N00296.001720
MOFFETT FIELD
SSIC NO. 5090.3

REMEDIAL INVESTIGATION REPORT
OPERABLE UNIT 2: SITES 3-11, 13, 14, 16-19, SOILS
NAS MOFFETT FIELD, CALIFORNIA

VOLUME 1
TEXT

MAY 1993

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for:

U.S. Department of Energy
Contract DE-AC05-840R21400

Submitted to:

Department of the Navy
Western Division
Naval Facilities Engineering Command
San Bruno, California 94066-2402

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OPERABLE UNIT 2

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- GB-14
- GB-15
- GB-16
- GB-17
- SB3-1
- SB3-1 (PI) Shallow Soil Sample Only
- SB3-2
- SB3-2 (PI) Shallow Soil Sample Only
- SB3-3
- SB3-3 (PI) Shallow Soil Sample Only
- SB3-4 Shallow Soil Sample Only
- SB3-5 Shallow Soil Sample Only
- SB3-6 Shallow Soil Sample Only
- SB3-7 Shallow Soil Sample Only
- SB3-8 Shallow Soil Sample Only
- SB3-9 Shallow Soil Sample Only
- SB3-21
- W3-12(A2)
- W3-13(A2)
- W3-14(B2)
- W3-15(B2)
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- W3-19(A1)
- W3-20(A1)
- W3-21(A1)
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- W3-24(A1)

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- GB-19
- GB-20
- SB4-1
- SB4-2
- SB4-3
- SB4-4(X)
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AP-4	
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AP-6	
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AP-11	
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- SB7-1 Shallow Soil Sample Only
- SB7-2 Shallow Soil Sample Only
- SB7-3 Shallow Soil Sample Only
- W7-16(C)
- W7-17(A2)
- W7-18(A1)
- W7-19(A1)
- W7-20(A1)
- W7-21(A1)

SITE 8 — Site 8

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- GB-26
- SB8-1 Shallow Soil Samples Only
- SB8-2 Shallow Soil Samples Only
- SB8-3 Shallow Soil Samples Only
- SB8-4 Shallow Soil Samples Only
- SB8-5 Shallow Soil Samples Only
- SB8-6 Shallow Soil Samples Only
- SB8-7 Shallow Soil Samples Only
- SB8-8 Shallow Soil Samples Only
- SB8-9 Shallow Soil Samples Only
- SB8-10 Shallow Soil Samples Only
- SB8-11 Shallow Soil Samples Only
- SB8-12 Shallow Soil Samples Only
- SB8-13 Shallow Soil Samples Only
- SB8-14
- SB8-15
- SB8-16
- SB8-17
- W8-2(A2)
- W8-3(C)
- W8-4(A1)
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- SB9-1
- SB9-2
- SB9-3
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SB11-3 Shallow Soil Samples Only	
SB11-4 Shallow Soil Samples Only	
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List of Acronyms

AA	atomic absorption spectrometry
ARAR	applicable, or relevant and appropriate requirements
ARC	Ames Research Center
ARPA	Advanced Research Projects Agency
ASTM	American Society for Testing and Materials
AVGAS	aviation gasoline
BAAQMD	Bay Area Air Quality Management District
BHC	hexachlorocyclohexane
bls	below land surface
BNA	Base, Neutral, and Acid Extractable Target Compounds
BTEX	benzene, toluene, ethyl benzene, and xylene
CAM	California Administrative Metals List
Canonie	Canonie Engineers
CA-SCL	California-Santa Clara County
CCR	California Code of Regulations
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
cm/s	centimeters per second
CPF	cancer potency factor
CPT	cone penetrometer test
CRQL	Contract Required Quantitation Limits
CRWQCB	California Regional Water Quality Control Board
CS	Confirmation Study
CSF	cancer slope factor
CSRS	Confirmation Study Ranking System
CSWRCB	California State Water Resources Control Board
DCA	dichloroethane
DCE	dichloroethene
DCTFA	dichlorotrifluoroethane
DERP	Defense Environmental Restoration Program
DHS	California Department of Health Services
DNAPL	dense nonaqueous phase liquids
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DTSC	Department of Toxic Substances Control
DWR	California Department of Water Resources
Eh	oxidation-reduction potential
EM	electromagnetic

EMB	Embankment Samples
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	U.S. Environmental Protection Agency
ESA	Earth Science Associates, Inc.
eV	electronvolt
FS	feasibility study
GB	geophysical boreholes
GC	gas chromatograph
GI	gastrointestinal
gpm	gallons per minute
GPR	ground penetrating radar
HAR	Hazard Assessment Rating
HAZWRAP	Hazardous Waste Remedial Actions Program
HI	hazard index
HIR	Hydrogeological Investigation Report
HLA	Harding Lawson Associates
HP	Hydropunch®
HPLC	high performance liquid chromatography
HQ	hazard quotient
HRS	Hazard Ranking System
HSP	Health and Safety Plan
IAS	Initial Assessment Study
ICP	inductively coupled plasma emission spectroscopy
ID	inside diameter
ILCR	incremental lifetime cancer risk
IRP	Installation Restoration Program
IS	Inferred Sources
IT	IT Corporation
ITAS	IT Analytical Services
JP	jet petroleum fuel
$KHCO_3$	potassium carbonate
K/J/C	Kennedy/Jenks/Chilton
K_{oc}	soil adsorption coefficient
K_{ow}	octanol-water partition coefficient
Lockheed	Lockheed Missile and Space Company's Lockheed Aerospace Center
LOAEL	lowest observed adverse effect level
LUFT	Leaking Underground Fuel Tank Field Manual
MBAS	methylene blue active substances
MCL	maximum contaminant levels
MEK	methyl ethyl ketone (2-butanone)
MEW	Middlefield-Ellis-Whisman
mg/L	milligrams per liter
µg/L	micrograms/liter
mg/kg	milligrams/kilogram

µg/kg	micrograms/kilogram
MIBK	methyl isobutyl ketone (4-methyl-2-pentanone)
mm	millimeter
Moffett Field	Naval Air Station Moffett Field
MOGAS	motor vehicle gas
MS	mass spectrometer
msl	mean sea level
mS/m	milliSiemens per meter
MV18	Mountain View Well 18
NACIP	Navy Assessment and Control of Installation Pollutants
NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities Engineering Command
NBA	North Base Area
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEC	National Electric Corporation
NEESA	Naval Energy and Environmental Support Activities
NEX	Navy Exchange
NOAEL	no observed adverse effect level
NPL	National Priorities List
OARF	Outdoor Aerodynamic Research Facility
OD	outside diameter
OU	operable unit
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCE	tetrachloroethene
P-CRESOL	4-methylphenol
PFN	potential false negatives
PID	photoionization detector
ppb	parts per billion
ppm	parts per million
PRP	potentially responsible party
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
Qobm	Quaternary older bay mud
Qybm	Quaternary younger bay mud
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act

List of Acronyms *(Continued)*

SCVWD	Santa Clara Valley Water District
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SI	site inspection
SOV	soil organic vapor
STLC	soluble threshold limit concentration
SVOC	semivolatile organic compounds
SWAT	Solid Waste Assessment Test
SWRP	Storm Water Retention Pond
TCA	trichloroethane
TCDD	tetrachlorinated dibenzo-p-dioxin
TCE	trichloroethene
TDS	total dissolved solids
TIP	total ionizables present
TOC	total organic carbon
TOX	total organic halogens
TPHC	total petroleum hydrocarbons
TTLC	total threshold limit concentration
USAF	U.S. Air Force
U.S. COE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
U.S. FDA	U.S. Food and Drug Administration
USGS	U.S. Geological Survey
UST	underground storage tanks
UV	ultraviolet
VOA	volatile organic analysis
VOC	volatile organic compounds
VTOL	Vertical Take Off and Landing
WESTDIV	Western Division of the Naval Facilities Engineering Command

Executive Summary

Naval Air Station Moffett Field (Moffett Field) is located on the southwest edge of San Francisco Bay in Santa Clara County, California. The basic mission of Moffett Field is to support antisubmarine warfare training and patrol squadrons. Moffett Field supports more than 70 tenants, including the California National Guard, and is the headquarters for the Commander Patrol Wings, Pacific Fleet. Presently, Moffett Field is the largest P-3 base in the world, with nearly 100 P-3C Orion patrol aircrafts. No heavy manufacturing or major aircraft maintenance is performed at Moffett Field, but a significant amount of unit and intermediate level maintenance is performed.

Since the early 1930s, wastes have been generated at Moffett Field through maintenance operations, fuel management, and fire training. The primary chemicals of concern are waste oils and jet fuels, solvents and cleaners, washing compounds, minor amounts of gasoline, hydraulic fluids, asbestos, paints, pesticides, battery acid, and polychlorinated biphenyls (PCB). Surrounding industries have contributed to the solvent contamination of groundwater in the region. Groundwater flow toward south San Francisco Bay has carried these contaminated waters onto areas of Moffett Field. In 1981, the Navy developed a priority list of contaminated installations and facilities requiring remedial action. This provided the impetus for the start of Installation Restoration Program (IRP) activities at Moffett Field.

The first phase of the IRP, the Initial Assessment Study (IAS), was completed in 1984. This was followed by Phase II (Confirmation Study), which is composed of four steps. Step I, the Verification Step, was completed in 1986. Step II, the Characterization Step, was modified to conform with U.S. Environmental Protection Agency (EPA) remedial investigation/feasibility study (RI/FS) guidance under the 1986 Superfund Amendments and Reauthorization Act (SARA) in 1987. The Western Division Naval Facilities Engineering Command (WESTDIV) contracted with the U.S. Department of Energy (DOE) under the Work for Others Program in 1987. Under this program, Martin Marietta Energy Systems, Inc. (Energy Systems) is responsible for the management and technical direction of the RI/FS at Moffett Field as part of their Hazardous Waste Remedial Actions Program (HAZWRAP). IT Corporation (IT) is under contract to Energy Systems for preparation and implementation of the RI.

The results of the Phase I RI field activities and summaries of previous field investigations are presented in the Phase I Characterization Report (IT, 1991a). Based on these data, the

Characterization Report assesses the quality of soil and groundwater at each of the 19 sites and identifies data gaps that were subsequently addressed during the Phase II remedial activities. Combined data obtained from both Phase I and II remedial activities are presented and integrated in this Operable Unit 2 (OU2) RI Report.

This OU2 RI Report presents the results of Phase I and II soil investigations for Sites 3 through 11, 13, 14, and 16 through 19. However, for purposes of the baseline risk assessment, the OU is divided into OU2 (west) and OU2 (east). OU2 (west) consists of Sites 8, 9, 10 (Chase Park area), 14, 16, 17, 18, and 19 (Tank 14). OU2 (east) includes Sites 3, 4, 5, 6, 7, 10 (runway area only), 11, 13, and 19 (Tanks 2, 43, and 53). The field and analytical data used to evaluate the OU2 site consisted primarily of the RI field and analytical data for soils in the vadose zone. Additional information from Moffett Field tank and sump removals and from source control investigations was used to supplement the RI information as applicable. If other sites are identified during the completion of the IRP, these sites will be included in the stationwide RI.

EPA has determined that the OU2 sites that overlie the regional groundwater plume or are within the Middlefield-Ellis-Whisman (MEW) regional study area are addressed by EPA in the 1989 Record of Decision (ROD) for the MEW study area. The OU2 (west) sites are within this area. Because the MEW ROD addresses soils in the regional study area, the OU2 (west) sites are not carried through the baseline risk assessment, FS, or ROD stages. The OU2 (east) sites have been evaluated through a baseline risk assessment.

Incremental lifetime cancer risks (ILCR) and hazard indices (HI) have been estimated for potential current and future exposure to organic chemicals in soil at Moffett Field OU2 (east). The upper acceptable risk range recommended by EPA is 10^{-6} to 10^{-4} (EPA, 1990). At Site 19 (Tank 53), the total ILCR is at the upper limit of that range due to benzene. The dominant exposure pathway is incidental soil ingestion. This calculated risk may be overestimated due to the limited amount and skewed distribution of the data. Additionally, the Navy and the EPA agreed to exclude IRP sites containing only petroleum and petroleum-related constituents from the CERCLA process. Accordingly, petroleum contamination at Site 19 will be addressed through separate corrective action, which is outlined in the Federal Facility Agreement revisions.

ILCRs and HIs have been estimated for potential current and future exposure to inorganic chemicals in soil at Moffett Field OU2 (east). Estimated ILCRs for beryllium are at the upper limit of the EPA risk range for the RME future residential exposure scenario at Sites 3, 4, 7, and 10. However, there are no known sources of beryllium at Moffett Field and this metal is not site related. Further, the higher risks are associated with the RME future residential exposure scenario at Site 7, which is a very unlikely scenario for Moffett Field. The estimated risks associated with this metal are likely to be due to naturally occurring background and the conservative assumptions used in the assessment of this metal.

The predicted potential hazard index (HI) exceeded one for future land use at Site 7. This is due to the predicted accumulation of metals in homegrown vegetables. It is unlikely that these metals are site related; they are more likely to be naturally occurring. These metals have been included as chemicals of potential concern in the baseline risk assessment because of uncertainty caused by the limited amount of available background data from unimpacted areas. Additionally, the hypothetical future land-use scenario (residential) is inconsistent with current projected development of the area and is highly unlikely. Even in a residential scenario, it is unlikely that sufficient land use would be available for development of a garden that could supply the daily quantities of produce assumed in the exposure assessment.

In conclusion, for the OU2 (east) sites, it is recommended that no FS be required and that the process move directly to a ROD.

1.0 Introduction

1.1 Purpose of Report

A remedial investigation (RI) was undertaken at Naval Air Station Moffett Field (Moffett Field) to address the potential contamination problems and to meet the intent of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and related California environmental regulations, as defined in the California Code of Regulations (CCR, Title 26, Subchapter 15).

Specific objectives of the RI were to:

- Confirm, characterize, and define the lateral and vertical extent of contamination at each site known or suspected to be a source of contaminant release.
- Supplement and refine the existing geologic, geochemical, hydrogeologic, and chemical database for the study sites.
- Evaluate the chemical migration pathways, site hydrogeology, and specifics of groundwater movement that influence the migration of site-related chemicals.
- Evaluate potential risks and hazards to public health and the environment.
- Provide sufficient data for assessing the need for interim remedial actions and for adequately designing such actions.

The RI is being conducted in a series of steps or phases at Moffett Field. Phase I documented the types and concentrations of chemicals of concern present at the various study sites. The results of Phase I RI field activities and summaries of previous field investigations are presented in the Phase I Characterization Report (IT Corporation [IT], 1991a). After October 1989, Phase II activities began, the results of which are presented in quarterly reports. The combined data obtained from both Phase I and II RI activities, as well as other applicable data, are integrated and presented in the RI Reports for each operable unit. This RI Report addresses Operable Unit 2 (OU2).

OU2 has been defined as soil investigations for Sites 3 through 11, 13, 14, and 16 through 19. This report will present a discussion of the available data for each site in OU2 (Figure 1.1-1).

1.2 Report Organization

The organization of Volume I of this RI Report is as follows:

- Chapter 1.0 introduces the report approach and objectives, report organization, operable unit definition, and site description and history.
- Chapter 2.0 discusses the RI activities conducted at Moffett Field. Other ongoing and previous studies that are pertinent to OU2 are also discussed in Chapter 2.0.
- Chapter 3.0 describes the environmental setting including surface features, meteorology, surface water, geology, soils, hydrogeology, demography/land use, and ecology.
- Chapters 4.0 through 18.0 discuss the nature and extent of contamination as it relates to the surface soils and the vadose zone beneath each site included in OU2.
- Chapter 19.0 discusses contaminant fate and transport for OU2.
- Chapter 20.0 discusses the baseline risk assessment for each site.
- Chapter 21.0 completes the RI Report by providing a summary and conclusions.
- Chapter 22.0 provides references for this document.

All data are presented in a summary fashion. Analytical data are presented as appendices. All tables and figures are included in Volume II of this report as separately tabbed sections. The results of specific sampling for soils analysis (Appendix A) are contained in Volume III. Volume IV contains the chemical concentration maps for soils (Appendix B), the soil gas survey data (Appendix C), and the boring logs (Appendix D). Volume IV also contains modeling information used to conduct the baseline risk assessment (Appendix E).

1.3 Operable Unit Definition

In December 1991, the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control, the California Regional Water Quality Board, and Moffett Field formally agreed to the designation of six operable units at Moffett Field and an accelerated investigation and remediation schedule. The revised schedule was a modification to the Federal Facility Agreement schedule.

The OU designations organized the existing 19 IRP sites (Figure 1.1-1) into independent groups with different schedules. Each OU was scheduled to proceed through the RI/feasibility study (FS) stages to a Record of Decision (ROD) that was specific to that OU. A stationwide FS and ROD will be prepared after completion of the OU RODs. Prior to the designation of OUs, the 19 IRP sites at Moffett Field were subject to the same schedule.

The objective of grouping the IRP sites into OUs was to expedite cleanup at the sites. By preparing a ROD for each OU, permanent cleanup can begin at OU sites before the stationwide ROD is issued. This approach allows sites to proceed through the RI/FS stages to the ROD and remediation stages "at their own pace." If additional work is required at any of the OUs, it would not impact the schedule of other OUs and could be implemented without waiting for investigation and reporting activities to be completed on the other OUs.

The IRP sites at Moffett Field were grouped into OUs based on physiographic setting. In addition to separating sites into different OUs, soil was separated from groundwater to reflect the status of the different investigations and to lessen the schedule impacts of any focused follow-up soil or groundwater investigations that might be required.

Because separate RI Reports, FS Reports, and RODs are required for each OU, the number of OUs was limited to six in order to minimize the administrative and reporting burden while still accomplishing the objective of expediting remediation (Moffett Field Information Release No. 8, March 1992).

The six OUs were defined as:

- OU1 - Sites 1 and 2 Soils
- OU2 - Sites 3-11, 13, 14, and 16-19 Soils
- OU3 - Sites 12 and 15 Soils
- OU4 - West Side Aquifers
- OU5 - East Side Aquifers
- OU6 - Wetland Areas.

Subsequent to this organization into OUs, EPA determined that the west side aquifers (OU4) and the OU2 sites that overlie the regional groundwater plume or are within the Middlefield-Ellis-Whisman (MEW) regional study area are addressed by EPA in the 1989 ROD for the MEW study area. EPA determined that the Navy should not submit the OU4 deliverables, including the RI/FS and the baseline risk assessment. However, EPA requested that the

information contained in the OU4 RI that is important to source identification be repackaged as a site characterization report (EPA, 1992a). This repackaged report has been identified as the "West Side Groundwater Site Characterization Report" and was submitted (final) to the EPA in March 1993.

Because the MEW ROD also addresses soils in the regional study area, those OU2 sites that overlap with the MEW ROD will not proceed through the baseline risk assessment, FS, or ROD phases. However, the other sites in OU2 will proceed through the baseline risk assessment, FS, and ROD phases as appropriate.

1.4 Site Description and History

Regulatory History. The Navy Assessment and Control of Installation Pollutants (NACIP) program was established September 11, 1980, as a component of the U.S. Department of Defense (DOD) Installation Restoration Program (IRP). The purpose of the NACIP program is to assess and control environmental effects of abandoned hazardous waste disposal sites at Navy shore facilities. The current Navy IRP, now called the Defense Environmental Restoration Program (Section 211) (DERP), is directed by the Naval Facilities Engineering Command (NAVFAC). The Western Division of the Naval Facilities Engineering Command (WESTDIV) is responsible for implementing the Navy IRP at Moffett Field. On December 11, 1981, the Navy required the development of a priority list of contaminated installations and facilities requiring remedial action. In July 1983, investigation under the IRP was initiated at Moffett Field. Previous investigations at Moffett Field are discussed in Chapter 2.0.

On December 11, 1980, Congress passed CERCLA, commonly known as "Superfund." This law requires that all federal facilities comply with state and federal requirements promulgated under CERCLA. On October 17, 1986, the Superfund Amendments and Reauthorization Act (SARA) renamed the IRP the DERP. In July 1987, Moffett Field was placed on the EPA's National Priorities List (NPL). At approximately the same time, the Navy initiated plans to conduct the current RI/FS at Moffett Field. The work plans for the RI/FS were approved by EPA on March 30, 1988.

Moffett Field Location and Description. Moffett Field is located in the Santa Clara Valley near the southern end of San Francisco Bay, 35 miles southeast of San Francisco,

California, and 10 miles northwest of San Jose, California. The installation encompasses approximately 2,200 acres in Santa Clara County. Moffett Field is bordered by the cities of Mountain View on the west and Sunnyvale on the south (Figure 1.4-1).

A sizeable portion of Moffett Field is situated on previously submerged land or marshlands that have been filled to their existing elevations. Much of the northern portion of the airfield has been filled to present elevations with materials of unknown composition. The original shoreline ran northwest through what is now the National Aeronautics and Space Administration (NASA) Ames Research Center (ARC) (Figure 1.4-2). In light of this fact, all of the prehistoric archaeological sites on the facility are located on the southern half of the airfield area (WESTDIV, 1990).

Archaeological sites are known to exist on Moffett Field. All of these sites are prehistoric shell middens, varying in size and complexity from temporary camps to high-use occupational areas that were used for centuries or millennia. Burials were noted during the original recording of some sites in the early 1900s. One site is believed to be the village of "Posolmi" noted during early ethnographic studies (WESTDIV, 1990).

All of these archaeological sites have been impacted to some extent through agricultural use in the late 1800s and early 1900s, and through the subsequent construction of buildings and the airfield at Moffett Field. The existing conditions of the eight sites located at Moffett Field are not known. It is possible that site integrity has been reduced significantly to preclude eligibility to the National Register of Historic Places (WESTDIV, 1990).

Moffett Field is bounded by salt evaporation ponds to the north, Stevens Creek to the west, U.S. Highway 101 to the south, and Lockheed Missile and Space Company's Lockheed Aerospace Center (Lockheed) to the east. The principal access to Moffett Field is through the Main (North) Gate. The same entrance is also used for the NASA-ARC facility, which is located to the west of Moffett Field but within its perimeter security fence.

Moffett Field is essentially divided in half by the runway system that is oriented northwest-southeast. Most of the aircraft and flight training operations are on the east side of the runway and the administrative support operations and functions are on the west side. There are 380 structures at Moffett Field. Many of these buildings were built by the U.S. Army when it occupied Moffett Field in the early 1940s.

Since the 1950s, the area surrounding the facility has become increasingly populated, and very little land is now available that is not committed to urban land uses or tidelands. The encroaching urbanization around the facility has been evident for some time. This has been demonstrated by community pressure to reduce noise levels and increase air safety. The Navy responded in the summer of 1961 by moving jet operations to Lemoore Field and utilizing the quieter and safer turbopropeller P-3C Orions.

The station has been in continuous operation by the military since it was commissioned in 1933. A variety of national defense missions has been executed by the station, including the present support of the Pacific Fleet Air Patrol Forces. The current mission of Moffett Field is to support antisubmarine warfare training and patrol squadrons. Today, more than 5,500 military; 1,500 civilian; and 1,000 reservist personnel support nearly 100 P-3C Orion patrol aircraft assigned to nine squadrons. Although no heavy manufacturing or major aircraft maintenance is performed at Moffett Field, a significant amount of intermediate level maintenance is accomplished.

The station supports more than 70 tenants - the most important being the Commander Patrol Wings, U.S. Pacific Fleet. Additionally, Moffett Field supports the California Air National Guard.

Other groups supported by Moffett Field include:

- Naval Air Maintenance Training Detachment 1012, Moffett Field
- Naval Aviation Engineering Service Unit, Moffett Field
- Fleet Aviation Specialized Operation Training Group, Pacific Detachment, Moffett Field
- Explosive Ordnance Disposal Unit Detachment, Moffett Field
- Branch Dispensary, Naval Regional Medical Center, Oakland
- Branch Facility, Naval Regional Dental Center, San Francisco
- DOD, Advanced Research Projects Agency (ARPA), Moffett Field
- Defense Property Disposal Office, Alameda.

Minor support is provided to the Naval Academy, Flying Club, printing office, and communications/training/research and development. Minor support is also provided to other military installations for vehicle maintenance and to private companies engaged in electronics.

Moffett Field affects the economic base of the local community and the region. Most of the 7,000 military and civilian personnel at Moffett Field reside in the immediate area and provide property revenues to the local county and city governments. Additionally, this population contributes to the local economy through the purchase of consumer foods, utilities, and services. Revenues are also realized through sales tax, vehicle fees, licenses, and permits.

Moffett Field has been selected for closure by the DOD. The schedule for closure has not been determined nor has the importance of Moffett Field on the demographics in the area.

1.5 Possible On-Site Sources

This section describes the sites included in OU2 at Moffett Field (Figure 1.1-1). The sites under investigation are as follows:

- Site 3 - Marriage Road Ditch
- Site 4 - Former Wastewater Holding Pond
- Site 5 - Fuel Farm French Drains and Bulk Tanks
- Site 6 - Runway Apron
- Site 7 - Hangars 2 and 3
- Site 8 - Waste Oil Transfer Area
- Site 9 - Old Fuel Farm and the Old Navy Exchange (NEX) Gas Station
- Site 10 - Chase Park Area and Runway
- Site 11 - Engine Test Stand Area
- Site 13 - Equipment Parking Area (Building 142)
- Site 14 - Tanks 19, 20, 67, and 68
- Site 16 - Public Works Steam Cleaning Rack Sump 60
- Site 17 - Paint Shop Sump 61
- Site 18 - Dry Cleaners' Sump 66
- Site 19 - Tanks 2, 14, 43, and 53.

Some of the sites are discrete, individual locations, while other sites are composed of multiple locations. Table 1.5-1 summarizes the sources and wastes reportedly disposed of at each site. A brief description of each site follows.

Site 3 - Marriage Road Ditch. Site 3 runs northward along the east side of Marriage Road, carrying surface drainage from the intersection of Marriage and Macon Roads to the northern boundary of Moffett Field. At that point, the drainage water is pumped to a perimeter canal, south of the evaporation ponds, that leads to Guadalupe Slough. The ditch was constructed prior to 1947 and originally extended across Macon Road to the aprons of Hangars 2 and 3. Storm drains in and around Hangars 1, 2, and 3 discharge into the ditch.

An estimated 150,000 to 750,000 gallons of mixed hazardous waste containing waste oils, solvents, fuels, detergents, paints, paint strippers, and hydraulic fluids was disposed of in the storm drains from the 1940s to the 1970s.

Site 4 - Former Wastewater Holding Pond. Site 4 is the area encompassing and surrounding the former wastewater holding pond, located north of Hangars 2 and 3 and west of the ponds. The former pond was unlined and received about 15 million gallons of wastewater from aircraft washing, equipment maintenance, and operations in Hangars 2 and 3 from 1968 to 1978 (Naval Energy and Environmental Support Activity [NEESA], 1984). The wastewater was held in the pond, treated, and discharged to the sanitary sewers. As many as 35,000 gallons of hazardous materials, which included toluene, methyl ethyl ketone (MEK), dry cleaning solvent, paint sludge, paint stripper, Freon-113, trichloroethene (TCE), trichloroethane (TCA), carbon remover, ethylene glycol, fuel, and oil, may have been discharged to the pond either directly or as components of wastewater.

Site 5 - Fuel Farm French Drains and Bulk Tanks. Site 5 is separated into a northern and a southern area. The northern area is located in the triangular area bordered by Macon Road, Patrol Road, and the golf course. The southern area is bounded by Macon Road on the east, runway aprons to the south and west, and Hangar 3 to the north. These tanks have been the main fuel facilities for Moffett Field since the 1950s. As a standard operating procedure in the 1950s and 1960s, water and fuel were pumped into French drains during routine tank drainage. The exact locations of the drains and the quantities of fuel dumped into the drains are unknown, although two open vertical pipes have been located immediately east of the operating fuel station. In the Initial Assessment Study (IAS), NEESA estimated that as many as 28,000 gallons of fuel could be present on top of the groundwater at the site, based on observations of fuel levels in wells. Although minor amounts of free product were noted at Site 5 during RI activities, there is no evidence that 28,000 gallons of fuel is present on top of the groundwater.

Site 6 - Runway Apron. Site 6 is designated the Runway Apron disposal site and was located adjacent to the former aprons northeast of Hangers 2 and 4. The site was paved over in 1979 during enlargement of the apron. An estimated 120,000 to 600,000 gallons of hazardous waste from aircraft maintenance, including solvents, oils, fuels, paints, and paint strippers, was disposed of at this site from the 1940s to the 1970s (NEESA, 1984).

Site 7 - Hangars 2 and 3. Site 7 consists of Hangars 2 and 3, which were constructed in 1942, and the paved area surrounding the hangars. From 1942 to 1978, hazardous waste that accumulated in the unpaved area surrounding the hangars flowed through deck drains to the Marriage Road Ditch. Unpaved areas at each corner of Hangars 2 and 3 were used to dispose of an estimated 120,000 to 600,000 gallons of paint, paint strippers, oils, solvents, fuels, hydraulic fuels, and other hazardous wastes. A power plant shop in the northeast corner of Hangar 3 disposed of chlorinated solvents, including TCE, into down-deck drains and on the unpaved areas around Hangar 3 (NEESA, 1984).

Site 8 - Waste Oil Transfer Area. Site 8 is located near Building 127, between Zook Road and McCord Avenue, where the off-site branch of the Defense Reutilization and Marketing Office (DRMO) maintained a 5,000-gallon waste oil tank from the 1940s until 1980. Trucks from the shops and squadrons disposed of waste oil into a sump next to the road before it was transferred into the tank. The tank reportedly also received about 100 gallons per year of transformer oils, possibly containing polychlorinated biphenyls (PCB), and 200 gallons per year of solvents. Oil was spilled onto the ground around the sump during oil transfer (NEESA, 1984).

