extracted: 08/17/95

Concentrated Extract Volume: 1 (mL) Date Analyzed: 09/02/95

Injection Volume: 1.0 (uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ___ Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) MG/L	Q
39-40-0	Diesel Fuel	0.10	U
39-40-2	Motor Oil	0.10	U
21274-30-0	JP-5	0.10	U
8008-20-6	Kerosene	0.10	U

31 REV 10/11/95 GDS

Inchcape Testing Services
Aquatec Laboratories

Laboratory Locations
55 South Park Drive
Colchester, VT 05446

75 Green Mountain Drive
South Burlington, VT 05403

150 Herman Melville Boulevard
New Bedford, MA 02740

Analytical Report

Inchcape Testing Services
1961 Concourse Drive
Suite #E
San Jose, CA 95131

Attention : Su Patel

Date : 09/14/95
ETR Number : 53077
Project No.: 93228
No. Samples: 8
Arrived : 08/15/95
P.O. Number: 95033

Page 1

Case:044 SDG:MF013 WO:9508317

Standard analyses were performed in accordance with Methods for Analysis of Water and Wastes, EPA-600/4/79-020, Test Methods for Evaluating Solid Waste, SW-846, or Standard Methods for the Examination of Water and Wastewater. All results are in mg/l unless otherwise noted.

Lab No./ Method No.	Sample Description/ Parameter		Result
267344	BW51B:08/15/95 (Water)		
	351.3	Total Kjeldahl Nitrogen mg/L	0.41
	SBIL-AQ (BW5-1B)	Hydrocarbon Plate Count CFU/ml	1680
267345	BW52B:08/15/95 (Water)		
	351.3	Total Kjeldahl Nitrogen	0.41
	SBIL-AQ (BW5-2B)	Hydrocarbon Plate Count	20
267346	BW53B:08/15/95 (Water)		
	351.3	Total Kjeldahl Nitrogen	0.41
	SBIL-AQ (BW5-3B)	Hydrocarbon Plate Count	10
267347	BW54B:08/15/95 (Water)		
	351.3	Total Kjeldahl Nitrogen	0.40
	SBIL-AQ (BW5-4B)	Hydrocarbon Plate Count	510
267348	LCS:(Liquid)		
	351.3	Total Kjeldahl Nitrogen	7.17

Comments/Notes

Hydrocarbon plate counts are reported in CFU/ml.

< Last Page > Submitted By : Aquatec Inc.

INCHCAPE TESTING SERVICES
ANAMETRIX LABORATORIES
(408) 432-8192
DATA REPORT

Analyte-Method: Nitrate as N-300.0
Client Project Number: 235
Matrix - Units: WATER - mg/L

Analyst: [signature]
Supervisor: [initials]

Anametrix Sample ID	Client Sample ID	Prep. Method	Instr. ID	Date Sampled	Date Prepared	Date Analyzed	D.F.	Reporting Limit	Results	Q
9508137-01	BW51B	300.0	IC1	08/14/95	08/16/95	08/16/95	1	0.020	4.3	
?08137-02	BW52B	300.0	IC1	08/14/95	08/16/95	08/16/95	1	0.020	4.0	
?08137-03	BW53B	300.0	IC1	08/14/95	08/17/95	08/17/95	1	0.020	4.9	
9508137-04	BW54B	300.0	IC1	08/14/95	08/17/95	08/17/95	1	0.020	3.0	
3165WA	MF013P1	300.0	IC1	N/A	08/16/95	08/16/95	1	0.020	ND	
3175WA	MF013P2	300.0	IC1	N/A	08/17/95	08/17/95	1	0.020	ND	

OMMENTS:

000003

INCHCAPE TESTING SERVICES
ANAMETRIX LABORATORIES
(408) 432-8192
DATA REPORT

Analyte-Method: **Phosphate as P-300.0**
Client Project Number: **235**
Matrix - Units: **WATER - mg/L**

Analyst:
Supervisor:

Anametrix Sample ID	Client Sample ID	Prep. Method	Instr. ID	Date Sampled	Date Prepared	Date Analyzed	D.F.	Reporting Limit	Results	Q
508137-01	BW51B	300.0	IC1	08/14/95	08/16/95	08/16/95	1	0.050	ND	
9508137-02	BW52B	300.0	IC1	08/14/95	08/16/95	08/16/95	5	0.25	ND	I
08137-03	BW53B	300.0	IC1	08/14/95	08/17/95	08/17/95	1	0.050	ND	
08137-04	BW54B	300.0	IC1	08/14/95	08/17/95	08/17/95	1	0.050	ND	
BG165WA	MF013P1	300.0	IC1	N/A	08/16/95	08/16/95	1	0.050	ND	
3175WA	MF013P2	300.0	IC1	N/A	08/17/95	08/17/95	1	0.050	ND	

COMMENTS: