COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN II)
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Contract Task Order 226

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)

REMAINING UST SITES INVESTIGATION FIELD WORK PLAN DRAFT

February 15, 1999

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CLEAN Contract Number N62474-94-D-7609
Contract Task Order 226

Subject: **Draft Remaining Underground Storage Tanks Investigation Field Work Plan, Moffett Federal Airfield**

Dear Messrs. Chao and Chan:

Enclosed are three copies of the above-referenced document. Tetra Tech EM Inc. (TtEMI) prepared this field work plan to present the methodology that will be used to investigate the remaining Navy underground storage tank (UST) sites at Moffett Federal Airfield (MFA).

The remaining UST sites will be investigated in two phases. The first phase will include soil sampling and the collection of groundwater samples using direct-push technology. The second phase will include the installation and sampling of monitoring wells. The results of this investigation will be presented in appendices to the Final Basewide Petroleum Site Evaluation Methodology Technical Memorandum dated October 2, 1998.

If you have any questions, please call Tisha Conoly at (303) 312-8855 or Timothy Mower at (303) 312-8874.

Sincerely,

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TC/jed

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Remaining Underground Storage Tanks Investigation Field Work Plan
Draft
Moffett Federal Airfield

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ACRONYMS AND ABBREVIATIONS

AST	Aboveground storage tank
ASTM	American Society for Testing and Materials
bgs	Below ground surface
BRAC	Base Realignment and Closure
BTEX	Benzene, toluene, ethylbenzene, and xylene
Cal/EPA	California Environmental Protection Agency
CANG	California Air National Guard
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-term Environmental Action Navy
CLP	Contract laboratory program
COC	Chemical of concern
CPT	Cone penetrometer test
CTO	Contract Task Order
DO	Dissolved oxygen
DoD	U.S. Department of Defense
DQO	Data Quality Objective
DTSC	Department of Toxic Substances Control
ECC	Environmental Chemical Corporation
Eh	Oxidation reduction potential
EPA	U.S. Environmental Protection Agency
FFA	Federal facilities agreement
ft/ft	Feet per foot
FWP	Field work plan
HSA	Hollow-stem auger
HTA	Heavier than air
IAS	Initial assessment study
ID	Identification
IDW	Investigation derived waste
IRP	Installation restoration program
LTA	Lighter-than-air
LLNL	Lawrence Livermore National Laboratories
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter
MCL	Maximum contaminant level
MFA	Moffett Federal Airfield
mg/kg	Milligrams per kilogram
mL	Milliliter
MS/MSD	Matrix spike/matrix spike duplicate
msl	Mean sea level
MTBE	Methyl tertiary butyl ether
NAS	Naval Air Station
NASA	National Aeronautics and Space Administration
ND	Non-detect
NEX	Naval Exchange

ACRONYMS AND ABBREVIATIONS (Continued)

NPL	National Priorities List
PAH	Polynuclear aromatic hydrocarbon
PID	Photoionization detector
ppb	Parts per billion
ppm	Parts per million
PRC	PRC Environmental Management, Inc.
PVC	Polyvinyl chloride
QA	Quality assurance
QAPP	Quality assurance project plan
QA/QC	Quality assurance/quality control
QC	Quality control
RBCA	Risk-based Corrective Action
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative percent difference
RWQCB	Regional Water Quality Control Board, San Francisco Bay Region
SOP	Standard operating procedure
SOW	Statement of work
SWRCB	State Water Resources Control Board
TM	Technical memorandum
TPH	Total petroleum hydrocarbons
TPH-d	TPH characterized as diesel
TPH-e	TPH extractable
TPH-g	TPH characterized as gasoline
TPH-p	TPH purgeable
TtEMI	Tetra Tech EM Inc.
UST	Underground storage tank
VOA	Volatile organic analysis
VOC	Volatile organic compound
WATS	West-side aquifers treatment system

1.0 INTRODUCTION

Tetra Tech EM Inc. (TtEMI) will conduct sampling activities at 12 petroleum sites at Moffett Federal Airfield (MFA) in Santa Clara County, California. This field work plan (FWP) describes the background of the petroleum sites investigation, the purpose of this additional investigation, field activities, field methods and procedures, analytical methods, and intended data uses.

The FWP is organized as follows: Section 2.0 discusses the purpose and objectives of petroleum site sampling; Section 3.0 presents the installation history, petroleum investigation background, and site geology. The investigative approach is presented in Section 4.0, and the history of and proposed field activities at the areas to be investigated are discussed in Section 5.0. The general methodology for the field activities and data evaluation is discussed in Section 6.0. Section 7.0 presents the quality assurance (QA) objectives and the quality control (QC) procedures. A schedule is presented in Section 8.0, and references are provided in Section 9.0. Tables and figures are included following the text.

2.0 PURPOSE AND OBJECTIVES

The purpose of the remaining underground storage tank (UST) sites investigation is to sample and assess 12 petroleum sites at MFA to evaluate whether petroleum constituents have been released to soil or groundwater. The 12 petroleum sites will be evaluated according to the methodology presented in the Final Basewide Petroleum Site Evaluation Methodology Technical Memorandum (TM) dated October 2, 1998 (TtEMI 1998). The objectives of the investigation are to collect the data required to compare soil and groundwater data to screening levels described in the TM and, if applicable, conduct a Tier 1 risk-based corrective action (RBCA) screening of each petroleum site. The results of the investigation and, if required, Tier 1 RBCA screening will be used to evaluate whether additional investigation or remediation activities are required on a site-specific basis.

3.0 BACKGROUND

MFA is located in California, 35 miles south of San Francisco, 10 miles north of San Jose, and about 1 mile south of San Francisco Bay. The facility encompasses approximately 2,200 acres in Santa Clara County. Directly adjacent to MFA are saltwater evaporation ponds, stormwater retention ponds, and wetlands to the north, Stevens Creek to the west, U.S. Highway 101 (Bayshore Freeway) to the south, and the Lockheed Martin facility to the east.

TtEMI is providing technical support to the U.S. Navy for investigations at MFA under contract task order (CTO) 226. CTO 226 is part of the second Comprehensive Long-term Environmental Action Navy (CLEAN II) contract for the environmental restoration of Navy facilities. The project began under Task 9 of CTO 079 and included evaluation of petroleum-contaminated soil and groundwater at several Installation Restoration Program (IRP) petroleum tank and sump sites at MFA. Task 4 of CTO 226 includes completing the evaluation of the IRP sites and additional petroleum sites at MFA.

The remainder of this section presents MFA history, petroleum sites background, and the basewide geology and hydrogeology.

3.1 INSTALLATION HISTORY

MFA was commissioned in 1933 to support the West Coast dirigibles of the lighter-than-air (LTA) program. In 1935, the station was transferred to the U.S. Army Corps, which used it for training purposes. In 1939, a permit was granted to Ames Aeronautical Laboratory to use part of the station. In 1942, the station was returned to Navy control as the heavier-than-air (HTA) program was initiated and began to take precedence over the LTA program. In April 1942, the base was renamed Naval Air Station (NAS) Moffett Field.

In 1945, the HTA program was moved to Half Moon Bay Field and NAS Moffett Field (MFA) was used as a major overhaul and repair shop. 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 craft. 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.

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 (CANG). 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 1992, MFA was designated for closure as an active military base under the U.S. Department of Defense (DoD) Base Realignment and Closure (BRAC) program. The National Aeronautics and Space Administration (NASA), which operates the Ames Research Center on the northern side of the station, assumed control of the facility in July 1994. At that time, the station was renamed Moffett Federal Airfield. The Navy plans to continue environmental restoration activities and remains responsible for remediating contamination caused by Navy operations in accordance with the memorandum of understanding between the Navy and NASA (Navy and NASA 1992).

The U.S. Environmental Protection Agency (EPA) proposed MFA as a National Priorities List (NPL) site in June 1986 and placed it on the NPL in July 1987. Placement on the NPL initiated the remedial investigation and feasibility study (RI/FS) process under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Environmental investigation and restoration activities at MFA are coordinated under a federal facilities agreement (FFA) signed by EPA and the California Environmental Protection Agency (Cal/EPA), including the Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board, San Francisco Bay Region (RWQCB).

The Navy, as part of the Installation Restoration Program, has been identifying, evaluating, and controlling the spread of contaminants from former hazardous waste sites. The Navy began its environmental investigation of MFA in 1984 with an initial assessment study (IAS) to gather data on the past use and disposal of hazardous materials (NEESA 1984). Nineteen sites have been identified as potential sources of waste, including nine sites identified in the IAS and 10 sites added during subsequent investigations (ERM and AR 1986a, 1986b; ESA and JMM 1986; ERM 1987). Data collected during these studies were used to plan the RI/FS for MFA. Five additional sites were added during the RI/FS, bringing the total number of sites to 24 (PRC 1996a). Under Task 9 of CTO 079, six IRP sites and the Naval Exchange (NEX) service station were evaluated. The IRP sites included Sites 5, 9, 12, 14-South, 15, and 19.

3.2 PETROLEUM SITES BACKGROUND

This section discusses the background, regulatory framework, and evaluation approach for petroleum sites at MFA.

3.2.1 Regulatory Framework

In 1995, Cal/EPA, including DTSC and RWQCB, and the Navy negotiated cleanup levels (screening levels) for petroleum contamination in groundwater and soil at MFA. The screening levels were set for total petroleum hydrocarbons (TPH) and individual petroleum constituents for which the State of California had established risk values (Cal/EPA 1994).

Constituent	Soil	Groundwater
TPH-purgeable (TPH-p)	150 milligrams per kilogram (mg/kg)	50 micrograms per liter (μg/L)
TPH-extractable (TPH-e)	400 mg/kg	700 μg/L
Benzene	4.4 mg/kg	1 μg/L
Toluene	2,700 mg/kg	680 μg/L
Ethylbenzene	3,100 mg/kg	1,000 μg/L
Xylene	980 mg/kg	1,750 μg/L

The State of California petroleum corrective action philosophy and approach changed significantly in 1995, when the California State Water Resources Control Board (SWRCB) revised its policy for petroleum sites. The revisions were based in part on recommendations by a petroleum site cleanup evaluation panel led by the Lawrence Livermore National Laboratories (LLNL). In a study funded in part by EPA, the LLNL panel reviewed records of petroleum sites and corrective actions in California. The panel made the following recommendations (Rice and others 1995):

- Petroleum contamination sites should be evaluated for constituent-specific risks using a tiered assessment approach to evaluate exposure risks.
- Regulatory agencies should grant no further action notices to sites that do not pose an unacceptable risk to on-site or off-site receptors. Sites with groundwater contamination should be granted no further action status if the site poses no risk under current or future land uses.
- Natural attenuation should be the selected remedial alternative at sites where petroleum contamination poses no current human health or environmental risk, contaminants pose no nuisance, and data indicate that the groundwater plume is not migrating farther.

In a December 1995 memorandum, SWRCB (1995) accepted the LLNL recommendations and recommended that RWQCB close low-risk soil cases. It recommended that long-term groundwater monitoring replace active remediation in low-risk groundwater cases, and that closure be considered at groundwater-contamination sites that neither currently pose unacceptable risks nor are likely to pose an unacceptable risk before contaminants degrade to concentrations below corrective action levels (SWRCB 1995). Finally, SWRCB recommended that the RBCA assessment method (ASTM 1995) be used to evaluate risks to human health.

In January 1996, RWQCB presented supplemental instructions to the SWRCB interim guidance (RWQCB 1996). The instructions recommended that soil-only cases be closed if they do not present an unacceptable risk, and that "low-risk groundwater impact cases [be managed] utilizing natural bioremediation as the preferred remedial alternative." The recommendations were labeled interim guidance and were subject to change pending State of California legislation (California State Bill 1764) and revisions to SWRCB Resolution 92-49.

On October 29, 1996, SWRCB issued a draft policy for cleanup of petroleum discharges (Resolution 1021b; SWRCB 1996). The resolution outlined general and specific provisions for site evaluation and corrective action. Specific provisions were broken down into the following four divisions: Source Removal, Initial Site Assessment, Low Risk Criteria, and Additional Site Assessment and Corrective Action. The low-risk criteria were further broken down into the following three categories: Low Risk Inhalation Exposure Sites, Low Risk Soil Only Sites, and Low Risk Groundwater Sites.

The Navy met with RWQCB representatives in March 1996 to discuss implementation of RBCA procedures at MFA petroleum sites. RWQCB indicated it prefers that all petroleum sites at MFA be evaluated in one document. TtEMI, as the Navy technical representative, recommended submittal of (1) a basewide document that describes the evaluation process and presents basewide information, and (2) site-specific reports as appendices that provide site-specific data and risk assessment summaries.

3.2.2 Evaluation Approach

TtEMI prepared the TM to present basewide information and describe the petroleum site evaluation process (TtEMI 1998). As outlined in the TM, each petroleum site will be evaluated according to the criteria outlined in the RWQCB (1996) interim guidance letter and SWRCB Resolution 1021b. In the RWQCB guidance, six criteria were identified for soil contamination and six for groundwater contamination to define low-risk sites. TtEMI will use these criteria to evaluate each petroleum site, whether the site is deemed low risk or not. The definitions for low-risk soil and groundwater contamination are:

(1) The leak has stopped and ongoing sources, including free product, have been removed or remediated.

(2) The site has been adequately characterized.

(3) (a) Low-risk soil contamination: Little or no groundwater impact currently exists and no contaminants are found at levels above established maximum contaminant levels (MCLs) or other applicable water quality objectives.

(b) Low-risk groundwater contamination: The dissolved hydrocarbon plume is not migrating.

(4) No water wells, deeper drinking water aquifers, surface water, or other sensitive receptors are likely to be affected.

(5) The site presents no significant risk to human health.

(6) The site presents no significant risk to the environment.

The SWRCB policy defines certain action levels for low-risk soil sites: actions must be taken to correct petroleum-saturated soils and detectable petroleum in soil within 20 feet of waters of the state. For low-risk groundwater sites, actions must be taken to correct the following conditions:

- Methyl tertiary butyl ether (MTBE) concentrations greater than 35 parts per billion (ppb).
- Benzene concentrations greater than 1 ppb, or
- Benzene concentrations greater than 1 part per million (ppm) where there is no drinking water well or surface water body within 750 feet of the source of the discharge.

These evaluation criteria drive the objective and methodology of this FWP.

3.2.3 Selection of Additional Petroleum Sites for Investigation

In the original scope of work for this project, the Navy planned to investigate 14 additional petroleum sites, although only 12 were ultimately selected. In order to select petroleum site areas for investigation, TtEMI developed a prioritization system. From a comprehensive list of all known tanks, sumps, and oil/water separators at MFA (totaling 155), tank sites were eliminated for a number of reasons. Sixty have been investigated and are undergoing evaluation according to methods specified in the TM; 32 are aboveground storage tanks (ASTs) and will be evaluated under a separate AST program; 10 do not contain petroleum waste; five do not exist as a result of numbering errors; nine are not owned by the Navy; two are still active; and 12 have been closed under other programs. Therefore, from the original 155 tank sites, 130 were eliminated from the evaluation process.

TtEMI reviewed existing information on the remaining 25 tank sites. According to reports provided by the Navy, each tank area was evaluated and prioritized based on the quantity and quality of information about the tank area. Nine of the tank sites may not require additional investigation and may be evaluated with existing information, at the discretion of the Navy. Four pairs of tanks were grouped together because they are located in close proximity to one another. With the paired tanks, 12 petroleum tank areas remain from the initial list of 155 tanks. All 12 tank areas will be investigated and evaluated in this FWP (Figure 1).

3.3 GEOLOGY AND HYDROGEOLOGY

The following two sections describe the geology and hydrogeology at MFA. Geologic and hydrogeologic information was obtained from the Geology and Hydrogeology Technical Memorandum for NAS Moffett Field (PRC and JMM 1992), unless otherwise cited.

3.3.1 Geology

MFA is located at the northern end of the Santa Clara Valley Basin, approximately 1 mile south of San Francisco Bay. The land is relatively flat, ranging from 2 feet below to 36 feet above mean sea level (msl). The Santa Clara Valley Basin is a large, northwest-trending structural depression between the San Andreas and Hayward faults. The valley is bordered on the west by the Santa Cruz Mountains and on the east by the Diablo Range (PRC and JMM 1992).

Regionally, the Santa Clara Valley contains as much as 1,500 feet of interbedded alluvial, fluvial, and estuarine deposits (Iwamura 1980). Locally, these sediments consist of varying combinations of clay, [illegible] and, and gravel that represent the interfingering of estuarine and alluvial depositional environments during the late Pleistocene and Holocene epochs. Alluvial fan deposits extend north to the northern edge of MFA, where they interfinger with estuarine deposits. These alluvial deposits consist of anastomosing (branching) stream channels (primarily gravel and sand) and floodplain (silt and clay with fine-grained sandy intervals) deposits. Estuarine deposits (organic-rich silt and clay) are found at the northern end of MFA. These sediments most likely were deposited during the Holocene period when the world-wide sea level was rising toward its present elevation.

A continuous clay layer (A/B aquitard) between 45 and 65 feet bgs has been observed in borings across MFA. This clay layer does not correspond to a world-wide rise in sea level. Instead, its deposition appears to be of late Pleistocene age. An even deeper (100 to 600 feet bgs) clay layer (B/C aquitard) corresponds to Sangamon-age interglacial deposits (PRC and JMM 1992; Sangines and others 1995). Beneath this aquitard are undifferentiated alluvial gravels, sands, silts, and clays that make up the mid- to early-Pleistocene-age deposits and the Pliocene/Pleistocene-age Santa Clara Formation.

3.3.2 Hydrogeology

Aquifer descriptions are based on existing data and lithologic interpretation of soil borings and cone penetrometer tests (CPTs). The shallow aquifer (upper 250 feet) is subdivided into the A, B, and C aquifers. A laterally extensive clay aquitard (B/C aquitard) effectively isolates the C aquifer (160 to

250 feet below ground surface [bgs]) from the upper aquifers. The A/B aquitard may be locally continuous under MFA because the B aquifer (70 to 120 feet bgs) appears to be free of solvent contamination.

The UST investigations will focus on the A aquifer because it is the most likely to be affected by petroleum contamination from surface spills or leaking USTs. In addition, groundwater at most locations across MFA exhibits an upward vertical gradient. This vertical gradient is evidenced by higher piezometric heads in deeper wells at locations where shallow (A aquifer) and deeper (B aquifer) wells are paired. Wells screened in the C aquifer have begun to flow under artesian pressure at MFA.

The A aquifer consists of stringer-like alluvial-channel deposits composed of sand and gravel incised in, and interbedded with, fine-grained flood-plain deposits. These channel deposits provide complex and tortuous pathways for contaminant transport. Channel orientation is generally south to north. The A aquifer extends from a depth of 5 to 65 feet bgs at the western side of MFA, and is divided into the A1- and A2-aquifer zones by a discontinuous, low-permeability horizon (A1/A2 aquitard) located between 25 and 30 feet bgs.

The sediments that comprise the A aquifer represent the distal end of a Holocene-aged coalescing alluvial-fan complex. Alluvial fans extend north from the Santa Cruz Mountains in the southern part of Santa Clara County to the San Francisco Bay. Near the bay, the gradient of the fans has decreased and the majority of the alluvial sediment is fine-grained material. At MFA, most of the alluvium consists of silt and clay with deposits of sand and gravel incised into the fine-grained matrix. The sand and gravel represent meandering stream channel deposits, and typically display fining-upward sequences, as observed in numerous cores drilled at MFA.

The sand and gravel appear to be confined to established stream channels. Observations of core samples collected at MFA indicate that the lower boundary of channel deposits is typically defined by sharp contact with finer-grained alluvium. This observation indicates that the channels are incised into the fine-grained alluvium. The cross-sectional width of the channel deposits ranges from several tens of feet to greater than 100 feet, and the cross-sectional geometries vary considerably.

Splay deposits of fine-grained sand (generally mixed with silt and clay) represent areas where a natural levee along the margin of a channel was breached and the released flood waters spread out onto the floodplain adjacent to the stream bed. The splay deposits most likely overlay fine-grained floodplain sediments because the depositional energy of these deposits was probably not sufficient to erode the existing alluvium. As a result, the splay deposits probably are not as vertically continuous as are the channel deposits.

Any given channel-deposit package may contain channel-deposit material (gravel and sand), splay deposit material (fine-grained sand and silt), and fine-grained alluvium (silt and clay). As previously stated, channel deposits at MFA typically display fining-upward sequences that begin with a poorly sorted mixture of gravel and coarse sand at the bottom of the sequence, overlain by a fining-upward sequence of coarse to fine sand, silt, or clay. One or more of these sequences may be partially or fully observed in any deposit package.

Groundwater flow in the A aquifer is toward the bay (north) with a horizontal gradient of 0.004 to 0.005 feet per foot (ft/ft), decreasing to the north. Hydraulic conductivity, based on aquifer pumping tests, ranges from 5.7 to 240 feet per day for the A aquifer. Measurements in well pairs completed in the A1- and A2-aquifer zones indicate minimal hydraulic head differences between the zones.

4.0 INVESTIGATION APPROACH

The objective of the remaining UST investigation is to collect data required to compare analytical results to the screening levels described in the TM and, if necessary, conduct a Tier 1 RBCA screening at the 12 selected sites. Data necessary to conduct a Tier 1 RBCA screening include maximum soil and groundwater contaminant concentrations at each site and spatial groundwater data to evaluate the presence of a groundwater plume and, if a plume exists, to evaluate its stability.

Very little is known about a majority of the USTs investigated in this field work. Because of the limited knowledge of these sites, TtEMI will conduct this investigation in two phases. The flow charts depicting the field work decision process are included as Figures 2 and 3. In the first phase, Mobilization 1, both soil and groundwater samples will be taken using direct-push technology. During this phase, groundwater samples from existing monitoring wells will also be collected. In the second phase, Mobilization 2, TtEMI will install groundwater monitoring wells based on field observations and laboratory analytical results from the first phase.

4.1 MOBILIZATION 1

The proposed field activities for each tank area have been selected based on information available for each tank area from previous investigations; however, general guidelines were used to select the direct-push and sample locations. In general, direct-push borings will be advanced in the following locations:

(1) Adjacent to the suspected source area, usually the tank location

(2) In any known release area, such as piping or joints

(3) 20 to 50 feet in the anticipated upgradient direction

(4) Approximately 50 feet from the tank location in the anticipated downgradient direction, or as close as possible to this distance where there are obstructions

Soil samples will be collected from the following direct-push boring locations:

(1) In the suspected source area, usually the tank

(2) In any known release area, such as piping or joints

(3) Where contamination is observed in the unsaturated zone

In these direct-push boring locations, the sampling methodology has been selected based on the historical tank contents. Ideally, all samples would be screened and samples collected at the area of apparent maximum contamination; however, due to the potential volatilization of gasoline constituents during screening, two methodologies have been developed.

First, for tanks that contained gasoline, no field screening will be conducted. Soil samples will be taken at the 1.5- to 2.0-feet bgs interval and every 5 feet (4.5- to 5.0-feet, 9.5- to 10-feet, etc.) to the depth of groundwater. The 1.5- to 2.0-foot interval has been selected for the occupational exposure scenario RBCA screening (TtEMI 1998).

Second, for fuel oil or diesel tank areas, one soil sample will be taken at the 1.5- to 2.0-feet bgs interval. A minimum of three soil samples total between 0 and 10 feet bgs (including the 1.5- to 2.0 feet bgs interval) will be taken for the construction worker Tier 1 RBCA screening at the following depths:

(1) Maximum apparent contamination in the unsaturated zone, based on photoionization detector (PID) readings and observations of soil samples

(2) At the capillary fringe

(3) Every 5 feet

Groundwater samples will be taken from temporary wells at all direct-push boring locations.

Soil and groundwater analyses at each tank site will also be selected based on the historical tank contents. For tanks that contained gasoline, soil and groundwater samples will be analyzed for TPH as gasoline (TPH-g) and benzene, toluene, ethylbenzene, and xylene (BTEX). If the tank contained gasoline after 1979, groundwater samples will also be analyzed for MTBE (Stout and others 1998).

Soil and groundwater samples from sites with tanks that contained fuel oil or diesel will be analyzed for TPH as diesel (TPH-d). Soil samples will be analyzed for polynuclear aromatic hydrocarbons (PAHs) if there is either visible staining or if volatile organic compounds (VOCs) are present as indicated by PID screening. Groundwater will be sampled and analyzed for PAHs during the second mobilization.

When previous investigations indicated other COCs above detection limits, samples will be analyzed for those, too. When tank contents are unknown, soil and groundwater samples will be analyzed for TPH-d, TPH-g, BTEX, and VOCs.

4.2 MOBILIZATION 2

Based on field observations and analytical results from the first phase of field work, monitoring well locations will be selected for installation during Mobilization 2. The decision process for selecting monitoring well analytes is shown in Figure 3. Whether monitoring wells will be installed is site-specific and will be evaluated by tank area.