Site 9 - Old Fuel Farm and Old NEX Gas Station. The Old Fuel Farm is located near Buildings 12 and 29 on the block formed by Bushnell Road, Severyns Avenue, North Akron Road, and McCord Avenue. Site 9 also includes the Old NEX Gas Station, which is located at the present site of Building 31. The Fuel Farm was used for fuel storage from the 1940s until 1964 and for transfer of fuel to aircraft fueling locations via underground fuel lines. According to the Navy (NEESA, 1984), aviation gas (AVGAS) was stored in six underground 10,000-gallon steel tanks adjacent to Building 29. Four additional 25,000-gallon underground storage tanks (UST) were also located in the Old Fuel Farm area. In the mid 1960s, two of the tanks began leaking. In 1964, the Fuel Farm was abandoned and the tanks were filled with water. An aboveground storage tank (25,000 gallons) located near Building 29 was used to store AVGAS, but has been removed.

Building 31, the Old NEX Gas Station, was also active between the 1940s and 1964; one waste oil (500 gallons) and three gasoline USTs (10,000 gallons) were located north of Building 31. These four tanks were removed in 1990.

Site 10 - Chase Park Area and Runway. Site 10 encompasses the runway and the Chase Park area. Chase Park is upgradient of known Moffett Field sources. A storage shed is present at Chase Park but no chemicals are stored there. No sources are known to exist in the runway area, although it is presumed fuels, oils, and hydraulic fluids may have been spilled there.

Site 11 - Engine Test Stand Area. The Engine Test Stand Area is located approximately 500 feet north of the intersection of Patrol and Zook Roads, and lies between the eastern edge of the runway and Devil's Slough. The site, which is used to test turbine engines, is fenced and underlain by both concrete and asphalt that constitute a pad approximately 200 feet on each side. A small drainage depression drains waste oils, hydraulic fluids, and fuels from the center of the pad to the southern edge of the pad. During past tests, fluids may have run onto the adjacent soils. An area approximately 75 feet by 45 feet appears to be "oil-stained" south of the pad. It is unknown how long the Engine Test Stand Area has been in use, how frequently it has been used, or the quantity of fluids that has run off the pad.

Site 13 - Equipment Parking Area (Building 142). The Equipment Parking Area is located northeast of Building 142, approximately 600 feet east of Hangar 3. Building 142 is used for repair and maintenance of aircraft ground support equipment. Waste and industrial wastewater from spills, leaks, and washing have resulted in surface wash and drainage onto a concrete/asphalt parking area east of and adjacent to Building 142. This runoff flows into a main north-south trending, unlined storm drain channel. Runoff also discharges into a small secondary east-west trending, asphalt-lined drainage channel along the north side of the parking area. A 20- to 25-foot-long portion of the north-south trending storm drain has apparently been excavated and backfilled with clean fill material. The gradient of the channel appears to be nearly flat. As of this report, the conditions still exist at this area.

Site 14 - Tanks 19, 20, 67, and 68. Tanks 19 and 20, near the South Gate exit, were adjacent to each other and were located in the southwestern part of Moffett Field. Before removal, the 5,000-gallon USTs contained unleaded vehicle fuel gasoline.

Tanks 67 and 68 were adjacent to each other and located in the southwestern part of the air station on the east side of the dry cleaners' building (Building 88). The dry cleaners' building is to be investigated as part of the Site 9 and Site 18 studies. Tank 67, which was removed in May 1990, was a 20,000-gallon UST that contained kerosene and other petroleum

products. Tank 68, which was closed in place and has not been removed, was reportedly a 2,000-gallon UST used to store waste solvents.

Site 16 - Public Works Steam Cleaning Rack Sump 60. The Public Works Steam Cleaning Rack (Sump 60) was located in the Public Works Vehicle Yard, between the South Gate and Chase Park. The wash rack system consisted of two catch basins that drained a concrete wash pad and led to an underground oil/wash separator. The rack is currently not in use. The age of the system, the frequency of use, the volume of wash water used, and the type and amount of discharge are unknown. Effluent reportedly flowed into a storm drain. Sump 60 was removed in October 1990.

Site 17 - Paint Shop Sump 61. The Public Works Paint Shop is located in Building 45 and has been active since the late 1930s (NEESA, 1984). Sump 61 was approximately 7 feet below land surface (bls) and was a concrete vault lined with brick (PRC Environmental Management, Inc. [PRC], 1991a). The sump reportedly received wastes from the paint shop and Hangar 1; however, most of the wastes from the paint shop were disposed of in the Runway and Golf Course Landfills (Sites 1 and 2) according to NEESA (1984). The wastes from the paint shop included both oil- and latex-based paints, thinners, toluene, and turpentine. The types of wastes from Hangar 1 are unknown. Sump 61 was removed in October 1990.

Site 18 - Dry Cleaners' Sump 66. The dry cleaners' sump was located on the north side of Building 88, which contains the dry cleaners and laundry. The dry cleaners' sump, which reportedly had cracks, is suspected to be a source of solvent contamination. Sump 66 was removed in May 1990.

Site 19 - Tanks 2, 14, 43, and 53. Tank 2 was a leaking UST located on the east side of Hangar 3. The tank, which was in use from 1979 to January 1987 and removed in May 1990, had a 2,000-gallon capacity. Wastes from the Power Plant Shop located in Hangar 3 were stored in this tank. Waste products that have been stored in the tank include oils, hydraulic fluids, MEK, jet petroleum (JP) fuels, B&B cleaner, PD-680 solvent, toluene, and Stoddard solvent. The tank was unmetered and no inventory could be calculated. The tank was reportedly emptied every 90 days (ERM-West, 1986).

Tank 14 was a 1,100-gallon UST that was used as a stand-by diesel fuel tank for Building 158 (the Operations Building). Before removal in May 1990, the tank was located in the lawn area 10 feet south of Building 158 and approximately 400 feet east of the intersection of Cody and Macon Roads.

Tank 43, which was located on the northeast corner of Hangar 3, was a 2,000-gallon UST that collected rinse water from engine cleaning racks, drains, and sinks in Hangar 3. The tank contained waste oils, solvents, waste fuel, MEK, Solvent PD-680, paint waste, and battery acids. The tank was emptied every 90 days, and the wastes were hauled off site (ERM-West, 1986). The tank, which had been in use since 1980, was removed in May 1990.

Tank 53, which was also removed in May 1990, was a UST located on the southeast corner of the intersection of Patrol and Marriage Roads. The 500-gallon tank was used to store unleaded gasoline for use at the golf course physical plant.

2.0 Study Area Investigations

This chapter discusses the investigations performed during Phase I and II RI activities. Previous investigations and other investigations pertinent to the RI are also described.

2.1 Previous Studies

Initial Assessment Study. The first phase of the NACIP program was the IAS. The IAS for Moffett Field was conducted for NEESA from July 1983 to April 1984, and nine potentially contaminated sites were identified. Based on information from historical records, aerial photographs, surface surveys, and personnel interviews, it was concluded that eight sites at Moffett Field could pose sufficient threat to human health or to the environment to warrant a Confirmation Study (CS), the second phase of the NACIP program. The eight sites (with current RI/FS site numbers) were:

- Site 1 - Runway Landfill
- Site 3 - Marriage Road Ditch
- Site 4 - Former Wastewater Holding Pond
- Site 5 - Fuel Farm French Drains and Bulk Tanks
- Site 6 - Runway Apron
- Site 7 - Hangars 2 and 3
- Site 8 - Waste Oil Transfer Area
- Site 9 - Old Fuel Farm and Old NEX Gas Station.

Confirmation Study. The objective of the CS phase was to quantify the concentrations of hazardous chemicals present and define the areal and vertical extent of contamination. In June 1985, WESTDIV authorized Earth Science Associates, Inc. (ESA) and James M. Montgomery Consulting Engineers to conduct the Verification Step (ESA, 1986a), which established the presence or absence of contamination at each site identified in the IAS.

The Characterization Step then provided additional data for defining the concentrations and distribution of chemical compounds that were previously identified in groundwater beneath and adjacent to the sites, and refined the current state of site knowledge.

The Confirmation Study Report (ESA, 1986a) contains general information on the geology and hydrogeology of the Moffett Field and includes the results of chemical analyses on soil and groundwater samples from new and existing monitoring wells.

The work plan for the Moffett Field Characterization Step identified the following nine specific tasks to be accomplished:

- Pre-site investigation
- Quality Assurance Project Plans (QAPP) for the laboratory analyses and field operations
- Sampling and Analysis Plan (SAP)
- Health and Safety Plan (HSP)
- On-site field investigations
- Chemical analyses of groundwater samples
- Characterization Study Report
- Assessment of public and private wells that may act as potential conduits for inter-aquifer cross contamination
- Meetings with regulatory agencies.

Before most of this work was executed, the NACIP program was replaced in 1987 with the Navy IRP (DERP), which is organized more closely to the EPA's RI/FS process. The Navy, where possible, incorporated the NACIP work into the DERP.

Potential Vertical Conduits. Previous investigations of potential vertical conduits (vertically oriented channels such as wells that may transport contaminants) on or near Moffett Field were performed by Harding-Lawson Associates (HLA) in 1985 and Canonie Engineers (Canonie) in 1986. The HLA study evaluated the MEW area south of Highway 101 and a portion of Moffett Field. The Canonie study encompassed all of Moffett Field.

ESA produced a potential vertical conduits report for Moffett Field (ESA, 1986b). The report lists wells identified in the MEW study and additional wells located on Moffett Field. Two inactive wells were sampled and had volatile organic compounds (VOC) of less than 3.5 micrograms/liter (µg/L).

To supplement the existing data, a potential conduits investigation was implemented by Kennedy/Jenks/Chilton (K/J/C), who produced three reports: "Suspected Wells Research Report" (K/J/C, 1988a), which located wells identified in previous studies by field surface

geophysical techniques; "Active Wells Report" (K/J/C, 1988b), which characterized the four active irrigation wells; and "Suspected Wells Investigation Report" (K/J/C, 1989), which provided additional information on suspected wells from field evaluations.

The Navy investigation revealed that the suspected wells did not exist. The two inactive wells were sealed and abandoned by the Navy in 1990 (IT, 1991b).

Tank and Sump Testing. During June 1986, ERM-West (ERM-West, 1986) and Aqua Resources identified active and inactive USTs that might require investigation or closure. The work was required by the State of California and Santa Clara County regulations (ERM-West, 1986). The study identified 33 USTs, 12 sumps or containment facilities, and 2 ponds that would require further study.

Results of investigations on potential soil and groundwater contamination near abandoned tanks and leak testing of 26 active USTs in 1987 (ERM-West, 1987) brought the number of potentially contaminated sites at Moffett Field to 19. Some of the UST sites are discrete individual locations while others comprise multiple locations. Descriptions of the sites covered in this report are provided in Chapters 4.0 through 18.0.

Hydrogeologic Assessment Study of Wastewater Flux Ponds. Moffett Field uses two earthen ponds for storage and treatment of industrial wastewater. The ponds, located north of Hangars 2 and 3, are unlined and have a combined storage capacity of 400,000 gallons. The flux ponds were constructed in 1975 to replace the original pond that was closed and removed.

The "Report of Hydrogeologic Investigation, Industrial Wastewater Flux Ponds," prepared for the Navy (Dames & Moore, 1988a), summarizes the following items:

- Construction and operation of the ponds
- Chemical characteristics of the waste discharged to the industrial wastewater flux ponds
- Chemical characteristics of surface water and sludge
- Physical and chemical properties of the vadose zone beneath the site
- Regional (within 1-mile radius) and local surface water and groundwater hydrology

- Local climatology in Sunnyvale area
- Regional and site-specific geologic setting.

Based on information collected during the investigation (Dames & Moore, 1988a), the wastewater flux ponds do not contain hazardous waste as defined under Title 22, Division 4, Chapter 30, Article II of the CCR. Volatile and semivolatile organics were not detected in samples from the pond water, sludge, or in the soil beneath the ponds. Metals were present at nonhazardous concentrations in samples from the pond water, sludge, and soils beneath the pond.

In this RI Report, specific data or conclusions from the "Report of Hydrogeologic Investigation" (Dames & Moore, 1988a) and the "Report of Waste Discharge" (Dames & Moore, 1988b) will be included, as appropriate.

2.2 Soil and Vadose Zone Investigation Methods

2.2.1 Soil Gas Surveys

Soil gas surveys were part of the field investigation for Sites 3, 5, 9, 10, and 12. The objectives of these surveys were to: (1) evaluate the distribution of volatile chlorinated and petroleum hydrocarbons in the vadose zone, and (2) identify potential groundwater contaminant source areas. Based partly on the results of the soil gas surveys, additional Phase II monitoring wells were located and sampled to quantify the levels of contamination in the groundwater.

Soil gas samples were taken in the field using a photoionization detector (PID) and reported as total ionizables present (TIP). The TIP detector measured total ionizable compounds with a 10.2 electronvolt (eV) ultraviolet (UV) source relative to an isobutylene standard and has an equipment resolution of 1.0 part per million (ppm). At selected sample stations, a soil gas sample was collected in a Tedlar® bag for analysis by a portable field gas chromatograph (GC). The GC analysis was used to quantify the following compounds:

- 1,1,1,1-dichloroethene (1,1,1,1-DCE)
- 1,1-dichloroethane (1,1-DCA)
- cis-1,2-DCE
- 1,1,1-TCA
- 1,1,2-TCA
- Benzene

- TCE
- Toluene
- m-xylene
- o-xylene.

Several of these compounds are known to exist at the MEW area and others are by-products of fuel and lubricants. The GC method is applicable to determining 10 to 10,000 parts per billion (ppb) levels of TCE in soil gas samples. Where a substantial number of sample points in an area had TIP-measured concentrations greater than 1.0 ppm, only selected samples were analyzed by GC. Sample stations with the highest total ionizable compound concentrations were sampled for GC analysis. Where the GC analysis identified several compounds in a sample area, additional samples were collected for GC analysis to assess the distribution of the various compounds.

Soil gas samples were collected uniformly from approximately 5-foot depths at 50- to 100-foot intervals along transect lines. A complete description of this sampling method and original locations of transect lines are in the SAP (Volume II of the Final Work Plan; IT, 1988a) and in Appendix G of the December 1988 Quarterly Report (IT, 1988b). Following completion of the initial screening lines using the TIP detector, additional transect lines were delineated for areas where levels of VOCs were above background (ambient air measured at the sample station). More than 160 readings were collected over 10,000 feet of transect lines.

2.2.2 Soil Sampling

The primary purposes of collecting soil samples were lithologic identification and logging of the soils and chemical analysis of the soils.

Soil samples were collected from augered soil borings, monitoring well borings, and shallow hand-driven borings. Soil samples from borings were collected using a California modified split-spoon drive sampler, which consists of an outer 18-inch steel barrel into which three 6-inch-long by 2-inch-diameter sample sleeves were inserted. Augered borings were generally advanced to a depth of 10 feet, unless groundwater was encountered at a more shallow depth. Depending on the water table depth, a fourth sample was collected from immediately above the water table or at 10 feet, whichever was more shallow. Using brass sleeves, 1-foot deep, hand-driven soil samples were collected at Sites 1, 3, and 11. Samples for chemical analysis were generally collected at 1-, 3-, 5-, and greater than 5-foot depths. In a few cases, augered borings were advanced to depths greater than 10 feet bls and samples for chemical analysis were collected.

Wells installed in the uppermost aquifer (A aquifer) were drilled using the hollow-stem auger method. Each borehole was continuously cored using a 5-foot-long (2-inch-diameter) California modified sampler. As a result, good descriptions of materials penetrated were obtained in zones where adequate core recovery was achieved. Wells installed in the second and third aquifer systems (B and C aquifers, respectively) were drilled using the casing hammer method and were logged by examination of the drill cuttings collected from the discharge system. Periodic split-spoon drive samples were taken to confirm soil descriptions. Boring logs are presented in Appendix D of this report.

2.2.3 Analytical Data Treatment

The majority of analytical data used in this report were generated during the Phase I and Phase II RI sampling efforts conducted by Martin Marietta Energy Systems, Inc. (Energy Systems) and IT. A listing of the RI analytical parameters is provided in Table 2.2-1. This table also provides the Contract Required Quantitation Limits (CRQL). These investigations were conducted in accordance with the quality assurance/quality control (QA/QC) requirements presented in the RI's SAP and QAPP (Volumes II and IV of the Final Work Plan; IT, 1988a). Data collected under other investigations were used to supplement the RI data.

For the most part, all contractors utilized EPA Contract Laboratory Program (CLP) methods, or, in the absence of a CLP method, a CLP-like method. CLP methods provide data of EPA analytical Levels III and IV as defined by the EPA's Data Quality Objectives (DQO) for Remedial Response Activities (EPA, 1987a). For data generated by CLP methods, the difference between Levels III and IV is based on the deliverable, not on laboratory QA/QC or technical quality; data generated by CLP methods have been produced under the most rigorous analytical QA/QC conditions specified by EPA.

Prior to reporting, internal validation of data was performed by the contract laboratory to ensure QA/QC standards were met. In addition, all analytical data used in this site characterization were subjected to third party validation. Systematic approaches undertaken in the third party validation effort varied with laboratory deliverables and primary project needs; the detail of laboratory documentation contained in the data packages depended on original project needs.

Although the intensity of additional nonlaboratory validation varied between sets of samples, all data used in this report are considered valid for the purpose of site characterization. Data collected under the Phase I and Phase II RIs are also considered valid for the purpose of risk

assessment. Further discussions of the CLP program, third party validation, and specific approaches and conclusions of contractor validation are provided in the following sections.

2.2.3.1 Contract Laboratory Program Laboratories

The CLP was created by EPA to standardize analytical methods used for compliance under CERCLA, which typically requires projects to collect large quantities of data at a reasonable cost. To acquire CLP status, a laboratory must acquire and maintain a contract with EPA to perform the specific CLP methods. Initial and on-going demonstration of analytical quality is achieved through extensive mandated QA/QC procedures and EPA vigilance. Hence, all laboratories performing CLP analyses should have comparable QA/QC programs; each CLP laboratory should have a QA/QC program that meets or exceeds the requirements of the EPA Statement of Work for analyses (EPA, 1988a,b).

In the DQO development process, EPA divided data into five levels. The level of a particular set of data is chosen based on the decision that must be made from the data. These levels are:

Level I: Field screening or analysis using portable instruments. Results are often not compound specific and not quantitative but results are available in real-time. It is the least costly of the analytical options.

Level II: Field analyses using more sophisticated portable analytical instruments. In some cases, the instruments may be set up in a mobile laboratory on site. There is a wide range in the quality of data that can be generated. It depends on the use of suitable calibration standards, reference materials, sample preparation equipment, and operator expertise. Results are available in real-time or several hours.

Level III: Analyses performed in an off-site analytical laboratory. Level III analyses yield technically defensible data. The laboratory may or may not be a CLP laboratory, may or may not use CLP methods, and usually does not follow the documentation and validation procedures of Level IV. However, if CLP processes are followed, data of the same technical quality as Level IV can be provided.

Level IV: CLP routine analytical services. All analyses are performed in an off-site CLP analytical laboratory following CLP protocols. Level IV is characterized by rigorous QA/QC protocols and extensive documentation of the data.

Level V: Analysis by nonstandard methods. All analyses are performed in an off-site analytical laboratory that may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits. CLP special analytical services are Level V.

These levels correlate to the Hazardous Wastes Remedial Actions Program (HAZWRAP) Levels A, B, C, D and E, respectively. All data generated by CLP fall into the Level III or Level IV category. All CLP-like data fall into the Level V category. For data generated by CLP methods, the Level III or IV label depends on the deliverable received, not on the analytical QA/QC level. Note that according to DQO guidance, CLP-generated analytical results are considered suitable for both site and risk assessment (EPA, 1987a).

2.2.3.2 Third Party Validation Guidelines

Guidance for review of CLP analytical results is provided by EPA guidance documents "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" (EPA, 1988a) and "Laboratory Data Validation Functional Guidelines for Inorganic Analyses" (EPA, 1988b) and, where applicable, by the HAZWRAP document "Requirements for Quality Control of Analytical Data" (HAZWRAP, 1990). These documents are designed to aid in technical review of field and laboratory performance. Yet, as pointed out in the EPA guidelines, "some areas of overlap between technical review and Contract Compliance Screening exist." Because each project is different, the contract requirements may need to be incorporated by the validator to ensure data usability, particularly for the CLP-like EPA Level V data.

2.2.3.3 IT Corporation: Phase I and Phase II Remedial Investigations

IT's Work Plan for Moffett Field was written in 1987 when formal data validation and HAZWRAP guidance had not been published; therefore, project-specific QA/QC was developed, approved by the agencies, and implemented. For both phases, EPA Level IV or V (CLP or CLP-like) analyses were performed. However, EPA Level II/III deliverables were received for Phase I data, and EPA Level IV (a complete CLP package, including raw data) was received for Phase II data. Thus, validation of Phase I data emphasized meeting contract/Work Plan requirements for data quality, while validation of Phase II data included review of raw data. These approaches overlap to the extent that QA/QC data were provided by the laboratory. Findings from the validation effort were incorporated into the project's database and are reflected in the qualifiers assigned to the validated data.

Phase I Data Validation. EPA Level II/III packages were received from the laboratory, and data review was based on laboratory reports only, not on raw data. IT reviewed the CLP analytical results according to the approved Work Plan and to the HAZWRAP guidance document "Requirements for Quality Control of Analytical Data" (HAZWRAP, 1990). The HAZWRAP document incorporates suggested approaches from EPA guidance documents

"Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" (EPA, 1988a) and "Laboratory Data Validation Functional Guidelines for Inorganic Analyses" (EPA, 1988b), and provides additional program-specific criteria.

QA sampling and analysis activities included collecting and analyzing field and laboratory QC samples. Field QC samples included trip blanks, equipment blanks, and field duplicates. Split samples, split with Energy Systems, were also taken. Reported laboratory QC samples included laboratory blanks, matrix spikes, and matrix spike duplicates.

Following data review, data quality is considered good. Analytical precision and accuracy were good with more than 90 percent of duplicate, spike, and split analyses being within the CLP method limits. Data are complete because more than 95 percent of the data are usable. Data are representative because the accepted and prescribed methods presented in the IT Moffett Field Work Plan were followed.

Phase II Data Validation. Complete HAZWRAP Level D (EPA Level IV) packages were received from the laboratory and data review was based on raw data. IT reviewed the CLP analytical results according to the HAZWRAP guidance document "Requirements for Quality Control of Analytical Data" (HAZWRAP, 1990). The HAZWRAP document incorporates suggestions from the EPA guidance documents "Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses," (EPA, 1988a) and "Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses," (EPA, 1988b), and provides additional program-specific criteria.

QA sampling and analysis activities included collecting and analyzing field and laboratory QC samples. Field QC samples included trip blanks, equipment blanks, and field duplicates. Split samples were not taken as part of the Phase II effort. Laboratory QC samples included laboratory blanks, matrix spikes, matrix spike duplicates, and blank spikes. Other QC procedures performed by the laboratory included instrument tuning, calibration checks, surrogate recovery monitoring, inductively coupled plasma spectrometer (ICP) interference checks, laboratory control checks, and serial dilution checks.

Data were rejected or qualified as estimated when performance criteria were not met. Due to the volume of data, specific reasons for qualification must be obtained from the validation report. However, the conclusions of the validation have been incorporated in the project's database and the effect of the rejected data on the sample population used for the RI can be

seen in the statistics tables. Data qualified as estimated were used quantitatively in the site characterization and risk assessment statistics along with nonestimated data. Rejected data were used for qualitative insights only.

Following data review, data quality is considered good. Analytical precision and accuracy were good with more than 90 percent of duplicate and spike analyses being within the CLP method limits. Data are complete because more than 95 percent of the data are usable. Data are representative because the accepted and prescribed methods presented in the IT Moffett Field Work Plan were followed.

Blank Contamination - OU2 Soils. Because Phase I and Phase II data were validated in accordance with prescribed EPA and HAZWRAP guidelines, the "5x/10x Rule" was systematically applied to all samples that had detectable concentrations of a contaminant in corresponding laboratory or field blanks. In brief, the "5x/10x Rule" states that if a compound is observed in a blank, quantities found in original samples at less than five or ten times the concentration in the blank can be attributed to sampling and analysis operations. The multiplier applied to a particular contaminant depends on the compound. For the purposes of data interpretation, these detected concentrations become "nondetects." Qualifiers provided in this report reflect the conclusions of the third-party validation effort.

No known on-site sources of acetone and methylene chloride were identified for the Moffett Field characterization. However, acetone and methylene chloride were observed in soil samples used for the OU2 characterization. In many cases, although the frequency of detection above the quantitation limit was low, acetone and methylene chloride were also detected in corresponding field or laboratory blanks. Split samples, split with Energy Systems in Phase I, were particularly scrutinized with respect to common laboratory contaminants. As both laboratories had method blanks containing common laboratory contaminants, methylene chloride or acetone concentrations could not be dismissed for all sites solely on the basis of laboratory contamination. The current CRQL for both methylene chloride and acetone in soils is 10 ppb, although historically the CRQL for methylene chloride was 5 ppb.

For common laboratory contaminants, like methylene chloride and acetone, data validation included application of the "10x Rule," and many qualifiers were changed to nondetected. As a result, most acetone and methylene chloride concentrations found in OU2 samples can be attributed to field or laboratory handling.

2.2.3.4 PRC Environmental Management, Inc.: " Additional Tank and Sump Field Investigation Technical Memorandum" (PRC, 1993)

This report documents the results of additional field investigations conducted from April through June 1992 to collect information in the vicinity of two Tanks (Tanks 14 and 53) and two sumps (Sumps 60 and 91). A complete discussion of analytical QA/QC was not provided; however, actual analytical results were presented in Appendices B and C of the referenced report. The results presented in Appendices B and C include validation qualifiers added to the results upon review by an independent validation firm. Validation was performed according to the EPA guidance document "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" (EPA, 1988a).

Analyses were performed for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), total petroleum hydrocarbons (TPHC), and benzene/toluene/ethyl benzene/xylene (BTEX analysis). Standard field sampling and QA/QC practices appear to have been followed. No work plan deviations were reported.

2.2.3.5 PRC Environmental Management, Inc.: "Final Tank and Sump Removal Summary Report" (PRC, 1991a)

A complete discussion of analytical QA/QC results of the tank and sump removal field investigation can be found in Appendix E of the "Final Tank and Sump Removal Summary Report." PRC reviewed the CLP analytical results according to the EPA guidance documents "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" (EPA, 1988a) and "Laboratory Data Validation Functional Guidelines for Inorganic Analyses" (EPA, 1988b). The review was based on laboratory reports only, not on raw data.

QA sampling and analysis activities included collecting and analyzing field and laboratory QC samples. Field QC samples included trip blanks, equipment blanks, and field duplicates. Laboratory QC samples included laboratory blanks, matrix spikes, matrix spike duplicates, and blank spikes. Other QC procedures regularly performed by the laboratory included instrument tuning and calibration checks.

DQOs were developed for PRC activities generated under the Comprehensive Long-Term Environmental Assessment, Navy (CLEAN) contract. Following the data review, PRC found that DQOs for the tank and sump removal were substantially met. Analytical precision was good with more than 90 percent of the relative percent differences (RPD) for spike recoveries being within the accepted QC limit. Accuracy of analytical procedures was good for most

samples as indicated by the surrogate and spike recoveries. More than 90 percent of the recoveries were within the QC limits. The completeness objective was achieved with more than 95 percent of the data being usable. Finally, all data were considered representative because the accepted and prescribed methods presented in the PRC Moffett Field Work Plan were followed.

2.2.3.6 PRC Environmental Management, Inc.: "Building 29, Area Field Investigation Technical Memorandum" (PRC, 1991b)

A complete discussion of analytical QA/QC results of the Building 29 investigation can be found in Appendix E of the "Building 29, Field Investigation Technical Memorandum." PRC reviewed the CLP analytical results according to the EPA guidance document "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" (EPA, 1988a). QA sampling and analysis activities included collecting and analyzing field and laboratory QC samples. Field QC samples included trip blanks, equipment blanks, and field duplicates. Laboratory QC samples included laboratory blanks, matrix spikes and matrix spike duplicates, and blank spikes. Other QC procedures regularly performed by the laboratory included instrument tuning, calibration checks, and surrogate recovery monitoring.

The majority of the data were received from the laboratory. However, if QC data were missing, data quality was interpreted based on other QC sources. For example, if the laboratory did not submit laboratory blank results, trip blanks, or equipment blanks, knowledge of common laboratory contaminants was used to assess the data. If surrogate recoveries were missing, surrogate recoveries of other samples and matrix spike/matrix duplicate recoveries were used. If no alternative QC sources could be used, it is stated in the report that applicable QC data were unavailable.

DQOs were developed for PRC activities generated under the CLEAN contract. Following the PRC data review, PRC found that DQOs for the Building 29 investigation were met. Analytical precision was good with more than 90 percent of the RPDs for duplicate analyses falling within the accepted QC limit. The accuracy of the analytical procedures was good for most samples as indicated by the surrogate and spike recoveries. The completeness objective was achieved with more than 90 percent of the data being usable. Finally, all data are considered representative because the accepted and prescribed methods presented in the PRC Moffett Field Work Plan were followed.

2.2.3.7 PRC Environmental Management, Inc.: "Site 9, Area Field Investigation Technical Memorandum" (PRC, 1991c)

A complete discussion of analytical QA/QC results of the Site 9 field investigation can be found in Appendix E of the "Site 9, Area Field Investigation Technical Memorandum." PRC reviewed the CLP analytical results according to the EPA guidance document "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" (EPA, 1988a) and "Laboratory Data Validation Functional Guidelines for Inorganic Analyses" (EPA, 1988b). The review was based on laboratory reports only, not on raw data.