No wells will be installed and regulatory closure will be requested for a tank area if both of the following conditions are met:

(1) Maximum identified soil concentration of chemicals of concern (COCs) are below screening levels

(2) All groundwater COCs are detected below 80 percent of screening levels, as shown in the table below.

Constituent	Soil Screening Level	Groundwater 80 Percent of Screening Level
TPH-p	150 mg/kg	40 µg/L
TPH-e	400 mg/kg	560 µg/L
Benzene	4.4 mg/kg	0.8 µg/L
Toluene	2,700 mg/kg	544 µg/L
Ethylbenzene	3,100 mg/kg	800 µg/L
Xylene	980 mg/kg	1,400 µg/L

If either of these conditions is not met, groundwater monitoring wells will be installed to assess COC concentrations over four quarters. Monitoring wells will be installed in the following locations:

(1) At the identified source

(2) Approximately 50 feet downgradient of the source (or as close as possible to this distance based on locations of buildings, utilities, or other obstructions)

(3) A second downgradient well, within the range of the local groundwater flow direction

An upgradient monitoring well will not be installed unless COCs were detected in the upgradient direct-push groundwater sample. Two wells will be located downgradient to assess plume movement and stability given the seasonal range of groundwater flow directions at each location. Groundwater monitoring wells will be sampled for four consecutive quarters and the resulting data will be assessed as described in the TM.

Soil samples will not be collected during Mobilization 2. Groundwater analyses will be the same as for Mobilization 1, with two exceptions. First, groundwater samples will be analyzed for PAHs if TPH-d was detected in the groundwater sampled during the first mobilization. Screening levels for PAHs have not been identified; therefore, PAH results are not required during Mobilization 1. However, PAHs will be used in the Tier 1 screening; therefore, samples will be analyzed for PAHs during Mobilization 2. Second, if the tank constituents are unknown, or COCs were identified during previous investigations, only analytes that were detected during Mobilization 1 will be analyzed for during Mobilization 2.

5.0 INVESTIGATION AREAS

Twelve petroleum sites were selected for investigation and assessment. These tank areas were selected based on a prioritization of petroleum-contaminated areas that have not yet been investigated. In the text below, the first subsection for each tank or tank area describes the tanks and their uses, if known. The second subsection describes tank removal and any previous soil or groundwater sampling, if the information is available. The final subsection discusses proposed field activities and the sampling rationale. Table 1 describes tank size, structure, capacity, and fuel type. The tank contents, other COCs identified, number of sample locations, sample type, and analytes are presented in Table 2. Matrices to be sampled include soil and groundwater. The procedures for the various field activities are described in Section 6.0.

The majority of tank and background information was supplied by Mr. Don Chuck of the Navy. Information was provided to TtEMI through an informal inventory of tank data, a basewide tank list, or in meetings with Mr. Chuck. All information is based on Mr. Chuck's knowledge of MFA unless another reference is cited.

5.1 TANKS 1 AND 32

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for the area around Tanks 1 and 32.

5.1.1 Site History

Tank 1 was a single-walled steel UST of approximately 3,000 gallons capacity. It was located adjacent to the Building 10 steam generating plant and was used to store diesel fuel for use in the plant boiler. The tank was installed in 1941; it was removed by the Navy in June 1991 (QEC 1991).

Tank 32 was a 5,000-gallon, steel UST used to store diesel fuel. The tank served as a standby supply of fuel for the boilers located in Building 10. Tank 32 was located approximately 6 feet south of Tank 1. The installation date is unknown; the tank was removed by the Navy in April 1994 (Chuck 1995).

5.1.2 Previous Investigations

During excavation of Tank 1, groundwater was present in the tank cavity at a depth of approximately 10 feet bgs. Visual inspection of the tank at the time of removal revealed numerous holes. Petroleum product on the sides of the tank cavity and in the groundwater was also observed. Two soil samples and one groundwater sample were taken from the excavation and analyzed for TPH-d. Soil sample results indicated 4,200 and 1,110 mg/kg for TPH-d; the groundwater sample result was non-detect (Chuck 1995).

During the removal of Tank 32, the tank and associated piping appeared to be in good condition; however, during excavation, stained soil and hydrocarbon odors were noted. Two soil samples and one groundwater sample were taken and analyzed for TPH-e. In the soil samples, TPH-e (constituents unidentified) concentrations were 740 and 900 mg/kg. No TPH constituents were found in the groundwater sample. After removal, the tank excavation was backfilled with clean material and the surface restored (Chuck 1995).

The maximum concentration of TPH-d in soil in the tank area exceeds the screening level described in the TM, as shown in the table below.

DATA FROM REMOVAL OF TANKS 1 AND 32	
Maximum Concentration	**TPH-d**
Soil (mg/kg)	4,200
Soil Screening Level (mg/kg)	*400*
Groundwater (μg/L)	Non-Detect (ND)
Groundwater Screening Level (μg/L)	*700*

5.1.3 Proposed Field Activities

During Mobilization 1 of the investigation, TtEMI will advance four direct-push borings, UST1-SB-01 through UST1-SB-04 (Figure 4). Water elevations were measured in wells W9-19, W9-37, and W9-44, located 230 to 290 feet from the former tank locations; they indicate a local groundwater flow direction of 5 to 30 degrees east of north. Direct-push boring UST1-SB-01 will be advanced adjacent to the former tank locations, UST1-SB-02 and -03 will be advanced downgradient, and UST1-SB-04 will be advanced upgradient. Soil samples will be collected from boring UST1-SB-01 at depths described in Section 4.0. Soil samples will be analyzed for TPH-d and, if there is visible staining or PID readings above background levels, PAHs. Groundwater samples will be taken from temporary direct-push wells at all four soil boring locations. A groundwater sample will also be collected from monitoring well W9-36, a well installed in the A2-aquifer zone during a previous investigation. Soil samples will be analyzed for TPH-d and possibly PAHs. Groundwater samples will be analyzed for TPH-d. Depending on the results of the first phase of field work, monitoring wells will be installed, if required, in the locations of soil borings UST1-SB-01, -02, and -03.

5.2 TANKS 3 AND 114

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for the area around Tanks 3 and 114.

5.2.1 Site History

Former Tanks 3 and 114, with capacities of 10,000 and 2,400 gallons, respectively, were located immediately south of Building 55. Tank 3 may have been installed in 1980; the Tank 114 installation date is unknown. Both tanks reportedly contained fuel oil to support the generators inside Building 55. Tanks 3 and 114 were removed by the Navy's Public Works Department in April and May 1994.

5.2.2 Previous Investigations

During excavation of Tanks 3 and 114, no holes or other contaminant pathways were discovered. Both tanks and associated piping were found to be in good condition. Groundwater was encountered at approximately 7.5 feet bgs. In the excavation pits, the groundwater was found to be free of visible contamination.

During removal of Tanks 3 and 114, four soil samples and two groundwater samples were collected within the excavation pit. The samples were analyzed for TPH-e, including diesel, jet fuel (JP-5), and motor oil, and VOCs. TPH-d was detected in one of the three soil samples from Tank 3, at 2.1 mg/kg. One soil sample collected during the removal of Tank 114 showed a TPH-d concentration of 57 mg/kg, a JP-5 concentration of 33 mg/kg, and a motor oil concentration of 39 mg/kg. In the groundwater sample collected during the removal of Tank 3, TPH-d was detected at 670,000 µg/L. The groundwater sample collected during the removal of Tank 114 showed TPH-d at 6,000 µg/L, JP-5 at 2,500 µg/L, and motor oil at 15,000 µg/L. Both groundwater samples contained TPH-d above the 700 µg/L screening level described in the TM, as shown in the table below.

DATA FROM REMOVAL OF TANKS 3 AND 114	
Maximum Concentration	**TPH-d**
Soil (mg/kg)	57
Soil Screening Level (mg/kg)	*400*
Groundwater (µg/L)	670,000
Groundwater Screening Level (µg/L)	*700*

ERM-West conducted an investigation in July 1995 to assess the lateral extent of soil contamination at the site (ERM 1995b). Thirteen direct-push boring soil and screening-level groundwater samples were collected and analyzed for TPH-d, TPH-g, BTEX, and VOCs. Direct-push boring soil samples were collected between 8 and 9 feet bgs. No hydrocarbons were detected in the direct-push soil samples. Groundwater was encountered at 7.5 feet bgs. Of the 13 groundwater samples collected, one was not submitted for analysis because product was present in the borehole. The maximum detection of TPH-d in the direct-push groundwater samples was 4,841 µg/L. Benzene was also detected in two of the direct-push groundwater samples at 1.3 and 1.8 µg/L. Toluene, ethylbenzene, and total xylenes were detected sporadically in the direct-push groundwater samples, but these results were considerably less than screening levels. No TPH-g was detected in any of the direct-push groundwater samples (ERM 1995b). The TPH-d and benzene groundwater sample results exceeded the screening levels outlined in the TM, as shown in the table below.

DATA FROM DIRECT-PUSH INVESTIGATION OF TANKS 3 AND 114						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	ND	ND	ND	ND	ND	ND
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*
Groundwater (µg/L)	4,841	ND	1.8	2.5	1.8	10.8
Groundwater Screening Level (µg/L)	*700*	*50*	*1*	*680*	*1,000*	*1,750*

Based on evaluation of direct-push groundwater sampling results, ERM-West installed four monitoring wells in August 1995 to assess the potential migration of the hydrocarbon-contaminated groundwater (ERM 1995b) (Figure 5). Soil samples were collected in monitoring well boreholes 3/114-MW2, 3/114-MW3, and 3/114-MW4 at approximately 6 feet bgs and analyzed for TPH-d, TPH-g, and BTEX. Only one detection, an unidentified hydrocarbon compound, was found in the soil samples collected from the monitoring well boreholes. In the groundwater samples collected from the monitoring wells, one detection of an unidentifiable compound within the TPH-d range (55 µg/L) and one detection of toluene (0.52 µg/L) were found (ERM 1995b), as shown in the table below.

DATA FROM GROUNDWATER INVESTIGATION OF TANKS 3 AND 114						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	ND	ND	ND	ND	ND	ND
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*
Groundwater (µg/L)	55	ND	ND	0.52	ND	ND
Groundwater Screening Level (µg/L)	*700*	*50*	*1*	*680*	*1,000*	*1,750*

5.2.3 Proposed Field Activities

During Mobilization 1 of the investigation, TtEMI will advance two direct-push borings, UST3-SB-01 and UST3-SB-02 (Figure 5). Water elevations measured in wells W7-3, W7-1, and W7-18, located 530 to 700 feet from the tank locations, indicate a local groundwater flow direction 18 to 33 degrees west of north. Direct-push boring UST3-SB-01 will be advanced between the former tank locations, and UST3-SB-02 will be advanced downgradient. One existing upgradient ERM-West monitoring well, 3/114 MW3, will be sampled. Water levels in the four ERM-West monitoring wells will be measured to verify the local groundwater flow direction. Soil samples will be collected from UST3-SB-01 at depths described in Section 4.0. Based on previous investigation results, soil samples will be analyzed for TPH-d and BTEX. Field screening will not be conducted because samples will be collected for BTEX analyses; therefore, samples will also be analyzed for PAHs. Groundwater samples will be taken from temporary direct-push wells at both soil boring locations. Groundwater samples will be analyzed for TPH-d and BTEX. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST3-SB-01 and -02. In this case, ERM-West well 3/114-MW1 will be sampled on the same schedule as the two new wells.

5.3 TANK 21

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for Tank 21.

5.3.1 Site History

Tank 21 was a steel 1,000-gallon UST used to store diesel fuel for the emergency backup generator located in Building 454. The Tank 21 installation date is unknown; the tank was removed by Environmental Chemical Corporation (ECC) in November 1995 (CWM 1994).

5.3.2 Previous Investigations

Tank 21 showed no apparent holes when it was removed. Hydrocarbon odor was present in the soil of the excavation pit. Two soil samples were taken from the excavation and analyzed for BTEX, TPH-d, and TPH-g. The maximum TPH-d detection in the two samples was 1,910 mg/kg. BTEX constituents were detected in the two soil samples at concentrations below soil screening levels. Groundwater was not encountered in the excavation of Tank 21; therefore, no groundwater samples were taken (ECC 1996). Maximum concentrations for samples collected during excavation are shown in the table below.

DATA FROM REMOVAL OF TANK 21						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	1,910	3.9	ND	16.1	11.5	50.5
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*

There are no downgradient monitoring wells within 600 feet of Tank 21. Two upgradient monitoring wells (SU04-4A and SU04-5A) are within 100 feet of the tank. The Navy does not have access to these Stanford University wells, and they have not been sampled in the last 10 years.

5.3.3 Proposed Field Activities

Tank 21 currently lies in a secured area overseen by the CANG, which may pose some obstacles to gaining access for proposed field activities. During Mobilization 1 of the investigation, TtEMI will advance four direct-push borings, UST21-SB-01 through UST21-SB-04 (Figure 6). Water elevations were measured in wells ERM-2, ERM-3, and W14-3, located 620 to 700 feet from the tank; they indicate a local groundwater flow direction from 10 degrees west of north to 55 degrees east of north. Direct-push boring UST21-SB-01 will be advanced adjacent to the former tank location, UST21-SB-02 and -03 will be advanced downgradient, and UST21-SB-04 will be advanced upgradient. Soil samples will be collected from UST21-SB-01 at depths described in Section 4.0. Based on previous investigation results, soil samples will be analyzed for TPH-d, TPH-g, PAHs, and BTEX. Groundwater samples will be taken from temporary direct-push wells at all soil boring locations. Groundwater samples will be analyzed for TPH-d, TPH-g, and BTEX. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST21-SB-01, -02, and -03.

5.4 TANK 29

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for Tank 29.

5.4.1 Site History

Tank 29 was a single-wall fiberglass UST installed in 1983; the tank was removed in 1993. The 4,000-gallon tank was used to store diesel fuel. An emergency generator in Building 105 and a boiler in Building 580 were supplied with fuel from Tank 29 (CWM 1993). Tank 29 failed an annual tightness test that indicated leaking piping. Tank 29 was therefore removed and replaced with a double-walled AST.

5.4.2 Previous Investigations

The tank was removed in December 1993. During removal of Tank 29, no hydrocarbon staining or odor was noted in the tank pit or excavated material. Groundwater encountered at the bottom of the excavation pit, approximately 9 feet bgs, had a hydrocarbon sheen. Visual inspection of the tank revealed no sign of corrosion, pitting, cracking, or leaking. The tank's fuel and supply lines were removed 5 days after tank removal. Although the tank test indicated a leak in the piping system, the lines showed no signs of deterioration (Chuck 1995).

One groundwater sample, at 9 feet bgs, two soil samples from the tank pit walls, at approximately 7 feet bgs, and four soil samples from beneath the product lines, at approximately 3.5 feet bgs, were collected during tank and product line removal. Hydrocarbon odor was noted in two of the soil samples collected from below the product line. The soil and groundwater samples were analyzed for TPH-d and BTEX. The only soil samples registering detections were taken from beneath the product lines, which had maximum concentrations of 950 mg/kg TPH-d, 0.053 mg/kg benzene, 0.64 mg/kg toluene, 0.55 mg/kg ethylbenzene, and 2.6 mg/kg xylene (Chuck 1995). The detection of TPH-d exceeds the screening level of 400 mg/kg. The groundwater sample showed no detections for BTEX compounds, but contained TPH-d at 12,000 µg/L. The detection of TPH-d exceeds the screening level of 700 µg/L for groundwater, as shown in the table below.

DATA FROM REMOVAL OF TANK 29					
Maximum Concentration	**TPH-d**	**B**	**T**	**E**	**X**
Soil (mg/kg)	950	0.053	0.64	0.55	2.6
Soil Screening Level (mg/kg)	*400*	*4.4*	*2,700*	*3,100*	*980*
Groundwater (µg/L)	12,000	ND	ND	ND	ND
Groundwater Screening Level (µg/L)	*700*	*1*	*680*	*1,000*	*1,750*

5.4.3 Proposed Field Activities

During Mobilization 1 of the investigation, TtEMI will advance four direct-push borings, UST29-SB-01 through UST29-SB-04 (Figure 7). Because the former location of the piping is inaccessible to a direct-push rig, one hand auger boring, UST29-HA-01, will be advanced to 2 feet bgs in the piping area. Water elevations measured in wells WZR-1, W12-4, and WU4-21, located 300 to 640 feet from the tank location, indicate a local groundwater flow direction 8 to 13 degrees west of north. Direct-push boring UST29-SB-01 will be advanced adjacent to the former tank location, UST29-SB-02 and -03 will be advanced downgradient, and UST89-SB-04 will be advanced upgradient. Soil samples will be collected from boring UST29-SB-01 at depths described in Section 4.0. One soil sample will be collected from the hand-augered boring at 1.0 feet bgs or maximum apparent contamination. Based on the previous investigation results, soil samples will be analyzed for TPH-d, PAHs, and BTEX. Groundwater samples will be taken from temporary direct-push wells at all four soil boring locations. Groundwater samples will be analyzed for TPH-d and BTEX. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST29-SB-01, -02, and -03.

5.5 TANKS 85 AND 85A

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for the area around Tanks 85 and 85A.

5.5.1 Site History

Tank 85 was a 1,000-gallon UST located under the storage shed addition to Building 6. The tank was used to store and supply aviation gasoline to the engine testing facility that was located in Building 6. The tank was installed in 1944 and removed in 1995 by ECC (ECC 1996).

Tank 85A was a 1,000-gallon steel UST; its use at the site is unknown. The tank installation date is unknown; it was removed in 1995 by ECC (ECC 1996).

5.5.2 Previous Investigations

Tank 85 was found in good condition, and no odor or any other sign of soil contamination in the excavation was noted. During the removal of Tank 85, two soil samples and one grab groundwater sample were taken from the excavation pit. One soil sample was also taken from the excavation soil stockpile. Both soil and groundwater samples were analyzed for TPH-d, TPH-g, and BTEX. No TPH-g was detected in the soil samples. The maximum detection of TPH-d was 78.4 mg/kg; no BTEX contamination was detected. The groundwater sample indicated 14,300 µg/L of TPH-d and 290 µg/L of TPH-g. No BTEX was detected (ECC 1996). Both TPH-d and TPH-g are above the screening level concentrations of 700 µg/L and 50 µg/L, respectively.

Tank 85A was discovered during the removal of Tank 85. It is likely that its use was the same as Tank 85. Tank 85A was in very poor condition and was removed in pieces. The soil in the excavation pit emitted a solvent odor. Two soil samples were taken from the excavation; one was taken from the soil stockpile, and one was taken underneath the piping. Groundwater was not reached in the excavation of Tank 85A; therefore, no groundwater samples were taken. The maximum detection of TPH-d in soil was found in the pipe trench (231 mg/kg). The maximum detection of TPH-g at 634 mg/kg was found in one of the soil samples from the excavation pits. This soil sample also contained the highest concentrations of ethylbenzene (8.47 mg/kg) and xylene (13.9 mg/kg). Neither benzene nor toluene was detected in this sample. Benzene and toluene were detected in other soil samples but at concentrations below the soil screening levels (maximum detections of 0.0038 and 0.0185 mg/kg for benzene and toluene, respectively), as shown in the table below (ECC 1996).

DATA FROM REMOVAL OF TANK 89						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	231	634	0.0038	0.0185	8.47	13.9
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*
Groundwater (µg/L)	14,300	290	ND	ND	ND	ND
Groundwater Screening Level (µg/L)	*700*	*50*	*1*	*680*	*1,000*	*1,750*

Both tanks were transported by Erickson, Inc. as hazardous waste to its facility in Richmond and recycled. The site was paved over with concrete (ECC 1996).

5.5.3 Proposed Field Activities

During Mobilization 1 of the investigation, TtEMI will advance four direct-push borings, UST85-SB-01 through UST85-SB-04 (Figure 8). The former tank locations are beneath a warehouse floor, and may be inaccessible. If access to the former tank location is available, boring UST85-SB-01 will be advanced in the former tank location. Water elevations measured in wells WIC-1, W9-18, and W9-37, located 110 to 375 feet from the tank location, indicate a local groundwater flow direction 10 degrees west of north to 30 degrees east of north. Direct-push boring UST85-SB-01 will be advanced closest to the tank location. Borings UST85-SB-02 and -03 will be advanced downgradient, and UST85-SB-04 will be advanced upgradient. If boring UST85-SB-01 is advanced in the former tank location, soil samples will be collected at depths described in Section 4.0; otherwise, soil samples will be collected only if PID readings or observations indicate the presence of contamination. Groundwater samples will be taken from temporary direct-push wells at all four soil boring locations. Because the contents of Tank 85A are unknown, groundwater samples will be analyzed for TPH-d, TPH-g, PAHs, VOCs, and BTEX compounds. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST85-SB-01, -02, and -03.

5.6 TANK 89

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for Tank 89.

5.6.1 Site History

Tank 89 was a 500-gallon steel UST located east of Building 251, and used to supply diesel fuel for an emergency generator for radar equipment. Building 251 housed radar equipment for the airfield. The tank was installed in 1955; it was removed on April 15, 1994 (CWM 1993).

5.6.2 Previous Investigations

The tank was removed by Navy Public Works and overseen by the County of Santa Clara (Navy 1994). The tank was situated under a 4-inch thick, 3-foot by 8-foot reinforced concrete pad. A 12-foot by 10-foot by 10-foot deep excavation was made to remove the tank. Groundwater was encountered at 5 feet bgs. During removal, no obvious holes were noted in the tank or piping; however, there was visible petroleum staining and a noticeable hydrocarbon odor in the excavation.

Two soil samples were collected from the excavation sidewalls at approximately 7.5 feet bgs and submitted for analysis of TPH-d. Sample results indicated TPH-d at 10,000 and 680 mg/kg in the samples from the west and north walls. These results exceed the screening level of 400 mg/kg outlined in the TM, as shown in the table below.

DATA FROM REMOVAL OF TANK 89	
Maximum Concentration	**TPH-d**
Soil (mg/kg)	10,000
Soil Screening Level (mg/kg)	*400*

An investigation was conducted by ERM-West in 1995 (ERM 1995b). Fifteen direct-push borings were advanced and soil and groundwater sampling was conducted in July 1995 (see Figure 9). The soil samples were collected between 8 and 9 feet bgs and analyzed for TPH-d, TPH-g, and BTEX. Direct-push groundwater samples were analyzed for the same constituents. TPH-d was the only constituent detected in soil and groundwater samples above the screening levels in the Tank 89 area. The maximum TPH-d detections were 1,134 mg/kg in soil and 4,861,000 µg/L (product) in groundwater, as shown in the following table.

DATA FROM TANK 89 DIRECT-PUSH INVESTIGATION						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	1,134	ND	ND	0.022	0.0039	0.216
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*
Groundwater (µg/L)	4,861,000	ND	2.1	2.4	49.9	123.7
Groundwater Screening Level (µg/L)	*700*	*50*	*1*	*680*	*1,000*	*1,750*

Based on the initial investigation, three groundwater monitoring wells were installed, and both soil and groundwater were sampled. Soil and groundwater samples were analyzed for TPH-d, TPH-g, and BTEX. Soil samples from the well boreholes contained no analytes of interest. The only constituent detected in the groundwater samples from July and August 1995 was TPH-d in samples from one well at 57 µg/L. This detection is below the TPH-e screening level of 700 µg/L in the TM, as shown in the table below.

DATA FROM TANK 89 GROUNDWATER INVESTIGATION						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	ND	ND	ND	ND	ND	ND
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*
Groundwater (µg/L)	57	ND	ND	ND	ND	ND
Groundwater Screening Level (µg/L)	*700*	*50*	*1*	*680*	*1,000*	*1,750*

5.6.3 Proposed Field Activities

During Mobilization 1 of the investigation, if the three ERM-West wells are accessible, TtEMI will sample the three wells and advance two direct-push borings, UST89-SB-01 and UST89-SB-02. If the ERM-West wells are inaccessible, TtEMI will advance four direct-push borings, UST89-SB-01 through UST89-SB-04 (Figure 9). Water elevations measured in wells WWR-3, WSI-3, and 65A, located 330 to 775 feet from the tank location, indicate a local groundwater flow direction 19 degrees east to 6 degrees west of north. Direct-push boring UST89-SB-01 will be advanced adjacent to the former tank location, UST89-SB-02 and -03 will be advanced downgradient, and UST89-SB-04 will be advanced upgradient. Soil samples will be collected from boring UST89-SB-01 as described in Section 4.0. Soil samples will be analyzed for TPH-d and possibly PAHs. Groundwater samples will be taken from temporary direct-push wells at all four soil boring locations. Groundwater samples will be analyzed for TPH-d. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST89-SB-01, -02, and -03.