QA sampling and analysis activities included collecting and analyzing field and laboratory QC samples. Field QC samples included trip blanks, equipment blanks, and field duplicates. Laboratory QC samples included laboratory blanks, matrix spikes and matrix spike duplicates, and blank spikes. Other QC procedures regularly performed by the laboratory included instrument tuning, calibration checks, surrogate recovery monitoring, ICP spectrometer interference checks, laboratory control checks, and serial dilution checks.

DQOs were developed for PRC activities generated under the CLEAN contract. Following the data review, PRC found that DQOs for the Building 29 investigation were met. Analytical precision was good with more than 95 percent of the RPDs for duplicate analyses falling within the accepted QC limit. The accuracy of the analytical procedures was good for most samples as indicated by the surrogate and spike recoveries. The completeness objective was achieved with more than 90 percent of the data being usable. Finally, all data are considered representative because the accepted and prescribed methods presented in the PRC Moffett Field Work Plan were followed.

2.2.3.8 Earth Sciences Associates: "Assessment of Potential for Public/Private Wells at Moffett Field Naval Air Station to Act as Conduits for Inter-Aquifer Cross-Contamination" (1986b)

This report presents conclusions of an evaluation of the public and private wells located within and in the immediate vicinity of Moffett Field that may have acted as potential conduits for contaminant migration. A complete discussion of analytical QA/QC was not provided; however, actual analytical results were provided in Appendix C of the referenced report. For comparative purposes, analyses performed by Canonie Engineers are also presented in this report for two wells that supported the ESA observations.

Analyses were performed by Montgomery Laboratories in Pasadena, California by GC/mass spectrometry (MS) for volatile and base/neutral/acid (semivolatile) priority pollutants as well

as six volatile non-priority pollutants. Low detection limits (actually CLP detection limits) were obtained. Standard field sampling and QA/QC practices appear to have been followed with respect to field and trip blank collection, which were clean. Two wells were not purged prior to sampling, which may have biased results toward contamination.

2.2.3.9 Harding-Lawson Associates: Remedial Investigation Report; Remedial Investigation/Feasibility Study Middlefield-Ellis-Whisman Area; Mountain View, California (1987a)

Harding Lawson's Work Plan for the MEW area was written between 1986 and 1987 when formal data validation guidance had not been published. Therefore, project-specific QA/QC was developed, approved by the agencies, and implemented. To determine data usability, HLA reviewed the data with respect to the available QA/QC sample results and documentation. Data were found to meet the objectives of the project. Conclusions of the assessment are included in the final RI Report (HLA, 1987a).

At the request of the EPA and subsequent to the HLA evaluation, additional validation by an outside contractor was performed on the MEW RI/FS data. As with the HLA review, because CLP-like documentation was not generated in this process, the validators used the other available, relevant QA/QC information to assess the data quality. EPA also performed site audits of the three laboratories that performed analyses in support of the MEW RI/FS to assess their QA/QC programs. After this review, EPA concluded that all data were "valid and adequate for the purposes of the Remedial Investigation and Feasibility Study" (EPA, 1988c).

2.3 Site Investigations

Investigations at the individual OU2 sites are described in the following subsections. Those activities were previously described in the Phase I and II Work Plans for the RI (IT, 1988a; IT, 1990a). Other current investigations in the OU2 area are described in Section 2.7.

Prior to the 1983 investigation at Moffett Field, off-site companies south of Moffett Field were in the process of a similar investigation. Five companies were initially involved in a study to investigate the origin and extent of TCE present in the soil and groundwater surrounding the five facilities. The area involved in the study was referred to as MEW. Other entities off site, such as the NASA-ARC and Lockheed, soon began studies to examine their contributions, if any, to the soil and groundwater contamination in the area. These investigations are described in Section 2.3.2.

2.3.1 On-Site Sources - Moffett Field Description of Sites

This section describes the following 15 sites that are being investigated as part of OU2 at Moffett Field:

- Site 3 - Marriage Road Ditch
- Site 4 - Former Wastewater Holding Pond
- Site 5 - Fuel Farm French Drains and Bulk Tanks
- Site 6 - Runway Apron
- Site 7 - Hangars 2 and 3
- Site 8 - Waste Oil Transfer Area
- Site 9 - Old Fuel Farm and the Old NEX Gas Station
- Site 10 - Chase Park Area and Runway
- Site 11 - Engine Test Stand Area
- Site 13 - Equipment Parking Area (Building 142)
- Site 14 - Tanks 19, 20, 67, and 68
- Site 16 - Public Works Steam Cleaning Rack Sump 60
- Site 17 - Paint Shop Sump 61
- Site 18 - Dry Cleaners' Sump 66
- Site 19 - Tanks 2, 14, 43, and 53.

Some of the sites are discrete, individual locations, while other sites are composed of multiple locations.

2.3.1.1 Site 3 - Marriage Road Ditch

Marriage Road Ditch runs northward along the east side of Marriage Road, carrying surface drainage from the intersection of Marriage and Macon Roads to the northern boundary of Moffett Field. A summary of Phase I activities with their results are described in the Phase I Characterization Report (IT, 1991a). The Phase I investigation activities at Site 3 included the continuous coring and geophysical logging of deep borings and the installation of seven groundwater monitoring wells. Phase I activities also included the collection and analysis of surface and shallow subsurface (soil borings) soil samples along Marriage Road Ditch, analysis of groundwater samples from the Site 3 wells, and a soil gas survey.

Following Phase I RI activities, cone penetrometer tests (CPT) and Hydropunch® (HP) groundwater samples were collected at Site 3. The CPT provided additional information on soil stratigraphy underlying the site. The HP was used to obtain additional groundwater quality information to assist in locating the Phase II borings/wells. Results of the CPT/HP were presented in the 1990 quarterly reports (IT, 1990b).

The Phase II RI activities consisted of installing four monitoring wells near the south end of the Marriage Road Ditch and sampling and analyzing soil from these well borings. Three additional soil borings were drilled in the area of the soil vapor plumes delineated east of the ditch.

Phase I and II well and soil boring locations are shown in Figure 2.3-1 and a listing is provided in Table 2.3-1. The soil borings range in depth from 14 to 16 feet. The Phase I and II wells were installed in the A, B, and C aquifers. Three soil samples from each soil boring and monitoring well were collected from 1 to 11 feet bls. (Soil samples from soil boring SB03-02 were collected from 4 to 10 feet bls.)

The soil lithologies are described in detail in the Phase I Characterization Report (IT, 1991a). The soil lithology is summarized as sandy-silty clay with fine lenses of interbedded sand and gravel. The coarser fractions are typically saturated. In the Phase II drilling activities, groundwater was initially encountered in the thin sand units 4 to 7 feet deep. The A1-aquifer zone in this area is in a fine- to coarse-grained sand. The top of the A1-aquifer zone under Site 3 ranges from 12 feet bls in monitoring well W03-20(A1) to 24 feet bls in monitoring well W03-19(A1). Groundwater was encountered at 4 to 7 feet bls. The surface soil is reworked due to the construction of the golf course.

The collected soil samples were analyzed for VOCs; pH; metals; PCBs; Base, Neutral, and Acid Extractable Target Compounds (BNA), and TPHC. The nature and extent of contamination at Site 3 are presented in Chapter 4.0.

2.3.1.2 Site 4 - Former Wastewater Holding Pond

Site 4 is the area encompassing and surrounding the former wastewater holding pond, located north of Hangar 3 and west of the existing ponds.

Phase I RI results are described in the Phase I Characterization Report (IT, 1991a). The Phase I RI activities consisted of drilling three stratigraphic boreholes, and three groundwater monitoring wells in the A, B, and C aquifers. Five A1-aquifer zone wells and one A2-aquifer zone well were installed prior to the Phase I effort.

Following Phase I RI activities, CPT and HP water sampling were conducted at Site 4. The CPT provided additional information on soil stratigraphy underlying the site. The HP was

used to obtain additional groundwater quality information to assist in locating the Phase II borings/wells. Results of this work are presented in the 1990 quarterly reports (IT, 1990b).

The Phase II RI activities consisted of drilling four soil borings in the area of the abandoned holding pond west of the existing ponds, and seven monitoring wells in the A1-, A2-, and B2-aquifer zones. Locations of the Phase I and Phase II IT wells and borings are shown in Figure 2.3-2 and a listing is provided in Table 2.3-2.

The soil borings range in depth from 14 to 16 feet. The soils in the unsaturated zone consist of 3 to 6 feet of fill material (silt, gravel, and some organic material). Below the fill material, the soils consist of clayey silts and interbedded sands. Groundwater was encountered at 6 to 8 feet bls.

The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. The nature and extent of contamination at Site 4 are presented in Chapter 5.0.

2.3.1.3 Site 5 - Fuel Farm French Drains and Bulk Tanks

Site 5 is separated into a northern and a southern area. The northern area is located in the triangular area bordered by Macon Road, Patrol Road, and the golf course. The southern area is bounded by Macon Road on the east, runway aprons to the south and west, and Hangar 3 to the north.

The Phase I RI activities consisted of drilling three geophysical soil borings as well as drilling and sampling one soil boring and thirteen groundwater monitoring wells (Figure 2.3-3). The results of these activities are discussed in the Phase I Characterization Report (IT, 1991a).

A soil organic vapor (SOV) survey was also conducted during Phase I activities at Site 5, in which four organic vapor plume areas were defined:

- Plume P-1 in the fuel tank secondary containment area in the northern section
- Plume P-2 located northwest of the north section in the area of monitoring well W05-21(A1)

- Plume P-3, made up of two small plumes in the areas of SB05-02 and SB05-01
- Plume P-4, in the north corner of the southern site near monitoring well W05-13(A1).

The Phase I soil gas survey maps are presented in Appendix C.

Following Phase I RI activities, CPT and HP water sampling were conducted at Site 5. The CPT provided additional information on soil stratigraphy underlying the site. The HP was used to obtain additional groundwater quality information to assist in locating the Phase II boring/wells. Results of this work are presented in the 1990 quarterly reports (IT, 1990b).

The Phase II RI activities consisted of drilling 28 soil borings (see Figure 2.3-3) and constructing 10 monitoring wells. In addition, nine free-product wells were installed at the tank farm area. Table 2.3-3 lists the wells/borings installed at Site 5 as part of the RI activities.

The soil borings range in depth from 12 to 25 feet. Monitoring wells were installed in the A, B, and C aquifers. The soils in the unsaturated zone above the A1-aquifer zone comprise dark brown silty clay and clayey silt with interbedded sand and gravel lenses. Groundwater at Site 5 is typically encountered at 5 to 13 feet bls.

Three soil samples were collected from the upper 10 feet of the vadose zone in each soil boring/monitoring well. The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. The nature and extent of contamination at Site 5 are presented in Chapter 6.0.

2.3.1.4 Site 6 - Runway Apron

Site 6 is designated the Runway Apron disposal site and was located adjacent to the former aprons north and east of Hangar 3.

During the Phase I RI activities, no soil borings or wells were drilled (Phase I Characterization Report [IT, 1991a]). The Phase I RI activities consisted of collecting water samples from seven existing monitoring wells installed by ESA and Emcon, and evaluating the groundwater data.

Following Phase I RI activities, CPT and HP water sampling were conducted at Site 6. The CPT provided additional information on soil stratigraphy underlying the site. The HP was used to obtain additional groundwater quality information to assist in locating the Phase II borings/wells. Results of this CPT/HP work are presented in the 1990 quarterly reports (IT, 1990b).

The Phase II RI activities consisted of drilling and installing three monitoring wells. Locations of these monitoring well borings are shown in Figure 2.3-4. Table 2.3-4 lists wells/borings drilled at Site 6 as part of the RI activities.

The wells were installed in the A1- and A2-aquifer zones. The soils in the unsaturated zone above the A1-aquifer zone consist of 3 to 4 feet of silty clay. In boring log W06-10(A1), this material is described as fill material. This clay is underlain by approximately 1 foot of silt and sandy clay followed by clay with interbedded clayey sand. Groundwater was encountered at 6 to 7 feet bls.

The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. The nature and extent of contamination at Site 6 are presented in Chapter 7.0.

2.3.1.5 Site 7 - Hangars 2 and 3

Site 7, which lies to the west of Macon Road near Patrol Road, consists of Hangars 2 and 3 and the paved area surrounding the hangars.

The Phase I RI activities consisted of installing five monitoring wells in the A and C aquifers and drilling three soil borings. Following Phase I RI activities, CPT and HP water sampling were conducted at Site 7. The CPT provided additional information on soil stratigraphy underlying the site. The HP was used to obtain additional groundwater quality information to assist in locating the Phase II borings/wells. The results of this work are presented in the 1990 quarterly reports (IT, 1990b).

The Phase II RI activities consisted of installing one monitoring well in the A2-aquifer zone. The locations of the Phase I and II monitoring wells are shown in Figure 2.3-5, and a list of the wells and borings is provided in Table 2.3-5. The soils in the vadose zone above the A1-aquifer zone consist of light brown clay and clayey sand. Groundwater was encountered at 7 to 9 feet bls.

The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. The nature and extent of contamination at Site 7 are presented in Chapter 8.0.

2.3.1.6 Site 8 - Waste Oil Transfer Area

Site 8 is located near Building 127, between Zook Road and McCord Avenue, where the off-site branch of the DRMO maintained a 5,000-gallon waste oil tank from the 1940s until 1980.

The Phase I RI activities included the continuous boring and geophysical logging of two borings and the installation of five monitoring wells. These wells were installed in the A, B, and C aquifers. Thirteen shallow boreholes were also drilled during Phase I activities. The groundwater and soil samples collected were analyzed and water levels were monitored in the wells.

Following Phase I RI activities, CPT and HP water sampling were conducted at Site 8. The CPT provided additional information on soil stratigraphy underlying the site. The HP was used to obtain additional groundwater quality information to assist in locating the Phase II borings/wells. Results of this work are presented in the 1990 quarterly reports (IT, 1990b).

The Phase II RI activities consisted of drilling four monitoring wells and four soil borings. Locations of these wells and soil borings are shown in Figure 2.3-6, and a list of the wells and borings is provided in Table 2.3-6. The Phase II wells were installed in the A1- and A2-aquifer zone.

Groundwater in the A1-aquifer zone was encountered at 8 to 18 feet bls, and in the A2-aquifer zone at 20 to 32 feet bls. The soil borings ranged in depth from 11.5 to 13 feet bls. The soils above the A1-aquifer zone consist of silty clays with interbedded sand lenses. The first foot of soil in the Phase II borings was logged as fill material. Groundwater was encountered at an average of 8 feet bls. The saturated zones were typically the thin inter-bedded sands.

The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. The nature and extent of contamination at Site 8 are presented in Chapter 9.0.

2.3.1.7 Site 9 - Old Fuel Farm and the Old NEX Gas Station

The Old Fuel Farm is located near Buildings 12 and 29 in the block formed by Bushnell Road, Severyns Avenue, North Akron Road, and McCord Avenue. Site 9 also includes the Old NEX Gas Station, which was located at the present site of Building 31.

The Phase I RI activities consisted of drilling six geophysical soil borings and drilling and sampling nine soil borings that were converted to monitoring wells. A soil gas survey was also performed at this site to delineate organic vapor plumes in the soil. The results of these activities are discussed in the Phase I Characterization Report (IT, 1991a), and the Phase I soil gas survey maps are presented in Appendix C.

Following Phase I RI activities, CPT and HP water sampling were conducted at Site 9. The CPT provided additional information on soil stratigraphy underlying the site. The HP was used to obtain additional groundwater quality information to assist in locating the Phase II boring wells. Results of this work are presented in the 1990 quarterly reports (IT, 1990b).

The Phase II activities consisted of drilling 14 soil borings and 32 monitoring wells in an effort to define the extent of soil and groundwater contamination. Locations of the Phase II soil borings and monitoring wells are shown in Figure 2.3-7, and a list of the wells and borings is provided in Table 2.3-7. Boring logs are presented in Appendix D.

The Phase II soil borings range in depth from 11.5 to 15 feet bls. Phase I and II monitoring wells were installed in the A and B aquifers. The soil in the unsaturated zone above the aquifers comprises silty clay and sandy silty clay with sand stringers. The clay is described as a light olive gray to yellow clay with low plasticity. The sand is commonly fine to medium grained and may have either a gravel or a clay matrix. Groundwater was encountered at depths ranging from 8 to 20 feet bls.

Soil samples were collected in the vadose zone at depths of 1 to 2.5 feet, 3 to 4.5 feet, and 5 to 6.5 feet. In the soil borings, an additional sample was collected at depths of 10 to 11.5 feet. The soil samples were analyzed for VOCs, pH, metals (only monitoring well soil samples were analyzed for metals), PCBs, BNAs, and TPHC. The nature and extent of contamination identified in the Phase I and Phase II RI activities for Site 9 are presented in Chapter 10.0.

2.3.1.8 Site 10 - Chase Park Area and Runway

Site 10 encompasses the runway and the Chase Park area. No Phase II RI activities were conducted at this site. Phase I RI soil sampling activities for Site 10 included the collection of soil boring/monitoring well soil samples, soil chemical analysis, and a soil gas survey.

A total of eight soil samples were collected from two monitoring well borings at Site 10. Both of the monitoring well borings are located on the east side of the runway and are shown in Figure 2.3-8. A list of the wells/borings drilled at Site 10 as part of the RI activities is provided in Table 2.3-8. No sources are located in the Chase Park area and no wells/borings were drilled in this area.

Because Site 10 is spread over the southern part of Moffett Field, lithologic information can be gathered from other sites adjacent to the Site 10 area. Lithology on the west side of the runway is provided with the Site 9 description, Section 2.3.1.7. On the east side of the runway, Site 10 wells provide information concerning the site lithology.

The east side wells indicated the uppermost soil (0 to 15 feet bls) is composed of thin sands and gravels (A1-aquifer zone) and interbedded clays. Interbedded clays are brown, very stiff, and range from plastic to nonplastic. Groundwater was encountered at depths ranging from 7 to 9 feet bls. The vadose zone predominantly comprises sandy, silty clay.

Soil samples for chemical analyses were collected from the vadose zone at 1-, 3-, 5-, 6-, 7-, and 9-foot depths from both monitoring well borings. Soils samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. The nature and extent of contamination at Site 10 are presented in Chapter 11.0.

2.3.1.9 Site 11 - Engine Test Stand Area

The Engine Test Stand Area is located approximately 500 feet north of the intersection of Patrol and Zook Roads, and lies between the eastern edge of the runway and Devil's Slough.

No Phase II RI activities were conducted at this site. Phase I soil RI activities for Site 11 included the collection of monitoring well boring soil samples, the collection of surface and shallow borehole soil samples, and soil chemical analyses.

Soil samples were collected from two monitoring well borings, from ten surface, and ten shallow soil borings located on 20-foot centers to the south of the concrete slab, and from an

additional eight shallow soil borings around the perimeter of the slab. A total of 54 soil samples were collected from 1-, 3-, 5-, and greater than 5-foot depths. Boring locations are presented in Figure 2.3-9, and a listing of wells and borings is provided in Table 2.3-9.

No geophysical borings were conducted at Site 11; however, several geophysical borings were conducted at the adjacent Golf Course Landfill (Site 2) whose geology is assumed to be typical of Site 11.

Logs of Site 2 geophysical borings into the lower alluvial materials show that silty clay is interfingered with sandy clayey gravel and sand lenses. The data also indicate variable thicknesses and limited areal extent of these lenses. Geophysical borings show an extensive sandy clay from land surface to approximately 22 feet bls. There is a 6-foot-thick silty clay that extends from 22 to 28 feet bls and then a continuous sandy clay to clayey sand to approximately 105 feet bls.

Site 2 geophysical borings in the upper alluvial materials reveal silty clay, which is mostly brown with some gray in places and is plastic in nature. There is an intermediate zone consisting of interfingered sand and silty sand, which varies in color from tan to brown and is nonplastic. The sand and silty sand seem to be consistent areally at the site; however, the thickness varies from location to location.

Groundwater was encountered at depths ranging from 14 to 20 feet bls. The vadose zone consists of approximately 5 feet of silty sandy gravel underlain by silty clay of medium to large plasticity.

All Phase I soil samples were analyzed for VOCs, BNAs, TPHC, oil and grease, PCBs, metals, and pH. The nature and extent of contamination at Site 11 are presented in Chapter 12.0 of this report.

2.3.1.10 Site 13 - Equipment Parking Area (Building 142)

The Equipment Parking Area is located northeast of Building 142, approximately 600 feet east of Hangar 3.

No Phase II RI activities were conducted at this site. Phase I soil RI activities for Site 13 included the collection of shallow soil boring samples and the chemical analyses of the samples.

Three shallow soil borings were installed in the north-south trending storm drain, and a fourth boring was installed in the center of the east-west trending drainage channel. Soil borings were sampled at approximate depths of 1 and 5 feet. Boring locations are presented in Figure 2.3-10, and a listing of the borings is provided in Table 2.3-10. The borings at this site are all shallow and there are no boring logs associated with these borings.

The stratigraphy of Site 13 is assumed to be similar to that of nearby Sites 5 and 7. Because of the concrete and/or asphalt pad at the site, little is known about the vadose zone. Groundwater at this site is expected to be at 6 to 7 feet bls.

A total of eight soil samples were collected and analyzed for VOCs, BNAs, TPHC, oil and grease, and metals during Phase I. The nature and extent of contamination at Site 13 are presented in Chapter 13.0.

2.3.1.11 Site 14 - Tanks 19, 20, 67, and 68

Tanks 19 and 20, near the South Gate exit, were adjacent to each other and were located in the southwestern part of Moffett Field. Tanks 67 and 68 were adjacent to each other and were located in the southwestern part of Moffett Field on the east side of the dry cleaners' building (Building 88). The dry cleaners' building area was investigated as part of Site 9 and Site 18 studies.

The soils and site geology at Site 14 are similar to those of adjacent Site 9. A discussion of the site geology of Site 9 was provided in Section 2.3.1.7. Groundwater in the area of Tanks 19 and 20 was first encountered at 10 to 15 feet bls and in the area of Tanks 67 and 68 at 6.5 to 15 feet bls.

Tanks 19 and 20. No Phase II RI field activities were conducted for Tanks 19 and 20. Phase I RI activities included the collection and chemical analyses of soil boring/monitoring well soil samples and a soil gas survey. Tanks 19 and 20 have been removed. Each tank had a capacity of 5,000 gallons and contained unleaded vehicle fuel.

IT installed three soil borings and six monitoring wells within 150 feet of the former tank site. Soil samples from the monitoring well borings and shallow soil borings at Tanks 19 and 20 were collected and analyzed from the vadose zone at 1-, 3-, 5-, and 6.5-foot depths. A total of 30 soil samples were analyzed for VOCs, metals, PCBs, BNAs, and TPHC. The

locations of monitoring well borings and soil sample borings for Tanks 19 and 20 are shown in Figure 2.3-11, and a list of the wells and borings is provided in Table 2.3-11.

Following Phase I RI activities, one CPT and one HP groundwater sample were collected at Site 14. The CPT provided additional information on soil stratigraphy underlying the site. The HP was used to obtain additional groundwater quality information. Results of this work are presented in the 1990 quarterly reports (IT, 1990b).

Tanks 67 and 68. IT did not conduct any Phase I or Phase II activities at Tanks 67 and 68. As part of the RI, however, several soil samples were obtained by the Navy during the removal of Tank 67 in May 1990. Soil samples were also taken at abandoned Tank 68 in September 1990 by the Navy. The removal activities, sampling scheme, and analytical results are presented in the "Final Tank and Sump Removal Summary Report," prepared by PRC (PRC, 1991a). This source was utilized to characterize the site at Tanks 67 and 68.

Upon excavation, Tank 67 was reported to be in good condition with some rust evident along the seams. After removal of Tank 67 and all associated piping, six soil samples were taken from the tank and piping trenches. These included four soil samples (TN67-NX, TN67-SX, TN67-EX, and TN67-WX) from the walls of the tank excavation and two soil samples (TP67-1 and TP67-2) from the piping trench to Building 88. Three soil samples were also collected during the construction of monitoring well W67-01(A1) at depths of 2.5, 5.0, and 7.5 feet bls. All soil samples were analyzed for VOCs, SVOCs, TPHC-diesel, TPHC-kerosene, and TPHC-gasoline. Sample locations are shown in Figure 2.3-12.

Tank 68 was reportedly closed in place sometime prior to 1987. During September 1990, in situ soil assessment was obtained by two slant soil borings. Boring W68-01(A1) was located approximately 20 feet northeast of Tank 68 and drilled at a 45 degree angle to the southwest. Boring SB68-01(A1) was located on the southwest side of Tank 68 and drilled at a 45 degree angle to the northeast. Soil samples from both borings were collected at depths of 2.5, 7.5, 12.5, 17.5, and 25.0 feet bls. Each sample was analyzed for VOCs, BNAs, TPHC-diesel, TPHC-kerosene, and TPHC-gasoline. Sample locations are shown in Figure 2.3-12.

A total of 19 soil samples were obtained near Tanks 67 and 68. The nature and extent of contamination at Site 14 are presented in Chapter 14.0.

2.3.1.12 Site 16 - Public Works Steam Cleaning Rack Sump 60

The Public Works Steam Cleaning Rack (Sump 60) is located in the Public Works Vehicle Yard, between the South Gate and Chase Park (Figure 2.3-13).

IT did not conduct any Phase I or II RI field activities. Site characterization is based on the removal activities and analytical data found in the "Final Tank and Sump Removal Summary Report" (PRC, 1991a) and "Additional Tank and Sump Field Investigation Technical Memorandum" (PRC, 1993).

The initial excavation included the removal of the sump, catch basins, and piping and extended approximately 4 feet bls. Due to visible contamination, the excavation was extended to 10 feet bls during which the 250-gallon tank and concrete vault were discovered and removed. Soil samples obtained during the sump removal in October 1990 included:

- Three soil samples from the floor of the initial excavation (SU60-WX, SU60-SX, and SU60-WY)
- Four soil samples from the wall of the enlarged excavation (SU60-NY, SU60-SY, SU60-EY, and SU60-WY)
- Three soil samples from the floor of the enlarged excavation (SU60-NY, SU60-SFY, and SU60-TY)
- Four soil samples from monitoring well W60-01(A1) at depths of 5, 10, 19.5, and 27.5 feet bls.

PRC installed monitoring well W60-02(A1) in May 1992. Soil samples obtained during the installation of this monitoring well included seven soil samples at depths of 7, 10, 15, 20, 22, 28, and 34 feet bls.

The soils and geology of Site 16 are similar to those of adjacent Site 9. A description of Site 9 geology is provided in Section 2.3.1.7. Groundwater is expected to be encountered at approximately 18 feet bls in this area.

All soil samples collected during the removal of Sump 60 were analyzed for VOCs, SVOCs, BNAs, BTEX, TPHC-gasoline, TPHC-diesel, total recoverable petroleum hydrocarbons (oil and grease), and metals, with the exception of the enlarged excavation soil samples, which were not analyzed for VOCs, SVOCs, and TPHC-gasoline. The soil samples collected from

monitoring well W60-02(A1) were analyzed for VOCs, TPHC-gasoline, TPHC-diesel, and TPHC-JP5. The nature and extent of contamination at Site 16 are presented in Chapter 15.0.

2.3.1.13 Site 17 - Paint Shop Sump 61

The Public Works Paint Shop is located in Building 45 and has been active since the late 1930s (NEESA, 1984). A concrete sump was located on the north side of the building (Sump 61) (Figure 2.3-14).

No Phase I RI activities were conducted at Site 17. Soil RI activities performed during Phase II included the Sump 61 removal and soil sampling by the Navy (PRC, 1991a), Site 9 IT soil boring/monitoring well soil samples near Building 45, and soil chemical analysis.

Sump 61, a concrete vault lined with brick, was located approximately 7 feet bls. The sump and all associated piping were removed in October 1990. The approximate excavation dimensions were 15 feet by 12 feet by 9 feet deep. Two soil samples were collected from the walls of the excavation (SU61-NX, SU61-SX). In addition, three soil samples were collected during the installation of monitoring well W61-01(A1), located 5 feet north of the excavation. Soil boring/monitoring well soil samples were collected at 6, 10, and 16 feet bls. All samples collected by PRC were analyzed for VOCs, BNAs, BTEX, TPHC-diesel, TPHC-gasoline, and metals.

IT installed three monitoring wells at Site 9 within approximately 140 feet of Sump 61. Monitoring well W09-31(A1) is located approximately 50 feet to the west of Sump 61. Monitoring well W09-23(A) is approximately 130 feet to the south and W09-28(A2) is 140 feet southeast of the sump. Each monitoring well boring was sampled at 1, 3, and 5 feet bls. All IT soil samples were analyzed for VOCs, BNAs, PCBs, TPHC, and metals.

Site 17 is located within the boundaries of Site 9; therefore, soil and geology are described by the Site 9 lithologic information in Section 2.3.1.7. Groundwater at this site is encountered at depths ranging from 8 to 18 feet bls.

A total of 14 samples were collected at or immediately adjacent to Site 17. The nature and extent of contamination at Site 17 are presented in Chapter 16.0.

2.3.1.14 Site 18 - Dry Cleaners' Sump 66

The dry cleaners' sump was located on the north side of Building 88, which contains the dry cleaners and laundry.

RI investigative data collected from Site 18 soils prior to Phase II RI activities include the Phase I soil gas survey (conducted by IT) for adjacent Site 9 and the 1987 ERM-West investigation.

Field testing of shallow soil gas was conducted as part of the Site 9 investigation. Approximately 35 locations were field tested for total ionizable compounds. A soil gas transect map and a contour map of the soil gas concentrations are provided in Appendix C.