5.7 TANK 106

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for Tank 106.

5.7.1 Site History

Very little information is available regarding Tank 106. The installation date is unknown and there is no record of tank removal. Tank 106 is a 5,000-gallon UST of unknown construction, near Building 49 and associated with a former gas station. The tank may have contained gasoline and may remain under Building 49.

5.7.2 Previous Investigations

There were no previous investigations of Tank 106. The two closest wells (FP5-6 and W5-18) are approximately 100 feet north of Building 49. Well W5-18 has not been sampled since 1992. Data in the Navy's quarterly sampling database indicate that well FP5-6 was sampled on September 13, 1994 and June 12, 1995 and the sample analyzed for TPH as diesel, jet fuel, motor oil, kerosene, and other heavy TPH components. Additionally, well FP5-6 was also sampled for TPH-g and BTEX on September 13, 1994. No detections were measured in samples from either sampling event.

5.7.3 Proposed Field Activities

Because the exact location of Tank 106 is unknown and the suspected location is under Building 49, if feasible, TtEMI will conduct a geophysical screening to locate the tank. If a geophysical screening is not feasible, TtEMI will advance four direct-push borings around the building (Figure 10). Water elevations were measured in wells W5-13, W7-13, and W5-9, located from 100 to 990 feet from the suspected tank location; they indicate a local groundwater flow direction of 16 degrees east to 52 degrees west of north. Direct-push borings UST106-SB-01, -02, and -03 will be advanced downgradient; UST106-SB-04 will be advanced upgradient. Because borings are unlikely to encounter the tank area or another source, soil samples will be collected only if PID readings or observations indicate the presence of contamination. Groundwater samples will be taken from temporary direct-push wells at all soil boring locations. Because the former use of Tank 106 is unknown, soil and groundwater samples will submitted for analysis of TPH-d, TPH-g, VOCs, and BTEX. Because the time period of tank operation is unknown, Mobilization 1 groundwater samples will be submitted for MTBE analysis. If groundwater monitoring wells are installed in the second phase of field work, they will be most likely be completed in soil boring locations UST106-SB-01, -02, and -03 based on laboratory analytical results.

5.8 TANK 111

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for Tank 111.

5.8.1 Site History

Tank 111 was a 2,500-gallon steel UST located near Building 48 that contained fuel oil. The installation date is unknown; the tank was closed in place by a Navy contractor on November 22, 1995.

5.8.2 Previous Investigations

Tank removal was scheduled for November 1995. During excavation, the top of the tank was located at 9 feet bgs (ECC 1996). The contractor attempted to remove the tank but operations were stopped because continued excavation may have undermined the adjacent building foundation. The tank had visible holes and was filled with groundwater. The Navy, a representative of Santa Clara County, and the tank removal contractor determined that the UST would be closed in place. As a result, Tank 111 was filled with concrete slurry.

One soil sample was taken from the soil excavated around Tank 111 (ECC 1996). One groundwater grab sample was also collected from the excavation. The soil and groundwater samples were submitted for analyses of TPH-d, TPH-g, VOCs, and BTEX. The analytical results indicated detections in the excavated soil sample of 64.1 and 0.13 mg/kg of TPH-d and TPH-g, respectively. The groundwater sample contained 350 µg/L of TPH-g. The TPH-g result in groundwater exceeds the 50 µg/L screening level for TPH-purgeable (TPH-p) in groundwater in the TM, as shown in following table.

DATA FROM REMOVAL OF TANK 111						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	64.1	0.13	ND	ND	ND	ND
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*
Groundwater (µg/L)	ND	350	ND	ND	ND	ND
Groundwater Screening Level (µg/L)	*700*	*50*	*1*	*680*	*1,000*	*1,750*

5.8.3 Proposed Field Activities

During Mobilization 1 of the investigation, TtEMI will advance four direct-push borings around Tank 111. Water elevations measured in wells 75A, W89-3, and W-89-5, located 175 to 725 feet from the tank location, indicate a local groundwater flow direction of 25 to 35 degrees east of north. Direct-push boring UST111-SB-01 will be advanced adjacent to the tank location, borings UST111-SB-02 and -03 will be advanced downgradient, and boring UST111-SB-04 will be advanced upgradient (see Figure 11). Soil samples will be collected from boring UST111-SB-01 at depths described in Section 4.0. Based on the results of previous investigations, soil samples will be analyzed for TPH-d, TPH-g, PAHs, and BTEX. Groundwater samples will be taken from temporary direct-push wells at all four soil boring locations. Groundwater samples will be analyzed for TPH-d, TPH-g, and BTEX. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST111-SB-01, -02, and -03.

5.9 TANK 115

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for Tank 115.

5.9.1 Site History

Tank 115 was a steel 5,000-gallon UST located near Building N245. Building N245 is also known as Building T-20D and is the current NASA child care facility. Installed in 1933, the tank originally stored aviation gasoline and served as a fuel storage and supply tank for the north mooring mast for the USS Macon, a dirigible.

5.9.2 Previous Investigations

The tank area was excavated in September 1994 (Chuck 1995). The pump pit was located; however, it appeared that the tank had previously been removed. The former tank area had been filled with pea gravel , and pipe connections for the tank had been cut and plugged. ECC removed the concrete pump vault used to house electrical controls for the UST in 1995 (ECC 1996). Two soil samples were collected from the excavation and analyzed for TPH-d, TPH-g, and BTEX. Analytical results indicated maximum detections of 39.1 mg/kg for TPH-d, and 6.5 mg/kg for TPH-g. BTEX results were 0.0216 mg/kg benzene, 0.152 mg/kg toluene, 0.0579 mg/kg ethylbenzene, and 0.164 mg/kg xylene. These results do not exceed the petroleum screening levels in the TM, as shown in the following table.

DATA FROM REMOVAL OF TANK 115 PUMP VAULT						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	39.1	6.5	0.0216	0.152	0.0579	0.164
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*

5.9.3 Proposed Field Activities

During the first phase of the investigation, TtEMI will advance four direct-push borings, UST115-SB-01 through UST115-SB-04 (Figure 12). Water elevations were measured in wells WU4-18, W8-4, and 95A, located 460 to 530 feet from the tank; they indicate a local groundwater flow direction of 43 degrees east to 10 degrees west of north. Direct-push boring UST115-SB-01 will be advanced adjacent to the former tank location, boring UST115-SB-02 will be advanced adjacent to the former pump vault, boring UST115-SB-03 will be advanced downgradient, and boring UST115-SB-04 will be advanced upgradient. Soil samples will be collected from boring UST115-SB-01 and -02 at depths described in Section 4.0. Groundwater samples will be taken from temporary direct-push wells at all four soil boring locations. Soil and groundwater samples will be analyzed for TPH-g and BTEX. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST115-SB-01, -02, and -03. It is unlikely that the tank was operated after 1979; therefore, groundwater samples will not be analyzed for MTBE.

5.10 TANK 116

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for Tank 116.

5.10.1 Site History

Tank 116 was a steel 5,000-gallon UST located near Building 146. The UST was outside the entrance gate to the transportation yard. Installed in 1933, the tank originally stored aviation gasoline and served the south mooring circle for the USS Macon. Approximately 300 feet upgradient of Tank 116 is Site 14-South. Site 14-South is a vehicle fueling facility with petroleum contamination from two former tanks. A recirculating in situ treatment system for remediating soils and groundwater was constructed in 1995 at Site 14-South (PRC 1995b).

5.10.2 Previous Investigations

The tank area was excavated in September 1994 (Chuck 1995). The pump and control pits were located and control switches were in place; however, it appeared that the tank had previously been removed. The former tank area was filled, and pipe connections for the tank had been cut and plugged. ECC removed the concrete vault used to house electrical controls for the UST in 1995 (ECC 1996). During exploratory excavation, hydrocarbon staining and odor were found near the bottom of the vault. Two soil samples were collected from the excavation and analyzed for TPH-d, TPH-g, and BTEX. Laboratory results indicated a maximum detection of 49.4 mg/kg for TPH-d and 5.1 mg/kg for TPH-g. BTEX maximum detections included 0.0113 mg/kg of toluene, 0.0056 mg/kg ethylbenzene, and 0.0277 mg/kg xylene. These results do not exceed the petroleum screening levels for soil in the TM, as shown in the following table.

DATA FROM REMOVAL OF TANK 116 PUMP VAULT						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	49.4	5.1	ND	0.0113	0.0056	0.0277
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*

5.10.3 Proposed Field Activities

TtEMI will advance five direct-push borings in the area surrounding the former location of Tank 116 (Figure 13). Water elevations were measured in wells 74A, W14-11, and W60-1, located from 310 to 350 feet from the tank location; well measurements indicate a local groundwater flow direction ranging from 30 to 10 degrees west of north. Direct-push boring UST116-SB-01 will be advanced adjacent to the former tank location, boring UST116-SB-02 will be advanced adjacent to the former pump vault, borings UST116-SB-03 and -04 will be advanced downgradient, and boring UST116-SB-05 will be advanced upgradient. Soil samples will be collected from borings UST116-SB-01 and -02 at depths described in Section 4.0. Groundwater samples will be taken from temporary direct-push wells at all five soil boring locations. Soil and groundwater samples will be analyzed for TPH-g and BTEX. It is unlikely that the gasoline tank operated after 1979; therefore, groundwater samples will not be analyzed for MTBE. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST116-SB-01, -03, and -04.

5.11 TANKS 121 AND 122

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for the area around Tanks 121 and 122.

5.11.1 Site History

Tanks 121 and 122 were steel, 250- and 500-gallon tanks that held diesel and gasoline and were located near the intersection of Moffett Boulevard and Middlefield Road. These tanks supplied fuel to emergency generators for a transmitter facility. This area now contains the Shenandoah Housing Complex. The tanks were discovered and removed in 1987 during construction of the Shenandoah Housing Complex.

5.11.2 Previous Investigations

Soil contamination was observed during tank removal. Kaldveer Associates sampled soil and groundwater around the former USTs in February 1990 (ERM 1994). Soil samples were collected, and three groundwater monitoring wells were installed (Figure 14). Diesel and gasoline constituents were identified in both soil and groundwater, but the extent of contamination was not delineated. The groundwater monitoring wells were abandoned in May 1990. An investigation was conducted in 1993 by ERM-West (ERM 1994). Sixteen soil borings were installed and HydroPunch samples were collected from each boring (Figure 14). Analytical results indicated TPH-g, TPH-d, and BTEX constituents in soil and groundwater samples. Maximum concentrations in soil and groundwater are summarized below.

DATA FROM DIRECT-PUSH INVESTIGATION OF TANKS 121 AND 122						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	6,100	1.7	ND	0.0010	0.0079	0.097
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*
Groundwater (µg/L)	97,000	3,700	77	160	310	200
Groundwater Screening Level (µg/L)	*700*	*50*	*1*	*680*	*1,000*	*1,750*

Based on the information collected, three monitoring wells were installed and sampled. The maximum constituent detections from the three groundwater samples are summarized below; all maximum detection results were from the MW-1 sample (Figure 14), as shown below.

DATA FROM GROUNDWATER INVESTIGATION OF TANKS 121 AND 122						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Groundwater (µg/L)	ND	1,000	2.0	ND	25	43
Groundwater Screening Level (µg/L)	*50*	*700*	*1*	*680*	*1,000*	*1,750*

A feasibility study and corrective action plan were prepared by ERM-West (ERM 1995a). The plan recommended soil excavation and recycling and groundwater extraction and aeration. No action has been conducted to date at the site.

5.11.3 Proposed Field Activities

TtEMI will sample the three existing wells installed by ERM-West (Figure 14). Water elevations measured in the three wells, MW-1, MW-2, MW-3, indicate a local groundwater flow direction 36 degrees west of north. Based on the results of previous investigation, groundwater samples will be analyzed for TPH-d, TPH-g, PAHs, and BTEX. Because there are no records of the tanks, it is unlikely that either tank operated after 1979; however, because the tank location is in a residential area that may include other sources of contamination, both upgradient and downgradient groundwater samples will be analyzed for MTBE. Additionally, because these wells are in a residential area, they will be sampled for four quarters.

5.12 TANK 131

The following subsections discuss the site history, results of previous investigations, and the proposed field activities for Tank 131.

5.12.1 Site History

Tank 131 was a 100-gallon steel UST located near Hangar 2 that contained gasoline. The installation date is unknown; the tank was removed by a Navy contractor on November 21, 1995.

5.12.2 Previous Investigations

Tank removal was conducted by ECC and overseen by an inspector from Santa Clara County in November 1995. The tank was observed to be rusted at the time of removal and there was a noticeable hydrocarbon odor from the excavation (ECC 1996). Two soil samples were taken from unspecified locations in the Tank 131 excavation. The soil samples were submitted for analysis of TPH-d, TPH-g, VOCs, and BTEX. The analytical results are summarized in the table below.

DATA FROM REMOVAL OF TANK 131						
Maximum Concentration	**TPH-d**	**TPH-g**	**B**	**T**	**E**	**X**
Soil (mg/kg)	1,080	8,120	29.2	154	48.6	257
Soil Screening Level (mg/kg)	*400*	*150*	*4.4*	*2,700*	*3,100*	*980*

Levels of TPH-g, TPH-d, and benzene all exceeded the screening levels for petroleum products outlined in the TM.

5.12.3 Proposed Field Activities

During Mobilization 1 of the investigation, TtEMI will advance three direct-push borings in the area surrounding the former location of Tank 131 (Figure 15). Water elevations measured in wells W7-1, W7-18, and W7-3, located 80 to 1,150 feet from the tank location, indicate a local groundwater flow direction of 18 to 33 degrees west of north. Direct-push boring UST131-SB-01 will be advanced adjacent to the former tank location, boring UST131-SB-02 will be advanced downgradient, and boring UST131-SB-03 will be advanced upgradient. Soil samples will be collected from boring UST131-SB-01 at depths described in Section 4.0. Based on the results of the previous investigation, soil samples will be analyzed for TPH-d, TPH-g, PAHs, and BTEX. Groundwater samples will be collected from temporary direct-push wells at all three soil boring locations. A groundwater sample will also be taken from monitoring well W7-1. Groundwater samples will be analyzed for TPH-d, TPH-g, BTEX, and MTBE. If monitoring wells are installed in Mobilization 2, they will be completed in the locations of soil borings UST131-SB-01 and -02. Based on the laboratory analytical results from Mobilization 1, well W7-1 may be sampled in Mobilization 2.

6.0 FIELD PROCEDURES

This section describes procedures for the proposed field activities. Field activities include conducting a utility survey, completing direct-push soil borings, collecting soil and groundwater samples, drilling, installing, and developing monitoring wells, and surveying sample locations. Standard operating procedures (SOPs) are referenced where appropriate.

6.1 OBJECTIVES

Specific objectives for the first phase of field work include:

(1) Collect soil samples with the maximum COC concentrations

(2) Collect sufficient soil data for Tier 1 RBCA screening

(3) Collect an upgradient direct-push groundwater sample

(4) Collect direct-push groundwater samples to select monitoring well locations in the second phase of field work

Specific objectives for the second phase of field work include:

(1) Install and sample monitoring wells at each tank site to assess the stability of the groundwater plume

(2) Collect sufficient groundwater data for Tier 1 RBCA screening

6.2 FIELD ACTIVITIES

The remaining UST sites investigation field work will include utility location, completing direct-push soil borings, well installation, soil and groundwater sample collection, and surveying.

6.2.1 Utility Location Survey

Underground utilities will be located adjacent to each proposed sample location before intrusive activities begin. Utilities will be located by a utility location subcontractor. If cleared by the location subcontractor, the location will be marked with paint. If the location is not cleared, other nearby locations will be selected until one is cleared and marked. A map of the final cleared locations of all points will be maintained by field personnel throughout the field effort.

6.2.2 Soil Borings and Temporary Well Installation Using Direct-Push Method

Soil borings will be advanced using a direct-push method. A sampler will be used to continuously collect soils at each boring. The actual diameter of the sampler may vary depending on the available equipment; however, continuous sampling using direct push is typically conducted with a 3-foot long by 2-inch (nominal) outer diameter barrel.

The sampler will be lined with either polybuterate or brass tubing to make sample handling easier. Brass liners will be used for soil sample collection at locations where the investigated tank contained gasoline. At all other locations, polybuterate liners will be used to screen samples visually and, after opening, with a PID.

The sampler will be driven ahead (and inside) of a drive casing. The drive casing and the sampler will be simultaneously pushed, driven, or vibrated into the ground. After being advanced the length of the sampler, the sampler will be retrieved while the drive casing remains in the ground to maintain an open borehole.

After the sample has been removed from the drive casing, it will be opened and the polybuterate or brass liner containing the sample will be removed. The polybuterate liner will be cut open to allow sample monitoring with a PID, visual classification, logging (SOPs 026 and 028 [PRC 1995a]), and any necessary sample collection. The brass liner with the soil samples for BTEX analysis will not be cut, but will be containerized as described in Section 6.2.4.

Groundwater samples will be taken from temporary monitoring wells constructed in the direct-push boreholes. The boreholes will be driven to the depth of groundwater, as identified from wet or saturated soils in the sampler. Once the depth to groundwater is reached, the drive casing and sampler will be advanced through the channeled zone of the A1-aquifer zone or an additional 5 feet, if no channels are found, to allow a sufficient volume of water to accumulate.

The sampler will be removed from the drive casing and will be replaced by 1-inch diameter polyvinyl chloride (PVC) casing with 20-slot PVC screen. The screened interval will be approximately 5 feet long; the actual length will depend on geologic conditions. Under unconfined conditions, the screened interval will extend from the high water line into the saturated zone. Under confining conditions, only the permeable section of the saturated zone will be screened.

Groundwater will be allowed to reach a static elevation as indicated by three water level readings within 0.1 feet measured over a 15-minute period or a water level measurement that coincides with observed saturated conditions in the core. The depth to water will then be measured and recorded in the field log book and on a groundwater sample collection form (Appendix A).

Groundwater from the temporary monitoring wells will be collected as described in Section 6.2.5. After groundwater samples are collected, the PVC casing will be removed and grout will be placed in the borehole to ground surface.

6.2.3 Drilling Procedures

Depending on the results of the direct push, up to five borings will be drilled at each tank site being investigated during the second mobilization of field work.

Soil cores will be collected using a hollow-stem auger (HSA) drill rig. A core barrel will be advanced into the subsurface while the auger is being advanced. Continuous core will be collected from just beneath the ground surface to total depth of the borings for visual characterization and logging. A hemispherical sand catcher located at the bottom of the core barrel will be used to minimize loss of coarse-grained sample.

The boreholes drilled as part of the additional petroleum sites investigation field activities will be completed as 2-inch diameter monitoring wells. The monitoring wells will be constructed of 2-inch diameter PVC casing with 10-slot PVC screen and washed sand no finer than 20 mesh (U.S. standard sieve) as filter material. The screened interval will be approximately 10 feet; the actual length will depend on geologic conditions. In unconfined conditions, the screened interval will extend from the high water line into the saturated zone. Under confining conditions, only the permeable section of the saturated zone will be screened.

Following installation, each well will be developed by the well driller using standard surge and pump operating procedures. These procedures consist of forcing water in and out of the screened interval with a close-fitting bailer or surge block, and pumping groundwater from the well until field measurements of temperature, pH, and conductivity have stabilized. A minimum of three filter pack and casing volumes plus any water lost to the formation during drilling will be removed from the well. Each well will be completed with either a flush-mounted steel protective surface casing or above-ground completion, depending on location.

6.2.4 Soil Sample Collection

This section discusses the methodology for soil sample collection (SOP 005 [PRC 1995a]). Soil samples will be analyzed for TPH-g, TPH-d, BTEX, MTBE, and PAHs, as described in Section 4.0.

Soil samples will be collected in either polybuterate or brass sleeves from the direct-push borings. The methodology for sample collection will be depend on the historical tank contents. For tanks that contained gasoline, no field screening will be conducted and the samples will be collected in a 6-inch long brass liner. The brass liner will not be cut; the ends of the liner will be covered with Teflon sheeting and capped for shipment to the laboratory. Soil samples will be collected in brass sleeves to minimize soil disturbance and BTEX volatilization.

Tank areas that contained diesel or fuel oil will be screened in the field. The polybuterate liner will be cut open, the sample screened with a PID, and the soil visually classified. The sample interval will then be immediately identified and containerized in precleaned, glass sample containers provided by the analytical laboratory. Any pebble- or gravel-size rock fragments and organic material (such as insects or roots) will be removed before placing the soil in sample containers. Once collected, all samples will be labeled according to procedures described in Section 6.3.1 and placed immediately into a cooler with ice.

6.2.5 Groundwater Sampling

Groundwater samples will be collected from both temporary wells and monitoring wells (SOP 010 [PRC 1995a]). This section describes the methodology for collecting groundwater from both sources.

For groundwater sampled from both direct-push wells and monitoring wells, groundwater chemical and physical parameters, including reduction/oxidation potential (Eh), dissolved oxygen (DO), conductivity, pH, temperature, and turbidity, will be measured before groundwater sample collection.

In samples from temporary wells, the sampler will be driven to depth as described in Section 6.2.2. A peristaltic pump (or equivalent) will be used to collect groundwater from the temporary well. The pump's tubing will be nonreactive to the samples being collected and will be capable of pumping at a low rate of 100 milliliters per minute (100 mL/min). The sample for BTEX and MTBE analysis will be collected first. Once collected, all samples will be labeled and placed immediately into a cooler with ice.

In sampling from monitoring wells, a peristaltic pump (or equivalent) will be used to purge the wells and withdraw the samples. Field personnel will follow micropurge groundwater sampling SOP 010A (PRC 1995a).

Samples for BTEX and MTBE analysis will be collected first from each well, and care will be exercised during filling so that no headspace remains in the samples. Once collected, all samples will be labeled and placed in a cooler with ice.

6.2.6 Decontamination and Waste Disposal

Drilling and sampling equipment will be decontaminated according to SOP 002 after each borehole is completed or sample collected (PRC 1995a). Sampling equipment will be washed with available site tap water and an Alconox solution and then rinsed with distilled and deionized water. Drilling equipment will be steam cleaned. When not in use, drilling and sampling equipment will be stored in a clean area. Equipment blanks will be obtained to assess the adequacy of decontamination and the potential for cross contamination between samples. The number and frequency of equipment blanks is discussed in Section 7.2.

Investigation-derived waste (IDW) generated during this investigation will be disposed of appropriately. Soils will be used as backfill in the borehole from which they came and the boreholes will be grouted to ground surface. Groundwater IDW and decontamination water generated during this investigation will be collected and placed in a storage tank. Wastewater currently stored in a storage tank is analyzed and disposed of appropriately. However, in the future, IDW water will be treated in the west-side aquifers treatment system (WATS). IDW water generated during the remaining UST investigation field work will be disposed of either in the current manner or processed through the WATS.

6.2.7 Surveying

All sample locations will be surveyed by a California-certified surveyor. The locations will be surveyed relative to benchmark H-111, south of Hangar 1, to an accuracy of ±0.1 foot horizontally, and ±0.01 foot vertically (casing) and ±0.1 foot vertically (ground surface). Horizontal coordinates will be reported in the California state planar coordinate system.

6.3 SAMPLE HANDLING PROCEDURES

The following subsections describe sample handling procedures, including sample identification and labeling, sample containerization and preservation, documentation, and sample shipment and chain of custody. A more detailed discussion of groundwater sample handling procedures is presented in the quality assurance project plan (QAPP) (TtEMI 1997).

6.3.1 Sample Identification and Labeling

The sample numbering scheme for sampling at the remaining UST investigation sites is compatible with the MFA computerized database management system. The numbering convention identifies each sample uniquely and provides a means of tracking the sample from collection to analysis. The sample ID number specifies (1) the sample matrix, (2) sample locations, and (3) specific sampling event. The identification (ID) number will be entered on sample labels, field sheets, chain-of-custody forms, and other records documenting sampling activities. The template in Table 3 provides an example of the sample numbering convention.

All blanks in the template will be filled and each of the five parts of the template must be right justified and backfilled with zeros. All characters, including dashes, parentheses, and decimal points, must be shown on labels, sampling tracking forms, chain-of-custody forms, and any other sampling documents. An example of a completed sample designation is described below.

A soil sample taken at UST 32 from sample site 1 between 4.5 and 5 feet will be designated:

UST32-SB01-4.5-5.0

A sample label will be affixed to each sample container when the sample is collected. The label will include the sample ID number, an abbreviation of the analysis to be conducted, the initials of the sampler, the time and date of collection, the preservatives used, and the project name. After the label is complete, it will be covered with clear plastic tape to prevent tampering and damage.