Samples for GC analysis were collected from 13 of the sample locations at Site 18. Six of the ten target compounds were found in these samples. The results of the GC analysis can be found in the Phase I Characterization Report (IT, 1991a).

Sump 66 was investigated by ERM-West (1987) as part of an examination of potential soil and groundwater contamination near Tanks 67 and 68. Field observations revealed cracks in the sump. During the investigation, ERM-West drilled two borings (B-13 and B-14) near the sump, collected soil samples, and converted B-14 to a monitoring well (ERM-4).

RI activities performed during Phase II included Sump 66 removal and soil sampling by the Navy (PRC, 1991a) and Site 9 IT soil boring/monitoring well soil samples near Building 88.

Sump 66, located approximately 3 feet bls, was removed in May 1990. The piping from Building 88 to Sump 66 was cut and grouted where it entered the building. Two soil samples were taken from the sump excavation walls (SU66-WX and SU66-NX) and one from the floor (SU66-FX). Sample locations are shown in Figure 2.3-15.

IT installed four monitoring wells and three soil borings within approximately 200 feet of Sump 66 at Site 9. Monitoring wells W09-12(B2) and W09-17(A2) are located approximately 70 feet northwest of Sump 66. Monitoring well W09-37(A1) and soil boring SB09-12 are located approximately 100 feet to the west of Sump 66. Soil boring SB09-11 is located approximately 180 feet to the north, and monitoring well W09-18(A1) and soil boring SB09-10 are located approximately 200 feet to the northeast. Each monitoring well was sampled at 1-, 3-, and 5-foot depths. The soil borings were sampled at 1-, 3-, 5-, and 10-foot depths.

Sample locations are shown in Figure 2.3-15. Groundwater at this site was encountered at depths ranging from 11 to 12 feet bls.

The soils and geology are similar to adjacent Site 9, which is described in Section 2.3.1.7.

A total of 27 Phase II samples were collected at or immediately adjacent to Site 18. The three PRC samples collected during the sump removal were analyzed for VOCs, TPHC-diesel, TPHC-motor oil, and TPHC-gasoline. The 24 IT samples obtained from monitoring wells and soil borings were analyzed for VOCs, BNAs, metals, PCBs, and TPHC. The nature and extent of contamination at Site 18 are presented in Chapter 17.0 of this report.

2.3.1.15 Site 19 - Tanks 2, 14, 43, and 53

Tanks 2 and 43 were located on the east/northeast side of Hangar 3, respectively. Tank 2 was a 2,000-gallon UST used to store waste oils and solvents. Tank 14 was a 1,100-gallon unvalved UST that was used as a stand-by diesel fuel tank for Building 158 (the Operations Building). The tank was located in the lawn area 10 feet south of Building 158 and approximately 400 feet east of the intersection of Cody and Macon Roads. Tank 43 was a 2,000-gallon UST used to collect industrial waste from Hangar 3. Tank 53 was a 500-gallon UST located on the southeast corner of the intersection of Patrol and Marriage Roads.

IT did not perform any Phase II RI activities at Site 19. Site characterization is based on IT Phase I soil boring/monitoring well soil samples and tank removal and soil sampling by the Navy (PRC, 1991a and 1993).

The soil lithology of the Site 19 area in the vicinity of Tanks 2 and 43 is typical of the adjacent Site 7. The groundwater at this site is expected to be encountered at 9 to 15 feet bls. The soil lithology of the Site 19 area in the vicinity of Tank 14 is similar to the adjacent Site 9. The groundwater at this site is expected to be encountered at 8 to 20 feet bls. The soil lithology of the Site 19 area in the vicinity of Tank 53 is typical of the adjacent Site 3. The groundwater at Tank 53 is expected to be encountered at 4 to 7 feet bls.

Tanks 2 and 43. IT installed a total of four monitoring wells and five shallow soil borings near Tanks 2 and 43 prior to their removal. All soil samples were collected from 1-, 3-, and 5-foot depths. Monitoring well W19-01(A1) was installed just north and downgradient of Tank 43, and monitoring well W19-02(A2) was located south of Tank 43. Monitoring wells W19-03(A2) and W19-04(A1) were installed approximately 400 feet north of Tank 43. Soil

borings SB19-01, SB19-02, and SB19-03 were drilled immediately adjacent to and surrounding Tank 2, and soil borings SB19-04 and SB19-05 were located immediately adjacent to and east of Tank 43. Monitoring well/soil boring locations are shown in Figure 2.3-16, and a list of the wells and borings is provided in Table 2.3-12.

Data collected from the Tank 2 removal activities during May 1990 included nine soil samples. After the removal of Tank 2, samples (TN2-NX, TN2-SX) were taken from the north and south wall during excavation. Review of the analytical results prompted further lateral excavation to remove contaminated soils. Groundwater prevented downward excavation. Samples TN2-NY, TN2-SY, and TN2-EY were collected from the walls of the enlarged excavation. Both the initial and expanded excavation samples were obtained at approximately 8 feet bls. Visible contamination reportedly remained in the walls after the final excavation. A soil sample was also collected from the pipe trench between the storage shed and Tank 2 at approximately 2 feet bls. Three soil samples from monitoring well W02-01(A1), located at the north end of the tank, were collected at 2.5, 5.0, and 7.5 feet bls.

A total of 29 soil samples were collected from the excavation of Tank 43. The initial excavation included the removal of the tank and associated piping. Inspection of the tank and piping indicated that the tank was in good condition with no noticeable leaks, but the pipe was severely corroded and showed signs of leakage. Two soil samples were collected from the walls of the initial tank excavation while 17 soil samples were collected from the initial piping excavation. The analytical results of these samples indicated the presence of additional contamination; therefore, the excavation was enlarged.

As with Tank 2, groundwater prohibited downward excavation. Four additional samples were then collected from the walls at the enlarged tank excavation and six additional soil samples were collected from the enlarged pipe trenches. All samples from the walls at the tank excavation were collected at 9 to 10 feet bls; the pipe trench samples were obtained between approximately 3 and 6 feet bls.

In addition to the 29 excavation soil samples, 5 soil samples were collected during the installation of nearby monitoring wells W43-01 and W43-02. Samples were collected from 2.5 and 7.5 feet bls in monitoring well W43-01 and 2.5, 5.0, and 7.5 feet bls in monitoring well W43-02. Soil sample locations for Tank 43 are shown in Figure 2.3-16.

A total of 28 IT soil samples from the monitoring well borings and shallow soil borings were collected and analyzed for VOCs, BNAs, PCBs, metals, and TPHC.

The 43 soil samples collected by PRC during the removal of Tanks 2 and 43 and from the three monitoring wells were analyzed for VOCs, BNAs, TPHC-diesel, TPHC-gasoline, and TPHC-motor oil. In addition, the PRC soil samples collected near Tank 43 (29 total) were also analyzed for metals.

Tank 14. IT did not perform any Phase I or II RI soil investigative activities at or immediately adjacent to Tank 14. The Tank 14 location is shown in Figure 2.3-17.

PRC data obtained during the removal of Tank 14 in June 1990 included seven soil samples from the walls and floor of the tank excavation and pipe trench as well as three soil samples collected during the installation of a nearby monitoring well. Inspection of the removed tank revealed no holes or breaches but some corrosion was evident where tar covering had been chipped.

The initial excavation consisted of removing the tank and all associated piping. The excavation was enlarged once the presence of additional contaminated soil was confirmed. The seven excavation soil samples included two samples from the east (TN14-EX) and west (TN14-WX) walls of the initial excavation. One sample was collected from each wall (TN14-NY, TN14-SY, TN14-EY, and TN14-WY) of the enlarged excavation and one sample (TD14-01) was collected from the pipe trench between Building 158 and Tank 14. The initial, enlarged, and pipe trench excavation samples were collected at depths of 9, 12, and 15 feet bls, respectively. The three soil samples from monitoring well WT14-01(A1) were collected at depths of 2.5, 7.5, and 12.5 feet bls.

PRC collected ten soil samples at Tank 14. As previously discussed, seven samples were collected during the excavation of Tank 14 and its piping, while three soil samples were collected during the installation of adjacent monitoring well WT14-01(A1). All of the soil samples were analyzed for BTEX, TPHC-diesel, TPHC-motor oil, and TPHC-gasoline.

Additional investigative sampling by PRC in May 1992 included the collection of six soil samples from the northern side of the previously discussed Tank 14 excavation. Geoprobe® equipment and mobile laboratory were utilized for the sampling and on-site screening of these six samples. Geoprobe samples were collected by driving a 1-inch-diameter steel tube into

the soil to the required depth and extracting the sample. Two samples, one from 8 to 9 feet bls and one from 13 to 14 feet bls, were collected at three locations. Each Geoprobe sample was analyzed for TPHC-diesel.

Tank 53. IT did not perform any Phase I or II RI activities at Tank 53; however, soil samples were collected from soil borings and monitoring wells from Site 3, which is adjacent to Tank 53. Two monitoring wells and two soil borings were installed within 130 feet of Tank 53, with soil samples being collected at the 1-, 3-, and 5-foot depths. Monitoring well W03-23(A1) is located approximately 100 feet north of Tank 53. Soil boring SB03-01 is located 130 feet north of the tank. Monitoring well W03-16(C) is located 120 feet south-southwest of the tank and soil boring SB03-02 is located approximately 110 feet southwest of Tank 53.

PRC data (obtained during the removal of Tank 53) included five soil samples from the walls and floor of the excavation and two soil samples obtained during the installation of a nearby monitoring well. Inspection of the removed tank revealed pin holes and corrosion pits. The surrounding soils were saturated with product and had a gasoline odor.

The initial excavation consisted of removing the tank and all associated piping. The excavation was enlarged upon confirmation of the presence of additional contaminated soils. The five excavation soil samples included one sample (TN53-SX) from the floor of the initial excavation and one sample from each wall (TN53-NY, TN53-SY, TN53-EY, and TN53-WY) of the enlarged excavation. Visible contamination reportedly remained in the walls after the final excavation. The initial excavation samples were collected at 5 feet bls while the enlarged excavation samples were detected at 6 feet bls. The soil samples from monitoring well W53-01(A1) were collected at 2.5 and 5.0 feet bls.

The nine IT soil samples from the monitoring wells/soil borings in adjacent Site 3 (within 130 feet of Tank 53) were analyzed for VOCs, BNAs, TPHC, PCBs, and metals. A total of seven soil samples were collected by PRC at Tank 53. As previously discussed, five samples were collected from the excavation of Tank 53 and two samples were collected during the installation of a monitoring well. All soil samples collected by PRC were analyzed for VOCs, BTEX, and TPHC-gasoline.

Additional investigative sampling by PRC in May 1992 included the collection of 24 soil samples from areas to the south, east, and west of the previously discussed Tank 53 excava-

tion and the collection of 3 soil samples during the installation of monitoring well W53-02(A1) located northeast of Tank 53 across Marriage Road. Geoprobe equipment and mobile laboratory were utilized for the sampling and on-site screening of the 24 samples surrounding the tank excavation. Geoprobe samples are collected by driving a 1-inch diameter steel tube into the soil to the required depth and extracting the sample. The Geoprobe samples were collected at depths from 2.0 to 7.0 feet bls. In addition to the on-site field screening performed by the mobile laboratory, a portion of 13 of the Geoprobe samples were sent to an analytical laboratory for analysis. All of the Geoprobe samples, whether analyzed on site or in the laboratory, were analyzed for TPHC-gasoline and BTEX. The three soil samples collected from W53-02(A1) were collected at 5, 10, and 12 feet bls and were also analyzed for TPHC-gasoline and BTEX compounds.

All of the referenced sample locations are shown in Figure 2.3-18. The nature and extent of contamination for this site are presented in Chapter 18.0 of this report.

2.3.2 Off-Site Sources

2.3.2.1 Middlefield-Ellis-Whisman Study Area

During 1981, an investigation initiated by Intel identified TCE in the soil and groundwater near the industrial area bounded by the Middlefield, Ellis, and Whisman Streets in Mountain View, California. In 1982, as a result of a program initiated by the California Regional Water Quality Control Board (CRWQCB) calling for investigation of USTs, and/or as a result of the company's own initiative, four other companies (Fairchild, Raytheon, Siltec, and National Electronic Corporation [NEC]) began investigating contamination at their facilities. In 1985, the CRWQCB referred all five companies to EPA for cleanup under CERCLA. Since then, a Regional Study Area was established by the MEW companies encompassing approximately 9 square miles, including about 2.5 square miles of Moffett Field and the NASA-ARC; about 2.5 square miles of light industrial and commercial land uses; about 1 square mile of agricultural, park, golf course, and undeveloped land uses; about 1.5 square miles of residential, school, and motel land uses; and about 1.5 square miles of roads (HLA, 1987b).

Since the five initial companies began their investigations, the number of potentially responsible parties (PRP) contributing to MEW contamination has grown to 20 as a result of additional investigations and includes three separately listed or proposed Superfund sites. Recent studies have shown that contaminated groundwater at the MEW area has migrated

onto Moffett Field and it appears to have mixed, in part, with contamination from Moffett Field (EPA, 1988d).

Chemical species detected in groundwater are predominantly volatile halogenated alkanes, alkenes, and aromatics. Nine of these compounds compose more than 90 percent of the chemicals detected in groundwater samples. TCE, TCA, total 1,2-DCE, and Freon-113 compose more than 60 percent of the chemicals detected.

2.3.2.2 National Aeronautics and Space Administration - Ames Research Center

Description of Sites. This section describes the three areas that EPA investigated to assess possible sites of environmental concern under CERCLA Section 120. The investigation covered all federal facilities that were generating, storing, treating, or disposing of hazardous waste. The sites under investigation are as follows:

- Storm drainage system
- USTs
- Drum dispensing and waste storage areas.

Storm Drainage System. The storm drainage system is made up of a concrete-lined drainage ditch that drains the runoff from NASA-ARC and Moffett Field into a marsh on the north side of the property. Due to age, cracks in the concrete lining have formed along the ditch, allowing chemicals to seep through and potentially contaminate underlying soils. Ebasco Services conducted a site inspection (SI) at the NASA-ARC facility during November 1988 (Ebasco, 1989). Isolated soil samples collected as part of this effort identified a variety of organic compounds; however, no consistent pattern was apparent. Groundwater collected from three locations indicated the presence of several different solvents; however, these solvents were not identified in the overlying soil. The data indicate that groundwater in this local area contains these compounds; however, the concentrations within the storm drainage system are not significant enough to be considered for inclusion in the Hazard Ranking System (HRS) scoring.

Underground Storage Tanks. The NASA-ARC facility contained approximately 40 USTs on site. Tanks containing AVGAS (JP-5) were found to be leaking into surrounding soil and groundwater. A majority of the tanks have since been removed and the remaining tanks are being investigated. It is suspected that these leaking tanks could contribute

contamination onto Moffett Field. NASA-ARC is planning to remove or replace all facility USTs.

Drum Dispensing and Waste Storage Area. Discolored soil was discovered in several areas at the NASA-ARC facility. Further studies identified three areas of discoloration: two drum storage areas and a shipping and receiving area. Elevated levels of oil and grease, toluene, and carbon tetrachloride were detected in the soils. Further studies and a remedial action plan are currently being developed for each area (Ebasco, 1988).

2.3.2.3 Lockheed Missiles and Space Company

Description of Sites. On March 5, 1987, the CRWQCB issued a request to Lockheed (the eastern neighbor to Moffett Field), pursuant to Section 13267 of the California Water Code, to define and characterize the horizontal and vertical extent of groundwater contamination at the site (McLaren, 1988). The sites under investigation are as follows:

- Buildings 181 and 182
- Building 186
- Building 187.

Buildings 181 and 182. Buildings 181 and 182 have been used for the production of aerospace components. Activities have included laboratory and electronics testing. Located south of Building 181 is a 6-foot by 13-foot, 5-foot-deep silver retention sump. The sump has reportedly received wastes from a former materials test laboratory in the building. Waste materials that may have been discharged to the sump include photographic development chemicals, used hydraulic fluids, and solvents. Lockheed is proceeding with closure of this sump (McLaren, 1988).

Industrial activities conducted within Building 182 include metal plating and etching, photographic processing, heat treating, machining, missile body subassembly and final assembly, painting, and laboratory testing. A small degreaser tank and a 12,000-gallon degreaser tank are located in Building 182. An acid retention sump, three metal process waste sumps, and a steam cleaning basin are located south of Building 182. Materials that have spilled reportedly include solutions containing beryllium, chromium, caustics, acids, and the solvents TCE and 1,1,1-TCA.

The acid retention sump may have received wastes from Building 182. Wastes that have been released into the sump include: beryllium, chromium, caustics, acids, and solvents (TCE and TCA). The condition of the concrete liner is unknown. Lockheed is in the process of emptying, cleaning, and closing this sump (McLaren, 1988).

Building 186. Building 186 was used as a power and steam generating facility until 1983 (McLaren, 1988). Located at the southeast corner of the building was a 750-gallon gasoline UST that was identified as a source area for hydrocarbon contamination. The tank was removed in 1983 and indications of hydrocarbon staining were present in the surrounding soils during extraction.

Building 187. Building 187 was used as a maintenance, painting, and flammable liquid storage facility (McLaren, 1988). Located at the southeast corner of the building was a 3,000-gallon underground waste coolant oil tank that was identified as a source of VOCs and hydrocarbon contamination. The tank was removed in 1987, and indications of hydrocarbon staining were present in the surrounding soils during extraction.

2.4 Surface Water and Sediment Investigation

Much of the runoff from Moffett Field is diverted into a single receptor ditch on the northeast portion of Moffett Field. Water from this ditch is pumped off site into a drainage canal, which eventually drains into Guadalupe Slough. Surface water and sediment sampling from this ditch were conducted in wet and dry seasons in 1989.

Samples were collected from the salt flat to the north of Moffett Field and from the marsh and slough area to the east (Figure 1.4-2). Dry season water and sediment samples were collected during August 1988. Wet season water samples were collected during January and February 1989.

A surface water grab sample and sediment core sample were collected at one location, Devil's Slough-2. A wet season water sample and sediment sample were collected in January and February 1989, respectively. A dry season water and sediment sample were collected in July and August 1988, respectively.

Results of this sampling and investigative effort will be discussed as applicable in the RI Reports for OU1 and OU6.

2.5 Hydrogeological Investigations

2.5.1 Well Installation

Phase I and II well installation activities began in May 1988 and were completed in April 1991. Well installation efforts included 111 A-aquifer wells, 13 B-aquifer wells, 8 C-aquifer wells, 13 free-product monitoring wells, and 7 landfill leachate monitoring wells.

The objectives of the drilling investigations at Moffett Field during Phases I and II of the RI were:

- To assess the quality of soil and groundwater
- To define the areal and vertical extent of soil and groundwater contamination
- To provide an opportunity for a detailed lithologic evaluation (logging) of soils collected as cores to establish the subsurface stratigraphy
- To determine locations for groundwater quality monitoring.

Two drilling techniques were used to install monitoring wells: (1) hollow-stem auger for the A-aquifer and free-product wells, and (2) casing hammer for landfill leachate and B- and C-aquifer wells.

The nature and extent of contamination of groundwater at Moffett Field are addressed in the West Side Groundwater Site Characterization Report and the RI Report for OU5.

2.5.2 Water Level Measurements

Water level data were collected monthly (third quarter 1988 to the present) from 106 wells to provide seasonal characterization of the potentiometric surface in the different hydrologic units. Data were used to construct the groundwater potentiometric surface contour maps and to establish horizontal and vertical flow directions. In addition to the monthly collection of water levels, continuous groundwater levels were obtained at selected locations to ascertain the south bay tidal effects on groundwater flow.

2.5.3 Aquifer Tests

A part of the RI for Moffett Field included determining the hydraulic properties of subsurface water-bearing materials. This was accomplished by employing aquifer test methods within the A1- and A2-aquifer zones. Eight sites at Moffett Field were selected for aquifer testing. Ten pump tests were conducted within these eight sites to characterize the hydraulic proper-

ties of the A1- and A2-aquifer zones. The results and interpretation of the aquifer tests are found in the West Side Groundwater Site Characterization Report.

2.6 Air Investigations

Air quality was screened (HNu) for worker protection during RI activities at the OU2 sites; however, no quantitative investigation of air quality at OU2 sites has been performed to date.

2.7 Other Ongoing Investigations

Following the Phase I Characterization Report (IT, 1991a), numerous work plans and reports were published by other investigators involving specific sites within Moffett Field. In addition, reports were published that evaluated individual sites on Moffett Field as a part of the Navy's source control measures. The following is a chronological summary of reports pertinent to OU2. It should be noted that this list is not inclusive of all published reports for Moffett Field. As applicable, this additional information is incorporated into this RI effort. Information and reports that became available subsequent to the RI will not be incorporated here but will be evaluated and the additional data (as applicable) will be incorporated into the FS or the basewide ROD.

May 1, 1991 - "Site 8 Waste Oil Transfer Area Final Action Memorandum." Prepared for the Navy by PRC and James M. Montgomery, Consulting Engineers, Inc. (1991a), this memorandum includes discussions and analyses of (1) previous and ongoing investigations in the area and (2) soil analytical and groundwater analytical results, and concludes with a recommended action. A tank/sump at Site 8 was presumed to have leaked 1,1,1-TCA, although this was never confirmed. In addition, low levels of 1,1-DCE and 1,1-DCA were found in three wells at the site. Because no source was identified at Site 8, source control was not warranted, and it was concluded that the contaminated groundwater would be most cost-effectively and efficiently handled as a part of the permanent, area-wide remedial actions.

May 2, 1991 - "Site 9 Action Memorandum, Volumes I and II." Prepared for the Navy by PRC (1991d), this report discusses and analyzes interim source control activities at Site 9. In addition, it provides a summary on the site history and operation, results of previous investigations, and a description of removal action alternatives. The findings of this report were based on ground penetrating radar (GPR), soil gas surveys, CPT and HP sampling, previously drilled boreholes and installed monitoring wells, and water level measurements. The report assumes four previously identified locations as potential sources at

the site (tanks and sumps located in the vicinity of Buildings 29, 31, 45, and 88). Contaminants of concern included AVGAS, gasoline, paints, thinners, toluene, turpentine, TCE, tetrachloroethene (PCE), and 1,2-DCE. The suggested removal action was groundwater extraction and treatment with air stripping/thermal oxidation combined with in situ bioremediation of contaminated soils at the Building 29 area.

May 10, 1991 - "Site Investigation Report, Inferred Sources 8 and 9." This report was prepared for the Navy by PRC and James M. Montgomery, Consulting Engineers, Inc. (1991b). Three objectives of this investigation were: (1) to determine whether current or previous activities in the Inferred Sources (IS) 8 and 9 contributed to the regional VOC plume, (2) to define the areal extent of VOC contamination, if any, attributable to IS 8 and 9, and (3) to interpret the local geology and hydrogeology. The report concludes that the two inferred sources studied in this investigation are not believed to exist on Moffett Field because trace concentrations of TCE were found in only two samples at Moffett Field. The study identified a VOC plume, characterized by chlorinated solvents, especially TCE, existing in the shallow aquifer zones in the vicinity of Moffett Field. The regional plume appeared to emanate from south of the Bayshore Freeway and migrate northward in the shallow aquifer zones to approximately 4,000 feet onto Moffett Field (HLA, 1987a). It was suggested that no further investigations at IS 8 and 9 were warranted because there was no direct evidence that the area was a source of contamination.

July 15, 1991 - "Final Tank and Sump Removal Summary Report." Prepared by PRC (1991a) for the Navy, this report describes the results of the tank and sump removal actions at Moffett Field, outlines the field activities, and presents a characterization of the removal area for Tanks 2, 14, 43, 53, 56A-56D, 67, 68, and Sumps 60, 61, and 66. This report also includes recommendations for future characterization work at the removal sites.

July 18, 1991 - "North Base Area Field Investigation Report." This report was prepared for the Navy by PRC and James M. Montgomery, Consulting Engineers, Inc. (1991c). This investigation covered the area from just north of Site 9 to the Cargill Salt Company (formerly Leslie Salt Company) evaporation ponds beyond the north end of the station. The North Base Area investigation included Sites 8 and 12. The objectives of the investigation were to confirm the data reported, to determine the potential for the existence of sources in the study area, and to interpret the A1-zone aquifer characteristics in the North Bay Area. Methods used included analyses of groundwater samples using the CPT/HP method. Low concentrations of VOCs were identified throughout much of the North Base Area;

however, none of the data indicated that a source existed. The study recommends that further studies be conducted and that tidal influences may reverse the groundwater flow direction in aquifers adjacent to the bay.

August 23, 1991 - "Building 29 Area Field Investigation Technical Memorandum." This report (PRC, 1991e) was prepared for the Navy by PRC. Building 29 is located in the northeast quadrant of Site 9. This technical memorandum summarizes data collected during soil gas sampling, GPR, CPT/HP sampling drilling and well installation, and groundwater sampling activities. This summary aided in further characterization of lateral and vertical distribution of fuel contaminants in the area surrounding Building 29. The study concluded that the fuel contamination in the area is restricted to the A1-aquifer zone; however, the lateral extent of contamination could not be determined due to the complex nature of the geology in the area. The study recommends that all the USTs located below the building be studied further to determine appropriate source control measures in the area. It also recommends that additional site characterization be conducted downgradient of the Building 29 area.

September 10, 1991 - "Site 14 Fuel Storage Area Action Memorandum." Prepared for the Navy by PRC (1991f), this memorandum documents the removal action alternative evaluation and remediation selection process for Site 14. Two fuel USTs (Tanks 19 and 20) were removed in October 1986. They were believed to have demonstrated evidence of leakage of petroleum hydrocarbon product contaminants in the A aquifer through vertical migration in the soil column. Groundwater from monitoring well W14-02(A1) was found to contain elevated concentrations of petroleum hydrocarbon constituents. The memorandum recommends groundwater extraction and treatment with a granular activated carbon adsorption unit as a remedial process. In situ soil vapor extraction is recommended for the treatment of vadose zone VOCs.

October 15, 1991 - "Draft Site 9 Field Investigation Technical Memorandum." This report, which was prepared for the Navy by PRC (1991g), describes the results of field investigations conducted during July 1991 supporting the source control actions at Site 9. This report examines the areas around Buildings 29, 31, and 88 and the southwest quarter of Site 9, and further defines the nature and extent of contamination in these areas. Source control recommended for groundwater treatment includes extraction at selected well points and treatment by local granular activated carbon units. The recommended source control for soils is the removal of the ten USTs located in the vicinity of Building 29, and the treatment or disposal of excavated soil.

October 26, 1991 - "Subsurface Hydrogeologic Investigation NASA-ARC, Moffett Field, California." Prepared for Facilities Engineering Branch NASA-ARC by Reidel Environmental Services, Inc. (1991), this investigation presents findings from field work undertaken in the NASA-ARC area. Three locations were focused on as a part of this investigation: (1) the Jet Fuel Supply Area, (2) the Severyns Avenue Area (Building N243), and (3) the Building N210 Parking Area. All of these sites are located downgradient of Site 9. The Jet Fuel Supply Area was documented as having up to 17,000 µg/L TPHC in groundwater from monitoring well 14D11A. The highest concentration of VOCs detected here was 78 µg/L (vinyl chloride). The Building N243 area yielded no petroleum hydrocarbons in groundwater sampled from monitoring well 14C15A; however, low concentrations of VOCs were reported, with the maximum concentration being 18 µg/L of PCE. The Building N210 area is located adjacent to and northwest of Building N243. Low concentrations of VOCs were also detected in groundwater from monitoring well 14D12A, located at the southern end of the parking lot. The maximum concentration detected was 26 µg/L (vinyl chloride). The report suggests that the vinyl chloride detected may have been a biodegradation product of 1,1-DCE and trans-1,2-DCE.

January 31, 1992 - Report of Findings of a Subsurface Investigation of Potential Solvent Contamination at the N245, E182, OARF, and VTOL Sites, NASA-Ames Research Center Moffett Field, California. This report was prepared by Kleinfelder, Inc. and it pertains to an investigation of soil and groundwater quality at four sites at the NASA-ARC where results of previous investigations, and/or verbal information from site personnel suggest the possibility that solvents may have been released to the subsurface. These areas include the Building N245 site, Electrical Vault E182 site, Outdoor Aerodynamic Research Facility (OARF) site, and the Vertical Take Off and Landing (VTOL) site. The objective of this project has been to investigate the presence and distribution of selected compounds, primarily solvents and petroleum hydrocarbons, in soil and groundwater at the four sites, and to assess potential source areas of contamination that may be (or have been) in the vicinity of the four sites. The report concludes that the shallow groundwater beneath all four sites is contaminated with VOCs. Low concentrations of VOCs were also found in the shallow soils at each of the sites. This suggests that soil contamination has resulted from past activities at the sites.

September 11, 1992 - "Additional Sites Investigation Draft Report." Prepared for the Navy by PRC and James M. Montgomery, Inc. (1992a), the purpose of this investigation and report was to determine if historical waste handling and disposal practices at three sites

(not previously identified) had caused soil and/or groundwater contamination. The three sites are:

- Zook Road Fuel Spill Site
- Patrol Road Ditch Site
- Golf Course Landfill Area.

The Zook Road Fuel Spill Site is north of the present fire station in an area of potential fuel spills that may have infiltrated to subsurface soils. The Patrol Road Ditch is located east of the golf course and parallels Patrol Road. According to Moffett Field personnel, liquid wastes from aircraft maintenance (motor oil, transmission fluids, and hydraulic fluids) may have been discharged into Patrol Road Ditch. The Golf Course Landfill Area is located in the northeast corner of the golf course. Base personnel also reported that this former landfill area probably contains a variety of waste materials.