6.3.2 Sample Containerization and Preservation

All samples will be containerized and packaged to maintain sample integrity before delivery to the analytical laboratory. Sample containers will be precleaned and preservative added by the supplier to analytical method specifications. Table 4 lists the containers for each type of analysis. Water samples to be analyzed for BTEX and MTBE will completely fill each container so that no air is present. Each container will be checked for air bubbles by inverting and tapping the container. If an air bubble is observed, additional sample will be added. The caps, which include Teflon linings, will be hand-tightened.

6.3.3 Documentation

In addition to sample labels, field sampling requires several other forms of documentation. This additional documentation is necessary to provide an accurate record of sampling events and field observations. This information will be recorded in field log books, daily quality control reports, extended chain-of-custody forms, soil boring logs, well installation forms, well development forms, groundwater sample data sheets, and field sampling forms. Examples of all forms are shown in Appendix A.

Documentation in the field log book will be completed legibly in permanent ink. Errors will be crossed out with a single line, dated, and initialed by the field team member recording the information. Unused portions of pages will be crossed out, and each page will be signed and dated.

6.3.4 Sample Shipment and Chain of Custody

After samples are collected and labeled, they will be placed in iced coolers. Chain-of-custody forms will be completed for all samples. Sample collection personnel will sign the COC and transfer coolers to the shipping courier. Coolers will be stored in a locked, on-site facility or held in the control of sampling personnel until they are shipped to the analytical laboratory.

Before samples are shipped, the field team leader will sign the chain-of-custody form, insert the form into a plastic bag, and tape the bag inside the lid of each cooler. The cooler will then be sealed with custody seals so that the seal must be broken to remove the samples. Sample coolers will be shipped by overnight courier to the laboratory. The field chain of custody will terminate when the laboratory receives the samples.

7.0 QUALITY ASSURANCE AND QUALITY CONTROL

This section describes the quality assurance and quality control (QA/QC) requirements for this field work plan.

7.1 DATA QUALITY OBJECTIVES AND DATA REQUIREMENTS

The following sections identify and respond to the seven steps identified in EPA's Data Quality Objectives (DQO) Process for Superfund (EPA 1994a).

7.1.1 State the Problem

Insufficient information is available at the 12 tank sites to: (1) in some cases, evaluate whether past activities released petroleum products to the environment, (2) compare COC levels to screening levels if a release has occurred, and (3) complete a Tier 1 RBCA screening if COC concentrations exceed screening levels.

Site histories are discussed in Section 5.0, and include previous investigations, the history of each tank, and the type of petroleum that might have been contained in the tank. The identification of a release and quantification of contaminant concentrations in soil and groundwater are important to assess potential human health risks.

7.1.2 Identify the Decision

The primary goal of the remaining UST sites investigation is to assess whether a release of TPH occurred as a result of past activities. If a release has occurred, COC concentrations will be compared to the screening levels described in the TM. The secondary goal is to collect data suitable for Tier 1 RBCA screening.

Outcomes from each site investigation will include a comparison of COC concentrations to the screening levels described in the TM and may include (1) a Tier 1 RBCA screening, and (2) an evaluation of the Tier 1 screening to evaluate whether additional investigation or remediation activities are required. All site investigations and Tier 1 screenings, if conducted, will be discussed in appendices to the TM.

7.1.3 Identify the Inputs to the Decision

Information regarding historical information about each tank, data from previous studies, regulatory guidance, and the data from this investigation will be used to evaluate whether a release of TPH has occurred. Soil and groundwater data from this investigation will be used for a Tier 1 RBCA screening, where applicable.

7.1.4 Define the Study Boundaries

The study boundaries are defined as the area surrounding each of the 12 tanks that may have resulted in a release to the environment. For each tank area, the study boundary is related to the specific history of the site. For example, if a release near a fuel line is suspected, the study boundary will include the fuel line.

7.1.5 Develop a Decision Rule

The remaining UST sites investigation results will be used to assess whether additional action is required at each tank site. For the evaluation process, the following decision rules will be observed:

- If the analytical results for soil and groundwater show that maximum detections of soil COCs are below screening levels and no groundwater COCs are detected above

80 percent of the screening level, no further action will be recommended and regulatory closure will be requested.

- If these conditions are not met, the analytical results for soil and groundwater will be used to conduct a Tier 1 RBCA screening.

- If it is found in the Tier 1 RBCA screening that the COCs are not present at concentrations that present risk, no further action will be recommended and regulatory closure will be requested. If COCs are at concentrations that present risk, then further evaluation or remedial action will be recommended.

7.1.6 Specify Limits on Decision Errors

The purpose of specifying limits on decision errors is to limit uncertainty in the data set. Uncertainty is limited by identifying the acceptable limit on decision errors. Areas of uncertainty in the data set include both analytical methods and statistical evaluation.

Data that may be used quantitatively in future tank investigations include data on organic compounds from soil and groundwater analysis. Detections for BTEX, MTBE, or PAHs that can be attributed to historical releases from the tank or related pipelines may be evaluated in Tier 1 RBCA and future risk screening. Analytical uncertainties will be checked through established QA/QC procedures. To limit other uncertainties, limit on decision errors will be determined and agreed on by the Navy and RWQCB.

One means of limiting uncertainty in the data set is biased sampling. Because the primary objective of the remaining UST investigation is to assess whether a release of TPH has occurred that presents a risk to human health and the environment, biased sampling is the preferred method to target areas of potential release. Biased sampling will be used at each site, in areas where existing data indicate that contaminants may be present. Samples will be collected at the known release point; therefore, a beta-type decision error (no action at a site with contamination) is highly unlikely. Additionally, COCs are human-made; therefore, there are no background populations.

7.1.7 Optimizing the Design for Obtaining Data

Samples will be selected either on a regular interval, or by direct observation or measurement of contaminants. Sample locations have been selected on a biased using site-specific information, such as groundwater flow directions. Section 4.0 discusses the sampling proposed after optimizing the design for obtaining data.

7.2 QUALITY CONTROL SAMPLES

Field and laboratory QC samples will be collected and analyzed by a Navy-approved laboratory (PRC 1995c). Complete descriptions of quality control samples are provided in Section 3.5 of the QAPP (TtEMI 1997). The field QC samples include:

- Field duplicate samples - 10 percent, groundwater only
- Matrix spike/matrix spike duplicate (MS/MSD) samples - 5 percent
- Equipment rinsate blanks - one per day per type of equipment for all COCs
- Trip blanks - one per cooler containing samples for BTEX, VOCs, and MTBE analysis

7.2.1 Field Duplicates

Field duplicate samples will be collected for groundwater samples only. Field duplicate samples are two samples collected at the same time from the same source that are submitted as separate samples to one laboratory for analysis. Field duplicates evaluate the consistency of the overall field sampling and analytical system. Field duplicates are collected at a frequency of 10 percent and are analyzed for the same parameters as the field samples collected during the event. These duplicate results are used to evaluate the precision of the analysis by calculating the relative percent difference (RPD). Table 2 identifies the number of field duplicate samples to be taken at each tank site.

7.2.2 Matrix Spike and Matrix Spike Duplicate

MS/MSD samples are aliquots of a sample spiked in the laboratory with known quantities of compounds and are analyzed through the same procedures used for the field sample. Analysis of the MS sample provides information about the accuracy of the laboratory procedure and the effect of the sample matrix on the recovery of target analytes. The RPD of MS/MSD recoveries is used to assess matrix-specific method precision (PRC 1995c). The MS/MSD samples will be specified to the laboratory by field personnel. Table 2 identifies the number of MS/MSD samples to be taken at each tank site.

7.2.3 Field Blanks

During the collection of field samples and when the laboratory tests the samples, contamination can be introduced from many external sources. In an attempt to discern these potential sources of contamination, two types of field blanks will be collected and analyzed. They include trip blanks and equipment rinsate blanks.

All blank sample results should remain below the method detection limit for each analyte of interest. If any contaminant (except common laboratory contaminants) is present in any of the blank samples, associated field samples containing the same contaminant must be qualified as not detected if the concentration of the field sample is less than five times the concentration found in the blank.

Equipment rinsate blanks. Equipment blank samples verify the effectiveness of sampling equipment decontamination procedures and are analyzed for the same compounds and analytes as the field samples collected. Contamination in equipment blank samples indicates that the sampling equipment may have been ineffectively decontaminated, handled, or both, resulting in possible cross contamination between sampling locations.

Trip blanks. The purpose of a trip blank is to demonstrate that contamination is not arising from the sample containers and that field samples are not contaminated during transit. A trip blank originates in the laboratory as a 40-mL vial (typically used for VOC analysis) filled completely with reagent-grade water. The trip blanks are then transported to the site with the empty sample containers that are used for sample collection. The trip blanks are stored at the site until the proposed field samples have been collected. One trip blank will then accompany each sample transport container containing field samples for VOC analysis back to the laboratory for analysis. The trip blank is not opened until it is returned to the laboratory at the time of analysis. Trip blanks are analyzed only for TPH-p, BTEX, and VOCs because they have the greatest potential for cross contamination.

7.3 DATA VALIDATION AND USABILITY

The following two sections discuss the requirements and methods for data review, verification, and validation.

7.3.1 Data Review, Verification, and Validation and Requirements

All data for the remaining UST sites investigation will be reviewed and verified after collection by an independent source according to the data validation statement of work (SOW) (PRC 1996b). At a minimum, 10 percent of the analytical data will be randomly selected for full data validation, and 100 percent of the analytical data will undergo cursory validation.

7.3.2 Validation and Verification Methods

Validation and verification of the data generated during field activities are essential to obtaining data of defensible and acceptable quality. Data values that are significantly different from the population are called "outliers." A systematic effort will be made to distinguish between true and false outliers. True outliers represent real variability in the data and errors, before field and laboratory personnel report the data. False outliers can result from improper sampling or analytical methodology, matrix interference, data transcription errors, or calculation errors. Outliers will be reported in the case narrative section of the analytical report. Additional verification methods for laboratory activities are presented in the following paragraphs. Laboratory and analytical laboratory data validation are discussed further in the QAPP (TtEMI 1997).

Laboratory Verification of Data

Laboratory personnel will verify analytical data at the time of analysis and reporting through reviews of the raw data for any nonconformance to the analytical method requirements. Detailed procedures for laboratory verification and corrective action will be provided in the laboratory's QA plan.

Analytical Data Validation

TtEMI staff or subcontractors will validate analytical data according to the CLEAN II SOW for Analytical Services (PRC 1995c). The following paragraphs describe validation requirements. All analytical data will be validated in accordance with the EPA data validation functional guidelines for organic analysis (EPA 1994c).

Cursory validation will be conducted on the data summary packages resulting from analysis using Contract Laboratory Program (CLP) and non-CLP methods. The data reviewer is required to notify TtEMI if any missing information is needed from the laboratory. Elimination of data from the review process is not allowed. All data will continue through the validation process and be qualified and requalified as many times as necessary to meet the established criteria. Full validation will be required on approximately 10 percent of a sample data group. Data summary packages consist of sample results and QA/QC summaries, including calibration and internal standard data. No minimum number of samples will be required for the sample data group; however, the maximum number of samples will not exceed 20. A more comprehensive full validation will be conducted on full data packages resulting from analysis of samples using CLP and non-CLP methods.

8.0 SCHEDULE

The final remaining UST sites investigation work plan will be submitted after receipt of regulatory agency comments. The field activities are scheduled to be conducted in May and June 1999. The 12 tank sites will be evaluated in appendices to the TM. For those sites completed during Mobilization 1, appendices will be submitted in August 1999. For those sites requiring four quarters of monitoring, appendices will be submitted in summer 2000. All scheduled dates are estimates and subject to change.

9.0 REFERENCES

American Society for Testing and Materials (ASTM). 1995. Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. Designation E 1739-95. ASTM. West Conshohocken, Pennsylvania. November.

California Environmental Protection Agency, Department of Toxic Substances Control (Cal/EPA). 1994. Letter from Mr. C. Joseph Chou (Cal/EPA) to Mr. Stephen Chao (Navy) regarding concurrence on petroleum cleanup levels. July.

Chemical Waste Management, Inc. (CWM). 1993. Phase I Environmental Site Assessment, Area 2, Buildings: 111, 161, 184, 250, 251, 258, 343, 544, 572. Naval Air Station Moffett Field, California. April 23.

CWM. 1994. Level I Environmental Site Assessment, Area 4, Buildings: 77, 418, 449, 454, and 463. Naval Air Station Moffett Field, California. May.

Chuck, Don. 1995. Information summary prepared by Mr. Don Chuck, U.S. Navy, describing known tank information and previous tank investigations (for U.S. Navy internal use).

Earth Sciences Associates, Inc., and James M. Montgomery Consulting Engineers, Inc. (ESA and JMM). 1986. Confirmation Study (Verification Step), Moffett Naval Air Station, California. April.

Environmental Chemical Corporation (ECC). 1996. Draft Closure Report for Mod. #3. Underground Storage Tank Removal at Moffett Federal Airfield, Moffett Field, California. January 5.

ERM and Aqua Resources, Inc., Joint Venture (ERM and AR). 1986a. Final Report Industrial Waste Engineering Study, Naval Air Station Moffett Field, California. April.

ERM and AR. 1986b. Hazardous Materials Underground Storage Tank Study, Naval Air Station Moffett Field, California. April.

ERM-West, Inc. (ERM). 1987. Investigation of Potential Soil and Groundwater Contamination Near Tanks 19 and 20, Tanks 66 (sump), and Tanks 67 and 68, Moffett Federal Air Station, California. May.

ERM. 1994. Remedial Investigation Report for Former Underground Storage Tank Site at Shenandoah Family Housing. Naval Air Station. Moffett Field, California. June.

ERM. 1995a. Draft Feasibility Study and Corrective Action Plan Report for Former Underground Storage Tank Site at Shenandoah Family Housing, Naval Air Station Moffett Field, California. April.

ERM. 1995b. Pre-Final Remedial Investigation Report for Former and Inactive Underground Storage Tank Sites. Moffett Federal Airfield. Moffett Field, California. December.

Iwamura, T.I. 1980. Saltwater Intrusion in the Santa Clara Valley Baylands Area, California. Santa Clara Valley Water District. September.

Naval Energy and Environmental Support Activity (NEESA). 1984. Initial Assessment Study of Naval Air Station, Moffett Field, Sunnyvale, California. March.

Navy and NASA. 1992. Memorandum of Understanding Between Department of Navy and NASA Regarding Moffett Field, California. December.

Navy Public Works Center. 1994. Tank Closure Summary Report for the Removal of Eleven Underground Storage Tanks and Four Aboveground Storage Tanks at the Naval Air Station, Moffett Field, California. July 5.

PRC. 1995a. Standard Operating Procedures (SOP). February.

PRC. 1995b. Site 14 Project Report. Moffett Federal Airfield, California. April.

PRC. 1995c. CLEAN II Statement of Work for Analytical Services. September.

PRC. 1996a. Final Station-wide Remedial Investigation Report, Moffett Federal Airfield, California. May.

PRC. 1996b. Statement of Work for Validation Services.

PRC and James M. Montgomery (JMM). 1992. Draft Final Geology and Hydrogeology Technical Memorandum, Naval Air Station Moffett Field, Mountain View, California. July.

Quorum Environmental Consultants, Inc. (QEC). 1991. Letter Report of Tank Removal. Moffett Field NAS, Mountain View, California. August 16.

Regional Water Quality Control Board, San Francisco Bay Region (RWQCB). 1996. Supplemental Instruction to State Water Board December 8, 1995 Interim Guidance on Required Cleanup at Low Risk Fuel Sites. January 5.

Rice, D.W., B.P. Dooher, S.J. Cullen, L.G. Everett, W.E. Kastenberg, R.D. Grose, and M.A. Marino. 1995. Recommendations to Improve the Cleanup Process for California's Leaking Underground Fuel Tanks (LUFTs). Environmental Protection Department, Environmental Restoration Division, Lawrence Livermore National Laboratories. Livermore, California. October 16.

Sangines, E.M., D.W. Andersen, and A.V. Busing. 1995. Recent Geologic Studies in the San Francisco Bay Area. Symposium for the Society of Economic Paleontologists and Mineralogists (SEPM), Pacific Section. SEPM, Volume 76. May 3-5.

State Water Resources Control Board (SWRCB). 1995. Memorandum-Interim Guidance on Required Cleanup at Low Risk Fuel Sites. December 8.

SWRCB. 1996. Memorandum-Draft Policy for Cleanup of Petroleum Discharge. October 29.

Stout, A.S., A.D. Uhler, T.G. Naymik, and K.J. McCarthy. 1998. Environmental Forensics - Unraveling Site Liability. Environmental Science & Technology News. pp. 260-264. June 1.

Tetra Tech EM Inc. (TtEMI). 1997. Final Quality Assurance Project Plan, Long-term Groundwater Monitoring, Moffett Federal Airfield, California. October.

TtEMI. 1998. Final Basewide Petroleum Site Evaluation Methodology Technical Memorandum, Moffett Federal Airfield, California. October 2.

U.S. Environmental Protection Agency (EPA). 1994a. Guidance for the Data Quality Objectives Process. EPAQA/G-4. September.

EPA. 1994b. National Functional Guidelines for Inorganic Data Review. EPA 540/R-94/013. February.

EPA. 1995c. National Functional Guidelines for Organic Data Review. EPA 540/R-94/013. February.

FIGURES

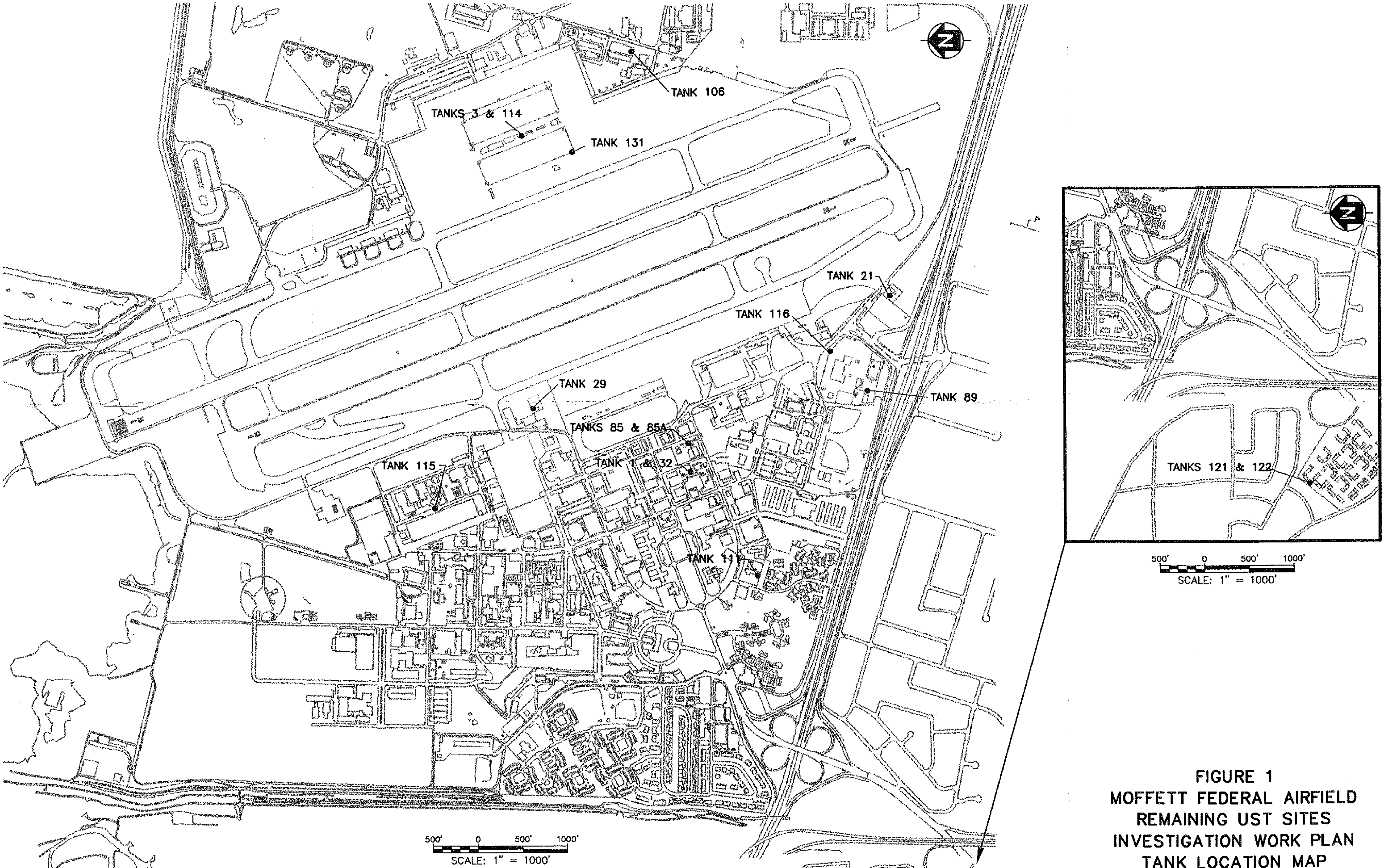
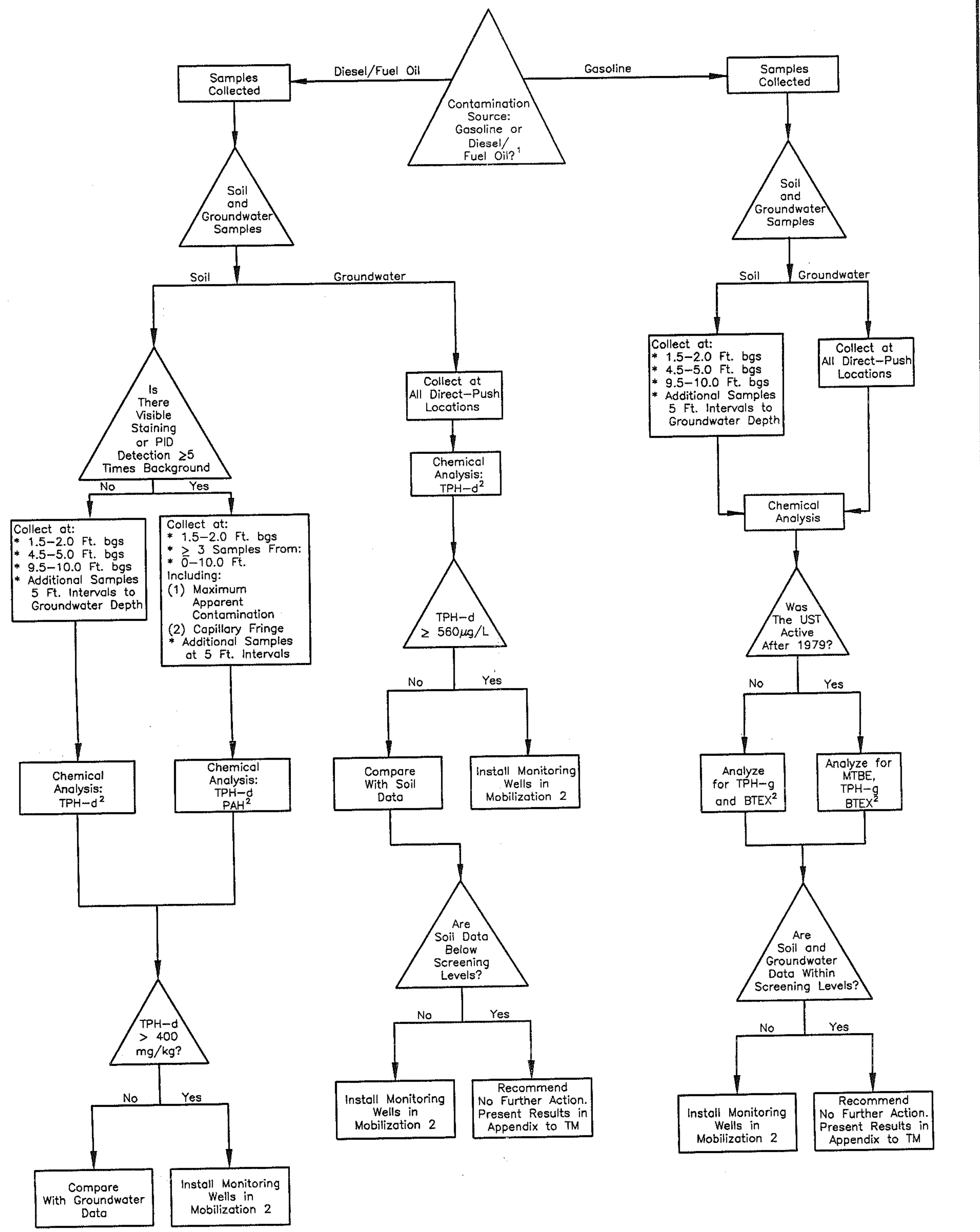


FIGURE 1
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK LOCATION MAP

DATE: 12/29/98 MVT DN FILE NAME: R:\089\2266\04\WORKPLAN\ALLSITES.DWG

DATE: 02/08/99 GWT DN FILE NAME: R:\069\226G\04\SAMP_PLAN.DWG

MOBILIZATION 1 DECISION FLOW CHART



NOTES:

1 IF CONTAMINATION SOURCE IS UNKNOWN, GASOLINE PATH WILL BE FOLLOWED. IN ADDITION TO THE STATED ANALYSES SOIL SAMPLES WILL BE ANALYZED FOR TPH–d AND PAH AND GROUNDWATER SAMPLES WILL BE ANALYZED FOR TPH–D.

2 IF OTHER COCs WERE DETECTED IN PREVIOUS INVESTIGATION ABOVE THE SCREENING LEVELS, ANALYSES WILL BE INCLUDED.

bgs	BELOW GROUND SURFACE
BTEX	BENZENE, TOLUENE, ETHYLBENZENE, XYLENES
COC	CHEMICAL OF CONCERN
Ft.	FEET
MTBE	METHYL TERTIARY BUTYL ETHER
mg/kg	MILLIGRAMS PER KILOGRAM
µg/L	MICROGRAMS PER LITER
PAH	POLYNUCLEAR AROMATIC HYDROCARBON
PID	PHOTOIONIZATION DETECTOR
ppm	PARTS PER MILLION
TM	BASEWIDE PETROLEUM SITE EVALUATION METHODOLOGY TECHNICAL MEMORANDUM
TPH–d	TOTAL PETROLEUM HYDROCARBONS AS DIESEL
TPH–g	TOTAL PETROLEUM HYDROCARBONS AS GASOLINE
UST	UNDERGROUND STORAGE TANK
VOC	VOLATILE ORGANIC COMPOUND

FIGURE 2
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
MOBILIZATION 1 DECISION FLOW CHART

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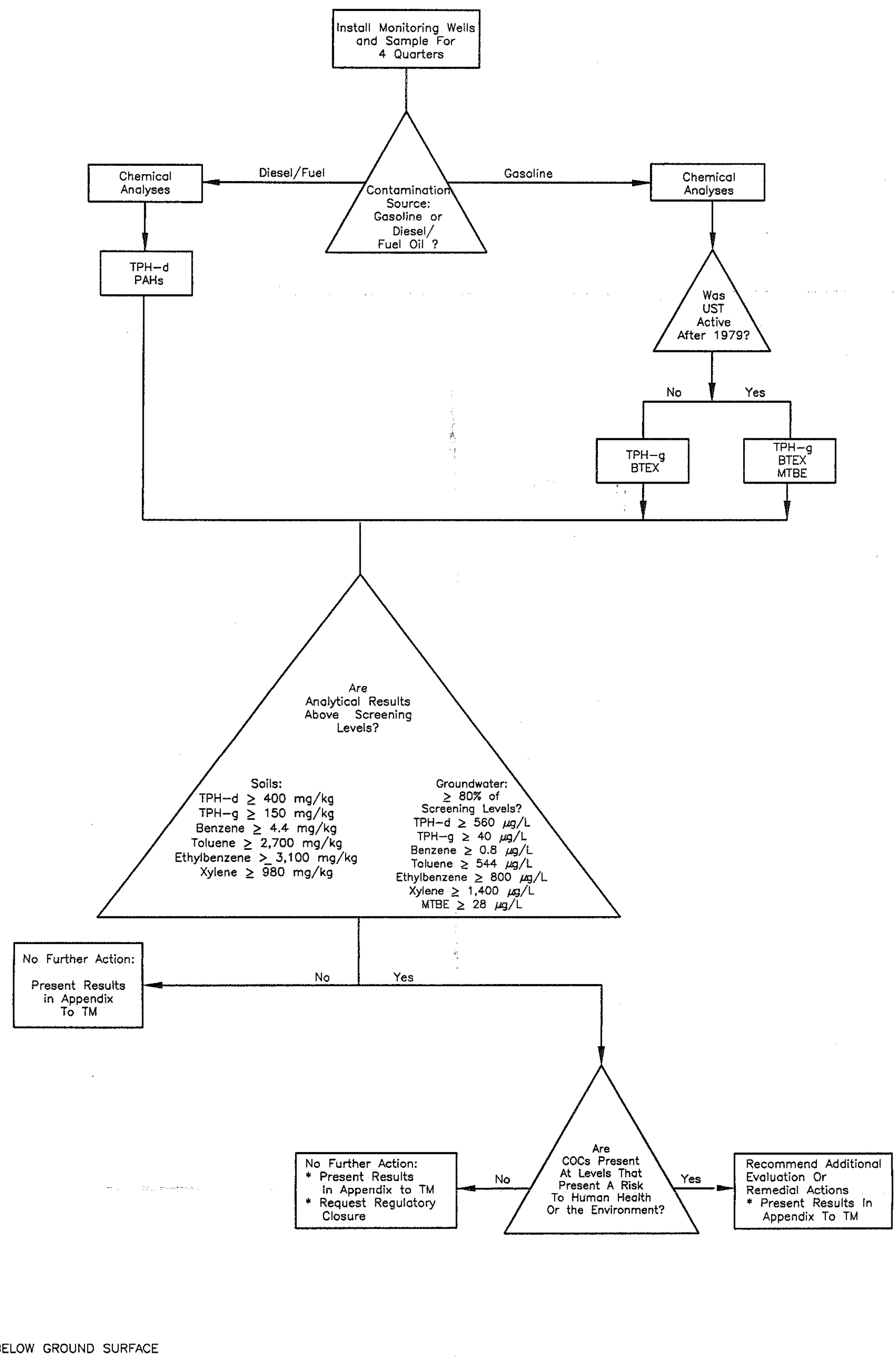
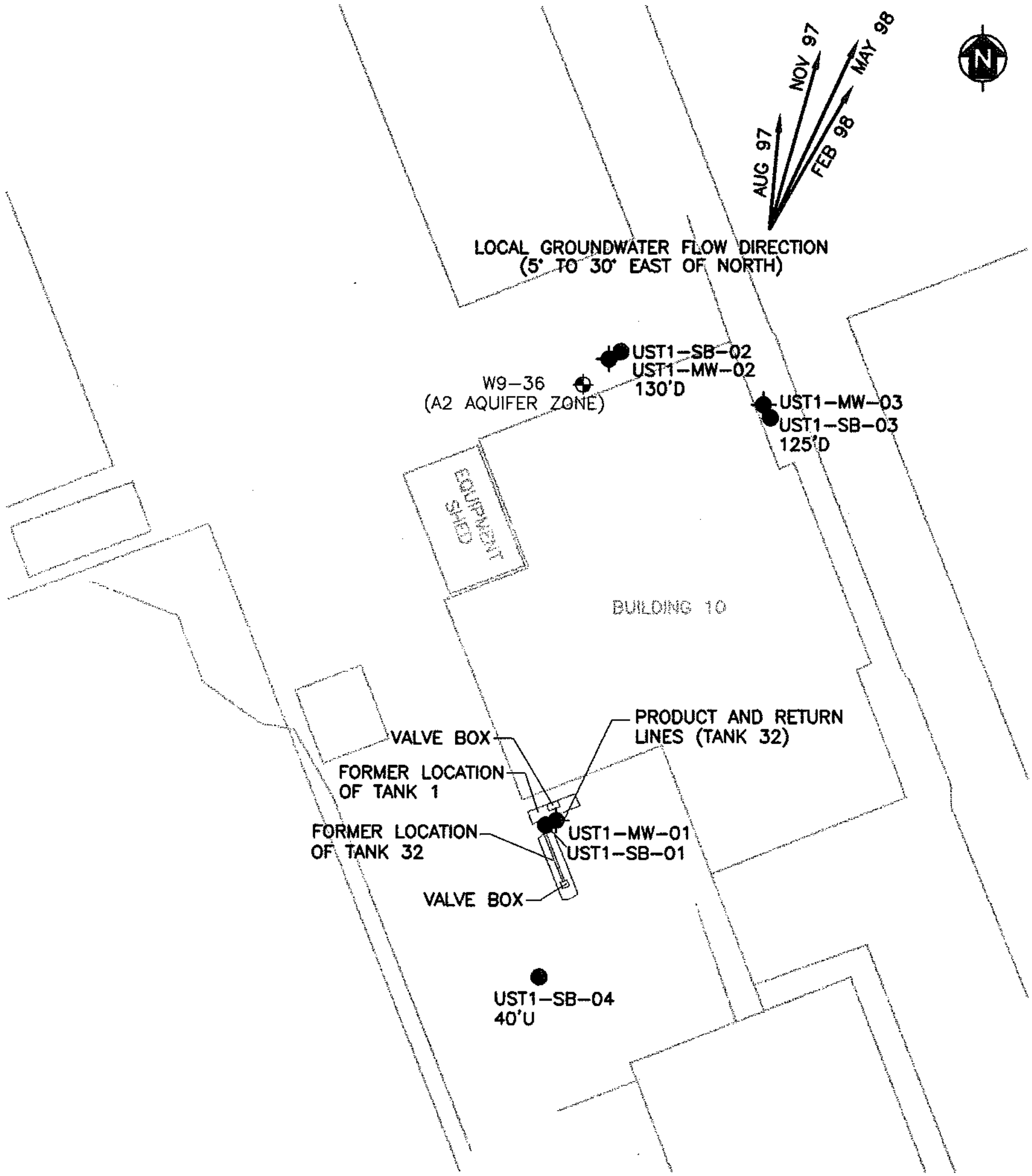
MOBILIZATION 2 DECISION FLOW CHART



NOTES:

bgs	BELOW GROUND SURFACE
BTEX	BENZENE, TOLUENE, ETHYLBENZENE, XYLENES
COC	CHEMICAL OF CONCERN
Ft.	FEET
MTBE	METHYL TERTIARY BUTYL ETHER
mg/kg	MILLIGRAMS PER KILOGRAM
µg/L	MICROGRAMS PER LITER
PAH	POLYNUCLEAR AROMATIC HYDROCARBON
ppm	PARTS PER MILLION
TM	BASEWIDE PETROLEUM SITE EVALUATION METHODOLOGY TECHNICAL MEMORANDUM
TPH–d	TOTAL PETROLEUM HYDROCARBONS AS DIESEL
TPH–g	TOTAL PETROLEUM HYDROCARBONS AS GASOLINE
UST	UNDERGROUND STORAGE TANK

FIGURE 3
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
MOBILIZATION 2 DECISION FLOW CHART



LEGEND

- EXISTING MONITORING WELL
- PROPOSED MONITORING WELL
- PROPOSED DIRECT-PUSH SAMPLE LOCATION
- 50'D DISTANCE DOWNGRADIENT
- 20'U DISTANCE UPGRADIENT

FIGURE 4
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANKS 1 AND 32 PROPOSED DIRECT-PUSH
SAMPLE AND MONITORING WELL LOCATIONS

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DATE: 02/08/99 DMF DN

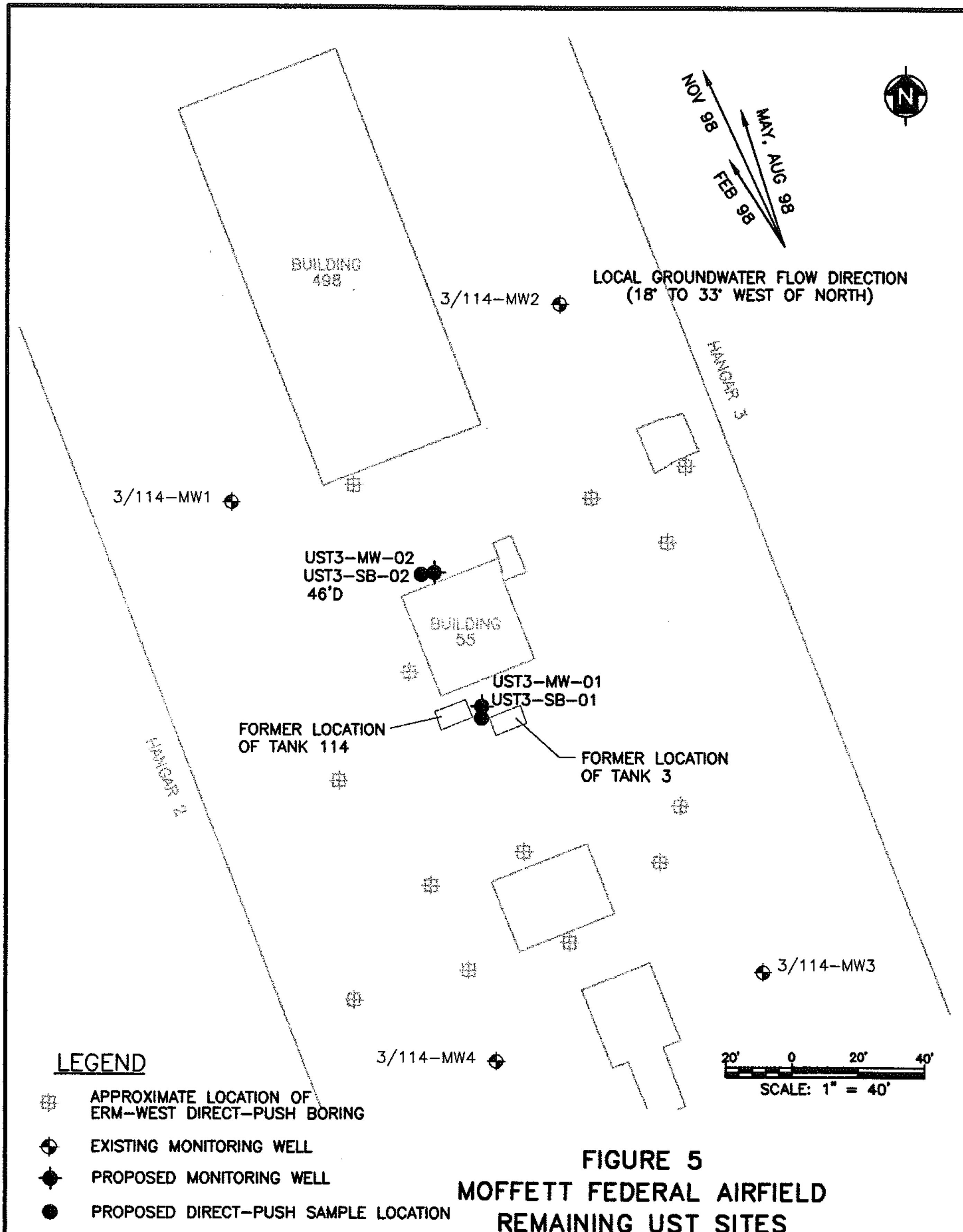
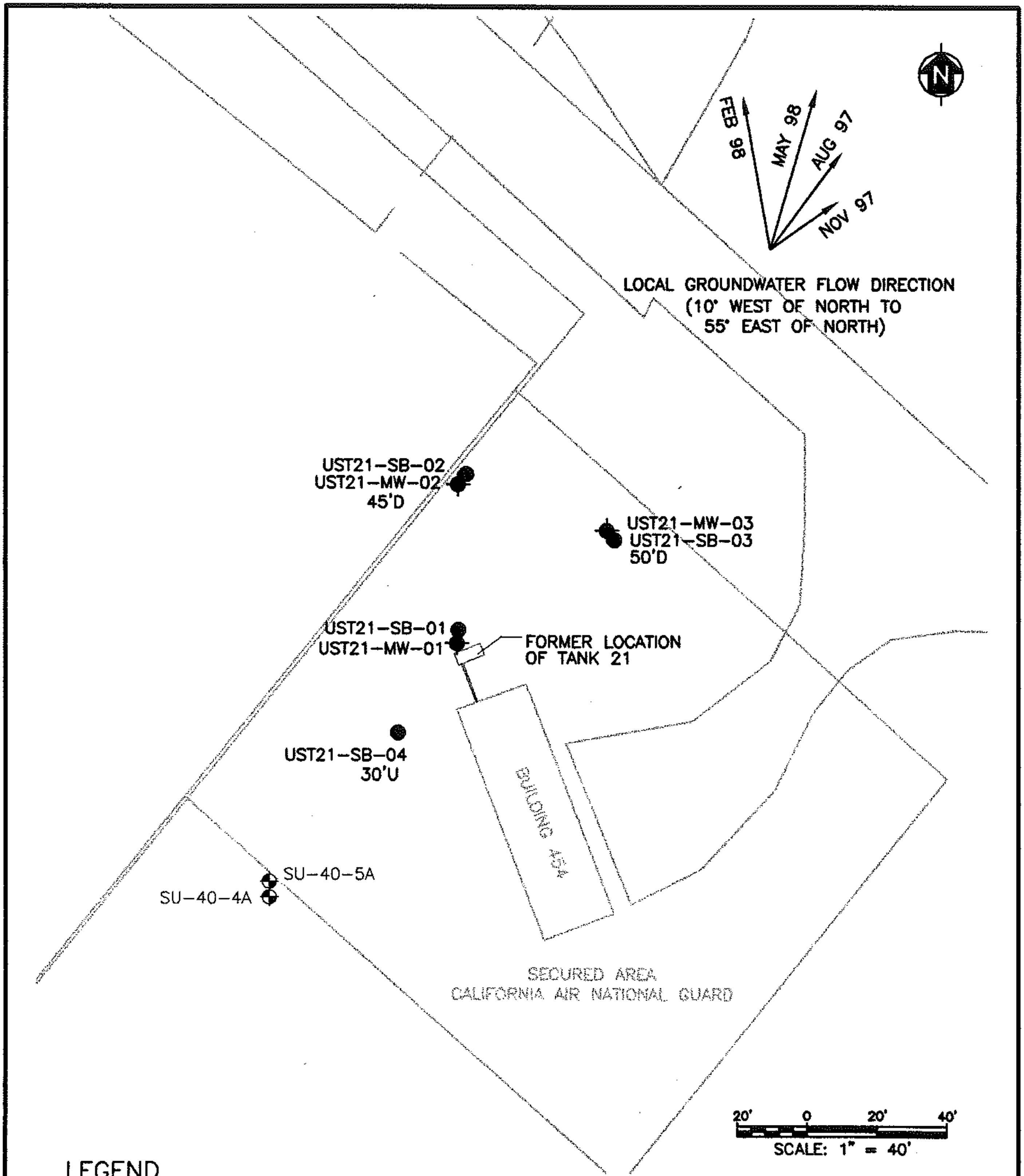


FIGURE 5
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANKS 3 AND 114 PROPOSED DIRECT-PUSH
SAMPLE AND MONITORING WELL LOCATIONS

DATE: 02/09/99 GWT DN FILE NAME: R:\069\2256\04\WORKPLAN\TANKS3-114.DWG



LEGEND

⊕	EXISTING MONITORING WELL
✦	PROPOSED MONITORING WELL
●	PROPOSED DIRECT-PUSH SAMPLE LOCATION
50'D	DISTANCE DOWNGRADIENT
20'U	DISTANCE UPGRADIENT

FIGURE 6
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK 21 PROPOSED DIRECT-PUSH
SAMPLE AND MONITORING WELL LOCATIONS

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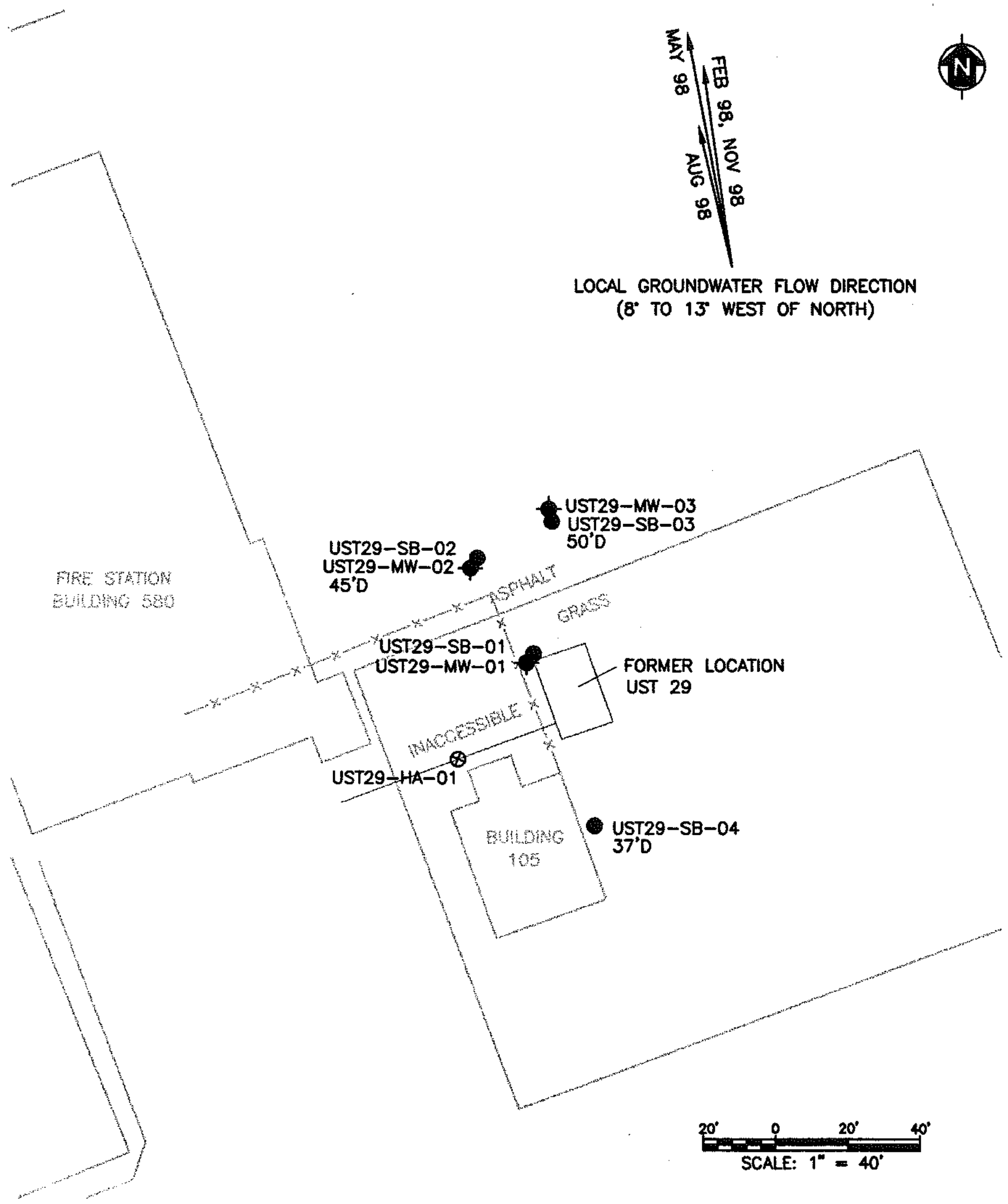
DATE: 02/08/99 DMF DN



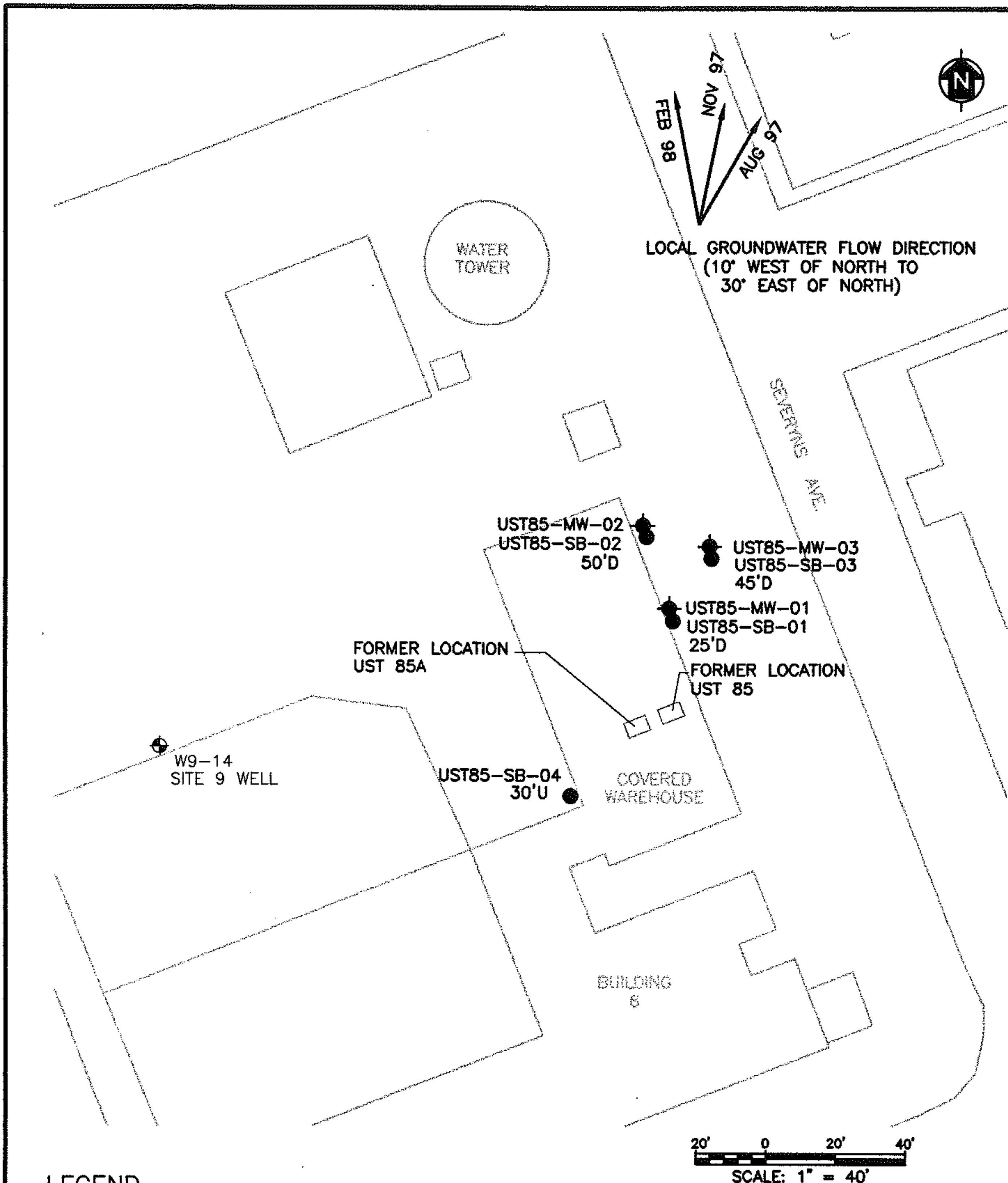
FILE NAME: R:\069\226G\04\WORKPLAN\TANK29.DWG