TPHC was detected at both the Zook Road Site and the Patrol Road Ditch Site, and the report recommends that additional sampling be conducted to determine the volume of contaminated soils and/or to confirm the levels of TPHC detected.

VOCs and BNA compounds of concern were not detected in the soil samples collected at the Golf Course Landfill Area. However, several pesticides and PCBs were present in soil samples collected near the water table. The human health risk should be evaluated and if these compounds pose a risk, they will be addressed in the OU2 FS. The report concludes that because the detected compounds were found in the soils at the water table and current maximum contaminant levels (MCL) for those compounds are very low, downgradient groundwater monitoring wells are recommended to monitor for the detected compounds as is an upgradient monitoring well to monitor for upgradient sources.

October 9, 1992 - "North Base Area Hydrogeologic Investigation Draft Final Report." Prepared for the Navy by PRC and James M. Montgomery, Inc. (1992b), this report was prepared in response to the EPA request that the Navy conduct additional investigations in the North Base Area to determine the feasibility of using limited hydraulic source control methods to prevent further migration of contaminants into the wetlands.

The objectives of this investigation were to assess the potential for mitigating contaminant discharges into the wetlands using hydraulic control methods and to further evaluate the nature and extent of contamination in the North Base Area. The report concludes that new

monitoring wells confirmed the presence of TCE in the A1-aquifer zone at the north end of the wetland near the NASA/Navy Storm Water Retention Pond (SWRP) and the presence of a paleochannel flow conduit in the A1-aquifer zone. Other findings provided in the report include the presence of VOCs in low concentrations in the A2-aquifer zone of the North Base Area and that the shape of the piezometric surface in both the A1- and A2-aquifer zones indicates that some VOCs are captured at Building 191 but are not being released into the wetland or NASA/Navy SWRP as long as pumping at Building 191 continues. PRC/James M. Montgomery made the following recommendations:

- Collection of soil samples near the NASA well
- Quarterly sampling of new North Base Area wells
- Quarterly sampling of Building 191 discharge water.

March 22, 1993 - "Additional Tank and Sump Investigation Field Investigation Technical Memorandum." Prepared for the Navy by PRC (1993), the purpose of this investigation is to further characterize the nature and extent of contamination at the tank and sump sites not included in the scope of FS activities. Sites addressed under this investigation include Tanks 14 and 53 and Sumps 60 and 91. Field activities conducted to provide the data necessary to characterize the nature and extent of contamination at the sites of Tanks 14 and 53 and Sumps 60 and 91 include collection of Geoprobe subsurface soil samples, drilling and sampling of soil borings, installation of groundwater monitoring wells, and collection of groundwater samples. The report concluded that:

- Contamination in the soils adjacent to Tank 14 was extremely isolated and required no further work.

- Fuel-related contamination remains in the soils at the Tank 53 area (highest to the southeast) and will be considered for remediation during future discussions with state regulatory agencies. Tank 53 is not a source for groundwater (A1-aquifer zone) contamination.

- Groundwater samples indicate Sump 60 is not a source of chlorinated VOCs.

- Sump 91 is not a VOC contaminant source.

Tank and Sump Status. The Navy has contracted PRC to coordinate with Moffett Field on tank and sump removal activities performed by the Staff Civil Engineers office. Technical memoranda are issued quarterly to report the status of ongoing investigations, and investigation results are reported as applicable. To the extent possible, this information is incorporated

into this RI effort. It should be noted that all information gathered from the tank and sump removal activities is evaluated and will be incorporated into the FS or ROD as applicable.

3.0 Physical Characteristics of the Study Area

3.1 Surface Features

Moffett Field is located on the southwest edge of San Francisco Bay and is situated on nearly flat interfluvial basin deposits of the Holocene and Pleistocene ages. Elevations at Moffett Field range from approximately 36 feet above mean sea level (msl) to 2 feet below msl.

San Francisco Bay, California's largest estuary, lies in the southern portion of a structural trough formed predominantly by Pliocene tectonics. The San Pablo Bay lies within the northern end of the structural trough north of Richmond. Seawater enters the Bay through the Golden Gate and fresh water enters through numerous rivers and estuarine systems. The main river at the south end of the Bay is the Coyote River, northeast of Moffett Field. The major rivers to the north flow into San Pablo Bay and include the Napa, Sacramento, San Joaquin, and Petaluma Rivers. An enormous amount of sediment has been deposited on the bay floor by these rivers.

Historically, tidal salt marsh and mud flats covered extensive areas of the southern portion of the Bay. Most of the marshes and mud flats in the southern portion of the Bay have been eliminated or greatly altered by diking and filling. The area just north of Moffett Field is within the historic margin of San Francisco Bay and was once open to tidal action. The area northeast of Moffett Field is now bordered by commercial salt evaporator ponds and dikes, and regular tidal action has been eliminated. Minor tidal action is present at the Jagel and Guadalupe Sloughs.

The northern half of Moffett Field lies in a flood-prone area (Figure 3.1-1) that is subject to flooding only during an exceptionally high tide. Low, undrained areas of Moffett Field are subject to periodic water ponding from precipitation events.

Intermittent-flowing Stevens Creek borders the facility on the west, and receives only minor runoff from the Moffett Field housing (Figure 3.1-2). Runoff from the remaining portions of Moffett Field, including parking lots, most roadways, and runways, is collected in a network of catchment basins that drain into an underground storm drain system. The runways also have a series of drainage ditches at approximately right angles to the runways and spaced approximately 600 feet apart. These ditches also drain to the underground storm drain system (Figure 3.1-2).

The storm drains empty into the unlined drainage ditches along Marriage Road, the eastern portion of Patrol Road, and the northern Moffett Field boundary. Water from the drainage ditches collects in a sump and is pumped into an off-site canal adjacent to the salt pond, which then drains into Guadalupe Slough. Guadalupe Slough drains into San Francisco Bay.

3.2 Meteorology

Moffett Field has a Mediterranean-type climate. It is subtropical with relatively dry summers and cool winters.

Temperature. The Pacific Ocean and the San Francisco Bay modify extremes in temperatures. Night and morning high fog dominates the area in the summer, but it "burns off" by noon. Cool valley breezes keep the average annual temperature at 58^{0}F. September has an average high of 65^{0}F, and January has the low mean temperature of 45^{0}F. Maximum temperatures have been recorded greater than 100^{0}F in June and September, and minimum temperatures have been as cool as 22^{0}F in December and January. A strong inversion dominates the valley in summer, causing haze between 1,000- and 2,000-foot altitudes. Inversions may occur at lower altitudes in the fall and winter, and ground fog may be heavy in December.

Winds. Day winds are usually moderate from the north and southwest, and are westerly during the evening. Occasionally, severe southwest winds will accompany winter storms. The average annual wind velocity is 7 miles per hour.

Precipitation. The maximum monthly average precipitation of 2.5 inches occurs during December and January and decreases during the spring and fall to between 1 and 2 inches per month. The summer dry period starts in May and extends through September. Rainfall during this period is less than 0.5 inch per month. The average annual rainfall is 13.2 inches (WESTDIV, 1985). Severe winter storms with heavy rains are infrequent. Thunderstorms can occur during any month but are usually low-intensity events. Snow is rare and does not accumulate if it does occur.

Humidity. The average humidity is 74 percent, with daily highs of 85 percent and lows of 60 percent. Much of the humidity is attributed to Moffett Field's proximity to San Francisco Bay.

3.3 Surface Water

No natural surface water features exist on Moffett Field; however, the northern boundary of Moffett Field is along the San Francisco Bay. The Coyote River and Guadalupe River drain into San Francisco Bay to the east of Moffett Field and Stevens Creek drains into the San Francisco Bay to the west.

Seawater. San Francisco Bay, California's largest estuary, forms the northern boundary of Moffett Field. Historically, tidal salt marsh and mud flats covered extensive areas of the southern portion of the San Francisco Bay; however, most have been eliminated or greatly altered. The large area to the north and northeast of Moffett Field was diked and is now bordered by commercial salt evaporation ponds. The salt evaporation ponds currently cover more than 1,000 acres that was at one time tidal salt marsh. A portion of Moffett Field extends into the salt evaporation ponds directly north. This area has been diked and filled with soil and other material to extend the runway approach. The only remaining open bodies of salt water are Jagel Slough, Devils Slough, and an unnamed ditch along the northern edge of Moffett Field. The activities taking place along the edge of San Francisco Bay has resulted in a blocking of most waterways; therefore, tidal actions such as wave height and run-up no longer influence the measured tide level (U.S. Army Corps of Engineers [USCOE], 1984).

Wetlands. Tidal marsh wetlands exist along the northern edge of Moffett Field. The wetlands on Moffett Field are approximately 40 acres in size, of which all are below sea level. An area of wetlands consisting of approximately 80 acres lies between the Moffett Field boundary and Stevens Creek. About one-half of this area is below sea level. The portion above sea level is a critical habitat for a variety of mammals and birds (WESTDIV, 1985).

Fresh Water. Although there are no streams on Moffett Field, several do exist to the east and west. The Coyote River is the largest and also the farthest from Moffett Field. The Guadalupe River is located closer to Moffett Field, but is smaller. Extensive information is available about the lower reach of this stream and represents what can be expected to occur to other Bay streams. Two small creeks are closer to the eastern boundary of Moffett Field, but they are intermittent. The creek closest to Moffett Field is Stevens Creek, which is located just to the west of Moffett Field.

Moffett Field is within the Stevens Creek watershed. Due to the relatively flat terrain, some of the precipitation accumulates in low-lying depressions, and a small amount is lost via evaporation and transpiration. Because the majority of the level surface is impervious due to structures, streets, runways, and other facilities, most of the precipitation results in stormflow runoff. The 2,000-acre drainage area of Moffett Field is essentially divided by the runway system. Runoff from the west side of the runway drains via storm water collection pipes and ditches northwest of the runway to a marsh area that drains to Stevens Creek. Storm water runoff from the east side accumulates in a brackish marsh where it is pumped to Moffett channel, which drains to Guadalupe Slough.

Flooding is mitigated in the vicinity of Moffett Field by various levees and the salt evaporation ponds owned by the Salt Division of Cargill. Available data indicate that the Bay tidal action could raise the water level 5 feet above msl; thus, Stevens Creek is subject to tidal action in the lower reaches (WESTDIV, 1985).

3.4 Geology

Regional Geology. Moffett Field is located on the southwest edge of San Francisco Bay and is situated on nearly flat interfluvial basin deposits of the Holocene and Pleistocene ages. Elevations at Moffett Field range from approximately 36 feet above msl to 2 feet below msl.

Moffett Field is located in a large northwest-trending trough (Santa Clara Valley) formed predominantly during the Pliocene (5 million years ago) and is associated with the Coast Range of California (ESA, 1986b). The valley is bordered on the west by the Santa Cruz Mountains and on the east by the Diablo Range.

The valley gently slopes to the northwest and is filled with unconsolidated to semiconsolidated sediments. Near the center of the valley the sediments are more than 1,500 feet thick and thin near the margins (Iwamura, 1980).

The northwestern portion of the trough has been intermittently inundated by seawater over the past million years and now forms the southern area of San Francisco Bay, which includes Moffett Field (Helley et al., 1979). The variation of sea level was in response to the climatic fluctuations resulting from the accumulation and melting of polar ice during the Pleistocene age (1,800,000 years ago until about 10,000 years ago).

During the colder periods of the Pleistocene age, ice accumulated in the polar regions, resulting in a lowering of sea level as much as 400 feet below the present day levels in the San Francisco Bay. During these periods of low water, the alluvial deposits from the mountain ranges to the east and west of the trough moved downslope. The results were that the alluvial deposits, consisting of gravel, sand, and silt, were interbedded with marine sediments consisting of fine grained clays and silt. The average rate of alluvial deposition near Sunnyvale, California, was about 5 inches per 1,000 years (Meade, 1967). Approximately 10,000 years ago the sea reentered the Bay and gradually rose to its present elevation, which has been maintained for the past 6,000 years.

Faulting. Two active regional faults bound the Santa Clara Valley: the San Andreas and the Hayward Faults. The nearly flat-lying units of the valley indicate that any movement associated with these faults has not caused significant deformation in the relatively shallow stratigraphic section. Similarly, the broad downwarping of the basin has not resulted in noticeable structural deformation. Some clay units, however, do exhibit localized fracturing with slickenside surfaces. These fractures may be due to several processes, including localized land subsidence, compaction, or Holocene (last 10,000 years) faulting.

Local Geology. The local geology represents the events that occurred during the Pleistocene (1,800,000 years) and Holocene (10,000 years to present) ages, but on a limited areal scale. The area underlying Moffett Field consists of interfingering of alluvial sediments and estuary deposits. The most recent alluvial-estuary sediments are coarse to fine grained and are derived from the Santa Cruz Mountains, southwest of Moffett Field. The gently sloping alluvial fans merge with the basin, tidal, and shallow marine deposits in and around the location of Moffett Field.

Surface geologic maps generated by Helley and Brabb in 1971 and modified by Iwamura in 1980 show alluvial fan deposits extending basinward (northeasterly) approximately to the Bayshore Freeway (Highway 101). North of Highway 101, interfluvial finer-grained deposits predominate with the San Francisco Bay being fringed by bay mud. The southward change near Highway 101 is from finer interfluvial deposits to coarser fan sediments and is approximately coincident with a steepening of the topographic slope toward the highlands. The topographic profile at and around Moffett Field is typical of bayland and alluvial fan interfingering systems. Drilling at Moffett Field did not penetrate the total thickness of the alluvial fan material (wells to 1,000 feet bls), but the material is assumed to be greater than 1,500 feet thick (Iwamura, 1980).

The major geologic activity in and around Moffett Field was the extensive deposition, up to 1,500 feet, of various material ranging from sand and gravel to clay. Based on the regional and local geology, it can be concluded that the amount of sand and gravel in the southern portion of Moffett Field was derived from alluvial material that also developed into sand and gravel bars that paralleled the stream channels. Because of the nearness of the source area, the deposits are relatively thick when compared to the sand and gravel deposits at the northern end of Moffett Field. As the sand and gravel moved northward toward the San Francisco Bay, it became more and more interfingered with the bay muds and the thickness of each unit became less (Helley et al., 1979). A transition occurred between the deposition of the Quaternary older bay mud (Qobm) and the Quaternary younger bay mud (Qybm) such that the deposition during the Qobm was related to stream-controlled deposits and the Qybm exhibited more control of deposition by sea and wave activity. As the northern boundary is approached, the sand and gravel units tend to pinch out. The sand and gravel within the bay mud appears to be the result of flooding and/or massive detritus flows moving downslope and fanning out over and mixing with the existing bay mud.

3.5 Soils

Soil Types. The U.S. Soil Conservation Service (1967; 1968) has identified two different soil associations on Moffett Field: the Reyes-Alviso Association and the Sunnyvale-Castro Association. Figure 3.5-1 depicts the location of the soil associations in and around Moffett Field. The Reyes-Alviso Association consists of very poorly drained, fine-textured soil developed in gleyed, fine-textured alluvium; the association occupies the level tidal flats of the San Francisco Bay. The Alviso soils constitute approximately 85 percent of the association and are dark gray to gray silty clay subsoils. The underlying alluvium is stratified with thin, discontinuous lenses of organic matter.

The Sunnyvale-Castro Association consists of poorly drained, fine-textured soils developed on gleyed, noncalcareous, fine-textured alluvium. The association occupies nearly level, topographically low positions of interfluvial basin deposits. These soils are very deep, slowly permeable, and are saturated at depth. Sunnyvale soils, which constitute approximately 50 percent of the association, have calcareous, dark gray, granular, silty clay surface soils and have strongly calcareous, gray silty clay subsoils. Castro soils, which make up about 35 percent of the association, have very dark gray, calcareous, clay surface layers and gray, partially lime-cemented subsoils. Underlying alluvium is gleyed, noncalcareous, and fine grained.

Soil Composition. The composition of soil in the Santa Clara Valley is due to source rocks and waters surrounding the depositional basin, and paleoenvironmental and paleoclimatological factors. Source rocks for the sediments in the valley are predominantly the Jura-Cretaceous Franciscan Formation and other Mesozoic volcanic rocks in the Santa Cruz Mountains to the southwest. The Franciscan Formation in this area includes sandstones (graywackes), cherts, blueschists, and other metamorphic rocks. The volcanic rocks include basalts, pillow lavas, and diabase as well as rhylotic and andesitic flows. The composition of the source rocks ranges from ultramafic (rocks rich in dark, ferromagnesian minerals) to silicic or felsic (rocks rich in light, alumina, and silica minerals).

The environment of deposition for the sediments at Moffett Field is considered estuarine to open bay. These environments include marsh and lagoon, which generally result in deposits rich in organic material. Local background levels for metals as reported by HLA (1987a), and bay area background levels suggested by the U.S. Geological Survey (USGS) (1984) are listed in Table 3.5-1. The locations of each of the background samples are shown in Figure 3.5-2. The MEW RI (HLA, 1987a) background sample sites are the Mountain View Well 18 area (MV18) and the Hetch-Hetchy Aqueduct right-of-way between Whisman Road and Tyrella Avenue. Hetch-Hetchy Aqueduct and MV18 samples were collected from surface to 6 inches bls with a hand-driven modified California-type split-spoon sampler with metal liners. The MV18 and Hetch-Hetchy data are from two composite samples that were made up from four subsamples taken from each sampling site, respectively (Figure 3.5-2). The Hetch-Hetchy and MV18 samples were analyzed for "total" priority pollutant metals determined by acid extraction of the soil (EPA Method 3050), followed by atomic absorption analyses using EPA Series 7000 methods. The MV18 and Hetch-Hetchy data are listed in Table 3.5-1.

HLA (1987a) also reports background data for select metals from another study (Wahler Associates, 1984) about 2.5 miles east of the MEW area. These data were collected for an investigation of surface soils that had potential lead contamination. The analytical methods utilized for these samples are not available.

The USGS background soil data for inorganics were obtained from a USGS study (1984) of surface soils of the United States. The specific data utilized as USGS background came from USGS Sample No. GC243050, which was collected approximately 8 miles to the west of Moffett Field. The sample was collected 8 inches bls from materials that were altered very little from their natural conditions. The USGS sampling interval for this study was conducted

from 1961 to 1975. The specific collection date of Sample No. GC243050 is not known. Due to the changing technology and available instruments during this period, several analytical methods were utilized (USGS, 1984). The analytical results of the initial samples were obtained by use of a semiquantitative six-step emission spectrographic method. The methods used for other elements were EDTA titration for calcium; colorimetric for zinc; and flame photometry for potassium. Many of the elements analyzed in the later samples were also analyzed by the emission spectrographic method. Other methods were used for the following elements: flame atomic absorption for mercury, magnesium, sodium, and zinc; flameless atomic absorption for mercury; and X-ray fluorescence spectrometry for calcium, iron, potassium, selenium, and silver.

Both of the background sampling locations utilized in the MEW RI were chosen for comparison of Moffett Field soils because of the close proximity and subsequent soil similarities of the MEW site and Moffett Field. The MEW area comprises primarily Bayshore Series soils. These soils are gray or dark grayish brown, calcareous, and basic in reaction in both surface and subsurface soils. The parent material is medium textured, alluvial material from areas of sandstone and shale rocks. The Moffett Field area comprises primarily Sunnyvale Series soils. These soils are typically black and fine textured and they are calcareous and basic in reaction in both surface and subsurface soils. The parent material is very finely divided alluvium from areas of sandstone and shale rocks (U.S. Soil Conservation Service, 1958).

EPA agreed that the MV18 and Hetch-Hetchy areas were suitable as background locations for the MEW RI for the following reasons:

- MV18 was installed in 1960 around the time when the first industrial development occurred in the MEW area. Agricultural activities adjacent to MV18 stopped around the same time that they stopped in the main industrial core of the MEW area. There have been no known commercial or industrial activities in the vicinity of MV18 since that time.

- Conventional agricultural activities in the Hetch-Hetchy area ceased when the two aqueduct pipes were installed in 1952 and 1964. The construction occurred approximately 7 to 10 years before the first major industrial development of the MEW area. The only known use of the surface of the Hetch-Hetchy area, other than for aqueduct maintenance, has been the operation of a containerized tree nursery. Such an operation is unlikely to use the types of surface and subsurface soil pesticides that make a conventional orchard an undesirable background sampling area.

Because the soils were so heterogeneous in nature, it was determined that several applicable background sample locations would be utilized to obtain a more accurate range of background inorganic concentrations in soils. Therefore, the USGS and Wahler samples, while farther from Moffett Field, were also utilized to obtain regional concentration trends.

The data reported in Table 3.5-1 represent all the background inorganics that are available. Not all inorganic parameters were analyzed, as is noted in the table. Table 3.5-2 has been provided to outline the lowest background value used for comparison purposes in the following nature and extent of contamination discussions.

In general, the inorganics detected at or above the lowest available background were reviewed in the nature and extent of contamination discussion. If the CRQL was greater than the lowest background value, all inorganic detections at or above that CRQL were reviewed as a part of the nature and extent of contamination discussions.

3.6 Hydrogeology

Regional Hydrogeology. The Santa Clara Valley groundwater basin occupies one of the large, northwest-trending regional valleys in the Coast Range of California (ESA, 1986b). The Santa Clara Valley is a gently northward-sloping trough and is filled with unconsolidated to semiconsolidated sediments as much as 1,500 feet thick near the center of the valley (Iwamura, 1980), and then thins to feather edges along the margins. The Santa Cruz Mountains and the Diablo Range form the western and eastern boundaries of the valley and groundwater basin. The northwest part of the trough has been intermittently inundated by the Pacific Ocean for approximately 1 million years (Helley et al., 1979) and formed the southern arm of San Francisco Bay. This inundation has been periodic as sea level rose and fell in response to climatic fluctuations. During warm periods, the basin was partially flooded and marine sediments accumulated in the bay. During colder, glacial periods, the sea level was lowered as much as 300 to 400 feet below its present elevation and alluvial and lacustrine sediments slowly accumulated in the basin. The average rate of alluvial deposition near Sunnyvale, California, was about 5 inches per 1,000 years (Meade, 1967). About 10,000 years ago, the sea entered the Bay once again, gradually becoming deeper until it reached the present elevation. Sea level has remained relatively constant for the last 6,000 years.

The unconsolidated basin-fill deposits consist of interbedded layers, tongues, and lenses of gravel, sand, silt, and clay. The coarser-grained sands and gravels that readily transmit

groundwater (aquifers) were deposited in the channels of streams, and in estuarine channels by relatively fast-moving water. The finer-grained clay and silt that restrain or restrict groundwater flow (aquitards) were deposited in slow-moving or still water in the open bay as well as in relatively flat estuarine and interfluvial marsh areas. Individual beds generally are thin and of limited areal extent resulting from lateral shifts of channels on the alluvial fans and in estuaries along the margins of the San Francisco Bay. Major transgressions of the Bay resulted in fine-grained deposits.

As a result of the ingress and egress of salt water and the continual erosion of the nearby hills and mountains, three distinctive zones containing several aquifers developed. For ease of understanding, an alphanumeric aquifer nomenclature was introduced (HLA, 1987b). The upper zone contains two definable aquifers: A and B. This subdivision is further supported by Helley (1990) when he states that a nonconformity exists at depth between the A and B aquifers. The A aquifer could be further divided into the A1- and A2-aquifer zones, and an A1/A2 aquitard. The A aquifers are generally thin and discontinuous and are made up of material ranging from silty sand to coarse gravel. The B aquifer contains three distinct zones, which are called the B1, B2, and the B3, with the B3 being the lowest in relative elevations (HLA, 1987a). Each of these aquifers also has a distinct aquitard between them. The B1-aquifer zone appears to grade into the A2-aquifer zone as the geologic environment changes from alluvial to estuarine. The B aquifer also consists of material ranging from silty sand to coarse gravel. In certain areas of the alluvial fans, the lower aquifer sequence is denoted as the C aquifer, and although it contains many alternating coarse- and fine-grained layers and extends to greater than 1,000 feet in depth, because of limited data, it has not been subdivided into the individual water-bearing units.

Local Hydrogeology. The hydrogeologic setting at Moffett Field consists of alluvial sand aquifers or sand and gravel aquifers separated by low permeability silt and clay aquitards. In the interior part of the Santa Clara Valley, the numerous aquifers have been divided by Iwamura (1980) into two broad zones or sequences: the upper-aquifer sequence and the lower-aquifer sequence. The distinction between the two aquifer sequences is that the upper-aquifer sequence is generally unconfined, although in places it acts as semiconfined. The lower-aquifer sequence is semiconfined under a laterally extensive clay aquitard at depths of 140 to 200 feet bls.

Shallow Aquifer Sequence. Aquifers in the upper zone (A and B aquifers) are generally thin and discontinuous. Aquifer materials range from silty, to fine sand, to coarse gravel.

The A and B aquifers are not presently pumped for beneficial uses because they produce only brackish water over most of Moffett Field.

The uppermost aquifer lies between 10 and 55 feet bls. Previous investigators have identified these thin, 3- to 20-foot thick aquifers as A and B1 (HLA, 1987a) and the "20-foot" and "45-foot" aquifers, respectively (Iwamura, 1980). After careful review of lithologic data, it appears that on Moffett Field, the B1 or "45-foot" aquifer is part of the A aquifer. This interpretation is based on the similarity of lithologic, sedimentary, and hydrologic characteristics of the A and B1 aquifer materials and is the result of lateral changes (facies changes) in the aquifer material and the dividing aquitards. Therefore, where these two water-bearing units exist within the uppermost 55 feet from land surface, the A aquifer is subdivided into the A1- and A2-aquifer zones.

Geologic and geophysical investigations at the MEW site (HLA, 1987b) and Moffett Field (IT, 1990a) indicate that the shallow interbedded alluvial deposits (A and B aquifers) dip toward the north at about 0.5 degree (1.1 percent grade) with the C aquifer being approximately horizontal.

Groundwater Hydraulics. Recharge to the shallow aquifer zone is primarily from infiltration on upgradient, coarse-grained deposits by percolation of rainfall, stream flow, and excess irrigation water. Recharge to the confined aquifer in the deep aquifer zone is the result of downward percolation of rainfall, stream flow, and excess irrigation water on alluvial fans at Moffett Field in the Santa Cruz Mountains.

Excessive pumping of groundwater from the C aquifer has resulted in land subsidence and seawater intrusion into the aquifer. Artificial recharge and groundwater withdrawal management programs conducted by the Santa Clara Valley Water District (SCVWD) has curtailed the land subsidence and seawater intrusion. Use of the groundwater at Moffett Field is now limited to only agricultural needs. Land subsidence in Moffett Field ranges from 2 feet in the north to 8 feet in the southeast part of Moffett Field.

3.7 Demography and Land Use

For the past several thousand years, the Santa Clara Valley has been influenced by four sequential cultures: Indian, Spanish, Mexican, and American. The area evolved from a grassland/forest wilderness environment populated by Indians, through an agricultural era during the Spanish mission and land grant period, followed by the Mexican mission period

after the withdrawal of the Spanish, to the current "modern" times of intense light industrial and urban development.

More than 1.3 million people presently reside in Santa Clara County and the population is continuing to grow. Moffett Field is bordered by the cities of Mountain View and Sunnyvale, California. The city of Mountain View is located on the west side of Moffett Field. Mountain View was primarily an agricultural community until the 1930s. Since the Navy commissioned Moffett Field in 1933, Moffett Field and the NASA-ARC have been two of the largest employers in the area. The other main industry is electronics. During the past 15 years, many electronics firms have established themselves in and around Mountain View. Presently, Mountain View's residential population of 61,000 increases to 120,000 during business hours when "Silicon Valley" workers commute into the area.

The city of Sunnyvale is located east of Mountain View and adjacent to the southern border of Moffett Field. The population of Sunnyvale is more than 114,000, and like Mountain View, the population increases during working hours. There are more than 525 manufacturers/wholesalers in Sunnyvale. The leading types of industry are research and development, high technology, and aerospace. Lockheed is the largest employer, with a workforce of approximately 25,000 persons.

Lockheed is the eastern neighbor to Moffett Field. The firm is involved in designing and manufacturing missile and space systems. It has designed and built several submarine-launched missile systems and has worked with the Navy at Moffett Field on various electronic systems' installations in patrol aircraft.

3.8 Ecology

Vegetation. Moffett Field is situated on a gently sloping tidal basin area of old mud flats once covered by tidal marsh plants. This scene is still typical of some of the areas north of Moffett Field; however, diking, construction of salt evaporation ponds, and filling activities have decreased the marsh habitat and has limited it to narrow buffer zones along the fringes of sloughs. Typically, cordgrass resides in the low tidal zones and gives way to pickleweed, salt grass, and other salt-tolerant plants on drier ground. This vegetation occurs mainly along Stevens Creek and Guadalupe Slough. The brackish water marsh vegetation occurs abundantly along the northern portion of the station, and where salt concentrations are low, the vegetation gives way to cattails and sedges. Where salt concentrations are low and the

ground is relatively dry, opportunistic (ruderal) vegetation invades. Common plants that occur are cranesbill, sweet clover, vetch, mustard, thistle, and sweet fennel along with a variety of grasses.

Wildlife. The tidal marsh areas provide a critical habitat for the production of fish and shellfish, and especially the lower food chain organisms such as zooplankton, brine shrimp, and bottom dwelling (benthic) organisms. As a result, this habitat is utilized by a variety of mammals and birds including migratory birds on the Pacific Flyway.

Typical marsh habitat shorebirds include the black-necked stilt, killdeer, sandpiper, great blue heron, great egret, and the American coot. A variety of ducks, gulls, and terns inhabit the marsh and salt evaporation ponds. The ruderal vegetation provides habitat for a multitude of sparrows, finches, meadowlarks, and mourning doves. Burrowing owls and ring-neck pheasants also occur in the vicinity of Moffett Field (WESTDIV, 1985; IT, 1988a).

Mammals include the common California ground squirrel, gray fox, black-tailed hare, striped skunk, California vole, and feral cat.

Sea life includes harbor seals, occasional steelhead trout, jacksmelt, sturgeon, sharks, rays, striped bass, and bait fish. Also included are shiner perch, gobies, long-jaw mudsuckers, and crangon shrimp.

Endangered, Threatened, and Rare Species. Federal agencies are required to carry out their programs to ensure that the existence of any endangered or threatened species is not jeopardized and that the habitat of these species is not adversely modified or destroyed.

The national list of endangered and threatened animal and plant species is published in the Code of Federal Regulations (CFR) at 50 CFR 17.11 (animals) and 17.12 (plants). The California state animal list is provided in CCR, Title 14, Section 670.5. The list of rare endangered plant species is published by the California Native Plant Society in its "Inventory of Rare and Endangered Vascular Plants of California" (1980). The following endangered, threatened, or rare species may inhabit Moffett Field:

- Birds - California least tern; California clapper rail; California black rail; brown pelican
- Animals - Salt marsh harvest mouse
- Plants - Marsh gum plant
- Insects - San Francisco forktail damsel fly.

4.0 Nature and Extent of Contamination, Marriage Road Ditch (Site 3)

4.1 Sources

Chapter 2.0 describes the investigation at Site 3, the Marriage Road Ditch, which is located east of the runway, dividing the golf course on the northeast property of Moffett Field (Figure 2.3-1). The probable source of contamination at the Marriage Road Ditch site is the surface runoff into storm drains adjacent to the site. It is estimated that 150,000 to 750,000 gallons of volatile organic wastes, including solvents, fuels, detergents, paint strippers, and hydraulic fluids, were released to the ditch (refer to the Phase I Characterization Report [IT, 1991a]).

A soil gas survey performed in the northeast quadrant of the site (east of the drainage ditch) showed organic vapor plumes in the golf course area east of the ditch. Field readings along the traverse using a PID indicated three areas of soil organic vapors with a high reading of 1,790 ppm. Field chromatograph readings along the traverses in this area (TL-7 and TL-14) (see IT March 1988 Quarterly Report [IT, 1988b]) indicated the presence of TCE at 47 and 28 ppb, 1,1,1-TCA at 267 ppb, and m- and p-xylenes at 43.6 ppb, plus several unknowns. As part of the Phase II activities, soil boring locations SB03-01, -02, and -03 were selected by screening with a HP and CPT. Results are discussed under VOCs, Section 4.2. Sources of these plumes are unknown.

4.2 Soils and Vadose Zone

The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC at the sample locations shown in Figure 2.3-1. A statistical summary of the analytical data (Phases I and II) is presented in Table 4.2-1. Detailed statistical analyses are discussed in the Risk Assessment, Chapter 20.0. An analytical summary of inorganics detected above the background levels (Table 3.5-2) is presented in Table 4.2-2. Complete analytical results can be found in Appendix A. Plate B-1 depicts the distribution of organic compounds detected in the soils at Site 3 for Phase I and II data.

4.2.1 Organics

VOCs. The primary VOCs detected in the Phase II activities were acetone, toluene, methylene chloride, and PCE. Acetone concentrations above the CRQL of 10 ppb in the Phase II samples ranged from 7 ppb in W03-19(A1) and W03-21(A1) to 19 ppb in W03-

24(A1). In the Phase I samples, acetone occurred at a maximum concentration of 72 ppb in Phase I soil boring SB03-07.

Methylene chloride was detected at a concentration of 33 ppb in one Phase II sample (W03-24[A1]). In the Phase I samples, the maximum concentration was 26 ppb in W03-14(B2). Methylene chloride occurred in low concentrations for each phase.

Using the CRQL for acetone (10 ppb), the 10x rule as outlined in Chapter 2.0 was applied to all samples showing concentrations of acetone in the associated laboratory blank. At Site 3, 1 sample out of 53 collected was considered to have acetone resulting from laboratory contamination. This was W03-14(B2) (5 to 10 feet, Phase I). Using the same principle for methylene chloride (CRQL, 5 ppm), 3 samples out of 53 collected were considered to have methylene chloride resulting from laboratory contamination. These samples were from W03-14(B2) (1 to 3 feet, 3 to 5 feet, and 5 to 10 feet bls).

Toluene concentrations in the Phase II samples ranged from 1 ppb in W03-20(A1) to 8 ppb in W03-24(A1). The maximum concentration in the Phase I soils was 3 ppb in W03-22(A2).

Other VOCs and their maximum concentrations detected in the Phase I and II soil samples included:

- 2-Butanone (6 ppb)
- Carbon disulfide (3 ppb)
- PCE (4 ppb)
- TCE (1 ppb).

Each of these concentrations is below its respective compound's CRQL and does not represent significant contamination.

Volatile organics for samples collected from Phase II soil borings SB03-01, -02, and -03, drilled in the SOV plume east of the Marriage Road Ditch, were below CRQL detection limits.

BNAs. Of the BNA analyses in the soils at Site 3, phthalates were detected in Phase II monitoring wells W03-19(A1), W03-20(A1), and W03-21(A1). In the Phase II samples, diethyl phthalate concentrations above the CRQL ranged from 64 to 510 ppb, and bis(2-ethylhexyl)phthalate ranged from 170 to 210 ppb. Bis(2-ethylhexyl)phthalate occurred at a

maximum concentration of 41,000 ppb in Phase I soil boring SB03-07 at 0.2 to 1.2 feet bls. Other semivolatiles detected in the Phase I samples and their concentrations include:

SB03-06

- Chrysene (540 ppb)
- Di-n-butylphthalate (480 ppb)
- Fluoranthene (1,200 ppb)
- Phenanthrene (590 ppb)
- Pyrene (1,100 ppb)

SB03-07

- Fluoranthene (2,500 ppb)

SB03-08

- Benzo(g,h,i)perylene (250 ppb)
- Indeno(1,2,3-c,d)pyrene (190 ppb)
- Fluoranthene (780 ppb)
- Phenanthrene (600 ppb)
- Pyrene (620 ppb).

All of these samples were detected at the surface (0.2 to 1.2 feet bls), which was the maximum depth sampled for soil analyses in these boreholes.

From the Phase I and Phase II data, the areas of greatest concentration appeared to be in the near-surface soils along the ditch.

The highest concentrations of semivolatiles appeared to be in the area of SB03-02 (from Phase I activities) at the north end of the ditch, and at SB03-06, SB03-07, and SB03-08 (from Phase I activities) at the south end of the ditch. Neither the vertical nor lateral extent of semivolatile concentrations has been fully determined because samples were collected near the surface directly in the ditch.

TPHC. In the Phase I activities, TPHC (JP-5) was detected in SB03-05, SB03-07, and SB03-08 in the Marriage Road Ditch. The highest concentration was detected in SB03-05 at 420 ppm. Where TPHC was detected in the Phase I activities, two zones of TPHC (JP-5)-contaminated soils along the drainage ditch were defined. One zone was localized around SB03-05 in the central area; the second zone was defined at SB03-07 and SB03-08 at the southern end of the Marriage Road Ditch. The vertical extent of contamination is undeter-

mined because samples were collected from shallow depths (maximum 1.2 feet bls, Phase I Report). No TPHC (JP-5) was detected in the Phase II activities.

PCBs. PCBs (Aroclor-1260) were detected in SB03-05, SB03-06, SB03-07, and SB03-08 in the Phase I activities. PCB concentrations ranged from 210 ppb in SB03-05 to 630 ppb in SB03-07. PCBs appeared to be concentrated along the southern half of the drainage ditch (from SB03-05 location to SB03-08). The PCBs appeared to be confined to near the surface because they were not detected above the CRQL below the 1-foot depth interval. In all Phase II samples, PCBs were below the CRQL.

4.2.2 Inorganics

All samples collected in Phase II samples were analyzed for metals. An analytical summary of inorganic concentrations above the background levels is presented in Table 4.2-2. The background levels are obtained from either the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) data (see discussion in Section 3.5 and Tables 3.5-1 and 3.5-2). If the CRQL for a given parameter was above the lowest background level or if an element did not have an available background value (antimony), then the CRQL was selected as the reference level. The following metals of concern at Site 3 were detected above the background concentrations.

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Silver
- Zinc.

Other metals detected above background levels included aluminum, calcium, iron, magnesium, and manganese; however, because these metals are naturally occurring at elevated concentrations in soils, they are not considered to be of concern in this discussion.

Antimony. No background values were available for antimony. Antimony concentrations detected at or above the CRQL (6 ppm) in the Phase II samples ranged from 6.6 ppm in

W03-24(A1) to 7.6 ppm in W03-19(A1). The maximum concentration in the Phase I samples was 9.0 ppm in W03-12(B1). No obvious antimony anomaly was apparent in the soils.

Arsenic. Arsenic detected at or above background (5.6 ppm, Hetch-Hetchy) in the Phase II samples ranged in concentration from 6.0 to 6.8 ppm. Arsenic was not detected above background in the Phase I soil borings/wells. All detections were within the MV18 background range of 5.9 to 11 ppm. No obvious arsenic anomaly was apparent in the soils.

Beryllium. Beryllium concentrations over the Hetch-Hetchy background value (0.7 ppm) in the Phase II samples ranged from 0.76 to 5.3 ppm. The maximum concentration in the Phase I samples was 6.5 ppm in SB03-02. When evaluated with the Phase I data, however, there appeared to be no obvious beryllium anomaly. Beryllium concentrations were slightly higher at the northern end of the drainage ditch.

Cadmium. Cadmium concentrations above background (0.7 ppm, Wahler) in Phase II soil samples ranged from 1.5 ppm in SB03-01 (from 6 to 8 feet) to 3.3 ppm in SB03-01 (from 2 to 4 feet). Cadmium exceeded the background level at eight Phase I locations, including surface samples. The maximum cadmium concentration in the Phase I samples was 18.2 ppm in SB03-03-P1. No concentration trends were apparent.

Chromium. Except for the Phase I boring well SB03-02 at the north end of the Marriage Road Ditch (chromium concentration of 153 ppm), all chromium values above background from the Phase I and Phase II sampling were of the same order of magnitude. Chromium values above background in the Phase II samples varied from 52.9 to 76 ppm, below the USGS background value of 150 ppm. No obvious concentration trend was apparent in the soils.

Cobalt. Cobalt concentrations above background (15 ppm, USGS) were detected in soil samples in seven Phase II wells/borings installed. The range of concentrations for cobalt was from 15.8 ppm in W03-21(A1) to 25.0 ppm in SB03-03. The Phase I concentrations at or above background ranged from 15.0 ppm in SB03-07 to 23.8 ppm in SB03-02(P1). Cobalt was detected above background in both Phase I and II wells at the maximum sampled depth. No concentration levels were detected that would indicate a significant cobalt anomaly.

Copper. Copper concentrations above background (15 ppm, Wahler) in Phase II soil samples ranged from 22.2 ppm in W03-21(A1) to 92 ppm in W03-20(A1). Copper was

detected above the background value at 16 Phase I locations (maximum concentration 79.8 ppm). No significant copper anomaly is apparent at Site 3.

Lead. Lead was detected above background (19 ppm, Wahler) at one Phase II location (W03-20[A1] at 91 ppm). In the Phase I samples, lead was detected above background at ten locations with concentrations ranging from 20 to 490 ppm. The locations with the higher concentrations of lead (greater than 100 ppm) were the Phase I soil borings SB03-02, SB03-03, SB03-05, SB03-06, SB03-07, SB03-09, and well W03-15(B2), directly in the drainage ditch. Higher concentrations of lead occurred in samples in the ditch with respect to other site locations. An anomalous occurrence of lead was indicated in this area (Figure 4.2-1).

Mercury. In the Phase II samples, mercury concentrations greater than the background level (0.1 ppm, Hetch-Hetchy) ranged from 0.18 in W03-20(A1) to 0.19 ppm in W03-24(A1). Mercury was detected above background in five Phase I soil borings/wells. The maximum concentration in the Phase I samples was 0.50 in SB03-06. These detections were all within the MV18 background range of 0.15 to 1.3 ppm.

Nickel. In the Phase II samples, nickel concentrations above background (30 ppm, USGS) ranged from 51 to 97.1 ppm. The maximum nickel concentration in the Phase I data was 107 ppm in SB03-02 (Phase I). When evaluated with the Phase I data, no obvious concentration trends were delineated. Nickel concentrations for all samples appeared to be of the same order of magnitude, suggesting that nickel is a natural trace element of clay.

Silver. The CRQL for silver is above the lowest background value available (see Section 3.5). In the Phase II samples, silver was detected above the CRQL (1 ppm) at concentrations ranging from 1.7 to 2.4 ppm. In the Phase I samples, silver was detected above the CRQL at four locations. The maximum concentration was 4.8 ppm in SB03-02 (Phase I). No concentration trends were apparent.

Zinc. In the Phase II samples, zinc concentrations above background (31 ppm, Wahler) ranged from 44 to 93.9 ppm. Zinc concentrations were detected above the background level at 16 Phase I locations. Concentrations in the Phase I samples ranged from 48.1 to 359 ppm. The majority of these detections were at or below the MV18 and Hetch-Hetchy background value of 110 ppm. All of these samples, with the exception of W03-22(A2), were collected as shallow surface samples in the Marriage Road Ditch. Higher concentrations of zinc appeared to be more prevalent in samples collected directly from the ditch (Figure 4.2-2).

5.0 Nature and Extent of Contamination, Former Wastewater Holding Pond (Site 4)

5.1 Sources

Chapter 2.0 describes the investigation at Site 4, the former wastewater holding pond, which is located immediately south of the Marriage Road Ditch, south of Macon Road (north of Hangars 2 and 3). Before closure, the unlined pond received approximately 15 million gallons of wastewater from aircraft washing, equipment maintenance, and operations in Hangars 2 and 3. Wastes reportedly included MEK, dry cleaning solvent, paint sludge, paint stripper, Freon-113, TCE, TCA, carbon remover, ethylene glycol, fuel, and oil, either directly or as components of wastewater.

5.2 Soils and Vadose Zone

The soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC (borehole locations are shown in Figure 2.3-2). A statistical summary of the analytical data (Phases I and II) is presented in Table 5.2-1. Detailed statistical analyses are discussed in the Risk Assessment, Chapter 20.0. An analytical summary of inorganics detected above the background levels (Table 3.5-2) is presented in Table 5.2-2. Complete analytical results can be found in Appendix A. Plate B-1 depicts the distribution of organic compounds detected in the soils at Site 4.

5.2.1 Organics

VOCs. VOCs were encountered primarily in the Phase II samples in W04-15(A1) and W04-16(A1) and in SB04-01, SB04-02, SB04-03, and SB04-04. Volatile organics detected in the Phase II activities included:

- Acetone
- 2-Butanone
- Chlorobenzene
- 2-Hexanone
- Methylene chloride
- PCE
- 1,1,1-TCA
- TCE
- Toluene
- Xylenes (total).

The most significant VOCs detected at Site 4 were total xylenes (maximum concentration 1,300 ppb in SB04-04) and chlorobenzene (maximum concentration 24,000 ppb in SB04-04). Toluene and acetone were the second most significant contaminants with a maximum concentration of 380 ppb for toluene (SB04-04) and 140 ppb for acetone (SB04-01).

In only one boring, 1,1,1-TCA was detected at 30 ppb (SB04-01), and 2-butanone was detected at a maximum concentration of 52 ppb in SB04-01. The remaining VOCs (PCE, 2-hexanone, methylene chloride, and TCE) were each detected at concentrations of less than 20 ppb.

No VOCs of significant concentrations were detected in the Phase I samples. Only toluene was detected at a maximum concentration of 13 ppb.

As indicated on Plate B-1, most of the VOCs detected in the Phase II activities are localized in the former holding pond.

BNAs. The most significant semivolatile constituents detected at Site 4 above their respective CRQL include:

- Bis(2-ethylhexyl)phthalate (6,000 ppb)
- 1,2-Dichlorobenzene (230,000 ppb)
- 1,3-Dichlorobenzene (2,700 ppb)
- 1,4-Dichlorobenzene (14,000 ppb)
- Fluorene (1,800 ppb)
- 2-Methylnaphthalene (22,000 ppb)
- Naphthalene (36,000 ppb).

These contaminants were detected above their respective CRQL in SB04-04 only. Other BNA contaminants detected above their respective CRQL included:

<u>SB04-01</u>
- Acenaphthalene (390 ppb)
- 4-Methylphenol (400 ppb)

<u>SB04-02</u>
- Anthracene (56 ppb)
- Benzo(a)anthracene (190 ppb - maximum)
- Benzo(a)pyrene (200 ppb - maximum)
- Benzo(b)fluoranthene (190 ppb - maximum)
- Benzo(g,h,i)perylene (98 ppb)
- Benzo(k)fluoranthene (200 ppb)

- Chrysene (230 ppb)
- Indeno(1,2,3-c,d)pyrene (100 ppb)
- Phenanthrene (330 ppb - maximum)
- Pyrene (420 ppb - maximum).

Other contaminants detected included diethyl phthalate (47 to 290 ppb in SB04-01 and W04-11[A1]) and fluoranthene (96 ppb in SB04-01 to 430 ppb in SB04-02).

Semivolatiles were concentrated primarily in the soils in SB04-01, SB04-02, and SB04-04. Phthalates were present in all Phase II boreholes/wells sampled except W04-16(A1) and SB04-03. Contour maps for 2-methylnaphthalene and bis(2-ethylhexyl)phthalate show the distribution of phthalates in the soil (see Figures 5.2-1 and 5.2-2). Concentrations of 2-methylnaphthalene above CRQLs ranged from 540 ppb in SB04-02 to 22,000 ppb in SB04-04. Concentrations of bis-2(ethylhexyl)phthalate ranged from 38 ppb in SB04-04X to 6,000 ppb in SB04-04 (W04-14[A1]). BNAs were also detected in boreholes/wells north of Macon Road.

Based on the evaluation of Phase I and II data for semivolatile organics, the primary source of soil contamination appears to be the abandoned pond where semivolatiles were detected to depths of 7.5 feet bls. This is the approximate depth where groundwater was first encountered. The extent of semivolatile concentrations in the soil has not been fully defined outside the immediate area of the former holding pond. The source and extent of semivolatiles at W04-13(B2) across Macon Road has not been determined.

TPHC. Aviation fuel (JP-5) was detected in the Phase II samples in SB04-01, SB04-02, and SB04-04 in the former wastewater holding pond. Concentrations of JP-5 ranged from 15 to 6,760 ppm. JP-5 was not detected above the CRQL in the Phase I and II monitoring wells north of Macon Road. Concentrations of JP-5 were detectable in the soils to a depth of 7.5 feet bls.

An evaluation of Phase I and II data for TPHC JP-5 indicated the primary area of soils contamination is in the immediate area of the abandoned pond, but the lateral extent has not been defined beyond the pond.

PCBs. Aroclor-1260 was detected in only one Phase II sample, SB04-02, at 6 to 7.5 feet bls (65 ppb). The sample is in the area of the abandoned holding pond. No PCBs were detected above the CRQL in Phase I samples. When evaluated with Phase I data, PCBs appeared to be confined to the immediate area of SB04-02.

5.2.2 Inorganics

All samples were analyzed for metals. Soil samples from the Phase I and II Characterization Study were compared to background concentrations (Table 5.2-2). The background levels for inorganics are obtained from either the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) data (see discussion in Section 3.5, Tables 3.5-1 and 3.5-2). If the CRQL for a given parameter was above the lowest background level identified in Table 3.5-1 or if the element did not have an available background value (antimony), then the CRQL was selected as the reference level. The following metals of concern were detected at Site 4 above background concentrations:

- Antimony
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc.

Other metals detected above background values included aluminum, calcium, iron, magnesium, and manganese; however, because these metals are naturally occurring in elevated concentrations in soils, they are not of concern in this discussion.

Antimony. No background values were available for antimony. Antimony was detected above the CRQL of 6 ppm in three Phase II wells with concentrations ranging from 6.4 to 9.2 ppm. Antimony was also detected above the CRQL in three Phase I wells. The maximum concentration in the Phase I soil samples was 57.2 ppm in W04-07.

Beryllium. Beryllium was detected above background (0.7 ppm, Hetch-Hetchy) in five samples: SB04-04X, W04-11(A1), W04-12(A2), W04-13(B2), and W04-15(A1). The

concentrations above the background value ranged from 0.70 to 2.5 ppm. The maximum beryllium concentration in the Phase I data was 2.3 ppm in W04-11(A1). There did not appear to be an obvious distribution pattern to indicate a contaminant plume at this site.

Cadmium. Cadmium was detected above background (0.7 ppm, Wahler) in one sample, SB04-04, at 4.7 ppm. Cadmium was below the background levels in the remaining Phase I and II wells. Because of the single detection of this constituent and the low concentration (it is just above the Hetch-Hetchy background value of 4 ppm), there does not appear to be an obvious distribution pattern that would indicate cadmium contamination at this site.

Chromium. Chromium was present above background (17 ppm, Wahler) in all Phase II soil borings/wells. The range of concentrations for chromium in Phase II soils was 43.1 ppm in SB04-01 to 86.7 ppm in SB04-04X. Chromium occurred above the background level in four Phase I wells. The maximum concentration in the Phase I samples was 81.7 ppm in W04-09(B2). These detections were at or slightly above the MV18 background range of 62 to 72 ppm and were at or below the USGS background value of 150 ppm. When evaluated with Phase I data, no obvious contamination trends were delineated.

Cobalt. Cobalt concentrations above background (15 ppm, USGS) were detected in soil samples in eight Phase II wells/borings installed. The range of concentrations for cobalt above background was from 15.6 ppm in SB04-04 to 20.1 ppm in SB04-04X. The Phase I concentrations at or above background ranged from 15.0 ppm in W04-07(C) to 20.1 ppm in W04-09(B2). Cobalt was detected above background in both Phase I and II wells at the maximum depth sampled of 6 to 7.5 feet bls. No concentration levels were detected that would indicate a significant cobalt anomaly.

Copper. Copper concentrations above background (15 ppm, Wahler) were detected in all Phase II wells/soil borings. The range of concentrations for copper in the Phase II samples was from 25.9 to 96.0 ppm. The maximum copper concentration in Phase I samples was 60.5 ppm in W04-07(A1). When Phase II analyses were evaluated with Phase I results, there appeared to be no obvious copper anomaly.

Lead. Lead concentrations above background (19 ppm, Wahler) ranged from 21.1 to 56.3 ppm in the Phase II soil borings/wells. Lead concentrations were above background in SB04-01, SB04-02, SB04-04, and W04-15(A1). Lead did not exceed the background value in any of the Phase I wells (W04-11[A1], W04-08[C], W04-07[C], W04-09[B2]) north of Macon

Road. Elevated concentrations appeared to be confined to the Phase II wells; however, because the lead concentrations were not significant (all samples were within or slightly above the MV18 background range of 49 to 54 ppm), no obvious distribution trend was delineated in these soil borings.

Mercury. In the Phase II wells, mercury concentrations above background (0.1 ppm, Hetch-Hetchy) occurred at 0.19 ppm in W04-13(B2). This is within the MV18 background range of 0.15 to 1.3 ppm. No mercury was detected above background levels in the Phase I samples.

Nickel. Nickel was detected in all of the Phase II soil borings/wells at concentrations above background (30 ppm, USGS). The range of nickel concentrations in Phase II samples was from 43.2 to 82.0 ppm. The maximum nickel concentration in Phase I samples was 80.6 ppm in W04-11(A1) (Phase I). When evaluated with Phase I data, no patterns were apparent that would suggest a nickel anomaly.

Selenium. The CRQL for selenium was above the lowest background value available (see Section 3.5). Selenium was not detected above the CRQL of 0.5 ppm in any Phase II samples, but was detected above the CRQL in one Phase I sample (W04-07[C] at 0.72 ppm). There does not appear to be a significant selenium anomaly in the Site 4 soils.

Silver. The CRQL for silver was above the lowest background value available (see Section 3.5). Silver occurred above the CRQL of 1.0 ppm in six Phase II borings/wells: SB04-01, SB04-02, SB04-03, SB04-04, SB04-04X, and W04-16(A1). These soil concentrations ranged from 1.2 to 2.6 ppm. In the Phase I samples, the maximum silver concentration was 4.8 ppm in W04-09(A1). When evaluated with the Phase I data, silver concentrations appeared to be insignificant. No anomaly was apparent at Site 4 that would suggest silver contamination.

Zinc. When compared with the background value (31 ppm, Wahler), zinc occurred in concentrations above this level in all Phase II boreholes/wells at Site 4 with concentrations ranging from 44.8 to 86.7 ppm. Zinc was also detected above the background level in four Phase I soil borings/wells (maximum concentration of 92.8 ppm). These detections were at or below the MV18 and Hetch-Hetchy background ranges of 100 to 110 ppm. No obvious zinc anomaly was defined.

6.0 Nature and Extent of Contamination, Fuel Farm French Drains and Bulk Tanks (Site 5)

6.1 Sources

Chapter 2.0 describes the investigation at Site 5, the Fuel Farm, which is located east of Hangars 2 and 3 at Macon Road. The Fuel Farm, which is still operating, contained the main fuel facilities for Moffett Field since the 1950s.

The site is separated into a northern and a southern section. Several large JP-5 tanks and one waste oil tank exist in the northern section of Site 5, and eight USTs containing diesel fuel, jet fuel, and unleaded gasoline exist in the southern section of Site 5 (Figure 2.3-3).

The primary sources of contamination at this site appear to be Fuel Tank 12 in the northern area, Tank 26, piping, and tanks associated with the operating fuel station. Tank 26 was removed by the Navy in June 1991. TPHC were detected on the west wall of the tank pit as motor oil and grease. Free-phase hydrocarbons were also observed in the Tank 26 pit during the removal activities (IT, 1992). PCBs were also detected; concentrations are discussed in Section 6.2. The contaminant sources for Areas P-2 and P-3 (Phase I SOV survey) are undetermined.

A TPHC (JP-5) organic plume was defined near Tanks 8 and 9 (FP05-02). These tanks are 150,000-gallon tanks, each containing JP-5, and could be potential sources of the TPHC (JP-5) contamination. Free-phase hydrocarbons were observed in FP05-07 (3 millimeters [mm]), FP05-08 (2 mm), and FP05-09 (1 mm) during their installation, but were not observed in subsequent monitoring events (IT, 1992). Also according to this same source, free-phase hydrocarbons were observed in W05-27(A1) (4 mm) after a 24-hour pump test had been performed on the well.

6.2 Soils and Vadose Zone

Three soil samples were collected from the upper 10 feet of the vadose zone in each soil boring/monitoring well. The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. A statistical summary of the analytical data (Phases I and II) is presented in Table 6.2-1. An analytical summary of inorganics detected above the background range is presented in Table 6.2-2. Complete analytical results can be found in compounds detected in the soils at Site 5 for Phase I and II data. Plate B-2 depicts the

distribution of organic compounds detected in the soils at Site 5 for Phase I and II data. The contamination identified in Phase I and II activities is discussed in the following sections.

6.2.1 Organics

VOCs. The VOCs detected in the Phase I and II activities at Site 5 consisted of:

- Acetone
- 2-Butanone
- Chloroform
- Chlorobenzene
- Ethyl benzene
- Methylene chloride
- Toluene
- Xylenes (total).

Acetone was the predominant volatile organic constituent at Site 5 with elevated concentrations identified in three areas at the site. In the northern area, acetone reached a maximum concentration of 320 ppb at FP05-09 (SB05-32) and 740 ppb at SB05-07. In the southern area near the operating fuel station, acetone in SB05-20 reached a maximum concentration of 120 ppb. In the Phase I samples, the maximum concentration of acetone was 56 ppb in W05-07(A1). The distribution of acetone in the soils corresponded closely with the distribution of the semivolatile compounds in the soil (see following discussion of BNAs), suggesting the sources for each of these contaminants were the same. The extent of acetone contamination was not well defined because of the wide distribution and low concentrations of acetone in the soils. Acetone was detected at the maximum depths sampled (8 to 9.5 feet bls).

Methylene chloride was detected in nine Phase I and II borings/monitoring wells. The maximum concentration was 75 ppb in Phase I soil boring W05-06(A1). Methylene chloride was detected to depths of 10 feet bls.

Using the CRQL for acetone (10 ppb), the 10x rule as outlined in Chapter 2.0 was applied to all samples showing concentrations of acetone in the associated laboratory blank. At Site 5, 29 of 144 samples were considered to have acetone resulting from laboratory contamination. Using the same principle for methylene chloride (CRQL, 5 ppm), one sample showed a methylene chloride concentration greater than 10 times the CRQL.

Elevated concentrations of 2-butanone also occurred in one boring (SB05-07 at 190 ppb maximum). All other concentrations of 2-butanone were low. Contamination was not believed to be extensive.

Toluene concentrations at Site 5 were all less than 9 ppb (with the exception of SB05-02, which was detected at 9 ppb). Toluene contamination was not considered to be significant at Site 5.

In the Phase II activities, other organic constituents detected included total xylenes (850 ppb maximum concentration in FP05-06) and ethyl benzene (2,700 ppb maximum concentration in P05-06). Both of these constituents were detected above the CRQL in only one Phase II well, and were below the CRQL in all Phase I samples. Contamination was therefore not believed to be widespread.

Chlorobenzene and chloroform were each detected in one Phase II soil borings (SB05-27 [chlorobenzene] and FP05-06 [chloroform]) at a concentration of 1 ppb, and were undetected in Phase I soil samples.