DATE: 02/15/99 DMF DN

LEGEND

- PROPOSED MONITORING WELL
- PROPOSED DIRECT-PUSH SAMPLE LOCATION
- ⊗ HAND AUGER SAMPLE LOCATION
- 50'D DISTANCE DOWNGRADIENT
- 20'U DISTANCE UPGRADIENT

FIGURE 7
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK 29 PROPOSED DIRECT-PUSH
SAMPLE AND MONITORING WELL LOCATIONS



FILE NAME: R:\069\226G\04\WORKPLAN\TANKS85-85A.DWG

LEGEND

- EXISTING MONITORING WELL
- PROPOSED MONITORING WELL
- PROPOSED DIRECT-PUSH SAMPLE LOCATION
- 50'D DISTANCE DOWNGRADIENT
- 20'U DISTANCE UPGRADIENT

DATE: 02/08/99 DMF DN

FIGURE 8
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANKS 85 AND 85A PROPOSED DIRECT-PUSH SAMPLE AND MONITORING WELL LOCATIONS

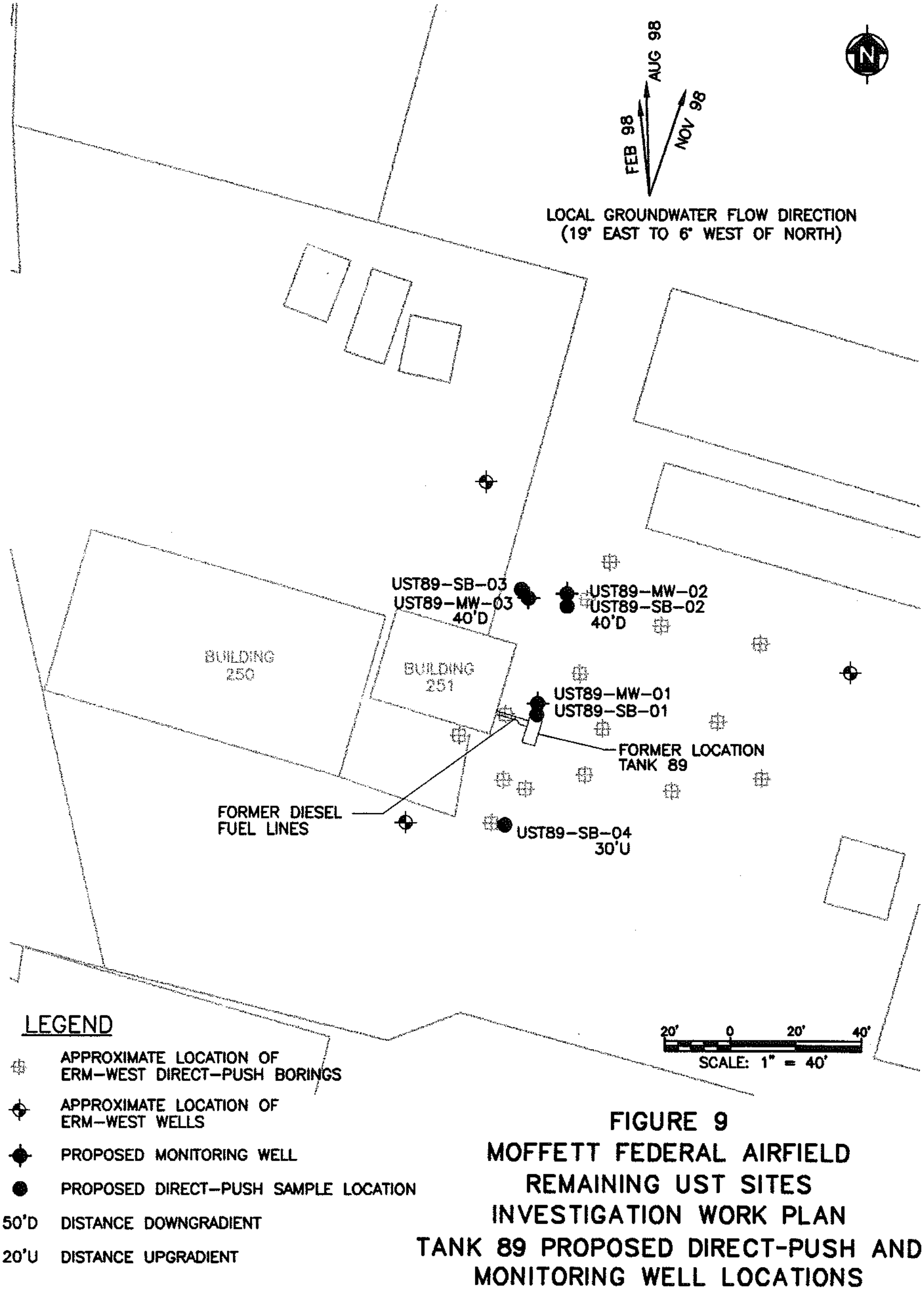
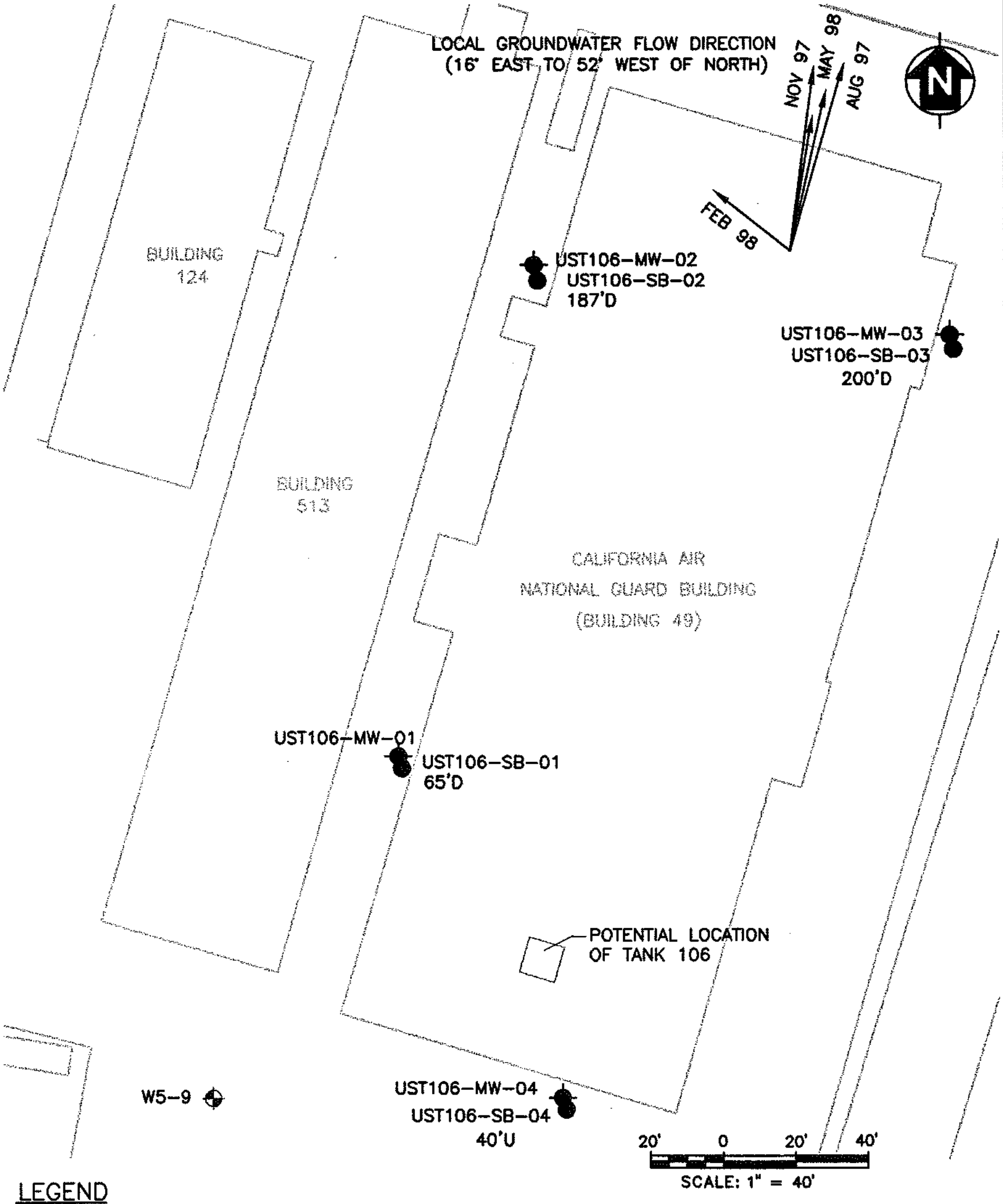


FIGURE 9
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK 89 PROPOSED DIRECT-PUSH AND MONITORING WELL LOCATIONS

FILE NAME: R:\089\226G\04\WORKPLAN\TANK89.DWG

DATE: 02/15/99 DMF DN

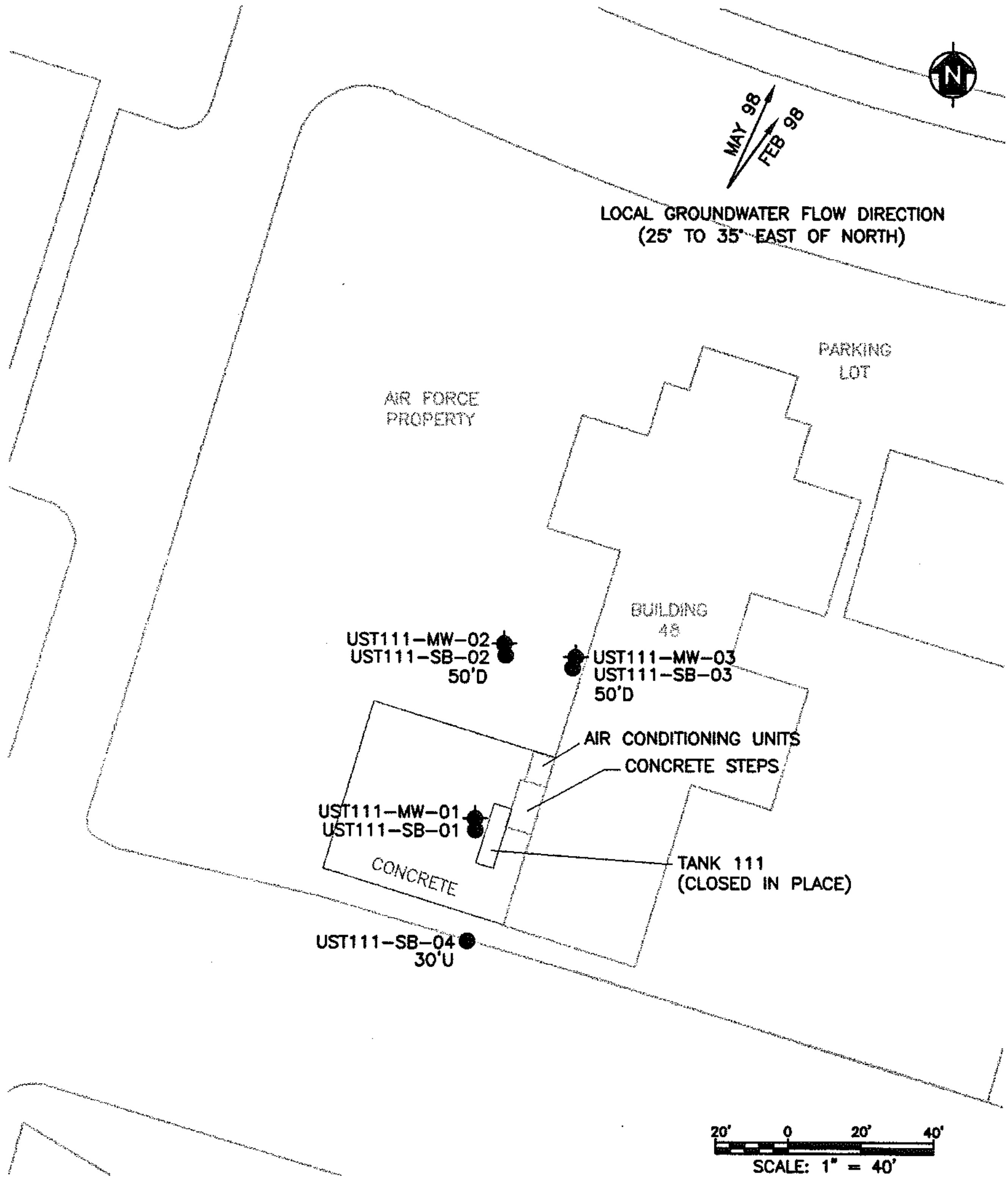


LEGEND

- EXISTING MONITORING WELL
- PROPOSED MONITORING WELL
- PROPOSED DIRECT-PUSH SAMPLE LOCATION
- 50'D DISTANCE DOWNGRADIENT
- 20'U DISTANCE UPGRADIENT

FIGURE 10
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK 106 PROPOSED DIRECT-PUSH
SAMPLE AND MONITORING WELL LOCATIONS

DATE: 02/08/99 DMF DN FILE NAME: R:\069\226G\04\WORKPLAN\TANK106.DWG



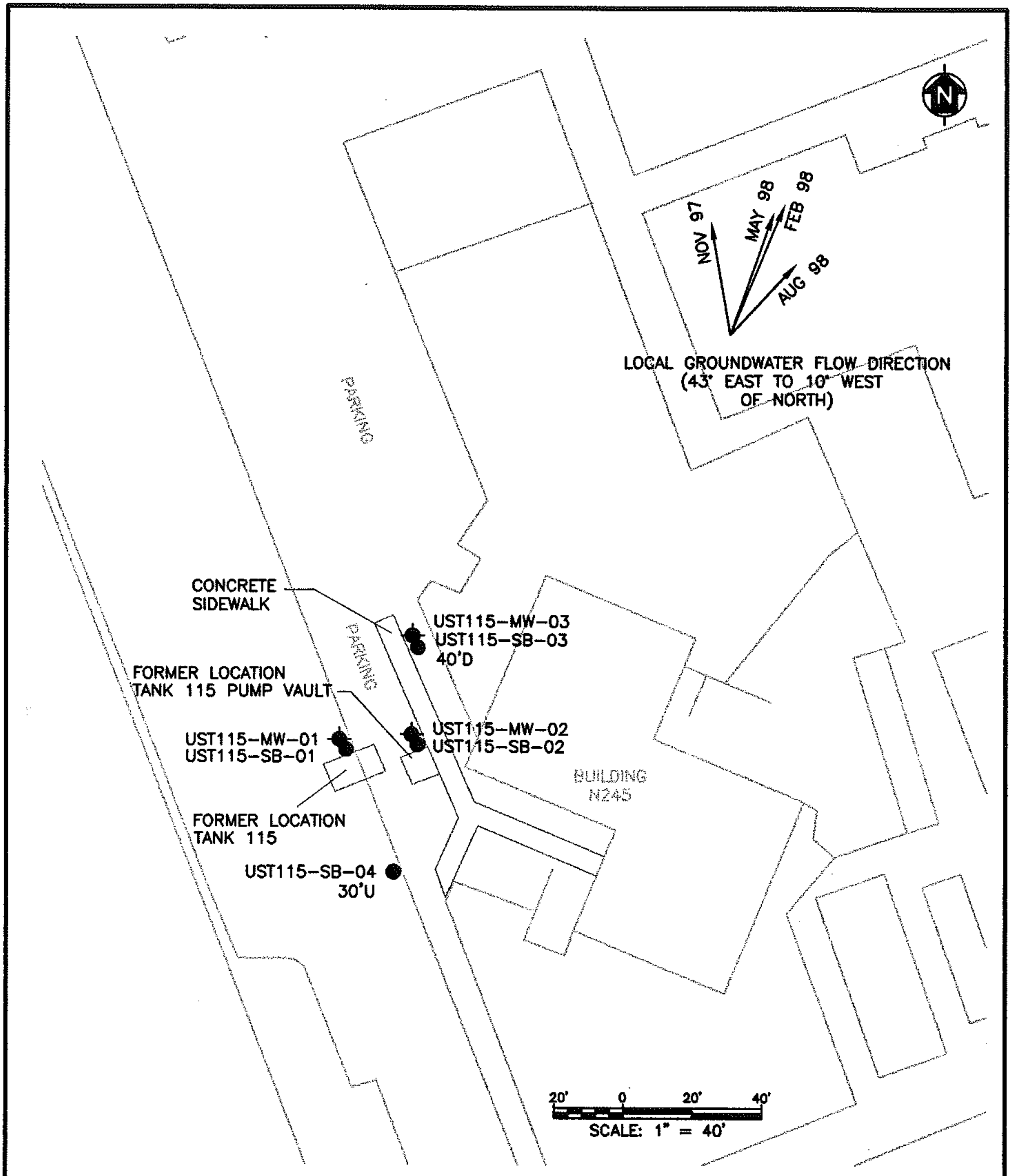
FILE NAME: R:\089\226G\04\WORKPLAN\TANK111.DWG

DATE: 02/15/99 DMF DN

LEGEND

- ◆ PROPOSED MONITORING WELL
- ● PROPOSED DIRECT-PUSH SAMPLE LOCATION
- 50'D DISTANCE DOWNGRADIENT
- 20'U DISTANCE UPGRADIENT

FIGURE 11
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK 111 PROPOSED DIRECT-PUSH
SAMPLE AND MONITORING WELL LOCATIONS



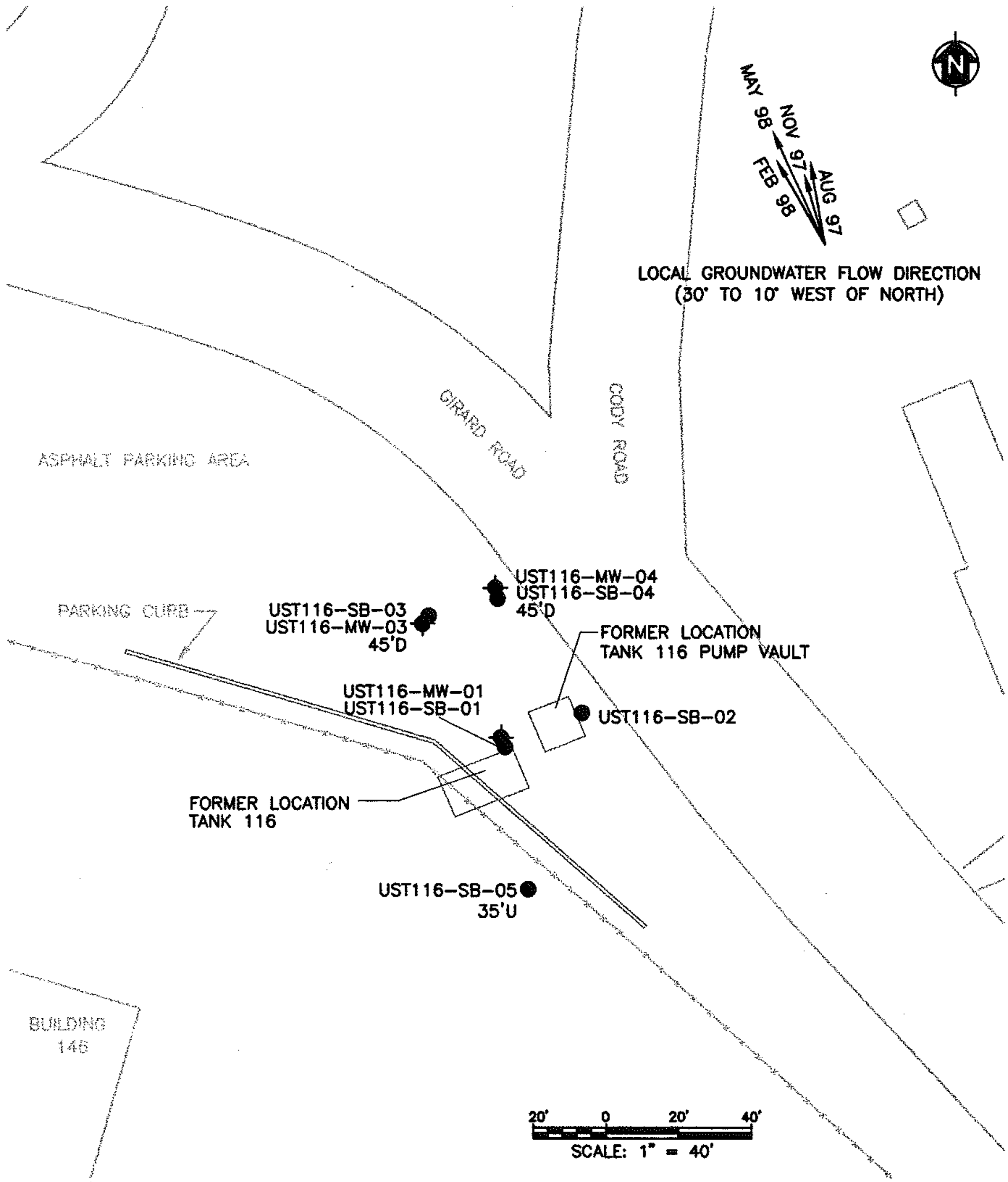
LEGEND

- PROPOSED MONITORING WELL
- PROPOSED DIRECT-PUSH SAMPLE LOCATION
- 50'D DISTANCE DOWNGRADIENT
- 20'U DISTANCE UPGRADIENT

FIGURE 12
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK 115 PROPOSED DIRECT-PUSH SAMPLE AND MONITORING WELL LOCATIONS

FILE NAME: R:\069\226G\04\WORKPLAN\TANK115.DWG

DATE: 02/08/99 DMF DN



LEGEND

✦	PROPOSED MONITORING WELL
●	PROPOSED DIRECT-PUSH SAMPLE LOCATION
50'D	DISTANCE DOWNGRADIENT
20'U	DISTANCE UPGRADIENT

FIGURE 13
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK 116 PROPOSED DIRECT-PUSH SAMPLE AND MONITORING WELL LOCATIONS

DATE: 02/08/99 DMF DN FILE NAME: R:\069\226G\04\WORKPLAN\TANK116.DWG

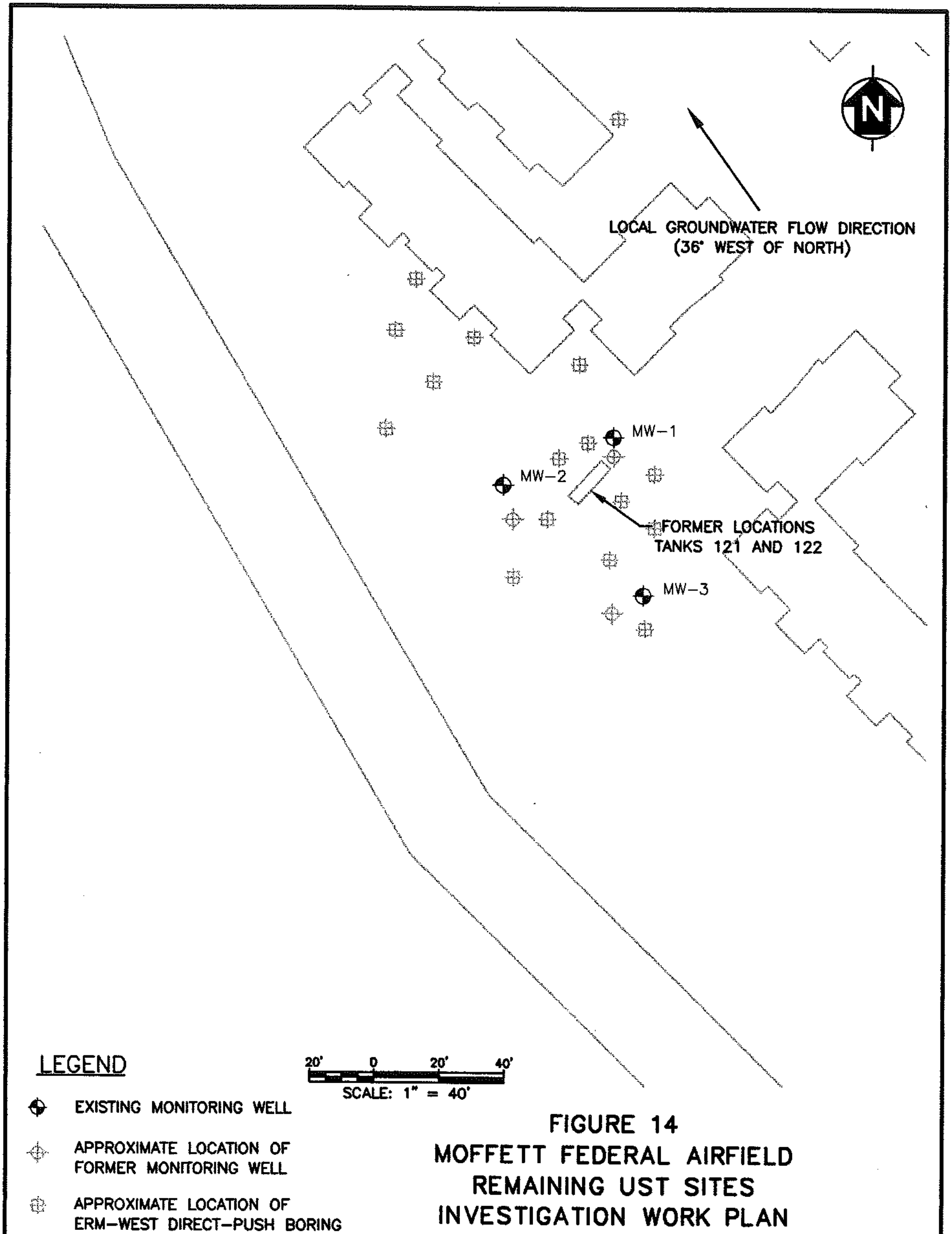


FIGURE 14
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANKS 121 AND 122 PROPOSED DIRECT-PUSH
SAMPLE AND MONITORING WELL LOCATIONS

FILE NAME: R:\069\2286\04\WORKPLAN\TANK121-122.DWG

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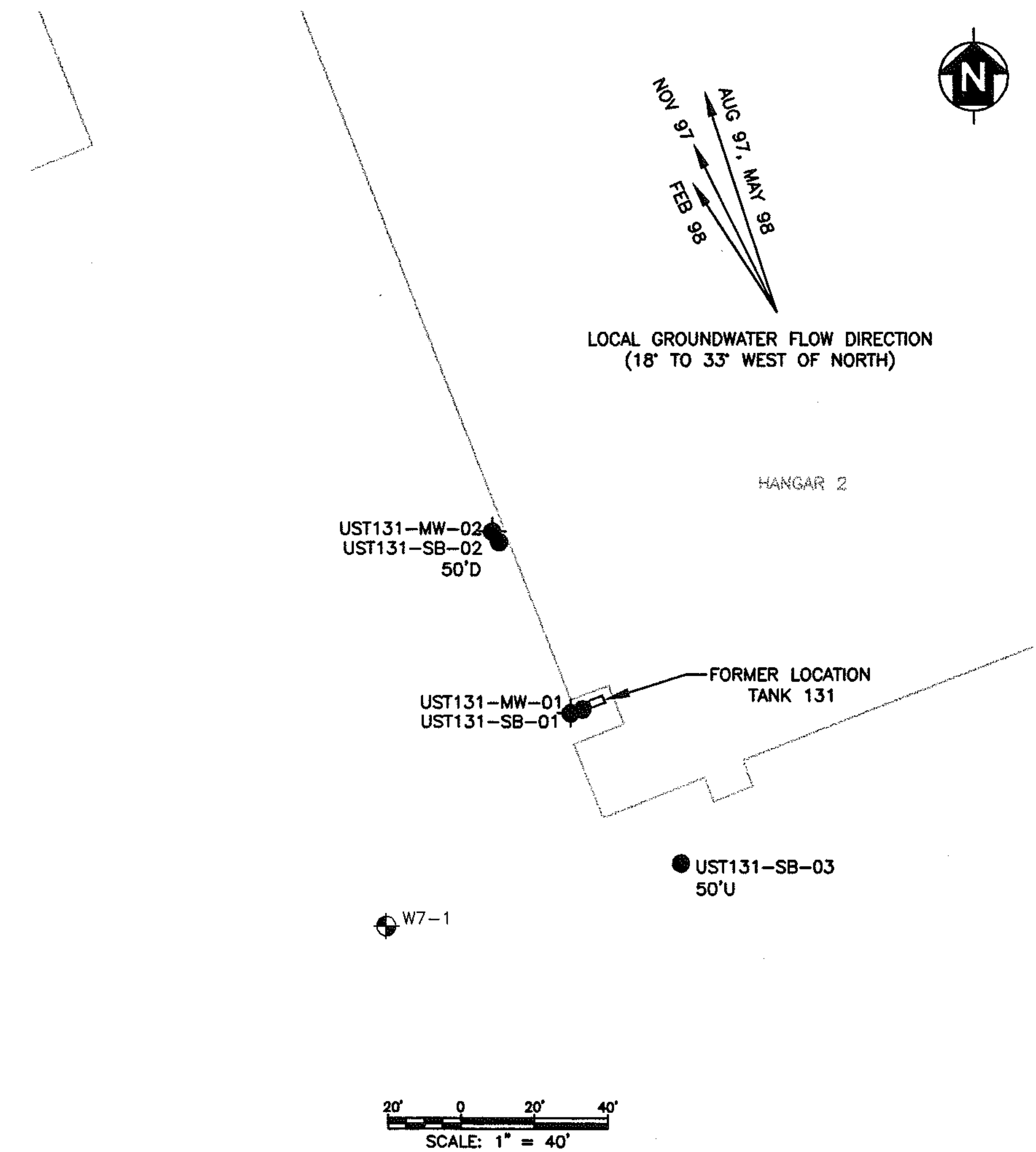

LEGEND

⊕	EXISTING MONITORING WELL
⊕	PROPOSED MONITORING WELL
●	PROPOSED DIRECT-PUSH SAMPLE LOCATION
50'D	DISTANCE DOWNGRADIENT
20'U	DISTANCE UPGRADIENT

FIGURE 15
MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES
INVESTIGATION WORK PLAN
TANK 131 PROPOSED DIRECT-PUSH
SAMPLE AND MONITORING WELL LOCATIONS

FILE NAME: R:\069\226G\04\WORKPLAN\TANK131.DWG

DATE: 02/08/99 DMF DN

TABLES

TABLE 1

MOFFETT FEDERAL AIRFIELD
REMAINING UST SITE INVESTIGATION WORK PLAN
INDIVIDUAL TANK DESCRIPTIONS

Tank Number	Capacity (gallons)	Historical Contents	Construction	Status	Date Installed	Date Removed
1	3,000	Diesel	Steel	Removed	1941	6/1/91
32	5,000	Diesel	Steel	Removed	Unknown	4/15/94
3	10,000	Fuel Oil	Fiberglass	Removed	1980	4/15/94
114	2,400	Fuel Oil	Concrete	Removed	Unknown	5/17/94
21	1,000	Diesel	Steel	Removed	Unknown	11/22/95
29	4,000	Diesel	Fiberglass	Removed	1983	12/15/93
85	1,000	Aviation Gasoline	Steel	Removed	1944	11/29/95
85A	1,000	Aviation Gasoline	Steel	Removed	Unknown	11/30/95
89	500	Diesel	Steel	Removed	1955	4/15/94
106	5,000	Gasoline	Unknown	Unknown	Unknown	Unknown
111	2,500	Fuel Oil	Steel	Closed in place	Unknown	11/22/95
115	5,000	Aviation Gasoline	Steel	Removed	1933	Unknown
116	5,000	Aviation Gasoline	Steel	Removed	1933	Unknown
121	250	Diesel	Steel	Removed	Unknown	10/9/87
122	500	Gasoline	Steel	Removed	Unknown	10/9/87
131	100	Gasoline	Steel	Removed	Unknown	11/21/95

TABLE 2

MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES INVESTIGATION WORK PLAN
PROPOSED SOIL AND GROUNDWATER SAMPLES

Sample Location	Contents	Other Identified COCs	Sample Type	No. of Sample Locations	TPH-d[1]	TPH-g[2]	BTEX[3]	VOCs[4]	MTBE[5]	PAH[6]	No. of MS/MSD[7]	No. of Field Duplicate (groundwater only)
Tanks 1 and 32	Diesel	None										
Mobilization 1												
			Soil	1	X					Δ		
			Groundwater	5	X							
Mobilization 2												
			Monitoring well	3	X					*		
Tanks 3 and 114	Fuel Oil	BTEX										
Mobilization 1												
			Soil	1	X	X	X			X	1	
			Groundwater	3	X	X	X				1	1
Mobilization 2												
			Monitoring well	3	*	*	*			*	1	1
Tank 21	Diesel	TPH-g, BTEX										
Mobilization 1												
			Soil	1	X	X	X			X		
			Groundwater	4	X	X	X					
Mobilization 2												
			Monitoring well	3	*	*	*			*		
Tank 29	Diesel	BTEX										
Mobilization 1												
			Soil	2	X	X	X			X		
			Groundwater	4	X	X	X					1
Mobilization 2												
			Monitoring well	3	*	*	*			*		1

TABLE 2 (continued)

MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES INVESTIGATION WORK PLAN
PROPOSED SOIL AND GROUNDWATER SAMPLES

Sample Location	Contents	Other Identified COCs	Sample Type	No. of Sample Locations	TPH-d[1]	TPH-g[2]	BTEX[3]	VOCs[4]	MTBE[5]	PAH[6]	No. of MS/MSD[7]	No. of Field Duplicate (groundwater only)
Tanks 85 and 85A	Gasoline and Unknown	Diesel										
Mobilization 1												
			Soil	0	Δ	Δ	Δ					
			Groundwater	4	X	X	X	X		X		1
Mobilization 2												
			Monitoring well	3	*	*	*	*		*		
Tank 89	Diesel	None										
Mobilization 1												
			Soil	1	X					Δ	1	
			Groundwater	4	X							1
Mobilization 2												
			Monitoring well	3	X					*		1
Tank 106	Gasoline/ Unknown	None										
Mobilization 1												
			Soil	0	Δ	Δ	Δ	Δ		Δ		
			Groundwater	4		X	X	X	X		1	
Mobilization 2												
			Monitoring well	3	*	X	X	*	*	*		
Tank 111	Fuel Oil	TPH-g										
Mobilization 1												
			Soil	1	X	X	X			X		
			Groundwater	4	X	X	X					
Mobilization 2												
			Monitoring well	3	*	*	*			*		

TABLE 2 (continued)

MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES INVESTIGATION WORK PLAN
PROPOSED SOIL AND GROUNDWATER SAMPLES

Sample Location	Contents	Other Identified COCs	Sample Type	No. of Sample Locations	TPH-d[1]	TPH-g[2]	BTEX[3]	VOCs[4]	MTBE[5]	PAH[6]	No. of MS/MSD[7]	No. of Field Duplicate (groundwater only)
Tank 115	Gasoline	None										
Mobilization 1			Soil	2		X	X					
			Groundwater	4		X	X					
Mobilization 2												
			Monitoring well	3		X	X					
Tank 116	Gasoline	None										
Mobilization 1												
			Soil	2		X	X					
			Groundwater	5		X	X					
Mobilization 2												
			Monitoring well	3		X	X					
Tanks 121 and 122	Diesel and Gasoline	None										
Mobilization 1												
			Soil	0								
			Monitoring well	3	X	X	X		X	X		
Mobilization 2												
			Monitoring well	3	*	*	*		*	*		
Tanks 131	Gasoline	TPH-d										
Mobilization 1												
			Soil	1	X	X	X			X		
			Groundwater	4	X	X	X		X		1	1
Mobilization 2												
			Monitoring well	4	*	*	*		*	*	1	1

TABLE 2 (continued)

MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES INVESTIGATION WORK PLAN
PROPOSED SOIL AND GROUNDWATER SAMPLES

Notes:

BTEX	Benzene, toluene, ethylbenzene, and xylene
COC	Chemical of concern
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTBE	Methyl tertiary butyl ether
PAH	Polynuclear aromatic hydrocarbon
PID	Photoionization detector
TPH-d	Total petroleum hydrocarbons - diesel
TPH-g	Total petroleum hydrocarbons - gasoline
VOC	Volatile organic compound
1	Analyzed by EPA Method 8015. Analysis will include TPH extractable as diesel and JP-5.
2	Analyzed by EPA Method 8015. Analysis will include TPH purgeable as gasoline.
3	Analyzed by EPA Method 8021.
4	Analyzed by EPA Method 8260.
5	Will be included in BTEX analysis, by EPA Method 8021.
6	Analyzed by EPA Method 8310.
7	For soil samples, all soil samples from the selected boring will be collected in duplicate for MS/MSD analysis. Five percent of samples will be submitted for MS/MSD analysis: 1 of 12 soil samples, 3 of 48 direct-push groundwater samples, and 2 of 37 monitoring well samples.
Δ	Will only be analyzed if observations or PID levels indicate the presence of COCs.
*	Will only be analyzed if detected in samples from Mo[illegible]ization 1.

TABLE 3

MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES INVESTIGATION WORK PLAN
SAMPLING NUMBERING TEMPLATE

Sampling Event Code	Site Code	Activity Code	Specific Location Code	Sample Depth
UST[1]	99[2]	AA[3]	BB[4]	99[5]

A- Alpha character only
B- Either alpha or numeric character
9- Numeric character only

1 Sampling Event Code. The sampling event code indicates the specific sampling event. For the remaining UST sites investigation, it will be UST.
2 Site code. The site code for samples at MFA will be designated by tank number.
3 Activity Code. The following activity codes may be used during the field investigation:

SB Soil boring sample
MW Monitoring well sample
HP Groundwater sample collected by direct push
EB Equipment blank
FB Field blank
TB Trip blank
DP Identified field duplicate

4 Specific location code. The specific location codes will correspond to the soil boring or other specific location designation. For example, soil boring 9 will be encoded "09." Blind duplicates will be assigned a "99" designation.
5 Depth designation. The depth designation indicates the depth from which a sample is collected. This part of the sample numbering template also provides the option of designating a depth range.

A soil sample taken at UST 32 from sample site 1 between 4.5 and 5 feet will be designated:

UST32-SB01-4.5-5.0

TABLE 4

MOFFETT FEDERAL AIRFIELD
REMAINING UST SITES INVESTIGATION WORK PLAN
SAMPLE CONTAINERS, VOLUMES, AND PRESERVATIVES

Soil Sampling Analytes					
	TPH-p	**TPH-e**	**BTEX**	**MTBE**	**PAHs**
EPA Test Method	8015	8015	8021	8021	8310
Container	brass liner	1, 8-ounce glass	brass liner	#	1, 8-ounce glass
Preservation	Cool to 4°C	Cool to 4°C	Cool to 4°C	Cool to 4°C	Cool to 4°C
Holding Time (days)	14	14	14	21	14
Detection Limit	0.5 mg/kg	10 mg/kg	0.5 (1.5 for xylene) μg/kg	25 μg/kg	2 to 40 μg/kg

Groundwater Sampling Analytes						
	TPH-p	**TPH-e**	**BTEX**	**VOCs**	**MTBE**	**PAHs**
EPA Test Method	8015	8015	8021	8260	8021	8310
Container	2, 40-mL VOA vials	2, 1-L Amber glass	3, 40-mL VOA vials	3, 40-mL VOA vials	#	2, 1 L Amber glass
Preservation	HCl pH<2	Cool to 4°C	HCl pH<2	HCl pH<2	HCl pH<2	Cool to 4°C
Holding Time (days)	14	7	14	14	14	7
Detection Limit	50 μg/L	100 μg/L	0.5 (1.5 for xylene) μg/L	5 μg/L	5 μg/L	2 to 40 μg/L

Notes:

#	Sample will be taken from the container for the BTEX analysis
BTEX	Benzene, toluene, ethylbenzene, and xylene
HCl	Hydrochloric acid
L	Liter
MTBE	Methyl tertiary butyl ether
μg/kg	microgram per kilogram
mg/kg	milligram per kilogram
mg/L	milligram per liter
mL	Milliliter
μg/L	microgram per liter
PAH	Polynuclear aromatic hydrocarbon
TPH-e	Total petroleum hydrocarbons-extractable
TPH-p	Total petroleum hydrocarbons-purgeable
VOA	Volatile organic analysis
VOC	Volatile organic compound

APPENDIX A

Originated by: ______________________

Company Name: ______________________

DATABASE UPDATES

Date: ______________________

Document Control No.: ______________________ (to be assigned by document control)

→ ***SUBMIT ALL UPDATES TO: TtEMI, DENVER attn: DOCUMENT CONTROL*** ←

POINT NAME (e.g. Well name)	SAMPLE ID	SAMPLE DATE (Provide both dates if known. At least 1 date is required to update a record)	DATE RECD. BY LAB	DATA ITEM TO CHANGE (see Instructions)	OLD VALUE	NEW VALUE	SUPPORTING DOCUMENTATION (or detailed reason for change if no documentation is available. Use the back of this page if more room is needed)

INSTRUCTIONS: All updates require supporting documentation. If none is available, then supply a detailed explanation for the requested change in the "Supporting Documentation" column. Use the back of this sheet if additional space is needed. When requesting a change to the database, complete the "Point Name" column with the appropriate well name, sump name, tank location etc. Complete the "Sample Id" column with the name of the sample as written on the chain of custody record. Enter the sample date or the date the sample was received by the analytical laboratory into the "Sample Date" or "Date Recd. by Lab" columns. Sample date is preferred over the date received by the laboratory but supplying both dates is the most beneficial. Specifically indicate the "Data Item to Change" and the "Old Value" and "New Value". For example if you want to change the zinc qualifier code for sample MW61-1(12.0) collected at well W61-1 on 10/19/91 from a "U" to a "J" qualifier, complete this form as follows and attach the supporting documentation:

W61-1	MW61-1(12.0)	10/19/91	10/21/91	Zinc qualifier code	U	J	Inorganic Analyses Data Sheet

Accepted by: ______________________ Date: __________

Accepted by: ______________________ Date: __________

Accepted by: ______________________ Date: __________

Accepted by: ______________________ Date: __________

Accepted by: ______________________ Date: __________

Tetra Tech EM Inc.

MICRO-PURGING GROUND WATER SAMPLING DATA SHEET

PAGE ____ OF ____

DATE ____________

WELL NAME ____________

PROJECT ____________

PROJECT No. ____________

WELL LOCATION ____________

SAMPLE DATE ____________

SAMPLING PERSONNEL ____________

SAMPLE ID ____________

DUPLICATE ID ____________

SCREEN INTERVAL ____________

STATION ELEVATION ____________ GND ___ TOC ___

STATIC WATER LEVEL(from TOC) ____________

WELL STICK UP ____________

STATIC ELEVATION ____________

WELL DEPTH ____________ MEAS ___ RPTD ___

FEET OF WATER ____________

GALLONS/FOOT ____________

CASING VOLUME ____________

IMMISCIBLE PHASES PRESENT YES ___ NO ___

TYPE ____________

MEASURED WITH ____________

PID READINGS (backgrnd) ____________

PID READINGS (TOC) ____________

WELL INSTALLED BY ____________

INSTALLATION DATE ____________

DEVELOPMENT DATE(S) ____________

FIELD CHEMISTRY CALIBRATIONS

DATE/TIME ____________ SPEC. CONDUCTANCE: STANDARD ________ UMHOS/CM AT 25C READING ________ UMHOS/CM AT ____

pH: pH 4.00 = ________ AT ________ C pH 7.00 = ________ AT ________ C pH 10.00 = ________ AT ________ C SLOPE ________

DISSOLVED OXYGEN: D.O. METER ________ MG/L AT ____ C PID: CALIBRATION GAS ________ PPM ________ SPAN ________ READING ________

PURGING

TIME	DISCHARGE RATE (mL/min)	DISSOLVED OXYGEN (MG/L)	pH	Eh/ORP (mV)	TEMP (C)	SPECIFIC CONDUCT. (UMHOS/CM AT C)	TURBID. (NTU)	CUMULATIVE VOL. OF WATER REMOVED (PURGED) Liters	CASING VOLS	PID/OVA READING LOCATION	VALUE	DEPTH TO WATER (Ft)	COMMENTS

SAMPLE PARAMETERS

CONDITION OF WELL: ____________

REMARKS ____________

FIELD EQUIPMENT

pH METER ____________ SERIAL NUMBER ____________

SPEC. COND. METER ____________ SERIAL NUMBER ____________

PUMP ____________ SERIAL NUMBER ____________

WATER LEVEL METER ____________ SERIAL NUMBER ____________

D. O. METER ____________ SERIAL NUMBER ____________

FILTER APPARATUS ____________ FILTERS ____________

TEMPERATURE MEASURE ____________

INTERFACE PROBE ____________ SERIAL NUMBER ____________

PID/OVA ____________ SERIAL NUMBER ____________

FIELD CHEMISTRY CALIBRATIONS

FRACTIONS ____________

NUMBER OF BOTTLES ____________

SAMPLE DEPTH ____________

FIELD NOTEBOOK ____________

SAMPLE METHOD ____________

DISCHARGE WATER CONTAINERIZED

YES ________ NO ________

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BOREHOLE LOG

Tetra Tech EM Inc.

SHEET ____ OF ____

LOCATION OF BOREHOLE	JOB NO.:	BOREHOLE DESIGNATION:
	CLIENT:	SURFACE ELEVATION:
	SITE:	DEPTH TO WATER:
	SUBSITE:	LOGGED BY:
	DRILLING CO.:	DRILLING DATE(S):
	DRILLING PERSONNEL/METHOD:	

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
											1		
											2		
											3		
											4		
											5		
											6		
											7		
											8		
											9		
											0		
											1		
											2		
											3		
											4		
											5		
											6		
											7		
											8		
											9		
											0		

Tetra Tech EM Inc.

GROUND WATER SAMPLING DATA SHEET

PAGE ____ OF ____

WELL NAME ________

DATE ________

PROJECT ________

PROJECT No. ________

WELL LOCATION ________

SAMPLE DATE ________

SAMPLING PERSONNEL ________

SAMPLE ID ________

DUPLICATE ID ________

STATION ELEVATION ________ GND ___ TOC ___

STATIC WATER LEVEL(from TOC) ________

WELL STICK UP ________

STATIC ELEVATION ________

WELL DEPTH ________ MEAS ___ RPTD ___

FEET OF WATER ________

GALLONS/FOOT ________

CASING VOLUME ________

IMMISCIBLE PHASES PRESENT YES ___ NO ___

TYPE ________

MEASURED WITH ________

PID READINGS (backgrnd) ________

PID READINGS (TOC) ________

WELL INSTALLED BY ________

INSTALLATION DATE ________

DEVELOPMENT DATE(S) ________

FIELD CHEMISTRY CALIBRATIONS

DATE/TIME ________ SPEC. CONDUCTANCE: STANDARD ________ UMHOS/CM AT 25C READING ________ UMHOS/CM AT ___

pH: pH 4.00 = ________ AT ________ C pH 7.00 = ________ AT ________ C pH 10.00 = ________ AT ________ C SLOPE ________

DISSOLVED OXYGEN: D.O. METER ________ MG/L AT ____ C PID: CALIBRATION GAS ________ PPM ________ SPAN ________ READING ________

	TIME	DISCHARGE RATE (GPM)	DISSOLVED OXYGEN (MG/L)	pH	Eh/ORP	TEMP (C)	SPECIFIC CONDUCT. (UMHOS/CM AT C)	TURBID. (NTU)	CUMULATIVE VOL. OF WATER REMOVED (PURGED) GALLONS	CASING VOLS	PID/OVA READING LOCATION	VALUE	COMMENTS
PUMPED													
BAILED													

PUMPED PARAMETERS STABLE (Y/N) | PUMPED=BAILED PARAMETERS (Y/N) | CONDITION OF WELL: ________

REMARKS ________

FIELD EQUIPMENT

pH METER ________ SERIAL NUMBER ________

SPEC. COND. METER ________ SERIAL NUMBER ________

PUMP ________ SERIAL NUMBER ________

BAILER ________ SIZE ________

WATER LEVEL METER ________ SERIAL NUMBER ________

D. O. METER ________ SERIAL NUMBER ________

FILTER APPARATUS ________ FILTERS ________

TEMPERATURE MEASURE ________

INTERFACE PROBE ________ SERIAL NUMBER ________

PID/OVA ________ SERIAL NUMBER ________

FIELD CHEMISTRY CALIBRATIONS

FRACTIONS ________

NUMBER OF BOTTLES ________

SAMPLE DEPTH ________

FIELD NOTEBOOK ________

SAMPLE METHOD ________

DISCHARGE WATER CONTAINERIZED

YES ________ NO ________

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Tetra Tech EM Inc.