Other organic constituents included 1,1,1-TCA (4 ppb in W05-05[C]), carbon disulfide (3 ppb maximum concentration in W05-09[A1]), and PCE (1 ppb concentration in W05-07[A1]). These constituents were detected in the Phase I samples and are presented on Plate B-2. Concentrations were low for these constituents, and contamination appeared to be insignificant.

With the exception of acetone, the volatile organics were either limited in areal extent (being confined to one or two boreholes) or had relatively low concentrations (refer to Table 6.2-1 for concentration range).

BNAs. The semivolatiles detected from the Phase I and II activities at Site 5 are summarized in Table 6.2-1 and include:

- Benzo(a)anthracene
- Benzo(k)fluoranthene
- Bis(2-ethylhexyl)phthalate
- Chrysene
- Diethyl phthalate
- Di-n-butylphthalate
- Di-n-octylphthalate

- Fluoranthene
- Fluorene
- 2-Methylnaphthalene
- Naphthalene
- Phenanthrene
- Pyrene.

Of these, bis(2-ethylhexyl)phthalate, diethyl phthalate, and 2-methylnaphthalene were the most widespread constituents.

An isoconcentration map for bis(2-ethylhexyl)phthalate was constructed from Phase I and II data and is shown in Figure 6.2-1. Five areas of contamination were delineated. The five areas correspond with the SOV plumes defined in Phase I activities; the reason for this correlation is unknown because phthalates would not have contributed to the SOV measurements. The areas of concern included:

- The northern tank farm section west of Tanks 26 and 12 (SOV Area P-1).
- Northwest of the northern tank farm section in the area of W05-21(A1) (SOV Area P-2).
- The area of SB05-01 in the extreme northern section of the site (SOV Area P-3).
- A small bis(2-ethylhexyl)phthalate "hot spot" was concentrated in the area of SB05-21. This location is in the northern part of the southern section at the Operating Fuel Station.
- A small area of contamination was located in Area P-4 at SB05-25X.

Also, three "hot spots" were found near Tanks 30 and 31 in the northern section (W05-04[A2]), Tank 9 in the southern section (W05-07[A1]), and Tank 18 in the southern section (W05-09[A1]). The vertical extent of the bis(2-ethylhexyl)phthalate varied, ranging from 2 to 3.5 feet bls in SB05-03 and SB05-09, to 6 to 7.5 feet bls in SB05-25X, W05-21(A1), W05-25(A2), and W05-27(A1).

Five areas of diethyl phthalate contamination were defined at Site 5 (Figure 6.2-2). These areas also correspond approximately with the SOV plumes delineated in the Phase I activities but, again, the reason for this correlation is unknown. The areas of concern include:

- A small diethyl phthalate "hot spot" defined in the area of SB05-03 (SOV Plume P-2).
- West of Tank 13 (SB05-07) in the area of SOV Plume P-1.
- Two small areas near Tank 26 at the southern end of the northern section.
- At SB05-25X in the northern end of the southern section, northeast of Tanks 8 and 9 (SOV Plume P-4).

The vertical extent of diethyl phthalate contamination varied from 2 to 3.5 feet bls in SB05-24 to 8 to 9 feet bls in SB05-25X.

In the Phase I and II samples, 2-methylnaphthalene was encountered in four soil borings/ wells:

- SB05-26 at 5.5 feet (north of Tanks 8 and 9 in the southern section)
- SB05-27 at 6 to 7.5 feet (near Tank 26 in the northern section)
- SB05-32 at 5 to 6 feet (northeast of Tank 13 in the northern section)
- W05-07(A1) at 5 to 8 feet (Fuel Operating Station).

The remaining semivolatiles - benzo(a)anthracene, chrysene, fluoranthene, phenanthrene, pyrene, di-n-octylphthalate, benzo(k)fluoranthene, fluorene, and naphthalene - were limited in extent. Di-n-butylphthalate was detected in Phase I soil samples W05-06(A1) at 100 ppb, W05-10(A1) at 40 ppb, and W05-14(A1) at 2 ppb.

TPHC. TPHC (JP-5) was detected in 12 Phase II soil borings/wells. Concentrations above CRQL detectable levels ranged from 10 ppm in P05-06 to 1,460 ppm in SB05-07. JP-5 was detected at a maximum depth of 6 to 7.5 feet bls. The maximum TPHC (JP-5) concentration in the Phase I soil samples was 1,000 ppm in W05-07(A1). From the Phase I and II data, four TPHC (JP-5) plumes were delineated (Figure 6.2-3).

The largest area of TPHC contamination in the northern section was located west of Tanks 12 and 13, centered on well FP05-01. The maximum TPHC (JP-5) concentration in the soils was 1,460 ppm (SB05-07). This plume was defined in the Phase I SOV survey as Area P-1. Tanks 12 and 13 are the probable sources of the hydrocarbons.

The second area of contamination was located at the southern end of the northern section south of Tank 10, at FP05-07. The maximum TPHC (JP-5) concentration in this area

(SB05-27) was 320 ppm. Tank 10 is a probable source of TPHC contamination at this location.

The third TPHC area of contamination was at W05-07(A1), in the southern section near Tanks 8 and 9. The maximum concentration in this area was 1,000 ppm. The area immediately east of the SOV plume was designated as P-4 in the Phase I activities. The possible sources of these hydrocarbons are Tanks 8 and 9.

The fourth TPHC area of contamination was located at SB05-20, at the Operating Fuel Station. The maximum concentration in this soil boring was 130 ppm. The probable sources of this plume are the tanks and piping at the operating fuel station.

A small "hot spot" was found at the extreme northern end of the site at SB05-01 (SOV Plume P-3). The TPHC (JP-5) concentration here was 10 ppm. The source of this plume is undetermined.

PCBs. PCBs were detected in one Phase II soil boring, SB05-31, near Tank 26 in the northern section to a depth of 6.5 feet bls. No PCBs were detected above CRQLs in the Phase I wells. The detected PCBs and their maximum concentrations consisted of:

- Aroclor-1016 (100 ppb)
- Aroclor-1221 (100 ppb)
- Aroclor-1232 (100 ppb)
- Aroclor-1242 (100 ppb)
- Aroclor-1248 (100 ppb)
- Aroclor-1254 (210 ppb)
- Aroclor-1260 (210 ppb).

The concentrations of PCBs detected in this boring were very consistent throughout the entire depth of the boring. The probable source of the PCBs in the soils is from the Tank 26 area.

6.2.2 Inorganics

Soil samples were compared to the background concentrations (see Section 3.5, Tables 3.5-1 and 3.5-2). Results of this comparison are presented in Table 6.2-2. The background levels for inorganics are obtained from either the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) data. If the CRQL for a given parameter was above the lowest background level identified in Table 3.5-1 or if the element had no available background

value (antimony), then the CRQL was selected as the reference level. The following metals were detected above background concentrations:

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc.

Other metals detected above the background levels included aluminum, calcium, iron, magnesium, and manganese; however, because these metals are naturally occurring in elevated concentrations in soils, they are not of concern for this discussion. The metals of concern are discussed in the following sections.

Antimony. No background values were available for antimony. Antimony was above the CRQL of 6 ppm in all Phase II sample locations with concentrations ranging from 6.1 to 8.5 ppm. In the Phase I samples, antimony was above the CRQL in eight wells. The concentrations in these wells ranged from 9 ppm in W05-14(A1) to 91.2 ppm in W05-08(A1). No obvious antimony plume could be delineated at Site 5.

Arsenic. Arsenic concentrations above background (5.6 ppm, Hetch-Hetchy) were detected in one Phase II sample from SB05-26 at a concentration of 5.8 ppm. Arsenic was detected above the CRQL in two Phase I wells. The maximum detected concentration was 16 ppm in W05-19(A1). These detections were below or within the MV18 background range of 5.9 to 11 ppm. No arsenic values were detected that would define site-related contamination.

Beryllium. Beryllium concentrations above background levels (0.7 ppm, Hetch-Hetchy) in the Phase II samples ranged from 0.71 ppm in W05-23(A1) to 4.0 ppm in SB05-01. Beryllium was also above the background level in 12 Phase I wells. The Phase I concentrations ranged from 0.74 ppm in W05-08(A2) to 5.8 ppm in W05-15(A1) and W05-16(A1). Beryllium was detected above background in both the Phase I and II wells at a maximum

depth of 6 to 7.5 feet bls; however, no concentration levels were detected that would indicate a beryllium anomaly.

Cadmium. Cadmium concentrations above background (0.7 ppm, Wahler) in the Phase II soil samples ranged from 1.1 ppm in SB05-25 and SB05-32 to 3.6 ppm in SB05-03. Cadmium concentrations in the Phase II samples were below the Hetch-Hetchy background value of 4 ppm. In the Phase I wells, cadmium concentrations were above the background levels in five soil borings/wells. The maximum concentration of cadmium in the Phase I samples was 1.5 ppm in W05-17(A1). Again, these detections were below the Hetch-Hetchy background value of 4 ppm, and no apparent contamination was seen at the site.

Chromium. The range of chromium concentrations above background (17 ppm, Wahler) in Phase II was from 56.0 ppm in SB05-32 to 112 ppm in SB05-21. The concentrations above background in the Phase I wells ranged from 40.2 ppm in W05-18(A1) to 197 ppm in W05-08(A1). The majority of these detections were within the MV18 background range (62 to 72 ppm) or below the USGS background of 150 ppm. The highest detections appear to represent natural variations.

Cobalt. Cobalt concentrations above background level (15 ppm, USGS) were detected in soil samples in 33 Phase II wells/borings. The range of concentrations above background for cobalt was from 15.1 ppm in SB05-12 to 34.4 ppm in SB05-21. The Phase I concentrations at or above background ranged from 15.0 ppm in W05-18(A1) to 33.8 ppm in W05-08(A1). Cobalt was detected above background in both Phase I and II wells at a maximum depth sampled of 12 to 13.5 feet bls. No concentration levels were detected that would indicate a significant cobalt anomaly.

Copper. In the Phase II wells copper concentrations above background (15 ppm, Wahler) ranged from 15.0 ppm in W05-23(A1) to 114 ppm in SB05-26. In the Phase I wells, copper was detected above background at concentrations ranging from 21.7 ppm in W05-19(A1) to 77.5 ppm in W05-15(A1). There appears to be no obvious copper anomaly at Site 5.

Lead. Lead concentrations above background (19 ppm, Wahler) in the Phase II samples ranged from 19.1 ppm in SB05-30 to 31.6 ppm in SB05-22. These detections were below the MV18 range of 49 to 54 ppm. Lead was detected above background in five Phase I locations. Concentrations ranged from 22.9 ppm to a maximum of 224 ppm in W05-10(A1). The occurrence of the single elevated lead concentration appears to be isolated.

Mercury. In the Phase II samples, mercury concentrations exceeding background (0.1 ppm, Hetch-Hetchy) ranged from 0.16 ppm in W05-23(A1) to 0.68 ppm in P05-06 and W05-25(A2). Mercury was detected above background in two Phase I wells (W05-04[A1] and W05-17[A1]) at 0.2 ppm. These detections were within the MV18 background range of 0.15 to 1.3 ppm. There appears to be no obvious mercury anomaly at this site.

Nickel. Nickel concentrations above the background level (30 ppm, USGS) in the Phase II soil samples ranged in concentration from 38.5 ppm in SB05-08 to 121 ppm in SB05-09. In the Phase I soil samples, nickel concentrations exceeding the background levels were detected in 13 soil borings/wells. Concentration levels in these samples ranged from 40.7 ppm in W05-10(A1) to 106 ppm in W05-08(A1).

Selenium. The CRQL for selenium was above the lowest background value available (see Section 3.5). In Phase II samples, selenium was detected above the CRQL of 0.5 ppm in one sample, SB05-31, at 0.78 ppm at 3 to 4.5 feet. In the Phase I soils, selenium was below the CRQL in all soil samples. Because there was no obvious source of selenium at this site, and concentrations and detections were low, it appeared that selenium was naturally occurring.

Silver. The CRQL for silver was above the lowest background value available (see Section 3.5). Silver concentrations above the CRQL (1 ppm) ranged from 1.1 ppm in W05-27(A1) to 3.2 ppm in SB08. In the Phase I soil samples, silver was above the CRQL in five soil borings/wells. The maximum concentration in the Phase I samples was 1.8 ppm in W05-05(C). Because there appeared to be no obvious source of silver at this site, silver at Site 5 was probably naturally occurring.

Zinc. Zinc concentrations above the background level (31 ppm, Wahler) ranged from 34.8 ppm in W05-23(A1) to 107 ppm in SB05-22. Zinc was above the background level in 13 Phase I soil borings/wells. The range of concentrations in these wells was from 43.9 (W05-19[A1]) to 188 ppm (W05-15[A1]). The majority of these detections were below the Hetch-Hetchy and MV18 background range of 100 to 110 ppm. The higher concentrations detected are most likely indications of natural variation within the soil.

7.0 Nature and Extent of Contamination, Runway Apron (Site 6)

7.1 Sources

Chapter 2.0 describes the investigation at the Runway Apron, Site 6, which is located northeast of Hangars 2 and 3. The site received an estimated 120,000 to 600,000 gallons of waste from aircraft maintenance including solvents, oils, fuels, paints, and paint strippers. The source of this would be from direct disposal onto the apron from maintenance activities and from surface runoff. This site, formerly a gravel area, was paved in 1979 and is now a facility parking lot.

7.2 Soils and Vadose Zone

The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. All RI sampling was conducted in Phase II. A statistical summary of the analytical data is presented in Table 7.2-1. Detailed statistical analyses are discussed in the Risk Assessment, Chapter 20.0. An analytical summary of inorganics detected above the background levels identified in Table 3.5-2 is presented in Table 7.2-2. Complete analytical results can be found in Appendix A. Plate B-1 depicts the distribution of organic compounds detected in the soils at Site 6.

7.2.1 Organics

VOCs. VOCs primarily occurred at the 2- to 3-foot-bls depth in W06-09(A1), and the upper 3 to 5 feet in W06-10(A1). The primary volatile constituents, acetone and toluene, occurred at less than 28 ppb and 5 ppb, respectively, in W06-08(A2). In the two remaining wells, acetone concentrations ranged from 29 to 150 ppb, toluene from 2 to 90 ppb, and total xylenes from 170 to 290 ppb. Other constituents above detection limits were 1,2-DCE (1 ppb found in W06-09[A1]), 2-butanone (27 ppb found in W06-09[A1]), and ethyl benzene (20 to 29 ppb found in W06-10[A1]). Volatile organics from previous wells (ESA, 1986b) consisted of benzene, toluene, and methylene chloride in W06-04(A1) (formerly MW-07), W06-05(A2) (formerly MW-14), W06-06(A1) (formerly MW-15), and W06-07(A1) (formerly MW-08). Concentrations were less than 10 ppb for each of these parameters. The lateral extent of volatile organics has not been fully defined as shown by the concentration map represented by total xylenes (Figure 7.2-1). Neither acetone nor methylene chloride was detected in

associated blanks for these samples. Low acetone and methylene chloride concentrations were not believed to be the result of laboratory contamination.

The monitoring wells W06-08(A2), W06-09(A1), and W06-10(A1) are near Site 13 and elevated VOC concentrations may be influenced by contamination from Site 13. It is unclear whether the source of these low levels of VOCs is Site 6 or 13.

BNAs. Elevated concentrations of semivolatiles were greatest in W06-10(A1) from 1 to 4.5 feet and in W06-09(A1) from 2 to 3.5 feet. The major semivolatiles encountered at Site 6 and their maximum concentrations in the well borings included the following:

Bis(2-ethylhexyl)phthalate	1,000 ppb	W06-10(A1)
Diethyl phthalate	250 ppb	W06-09(A1)
Fluorene	130 ppb	W06-10(A1)
2-methylnaphthalene	960 ppb	W06-10(A1)
4-Methylphenol	2,000 ppb	W06-10(A1)
Naphthalene	560 ppb	W06-10(A1)
Phenanthrene	260 ppb	W06-10(A1)
Pyrene	69 ppb	W06-10(A1)

Except for diethyl phthalate, these semivolatiles were below the CRQL in W06-08(A2). The occurrence of semivolatiles was not apparent in the Verification Study wells at Site 6 (ESA, 1986b). The lateral extent of semivolatiles has not been defined, as shown by the concentration map represented by 2-methylnaphthalene (Figure 7.2-2), and may reflect contamination from Site 13 as discussed for the VOCs.

TPHC. Aviation fuel (JP-5) was detected in the soils at W06-09(A1) at 6 to 7.5 feet (14 ppm) and W06-10(A1) at 1 to 2.5 feet (420 ppm). The lateral extent of TPHC has not been defined as indicated by the concentration map in Figure 7.2-3.

PCBs. PCBs were not detected at Site 6.

7.2.2 Inorganics

All samples were analyzed for metals, and the results were compared to background levels (see Table 3.5-2). The background levels are obtained from either the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) data (see discussion in Section 3.5, Tables 3.5-1 and 3.5-2). If the CRQL for a given parameter was above the lowest background level in Table 3.5-1 or if the element had no available background value (antimony), then the

CRQL was selected as the reference level. Results of concentrations over the background levels are presented in Table 7.2-2. The following metals at Site 6 were detected above the background concentrations.

- Antimony
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Nickel
- Silver
- Zinc.

The metals aluminum, calcium, iron, magnesium, and manganese are not of concern at this site because they are naturally occurring in elevated concentrations in soil. The following discussion addresses the metals of concern.

Antimony. No background values were available for antimony. Antimony was detected above the CRQL (6 ppm) in one Phase II sample, W06-09(A1), at 9.9 ppm. There was no obvious antimony anomaly in the soils sampled. Antimony concentrations from previous data (ESA, 1986b) are less than 0.14 ppm. Antimony concentrations did not appear to be site related at Site 6.

Beryllium. In the Phase II wells, beryllium was detected above the background level (0.7 ppm, Hetch-Hetchy) in one well (W06-10[A1]) at a maximum concentration of 0.84 ppm. A maximum concentration of 0.67 ppm was detected in W06-01(A1) (ESA, 1986b). When evaluated with the ESA data, there did not appear to be a contamination trend in the soils for beryllium as these detections were within or below the MV18 background range of 0.9 to 1.2 ppm.

Cadmium. Cadmium was detected above the background level (0.7 ppm, Wahler) in three soil borings, W06-08(A2), W06-09(A1), and W06-10(A1). The range of cadmium concentrations in these borings was from 1.2 to 1.5 ppm. Cadmium concentrations were less than 0.29 ppm in ESA well W06-01(A1). These detections were below the Hetch-Hetchy background value of 4 ppm. When compared with previous samples, an anomalous cadmium trend was not apparent in the soils for cadmium.

Chromium. Chromium was present above background (17 ppm, Wahler) in all Phase II soil borings/wells. The range of concentrations for chromium was from 53.2 ppm in W06-09(A1) to 74.4 ppm in W06-10(A1). The maximum chromium concentration in previous soil borings/wells was 40 ppm in W06-01(A1) from 3 to 4.5 feet (ESA, 1986b). These concentrations were generally within the MV18 background range of 62 to 72 ppm and were well below the USGS background of 150 ppm. Because of the narrow range of chromium concentrations in the samples and the relatively low concentrations above background, there did not appear to be site related contamination at Site 6.

Cobalt. Cobalt was detected above background (15 ppm, USGS) in soil samples in three Phase II wells/borings installed with concentrations ranging from 15.7 ppm to 21.8 ppm, both values occurring in W06-10(A1). Cobalt was not analyzed in the ESA wells at Site 6. Cobalt was detected above background in the Phase II wells/borings at the maximum depth sampled of 5 to 6.5 feet bls. No concentration levels were detected that would indicate a cobalt anomaly.

Copper. Copper concentrations above background (15 ppm, Wahler) were detected in soil samples from all three Phase II wells. The range of concentrations for copper was from 22.5 ppm in W06-10(A1) to 41.3 ppm in W06-10(A1). Copper was detected above background at the maximum depth sampled (5 to 6.5 feet bls). These detections were below the MV18 background range of 39 to 44 ppm. When Phase II analyses were evaluated with previous analytical results (well W06-01[A1], [ESA, 1986b]), no significant copper anomaly was delineated.

Lead. Lead was detected above background (19 ppm, Wahler) in the 1- to 3-foot-bls sample from W06-08(A2) at a concentration of 25.8 ppm. The detected concentration was below the USGS background of 30 ppm.

Nickel. Nickel concentrations were detected in all three of the Phase II boreholes/monitoring wells. The range of nickel concentrations above the USGS background level of 30 ppm in Phase II samples was from 55.1 to 81.1 ppm, with both of these values occurring in W06-08(A2). The maximum concentration of nickel was in ESA well W06-01(A1) at 61 ppm. When evaluated with data from previous activities (ESA, 1986b), no obvious nickel distribution trend was delineated that would suggest a nickel anomaly.

Silver. The CRQL for silver was above the lowest background value available (see Section 3.5). Silver occurred in concentrations above the CRQL (1 ppm) in soil samples from all Phase II soil borings/wells. The range of silver values in the Phase II wells was from 1.3 ppm in W06-09(A1) to 2.4 ppm in W06-10(A1). Silver concentrations above the CRQL were found at depths from 6 to 7.5 feet bls. The maximum concentration in ESA well W06-01(A1) was less than 0.48 ppm. When evaluated with previous soil data (ESA, 1986b), no significant silver contamination could be delineated, and these higher values are thought to represent natural variations within the soils at this site.

Zinc. Zinc occurred in concentrations above the background value (31 ppm, Wahler) in soil samples from all Phase II wells. Zinc concentrations above background ranged from 44.4 to 64.6 ppm. Both of these values were detected in W06-10(A1) soil samples. Zinc concentrations were detected at depths from 6 to 7.5 feet bls. This is the approximate depth where saturated soils were first encountered. These detected values were within the Wahler background range of 31 to 93 ppm.

When evaluated with previous soil data (ESA, 1986b), no significant zinc contamination could be delineated. The maximum zinc concentration was 53 ppm in ESA well W06-01(A1).

8.0 Nature and Extent of Contamination, Hangars 2 and 3 (Site 7)

8.1 Sources

Site 7, which includes Hangars 2 and 3 and the surrounding paved area, is located immediately east of the runway, south of Marriage Road Ditch. The Site 7 investigation description is provided in Chapter 2.0 of this report. The suspected sources of contamination at this site are from spilled fuel and lubricant from aircraft and ground support vehicles. The wastes were flushed into drains emptying into the Marriage Road Ditch. Additionally, shop operations chemicals (chlorinated solvents, including TCE) were disposed of at unpaved areas around the hangars. Two USTs were located on the east side of Hangar 3 (Site 19, which may have contributed to the contamination at Site 7).

8.2 Soils and Vadose Zone

The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. A statistical summary of the analytical data (Phases I and II) is presented in Table 8.2-1. Detailed statistical analyses are discussed in the Risk Assessment, Chapter 20.0. An analytical summary of inorganics detected above the background range is presented in Table 8.2-2. Complete analytical results can be found in Appendix A. Plate B-3 depicts the distribution of organic compounds detected in the soils at Site 7 for Phase I and II samples.

8.2.1 Organics

VOCs. VOCs at Site 7 in Phase II well W07-17(A2) consisted of acetone (maximum concentration 57 ppb) and toluene (maximum concentration 7 ppb). These constituents were detected to depths of 2 to 4 feet bls and 4 to 6 feet bls, respectively.

Acetone was also detected in Phase I wells W07-18(A1) and W07-20(A1) at maximum concentrations of 72 and 50 ppb, respectively. Using the CRQL for acetone (10 ppb), and methylene chloride (5 ppb), the 10x rule as outlined in Chapter 2.0 was applied to all samples showing concentrations of acetone in the associated blank. At Site 7, no samples were considered to contain these compounds as a result of laboratory contamination. Toluene was detected at 2 ppb in W07-18(A1) and W07-19(A1) (Phase I) and at a maximum of 4 ppb in W07-20(A1). Other VOCs detected above the CRQL in the Phase I activities and their maximum concentrations in well borings included:

2-Butanone	11 ppb	W07-18(A1)
Carbon disulfide	1 ppb, one sample only	W07-16(C)
Ethyl benzene	3 ppb	W07-18(A1)
Total xylenes	16 ppb	W07-18(A1)
TCE	3 ppb, one sample only	W07-20(A1)

Concentrations of these constituents were low and contamination by these compounds appeared to be insignificant.

BNAs. Bis(2-ethylhexyl)phthalate was the only semivolatile detected in Phase II well W07-17(A2) at a maximum concentration of 64 ppb and a depth of 4 to 6 feet bls. This contaminant was widespread at Site 7 and was encountered in all of the Phase I wells/boreholes. The maximum concentration for bis(2-ethylhexyl)phthalate in the Phase I samples was in SB07-02 (2,000 ppb) at a depth of 5 feet. The concentration map (Figure 8.2-1) shows the distribution of this contaminant. This map was developed using the highest value for bis(2-ethylhexyl)phthalate from each well regardless of the depth of the sample. The areal extent of bis-2(ethylhexyl)phthalate contamination has not been fully determined at this site.

Other semivolatiles detected at Site 7 included phenanthrene (120 ppb) and di-n-butyl-phthalate (89 ppb) in Phase I soil borings SB07-01 and SB07-03, respectively.

TPHC. TPHC (JP-5) was not detected in the Phase II wells but was detected in two Phase I soil borings/wells samples, SB07-01 (160 ppm) at a depth of 1 to 2 feet bls and W07-20(A1) (110 ppm) at a depth of 3 to 4 feet bls. TPHC did not appear to be widespread at this site.

PCBs. No PCBs were detected above the CRQLs in any of the Phase I or II wells/borings at Site 7.

8.2.2 Inorganics

All samples were analyzed for metals, and Phase I and II results are presented in Table 8.2-2. Soil samples were compared to background concentrations discussed in Section 3.5. The background levels are obtained from either the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) data (see discussion in Section 3.5, Tables 3.5-1 and 3.5-2). If the CRQL for a given parameter was above the lowest background level in Table 3.5-1 or if the element had no available background value (antimony), then the CRQL was selected as the

reference level. The following metals of concern at Site 7 were detected above background concentrations:

- Antimony
- Beryllium
- Chromium
- Cobalt
- Copper
- Mercury
- Nickel
- Silver
- Zinc.

Other metals detected above background levels included aluminum, calcium, iron, magnesium, and manganese. Because these other metals are naturally occurring at elevated concentrations in soils, they are not considered to be of concern for this discussion. The results of analyses for these metals are also summarized in Table 8.2-2. The metals of concern are discussed in the following sections.

Antimony. No background values were available for antimony. In the Phase II samples, antimony was detected above the CRQL of 6 ppm in three samples ranging from 6.3 to 8.6 ppm, with both of these values occurring in W07-17(A2). In the Phase I samples, concentrations above the CRQL ranged from 7.0 ppm in W07-16(C) to 24 ppm in SB07-02. Antimony in borehole SB07-02 was attributed to metal shavings in the soil that were the result of maintenance operations at this site (refer to the Phase I Site Characterization Report, [IT, 1991a]). It is believed that the laboratory acid extraction process used in the analyses leached the material from the metal shavings rather than the soil, and the antimony levels do not represent soil concentrations (see the following discussions for copper and zinc).

Beryllium. In Phase II samples, beryllium was detected at 1.1 ppm at a depth of 4 to 6 feet in W07-17(A2). No significant beryllium concentrations were detected in the Phase I wells. The highest beryllium concentration encountered in the combined Phase I and II samples was 3.4 ppm in W07-20(A1). The background level for beryllium is 0.7 ppm (Hetch-Hetchy). These two detections are thought to represent natural variations within the soil and are not indications of site contamination.

Chromium. In Phase II samples, chromium occurred above background (17 ppm, Wahler) at a maximum concentration of 88.4 ppm and a depth of 3 to 4 feet in W07-17(A2). Chro-

mium occurred above the background levels in eight Phase I Site 7 boreholes/wells. All chromium concentrations were less than the maximum concentration (88.4 ppm) detected in W07-17(A2). These detections were within or just above the MV18 background range of 62 to 72 ppm and well below the USGS background level of 150 ppm. Because the range of chromium concentrations was relatively small at Site 7 and the concentrations were low, no anomalous chromium trend was apparent.

Cobalt. Cobalt concentrations above background level (15 ppm, USGS) were detected in all soil samples from the Phase II wells. The range of concentrations for cobalt was from 18.3 ppm to 21.1 ppm, with both of these values occurring in W07-17(A2). The Phase I concentrations above background ranged from 15.2 ppm in SB07-01 to 17.8 ppm in W07-18(A1). Cobalt was detected above background in both Phase I and II wells at the maximum depth sampled of 6 to 7.5 feet bls. No concentration levels were detected that would indicate a cobalt anomaly.

Copper. In the Phase II samples, copper was detected at a maximum concentration of 96.4 ppm in W07-17(A2), at a depth of 3 to 4.5 feet bls. A copper anomaly was detected in one Phase I soil boring, SB07-02, at a concentration of 20,500 ppm. This was attributed to the presence of metal shavings in the soil generated from maintenance operations, which may have been extracted by the leaching procedures for metal analysis in the laboratory, and may not necessarily reflect the presence of contaminants in the soils according to the Phase I Site Characterization Report (IT, 1991a).

Mercury. In Phase II well W07-17(A2), mercury was detected at concentrations ranging from 0.18 to 0.2 ppm. The background concentration for this parameter was 0.1 ppm (Hetch-Hetchy). Mercury was present over the background levels in one Phase I sample, W07-19(A1), at 0.2 ppm. In W19-04(A1), adjacent to Site 7, mercury was detected at 1 foot deep at a concentration of 0.5 ppm. These detections were within or below the MV18 background range of 0.15 to 1.3 ppm.