MICRO-PURGING GROUND WATER SAMPLING DATA SHEET

PAGE ____ OF ____

DATE ____________

WELL NAME ____________

PROJECT ____________

PROJECT No. ____________

WELL LOCATION ____________

SAMPLE DATE ____________

SAMPLING PERSONNEL ____________

SAMPLE ID ____________

DUPLICATE ID ____________

SCREEN INTERVAL ____________

STATION ELEVATION ____________ GND ___ TOC ___

STATIC WATER LEVEL(from TOC) ____________

WELL STICK UP ____________

STATIC ELEVATION ____________

WELL DEPTH ____________ MEAS ___ RPTD ___

FEET OF WATER ____________

GALLONS/FOOT ____________

CASING VOLUME ____________

IMMISCIBLE PHASES PRESENT YES ___ NO ___

TYPE ____________

MEASURED WITH ____________

PID READINGS (backgrnd) ____________

PID READINGS (TOC) ____________

WELL INSTALLED BY ____________

INSTALLATION DATE ____________

DEVELOPMENT DATE(S) ____________

FIELD CHEMISTRY CALIBRATIONS

DATE/TIME ____________ SPEC. CONDUCTANCE: STANDARD ________ UMHOS/CM AT 25C READING ________ UMHOS/CM AT ___ C

pH: pH 4.00 = ________ AT ________ C pH 7.00 = ________ AT ________ C pH 10.00 = ________ AT ________ C SLOPE ________

DISSOLVED OXYGEN: D.O. METER ________ MG/L AT ____ C PID: CALIBRATION GAS ________ PPM ________ SPAN ________ READING ________

PURGING

TIME	DISCHARGE RATE (mL/min)	DISSOLVED OXYGEN (MG/L)	pH	Eh/ORP (mV)	TEMP (C)	SPECIFIC CONDUCT. (UMHOS/CM AT C)	TURBID. (NTU)	CUMULATIVE VOL. OF WATER REMOVED (PURGED) Liters	CASING VOLS.	PID/OVA READING LOCATION	VALUE	DEPTH TO WATER (Ft)	COMMENTS

SAMPLE PARAMETERS

CONDITION OF WELL: ____________

REMARKS ____________

FIELD EQUIPMENT

pH METER ____________ SERIAL NUMBER ____________

SPEC. COND. METER ____________ SERIAL NUMBER ____________

PUMP ____________ SERIAL NUMBER ____________

WATER LEVEL METER ____________ SERIAL NUMBER ____________

D. O. METER ____________ SERIAL NUMBER ____________

FILTER APPARATUS ____________ FILTERS ____________

TEMPERATURE MEASURE ____________

INTERFACE PROBE ____________ SERIAL NUMBER ____________

PID/OVA ____________ SERIAL NUMBER ____________

FIELD CHEMISTRY CALIBRATIONS

FRACTIONS ____________

NUMBER OF BOTTLES ____________

SAMPLE DEPTH ____________

FIELD NOTEBOOK ____________

SAMPLE METHOD ____________

DISCHARGE WATER CONTAINERIZED

YES ________ NO ________

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Date Received: ____________

SDG Nos.: ____________

Page: ______ of ______

Case Narrative Included (Y/N): ______

CHEMICAL DATA TRANSFER LIST

PRC/JMM SAMPLE ID	SAMPLE DATE	METHOD CODES								VALIDATION COMPANY	COMMENTS
		VALIDATION STATUS / LEVEL									
TOTAL NO. OF SAMPLES: ______										TOTAL PAGES: ______	

Originated by: ____________ Date: ______

Entered into MOFFDOCS by: ____________ Date: ______

Entered into SAMTRAK by: ____________ Date: ______

Entered to database by: ____________ Date: ______

P = PENDING VALID. C = VALID. COMPLETE U = VALID. STATUS UNKNOWN R = RETURNED TO LAB. N = NO VALID. CONDUCTED
1 = NEESA LEVEL A 2 = NEESA LEVEL B 3 = NEESA LEVEL C 4 = NEESA LEVEL D 5 = NEESA LEVEL E

NOTE: Please return this form signed and dated to: PRC Denver, attn: Moffett Field Document Control, after the data has been entered into the Moffett database.

C:\FORMS\TRANSFER.FRM mjb 02-08-92

Date: ____________
Date for week ending: __________
Field team leader: ____________________

Page: ______ of ______
Batch No. ______________
To be assigned by Document Control

FIELD FORMS TRANSFER LIST

CHAIN OF CUSTODY RECORD (enter the 1st sample Id. listed on ea. COC)	EXTENDED CHAIN OF CUSTODY FORM (enter the 1st sample Id. listed on ea. form)	GROUNDWATER SAMPLING DATA SHEET or GRAB SAMPLE FORM (enter location name from the top of ea. sheet)	NEW LOCATION FORM (enter location name from the top of ea. sheet)
TOTAL PAGES:	TOTAL PAGES:	TOTAL PAGES:	TOTAL PAGES:

Originated by: ______________________________ Date: __________

Entered into SAMTRAK by: ______________________________ Date: __________

Entered into Document Tracking by: ______________________________ Date: __________

Entered to database by: ______________________________ Date: __________

TETRA TECH EM Inc.

DAILY QUALITY CONTROL REPORT

NAVAL AIR WEAPONS STATION CHINA LAKE	DATE:	TEMPERATURE:
	DAY:	WIND:
	WEATHER:	HUMIDITY:

PROJECT:

CONTRACT NUMBER:

PRC PROJECT NUMBER:

SUBCONTRACTORS ON SITE

PERSONNEL ON SITE

FIELD TEAM LEADER:

EQUIPMENT ON SITE:

WORK PERFORMED (INCLUDING SAMPLING)

QUALITY CONTROL ACTIVITIES:

HEALTH AND SAFETY LEVELS AND ACTIVITIES:

PROBLEMS ENCOUNTERED/CORRECTIVE ACTION TAKEN:

ENVIRONMENTAL MANAGEMENT, INC. **DAILY QUALITY CONTROL REPORT**

DEVIATIONS FROM FIELD WORK PLAN:

SPECIAL NOTES:

TOMORROW'S EXPECTATIONS:

DISTRIBUTION:	**SUBMITTED BY:**

TETRA TECH EM INC.

MONITORING WELL INSTALLATION RECORD
FLUSH MOUNT INSTALLATION

WELL LOCATION INFORMATION

WELL NO. ____________
BOREHOLE NO. ____________
SITE ____________
SUBSITE ____________
DATE ____________
RECORDED BY ____________
WELL PERMIT NO. ____________

SURFACE COMPLETION INFORMATION

TYPE OF INSTALLATION
- ☐ OPEN HOLE
- ☐ INSIDE HOLLOW STEM AUGER

TYPE OF FLUSH MOUNT
- ☐ CHRISTY BOX
- ☐ ____________
- ☐ LOCKING COVER
- ☐ WATERTIGHT CAP
- ☐ LOCKING CAP

SURFACE SEAL
- ☐ NON-SHRINKING CEMENT
- ☐ CONCRETE
- ☐ ____________
- ☐ CHECKED FOR SETTLEMENT
- ☐ INTERNAL MORTAR ADDED

GROUND SURFACE ELEVATION
- ☐ SURVEYED

DATE ____________

MEASURING POINT
- ☐ TOP OF WELL CASING
- ☐ GROUND SURFACE
- ☐ ____________

DRILLING INFORMATION

DRILLING COMPANY/PERSONNEL
____
____
____

DRILL RIG ____________

DRILLING METHOD
- ☐ HOLLOWSTEM AUGER
- ☐ AIR ROTARY
- ☐ MUD/WATER ROTARY
- ☐ ____________

DRILLING BEGAN
DATE ______ TIME ______

WELL COMPLETION BEGAN
DATE ______ TIME ______

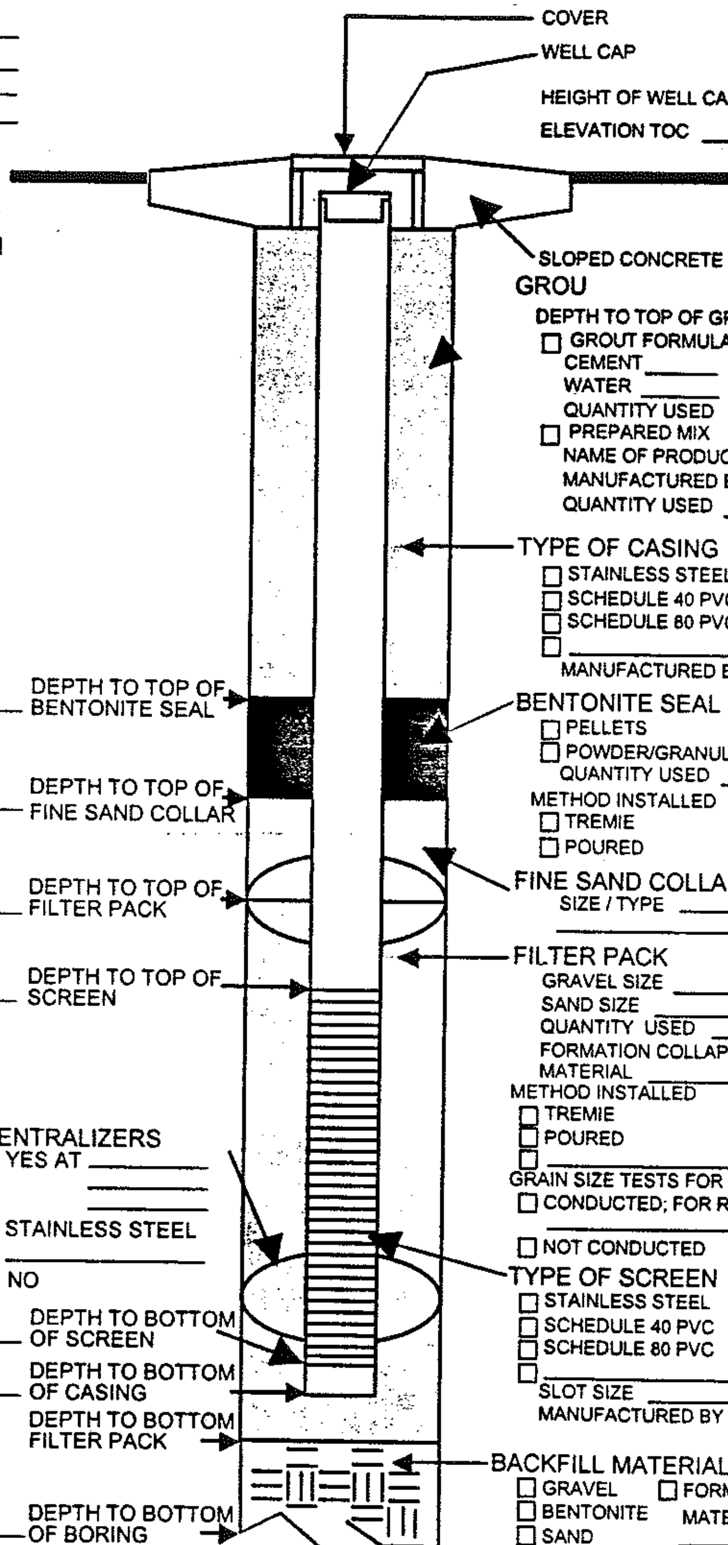
WELL COMPLETION FINISHED
DATE ______ TIME ______

DRILLING FLUID TYPE
- ☐ BENTONITE ☐ WATER
- ☐ POLYMER ☐ ______

DRILLING FLUID LOSS
- ☐ YES ________ GALLONS
- ☐ NO

WATER ADDED DURING COMPLETION
- ☐ YES ________ GALLONS
- ☐ NO

TOTAL FLUID LOSS TO FORMATION
________ GALLONS



COVER

WELL CAP

HEIGHT OF WELL CASING ____________

ELEVATION TOC ____________

GROUND ELEVATION ____________

SLOPED CONCRETE PAD / SURFACE SEAL

GROU

DEPTH TO TOP OF GROUT ____________
- ☐ GROUT FORMULA (PROPORTION OF EACH)
  CEMENT ______ BENTONITE ______
  WATER ______ OTHER ______
  QUANTITY USED ____________
- ☐ PREPARED MIX
  NAME OF PRODUCT ____________
  MANUFACTURED BY ____________
  QUANTITY USED ____________

TYPE OF CASING
- ☐ STAINLESS STEEL
- ☐ SCHEDULE 40 PVC
- ☐ SCHEDULE 80 PVC
- ☐

CASING DIAMETER
INSIDE ________
OUTSIDE ________

MANUFACTURED BY ____________

DEPTH TO TOP OF BENTONITE SEAL ______

BENTONITE SEAL
- ☐ PELLETS
- ☐ POWDER/GRANULAR
- ☐ SLURRY
- ☐ ________

QUANTITY USED ____________

METHOD INSTALLED
- ☐ TREMIE
- ☐ POURED
- ☐ ________
- ☐ NOT USED

DEPTH TO TOP OF FINE SAND COLLAR ______

FINE SAND COLLAR (OPTIONAL)
SIZE / TYPE ____________
____

DEPTH TO TOP OF FILTER PACK ______

FILTER PACK
GRAVEL SIZE ______ ; ______ TO ______ FT.
SAND SIZE ______ ; ______ TO ______ FT.
QUANTITY USED ____________
FORMATION COLLAPSE: ______ TO ______ FT.
MATERIAL ____________

METHOD INSTALLED
- ☐ TREMIE
- ☐ POURED
- ☐ ____________

GRAIN SIZE TESTS FOR FILTER PACK
- ☐ CONDUCTED; FOR REPORT, REFER TO ____________
- ☐ NOT CONDUCTED

DEPTH TO TOP OF SCREEN ______

CENTRALIZERS
- ☐ YES AT ________
  ____
  ____
- ☐ STAINLESS STEEL
- ☐ ________
- ☐ NO

TYPE OF SCREEN
- ☐ STAINLESS STEEL
- ☐ SCHEDULE 40 PVC
- ☐ SCHEDULE 80 PVC
- ☐ ____________

SCREEN DIAMETER
INSIDE ________
OUTSIDE ________

SLOT SIZE ____________
MANUFACTURED BY ____________

DEPTH TO BOTTOM OF SCREEN ______

DEPTH TO BOTTOM OF CASING ______

DEPTH TO BOTTOM FILTER PACK ______

BACKFILL MATERIAL
- ☐ GRAVEL
- ☐ BENTONITE
- ☐ SAND
- ☐ ____________
- ☐ FORMATION COLLAPSE MATERIAL ____________
  ____

DEPTH TO BOTTOM OF BORING ______

TOTAL LENGTH OF CASING AND SCREEN ____________

DEPTH TO WATER FOLLOWING INSTALLATION (TOC) ____________

DIAMETER OF BOREHOLE ____________

NOTES:
1. SCALE: NONE
2. RECORD DEPTHS/LENGTHS IN TENTHS OF FEET, NOT IN INCHES
3. RECORD CONSTRUCTION DEPTHS BELOW GROUND LEVEL

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TETRA TECH EM INC.

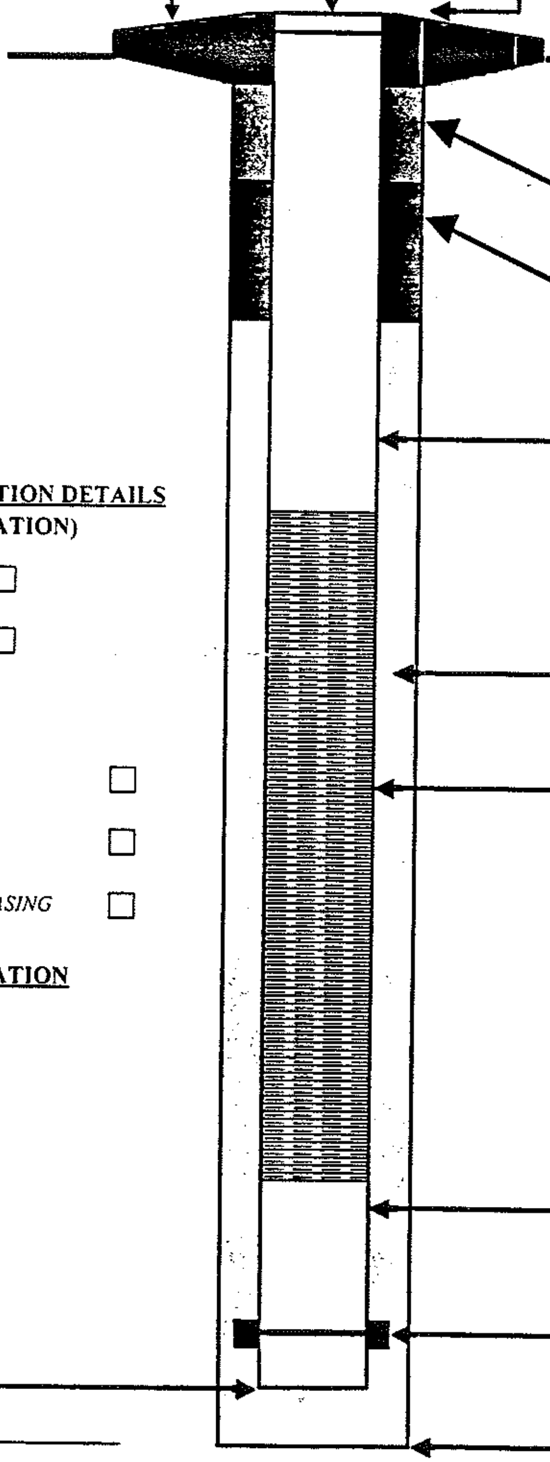
MONITORING WELL COMPLETION DIAGRAM

3-FOOT DIAMETER CONCRETE PAD

FLUSH-MOUNTED PROTECTIVE CASING

ELEVATION TOC: ______ FEET

GROUND ELEVATION : ______ FEET



WELL

WELL NO.:

BOREHOLE NO.:

SITE:

SUBSITE:

DATE:

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:

DRILLING METHOD:

DRILLING DATE(S):

INSTALLATION DATE(S):

BOTTOM OF WELL

FEET: ____________

BENSEAL (BENTONITE) GROUT

FROM ________ TO ______ FT. BELOW GROUND

BENTONITE PELLETS

FROM ________ TO ______ FT. BELOW GROUND

PVC RISER CASING

FROM ________ TO ______ FT. BELOW GROUND

______ SAND PACK

FROM ________ TO ______ FT. BELOW GROUND

_____ SLOT PVC SCREEN

FROM ________ TO ______ FT. BELOW GROUND

WATER ADDED DURING INSTALLATION

YES ☐ GALLONS: ______

NO ☐

PVC SILT TRAP

FROM ________ TO ______ FT. BELOW GROUND

STAINLESS STEEL CENTRALIZERS:

FEET

FEET

TOTAL DEPTH OF BOREHOLE : ______ FT.

_____ BOREHOLE

BACKFILL MATERIAL : ____________

Tetra Tech EM Inc.
1099 18th St
Suite 1960
Denver, CO 80202
(303) 295-1101

CHAIN-OF-CUSTODY RECORD#: ________

DATE: ________ Page ___ of ___

LAB ________

PROJECT NAME	PROJECT JOB #
SAMPLER(S): PRINTED NAME AND SIGNATURE	TECHNICAL CONTACT
	PO NUMBER

SAMPLE I.D.	DATE OF COLLECTION	TIME OF COLLECTION	SAMPLE MEDIUM (MATRIX)*	NO./CONTAINER TYPES	PRESERVATIVE / ANALYSES REQUIRED / FIELD SAMPLE PREPARATION

Larboratory, Please distinguish. Call if you are uncertain.
The number zero is "0" and the letters O are "O" or "o"

	SIGNATURE	NAME (print)	COMPANY	DATE	TIME
RELINQUISHED BY:					
RECEIVED BY:					
RELINQUISHED BY:					
RECEIVED BY:					
RELINQUISHED BY:					
RECEIVED BY:					

REMARKS: (Note: Identify samples for which extra volume was collected for MS/MSD and record air bill # on chain-of-custody form.)

AIRBILL #

REQ. TURN AROUND

INSTRUCTIONS: Under "ANALYSIS REQUIRED," and "FIELD SAMPLE PREPARATION," enter only one of the following four codes for each analysis requested and each sample listed:

U = UNPRESERVED AND UNFILTERED SAMPLE P = PRESERVED SAMPLE F = FILTERED SAMPLE B = BOTH PRESERVED & FILTERED SAMPLE

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EXTENDED CHAIN-OF-CUSTODY#: ________ DATE: ________ Page ___ of ___

(FOR SOIL BORING & GROUND WATER SAMPLES)

LAB ________

THIS FORM IS FOR INTERNAL USE ONLY
DO NOT SEND TO LABORATORY
SEND TO DATA MANAGER

PROJECT NAME	PROJECT JOB #
SAMPLER(S): PRINTED NAME AND SIGNATURE	SAMPLING TEAM #

SAMPLE I.D.	DATE OF COLLECTION	INVESTIGATION*	POINT NAME	SITE/OPERABLE UNIT (OU)	POINT TYPE*	SAMPLE TYPE*	TOP SAMPLE DEPTH	BOTTOM SAMPLE DEPTH	SAMPLE MEDIUM	GRAB/ COMP	SAMPLER'S COMPANY*

Enter "QC SAMPLE" for trip blanks, rinsates & field blanks

REMARKS: (Note: Identify any equipment rinsates and trip blanks and the associated samples listed on this form.)

INSTRUCTIONS: Complete all columns for each row you use. Enter only the codes listed below for columns containing an asterisk (*). Enter the three initials for the field sampler who collected the sample. Draw a vertical arrow down the column if an entry in any row applies to additional rows in the same column (eg. Sample Date). Consult data management team or project manager for POINT NAMES and INVESTIGATION codes prior to beginning field activity.

SAMPLE MEDIUM:
Air
Waste
Plants
Water
Product
Sediment
Sludge
Soil
Soil Gas
Tissue

INVESTIGATION:
CTO50RI_97 = CTO 50 RI
11/97 - 1/98

POINT TYPE:
MW = Monitoring well
SB = Soil boring
SL = Surface Location
TANK = Underground storage tank
EXCV = Excavation pit
GP = Geoprobe/Simulprobe
HP = Hydropunch
SPUNCH = Soil Punch
QC = QC samples

SAMPLE TYPE:
Norm = Real sample
FD = Field Duplicate
ER = Equipment Rinsate
TB = Trip Blank
MS/MSD = Matrix Spike/Matrix Spike Duplicate
FB = Field Blank

TOP SAMPLE DEPTH (soil samples): indicates the depth to the top of the interval sampled, measured in feet.

BOTTOM SAMPLE DEPTH (soil samples): indicates the depth to the bottom of the interval sampled, measured in feet.

SAMPLER'S COMPANY:
TTEMI = Tetra Tech EM Inc.
MK = Morrison Knudson
Other = Other company

TETRA TECH EM INC.

HYDROPUNCH/ GEOPROBE/ CPT /GRAB SOIL/ SEDIMENT/ WATER NEW LOCATION FORM

Project Name and Number	Investigation Name*	Originating Consultant*

Station (Point) Name	Station (Point) Type*	Origination Date	Station Description	Total Depth (ft)	Source of Location Data*

INVESTIGATION:

Phase 1 EBS

ORIGINATING CONSULTANT:

TTEMI = Tetra Tech EM Inc.
MK = Morrison Knudson

STATION (POINT) TYPE:
MW = Monitoring Well
SB = Soil Boring
SL = Surface Location
HP = Hydropunch
TANK = Underground Storage Tank
SPUNCH = Soil Punch

SOURCE OF LOCATION DATA:

SURVEY
GPS
MAP