Nickel. In Phase II samples, the maximum concentration of nickel detected above the background level of 30 ppm (USGS) was 85.7 ppm at a depth of 3 to 4.5 feet in W07-17(A2). The maximum nickel concentration from the Phase I data was 84.3 ppm in W07-18(A1). No nickel anomaly could be delineated at Site 7 because nickel concentrations were relatively low and were within a narrow concentration range.

Silver. The CRQL for silver was above the lowest background value available (see Section 3.5). Silver was below the CRQL (1 ppm) in the Phase II Site 7 well W07-17(A2); however, silver was above the CRQL in four Phase I soil borings/wells (SB07-01, W07-16[C], SB07-02, SB07-03). The highest concentration in these four soil borings/wells was 12.4 ppm (SB07-03). Because the range of concentrations was narrow and relatively low, no silver concentrations were delineated that would indicate a silver anomaly at Site 7.

Zinc. The background level for zinc (31 ppm, Wahler) was exceeded in W07-17(A2) (Phase II) at 4 to 6 feet with a maximum concentration of 97.1 ppm. In the Phase I samples, SB07-02, the maximum zinc concentration was 8,660 ppm at 1 foot deep. As with the copper and antimony anomalies discussed previously, this has been attributed to the presence of metal shavings in the soil from maintenance operations and not necessarily from the extraction of zinc in the soil (IT, 1991a). No other zinc concentrations were identified at this location that would indicate zinc contamination.

Cadmium was not detected above background in the Phase I or Phase II samples for Site 7; however, cadmium was detected in the Phase I wells at Site 19, the former storage tanks adjacent to Hanger 3. The maximum cadmium value in the soil from these samples was 9.4 ppm in W19-04(A1) at 1 foot deep. Cadmium was also detected in this same area at W19-03(A1) (4.8 ppm at 3 feet). These detections were slightly above the Hetch-Hetchy background (4 ppm) and the MV18 range of <1 to 3 ppm. Cadmium did not appear to be widespread at this location.

9.0 Nature and Extent of Contamination, Waste Oil Transfer Area (Site 8)

9.1 Sources

Chapter 2.0 describes the investigation at Site 8, the Waste Oil Transfer Area, which is located on the west side of the runway near Building 127, between Zook Road and McCord Avenue. The probable sources of contamination in the soils and groundwater at this site are from spills resulting from the transfer activities of waste oil, solvents, and transformer oil. The site consists of a sump connected to a 5,000-gallon waste oil tank, which has been removed. This unit was in operation from the 1940s until 1980. It is estimated that the tank received approximately 100 gallons of transformer oil and 200 gallons of solvents per year.

9.2 Soils and Vadose Zone

The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. A statistical summary of the analytical data (Phases I and II) is presented in Table 9.2-1. Detailed statistical analyses of Site 9 are discussed in the Risk Assessment, Chapter 20.0. An analytical summary of inorganics detected above the background levels identified in Table 3.5-2 is presented in Table 9.2-2. Complete analytical results can be found in Appendix A. Plate B-4 depicts the distribution of organic compounds detected at Site 8 for Phase I and II samples.

9.2.1 Organics

VOCs. The major VOCs detected in the Site 8 boreholes/wells are acetone, methylene chloride, xylenes, 2-butanone, and carbon disulfide. The VOCs were detected at the 5- to 6-foot-bls depth in all Phase II borings. These compounds were also detected in the Phase I samples at concentrations less than the maximum in the Phase II samples. The concentration ranges above the CRQLs for the major organic compounds detected are tabulated as follows:

Acetone	18 ppb (W08-08[A1]) to 900 ppb (W08-12[A2])
2-Butanone	4 ppb (SB08-04) to 70 ppb (SB08-14)
Carbon disulfide	1 ppb (SB08-15) to 3 ppb (W08-04[A1], W08-11[A1], W08-12[A2])
Methylene chloride	4 ppb (W08-08[A1]) to 120 ppb (W08-10[A2])
Xylenes (total)	2 ppb (W08-11[A1]) to 4 ppb (W08-02[A2], W08-08[A1]).

These compounds were also detected in the Phase I samples at concentrations less than the maximums in the Phase II samples.

Using the CRQL for acetone (10 ppb), the 10x rule as outlined in Chapter 2.0 was applied to all samples showing concentrations of acetone in the associated laboratory blank. At Site 8, one sample was considered to have acetone resulting from laboratory contamination. This was from SB08-04 at 1 to 3 feet deep bls. Using the same principle for methylene chloride (CRQL, 5 ppm), no samples were considered to have methylene chloride resulting from laboratory contamination.

Additionally, toluene was detected in W08-10(A2), W08-05(A1), and SB08-16 at concentrations less than 4 ppb, and benzene was detected in W08-10(A2) at 2 ppb. From the Phase I soil samples, toluene was detected at a maximum concentration of 4 ppb in W08-04(A1), ethyl benzene in W08-02(A2) at 2 ppb, PCE in W08-04(A1) at 3 ppb maximum, and TCE in W08-04(A1) at 1 ppb. Concentrations of these compounds were low, and the extent of contamination was considered to be negligible.

The Phase I and II data were evaluated to determine the extent of soil contamination by VOCs. Figure 9.2-1 shows the contamination plume for the VOCs as typified by acetone (this was the most pervasive constituent detected in the soils at Site 8). The areas of highest concentration were delineated by the 100 ppb contour in this figure. Several acetone plumes were delineated at Site 8; however, the extent was not fully defined to the north of the plumes. Acetone was detected at the maximum sample depth of 10 to 11.5 feet bls.

During an investigation conducted on the NASA-ARC property (LeClaire, 1992), TCE was detected in a monitoring well installed near the property boundary and Site 8. TCE concentration in the groundwater at this well was 20,000 ppb. A subsequent SOV survey was conducted in the area in March 1992 by PRC. Samples from 24 data points showed TCE concentrations ranging from 0.01 to 0.2 ppb in the soil. Data from the SOV survey do not support the elevated TCE concentrations detected in the groundwater by NASA. Additional investigations are being planned for this area by NASA.

BNAs. Semivolatile compounds detected in the Phase I and II soil samples and their ranges of concentration were:

Benzoic acid	150 ppb in SB08-11 to 2,000 ppb in SB08-02
Bis(2-ethylhexyl)phthalate	43 ppb in SB08-11 to 2,100 ppb in SB08-05

Dibenzo(a,h)anthracene	99 ppb only in SB08-02
Diethyl phthalate	44 ppb in W08-08(A1) to 520 ppb in W08-10(A2)
Di-n-butylphthalate	48 ppb in SB08-01 to 840 ppb in SB08-10
2,4-Dinitrophenol	240 ppb only in SB08-02
4,6-Dinitro-2-methylphenol	69 ppb only in SB08-02
Naphthalene	560 ppb only in W08-10(A2)
2,4,6-Trichlorophenol	47 ppb only in SB08-02.

Diethyl phthalate, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and benzoic acid were all detected at multiple locations. The remaining semivolatiles were detected in SB08-02 only.

The extent of contamination represented by bis(2-ethylhexyl)phthalate extended along the southern perimeter of the site. The highest concentrations were in SB08-05 adjacent to abandoned Sump 62. The extent of contamination south of the site has not been defined. Bis(2-ethylhexyl)phthalate was detected to the maximum sample depth of 5 to 6.5 feet bls.

TPHC. TPHC (JP-5) was not detected in any of the Phase II soil samples. In the Phase I samples, TPHC (JP-5) was detected at a concentration of 58 ppb in W08-06(A1) (1 to 2.5 feet), and 380 ppm in SB08-04 (1 to 2 feet), which may indicate some surface spillage.

PCBs. No PCBs were detected above the CRQLs in any Phase I or II soil samples.

9.2.2 Inorganics

All samples collected from the Phase I and II monitoring wells and Phase I soil borings were analyzed for metals. No soil samples from the Phase II soil borings (SB08-14, SB08-15, SB08-16, and SB08-17) were analyzed for metals. Metals were compared to the background levels as outlined in Section 3.5. The background levels are obtained from either the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) data (see discussion in Section 3.5, Tables 3.5-1 and 3.5-2). If the CRQL for a given parameter was above the lowest background level in Table 3.5-1 or if the element had no available background value (antimony), then the CRQL was selected as the reference level. Those metals detected above the background levels are presented in Table 9.2-2. The following metals of concern at Site 8 were detected above the background concentrations:

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chromium

- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc.

Other metals detected above background levels included aluminum, calcium, iron, magnesium, manganese, and sodium; these metals are naturally occurring in soils at elevated levels and are therefore not discussed in the following sections.

Antimony. No background values were available for antimony. In Phase II samples, antimony was detected above the CRQL of 6 ppm at concentrations ranging from 6.6 ppm in W08-11(A2) to 10.7 in W08-08(A1). This metal was not detected in any other Phase II wells. Antimony was detected above the CRQL in 12 Phase I borings/wells. The maximum concentration in the Phase I soil samples was 24 ppm in SB08-01.

Arsenic. Arsenic was detected above background (5.6 ppm, Hetch-Hetchy) in one of the Phase II wells (W08-12[A2]) at concentrations ranging from 8.5 to 11.1 ppm. In the Phase I data, arsenic was detected at a maximum concentration of 6.8 ppm in SB08-05. Detected concentrations were at or below the MV18 background range of 5.9 to 11 ppm. No obvious contamination trend was delineated because concentrations were low and the concentration range was narrow.

Beryllium. In the Phase II wells, the range of beryllium concentrations above the background level (0.7 ppm, Hetch-Hetchy) was from 1.5 ppm in W08-12(A2) to 4.2 ppm in W08-11(A2). The maximum concentration in the Phase I samples was 4.8 ppm in W08-04(A1). When evaluated with Phase I data, there did not appear to be an obvious contamination trend in the soils for beryllium, and these higher values appear to indicate natural variations for the soils at this site.

Cadmium. Cadmium was detected above background (0.7 ppm, Wahler) in three Phase II wells (ranging from 1.6 ppm in W08-08[A1] to 0.85 ppm in W08-12[A2]). In the Phase I samples, cadmium was detected in four soil borings/wells. The maximum cadmium concentrations in these samples was 1.2 ppm in well W08-04(A1) and in borings SB08-05 and

SB08-07. These levels were all below the Hetch-Hetchy background value of 4 ppm. There does not appear to be a cadmium anomaly at Site 8.

Chromium. In Phase II samples, chromium concentrations above background (17 ppm, Wahler) ranged from 45.5 ppm in W08-10(A2) to 85.4 ppm in W08-11(A2). The maximum chromium concentration in the Phase I data was 84.1 ppm in W08-02(A2). These values were below the USGS background value of 150 ppm. Because of the narrow range of chromium concentrations, and the overall low chromium values when compared to naturally occurring chromium, there did not appear to be obvious chromium contamination at Site 8.

Cobalt. Cobalt concentrations above background (15 ppm, USGS) were detected in soil samples from four Phase II wells/borings. These concentrations ranged from 16.1 ppm in W08-08(A1) to 23.0 ppm in W08-10(A2). The Phase I concentrations ranged from 15.1 ppm in W08-04(A1) to 23.5 ppm in SB08-11. Cobalt was detected above background in both Phase I and II wells at a maximum depth sampled of 5.0 to 6.5 feet bls. No concentration levels were detected that would indicate a cobalt anomaly.

Copper. Copper concentrations above background (15 ppm, Wahler) were detected in all four of the Phase II wells installed. These concentrations ranged from 29.8 ppm in W08-08(A1) to 50.5 ppm in W08-12(A2). Copper was detected above background at the maximum depth sampled (5.0 to 6.5 feet). In the Phase I samples, copper concentrations above background ranged from 23 ppm in SB08-10 to 21,600 ppm in SB08-01. With the exception of the one elevated sample, the copper detected was within the Hetch-Hetchy background range of 44 to 47 ppm. When evaluated with Phase II data, the elevated copper at SB08-01 appeared to be localized.

Lead. Although lead was not detected above the background level (19 ppm, Wahler) in any of the Phase II wells, it was detected above background in two Phase I soil borings, SB08-05 at 61.6 ppm and SB08-02 at 23.6 ppm. These detections do not indicate site contamination and are most likely representative of the natural variation within the soil.

Mercury. Mercury was detected at concentrations over the background level of 0.1 ppm (Hetch-Hetchy) in one Phase II well, W08-10(A2), at concentrations ranging from 0.15 to 0.29 ppm. Mercury was not detected above background levels in the Phase I samples. The detections were within the MV18 background range of 0.15 to 1.3 ppm. Because of the low

concentration value of the mercury detected and the limited extent of mercury in the soils, no mercury contamination was delineated.

Nickel. Nickel concentrations above the background level (30 ppm, USGS) were detected in all four of the Phase II monitoring wells. Concentrations above background ranged from 42.0 ppm in W08-10(A2) to 88.4 ppm in W08-10(A2). Nickel was detected at 5 to 6.5 feet bls, the maximum depth sampled in the Phase II wells. In the Phase I data, the highest nickel concentration was 111 ppm in SB08-09. No obvious nickel distribution trend could be delineated that would suggest nickel contamination.

Selenium. The CRQL for selenium was above the lowest background value available (see Section 3.5). Selenium was not detected above the CRQL (0.5 ppm) in the Phase II wells, but was detected in two Phase I soil borings, SB08-06 and SB08-03, at a maximum concentration of 0.74 ppm. Because selenium was detected at low concentrations and because there was a minimal number of detections, contamination was not defined for selenium.

Silver. The CRQL for silver was above the lowest background available (see Section 3.5). In the Phase II samples, silver was detected above the CRQL of 1 ppm at 1.8 ppm in W08-10(A2). The maximum concentration of silver in the Phase I samples was 5.0 ppm in SB08-11. When evaluated with Phase I data, no obvious distribution trend was delineated that would suggest silver contamination.

Zinc. Zinc concentrations above background (31 ppm, Wahler) ranged from 46.2 ppm in W08-08(A1) to 84.8 ppm in W08-11(A2). Zinc was detected at 5- to 6.5-foot-bls depths in the Phase II wells. The concentrations of zinc in the Phase I and Phase II samples were evaluated, and high concentrations of zinc were detected in the Phase I soil boring, SB08-01 (8,710 ppm at 1 foot and 4,120 ppm at 3 to 4 feet). In the remaining samples, zinc occurred at concentrations above background, ranging from 44.6 ppm (SB08-10) to 95 ppm (W08-04[A1]). The detections were generally at or below the Wahler background range of 31 to 93 ppm. It appeared that the zinc anomaly in the Phase I samples was localized in the immediate vicinity of SB08-01, and no extensive zinc contamination was delineated.

10.0 Nature and Extent of Contamination, Old Fuel Farm and Old NEX Gas Station (Site 9)

10.1 Sources

Site 9, the Old Fuel Farm, is located on the west side of the runway, immediately west of Hangar 1. The site was used for fuel storage from the 1940s until 1964. Aviation gas was stored in six underground 10,000-gallon steel tanks adjacent to Building 29 (Tank 79, Tank 80, Tank 81, Tank 82, Tank 83, and Tank 84). These tanks are inactive but have not been removed. This area is now a parking lot for Building 12. Also in this area are four inactive 25,000-gallon AVGAS USTs (Tank 47, Tank 48, Tank 49, Tank 50) and a 25,000-gallon aboveground tank at Building 29 (Tank 52) that was removed. A 500-gallon waste oil tank (Tank 56a) and three 10,000-gallon (Tank 56B, Tank 56C, and Tank 56D) USTs that were used to fuel motor vehicles were located near Building 31, the Old NEX Gas Station. Locations of these tanks are shown in Figure 10.1-1. These tanks were excavated in 1991 (PRC, 1991a). In addition to the aforementioned tanks, other tanks and sumps identified at Site 9 in the Phase I activities included:

- Two waste paint sumps (Sumps 61 [removed] and 62 [active], Site 17)
- Nine removed or closed gasoline fuel tanks (Tanks 33 through 41)
- Two tanks (removed) (Tanks 67 and 68, exhumed Site 14)
- Sump 66 (removed) believed to contain dry cleaning solvents (Site 18)
- A removed 3,000-gallon fuel oil tank (Tank 1)
- An abandoned oil/water separator (Sump 25, Site 15)
- A removed vapor condensation recovery tank (Tank 42, Site 15)
- An active fuel oil/diesel tank (Tank 32)
- An abandoned diesel tank at Building 15 (Tank 87)
- Two abandoned motor vehicle fuel tanks at Building 10 (Tanks 86A and B).

Sites 14, 17, and 18 are discussed in Chapters 14.0, 16.0, and 17.0 of this report, respectively. Site 15 will be specifically addressed in the OU3 RI Report. The sources are further identified for each analyte discussed in the following section.

10.2 Soils and Vadose Zone

Soil samples were collected in the vadose zone at depths of 1 to 2.5 feet bls, 3 to 4.5 feet bls, and 5 to 6.5 feet bls, and in the soil borings an additional sample was collected at a depth of 10 to 11.5 feet bls. The samples were analyzed for VOCs, pH, metals (only monitoring well soil samples were analyzed for metals), PCBs, BNAs, and TPHC. A statistical summary of the analytical data (Phases I and II) is presented in Table 10.2-1. Detailed statistical analyses

for Site 9 are discussed in the Risk Assessment, Chapter 20.0. An analytical summary of inorganics detected above the background levels is presented in Table 10.2-2. Complete analytical results can be found in Appendix A. Plate B-5 depicts the distribution of organic compounds detected in the soils at Site 9.

The contamination identified in the Phase I and II activities is discussed in the following sections.

10.2.1 Organics

10.2.1.1 VOCs

Multiple VOCs were detected in the soils at Site 9. Primary VOCs (maximum concentrations greater than 25 ppb) included:

- 1,2-DCE (total)
- 2-Butanone
- Acetone
- Benzene
- Ethyl benzene
- Methylene chloride
- PCE
- Toluene
- TCE
- Total xylenes.

Using the CRQL for acetone (10 ppb), the 10x rule as outlined in Chapter 2.0 was applied to all samples showing concentrations of acetone in the associated laboratory blank. At Site 9, 10 of 184 samples were considered to contain acetone resulting from laboratory contamination. Using the same principle for methylene chloride (CRQL, 5 ppm), 12 of 184 samples were considered to have methylene chloride resulting from laboratory contamination.

Isoconcentration contours could not be easily delineated for each occurrence at a given horizon because trends were not consistent across a given horizon; therefore, the contaminant occurrences for the primary VOCs discussed in the following sections were generated by plotting the highest concentration of the specific parameter from each well or borehole, and are not a function of depth. This shows the general extent of soil contamination for each parameter.

1,2-DCE (total). Concentrations of 1,2-DCE in the Phase II samples ranged from 1 to 110 ppb. 1,2-DCE was not detected above the CRQL in the Phase I samples. Although concentrations were low, several small areas of contamination were identified from Phase I and II soil data (see Figure 10.2-1). The plume locations and sources are:

- Area 9C, the northeast corner of the Site 9; SB09-01 had a maximum concentration of 28 ppb (source unknown).
- Area 9D, near Sumps 61 and 62; W09-28(A2) had a maximum concentration of 14 ppb (possible source - Sump 61).
- Area 9E; SB09-06 had a maximum concentration of 110 ppb (no obvious source).
- Near the oil/water separator (Sump 25); W09-42(A2) had a maximum concentration of 65 ppb.
- Site 18, near dry cleaning solvent sumps; SB09-11 had a maximum concentration of 86 ppb (probable sources - Tanks 67 and 68 or Sump 66). The maximum concentration from the PRC activities from this area (see PRC, 1991a) was 55 ppb.
- Area 9F; a small plume was identified near Building 3 (source unknown).
- Area 9G, near the extreme southwest corner of Site 9; W09-41(A2) had a maximum concentration of 16 ppb (source unknown).
- Also, low concentrations were detected at the Old NEX Gas Station (14 ppb) and at the Old Fuel Farm (15 ppb) according to PRC data (1991a).

The 1,2-DCE plumes identified with the Phase I and II soils data correlate closely with the soil gas survey plumes identified in the Phase I soil gas survey. This parameter was detected in soils above the CRQL at a maximum depth of 10 to 11.5 feet bls.

The maximum concentration of 1,2-DCE in soil was detected at the 10- to 11.5-foot depth interval (near the water table) and the mean concentration was higher (37.7 ppb) than the more shallow samples. The average 1,2-DCE concentration for the more shallow horizons ranged from 12.8 to 13.9 ppb (Table 10.2-1). These results strongly suggest that much of the DCE contamination observed in the soil zones results from interaction with contaminated groundwater originating at the MEW site.

2-Butanone. A small 2-butanone plume was identified at the Old NEX Gas Station (Area 9B). The maximum concentration of 2-butanone in Phase I and II samples occurred in W09-09(A2) at 170 ppb. The maximum depth where 2-butanone was detected above the CRQL was 5 to 6.5 feet bls in W09-09(A2). Also, concentrations of 2-butanone (150 ppb) were detected at the Old NEX Gas Station during the tank removal activities conducted by PRC in 1991 (PRC, 1991a).

Acetone. Acetone contamination was widespread at Site 9 (see Figure 10.2-2) and was detected to a maximum sample depth of 10 to 11.5 feet bls. Eight plumes were delineated at this site including:

- Area 9C; SB09-04 had a detection of 190 ppb (near Tanks 79, 80, 81, 82, 83, and 84)
- Building N210; W09-04(B2) had a detection of 110 ppb (source unknown)
- Area 9E; W09-15(B2) has a detection of 41 ppb (source unknown)\
- Site 15; W09-30(A1) had a detection of 250 ppb (near Sump 25, Tanks 33-41)
- Southwest corner of Site 9; W09-41(A2) had a detection of 27 ppb (source unknown)
- Near Building 15; W09-40(B2) had a detection of 90 ppb (possibly Tank 87)
- Old NEX Gas Station; SB09-05 had a detection of 6,500 ppb (near Tanks 56A through D).
- Site 18; W09-12(B2) had a detection of 22 ppb near Sump 66.

Although acetone concentrations from W09-15(B2), W09-40(B2), and W09-41(A2) are less than 10x the CRQL, there were no contaminated laboratory blank samples associated with the validated samples; therefore, the 10x rule does not apply.

Benzene, Toluene, Ethyl Benzene, Total Xylenes. A BTEX plume was also defined at the Old NEX Gas Station (Area 9B) (Figure 10.2-3). Maximum concentrations of total BTEX (191,053 ppb) occurred in SB09-05 at 10 to 11.5 feet bls, which was the maximum depth where BTEX was detected. BTEX-contaminated soils appeared to be confined to this area. The apparent sources of this plume are Tanks 56A through 56D and associated piping. Extensive BTEX contamination was also detected in the tank pit soils and product line trench

sampled during the tank removal activities at this Area C (PRC, 1991a). Additionally, a small plume was delineated at SB09-03 at 25 ppb in Area 9C (potential sources, Tanks 47, 48, 49, and 50). Toluene, ethyl benzene, and xylenes were also detected in this area during the field investigation conducted by PRC in 1991 (PRC, 1991c).

Methylene Chloride. Methylene chloride was detected in 13 of the 56 soil borings/monitoring wells sampled. Phase I and Phase II validated methylene chloride concentrations range from 10 ppb to SB09-10 at 1 to 2.5 feet to 4,700 ppb in SB09-05 (Old NEX Gas Station) at 10 to 11.5 feet. In W09-05(B3), near building N210, the maximum methylene chloride concentration was 130 ppb. All others were less than 64 ppb (in SB09-02 in Area 9C). Methylene chloride concentrations center primarily around the Old NEX Gas Station (SB09-09, W09-02[A2]). There does not appear to be a well-defined distribution trend for minor concentrations less than 50 ppb.

PCE. From the Phase I and II soil data, elevated concentrations of PCE were detected around SB09-02 and W09-26(A1) at Area 9C in the extreme northeast corner of Site 9. The maximum concentration of PCE in SB09-02 was 110 ppb. A small PCE plume was detected at W09-21(A2), adjacent to Hangar 1, where the maximum concentration above the CRQL was 120 ppb. The source of the PCE is unknown, but it was detected to a maximum depth of 6.5 feet bls. PCE was also detected during the removal of Tank 68 (140 ppb maximum concentration) (PRC, 1991a).

TCE. Several small TCE plumes were delineated from the Phase I and Phase II data at Site 9 (see Figure 10.2-4). The areas defined by these plumes included:

- Area 9F, south of Building 3; SB09-08 had a maximum TCE concentration of 330 ppb. The maximum depth of TCE detections was 10 to 11.5 feet bls (source unknown).

- Area 9E; SB09-06 had a maximum TCE concentration of 170 ppb. TCE was detected to the maximum depth sampled (10 to 11.5 feet bls) (source unknown).

- Site 18, dry cleaning solvent sumps; SB09-12 had a maximum TCE concentration of 110 ppb, and W09-12(B2) had a maximum TCE concentration of 130 ppb. TCE was detected at a maximum depth of 10 to 11.5 feet bls (suspected source is Sump 66).

- Near Area 9G, near Building 104; W09-41(A2) and SB09-14 had maximum TCE concentrations of 150 ppb and 220 ppb, respectively. The maximum depth where TCE was detected was 10 to 11.5 feet bls (source unknown).

- TCE was also detected in the Sump 68 area from the PRC activities (April 1991) at a maximum concentration of 28 ppb and at Building 29 (Old Fuel Farm) at a maximum concentration of 100 ppb. These plumes are not shown in Figure 10.2-4.

Also, a small TCE plume was delineated in the immediate area of W09-34(A2) (maximum concentration, 12 ppb). In all of the soil borings and wells in the southern half of Site 9, TCE concentrations were detected at more than 10 ppb. In the northern half of Site 9, from South Road northward, all TCE concentrations were below 10 ppb in the soils. As with 1,2-DCE, the mean concentration for TCE in the soil was significantly higher at the 10- to 11.5-foot-bls interval (166 ppb) near the water table than in the more shallow samples (average TCE concentration ranged from 22.7 ppb at 1 to 3 feet bls and 22.13 ppb at 3 to 5 feet bls to 166 ppb at the 10- to 11.5-foot-bls interval [see Table 10.2-1]). Based on these results, it is likely that the TCE soil contamination observed in the Site 9 area is largely (if not entirely) from contaminated groundwater from the MEW site.

10.2.1.2 TPHC

TPHC (JP-5) was not detected above the CRQL in any Phase I or Phase II soil samples at Site 9; however, data from eight PRC soil borings (PRC, 1991c) indicated the presence of TPHC in three areas:

- Near Building 29 - 10,000-gallon AVGAS tanks (Tanks 79, 80, 81, 82, 83, and 84), and 25,000-gallon AVGAS tanks (Tanks 47, 48, 49, 50, and 52)
- Old NEX Gas Station
- Area 9E, near W09-21.

In the Building 29 area, TPHC concentrations from the PRC data were as follows:

- TPHC-gasoline - 3.5 to 2,100 ppm
- TPHC-kerosene - 17 ppm
- TPHC-motor oil - 95 ppm.

At the Old NEX Gas Station, TPHC concentrations from the PRC data were:

- TPHC-gasoline - 0.11 to 1,800 ppm
- TPHC (JP-5) - 1.3 to 68 ppm.

TPHC (JP-5) was detected in Area 9E at concentrations ranging from 1.2 to 4.2 ppm.

PRC also performed trenching activities over the 10,000-gallon aviation fuel tanks and 25,000-gallon aviation fuel tanks at Building 29, and collected seven soil samples from the trenches. In these samples, TPHC-gasoline ranged from 8.2 to 690 ppm; TPHC-diesel and TPHC-kerosene were below detection limits; TPHC (JP-5) ranged from 210 to 360 ppm; and TPHC-motor oil ranged from 53 to 1,600 ppm.

In 1991, Tanks 56A, B, C, and D at the Old NEX Gas Station were removed and petroleum-contaminated soil was excavated. Soil samples were collected from the excavations (PRC, 1991a). TPHC concentrations in the tank excavations were:

- Tank 56A - TPHC-gasoline - 0.6 to 14 ppm
- Tank 56B - TPHC-diesel - 44.5 ppm
- Tanks 56C, 56D - TPHC-gasoline - 12.1(J) to 4,570(J) ppm
  (J indicates an estimated value).

10.2.1.3 PCBs

PCBs were not detected at Site 9.

10.2.1.4 BNAs

The semivolatiles detected at Site 9 included:

- Bis(2-ethylhexyl)phthalate
- Chrysene
- Diethyl phthalate
- 2,4-Dimethylphenol
- Di-n-butylphthalate
- Di-n-octylphthalate
- 2-Methylnaphthalene
- 4-Methylphenol.

Of these, bis(2-ethylhexyl)phthalate was the most widespread constituent. An isoconcentration map from Phase I and Phase II data for bis(2-ethylhexyl)phthalate is shown in Figure 10.2-5. Several plumes of this contaminant were delineated:

- At Site 17 near Sumps 61 and 62 (Area 9D), a plume was identified with the highest concentrations of bis(2-ethylhexyl)phthalate in W09-28(A2) (maximum concentration 2,000 ppb). The sumps are a potential source of contamination. Bis-2(ethylhexyl)phthalate was identified in the spoil pile of the Sump 61 excavation by PRC (PRC, 1991a).

- Near Buildings 126 and 64 near the southeast corner of Site 9 (Area 9E), concentrations of 860 and 600 ppb bis(2-ethylhexyl)phthalate were detected in W09-21(A2) and W09-18(A1), respectively (source unknown).

- In Area 9E, in the parking lot adjacent to Severyns and South Avenues, a small plume was delineated in this area, centered around W09-20(A2). The maximum concentration of bis(2-ethylhexyl)phthalate was detected at 250 ppb (source unknown).

The contaminant was detected to the maximum depth sampled (5 to 6.5 feet bls) for these plumes. These three areas also correlated to the SOV survey conducted in the Phase I activities (Phase I Characterization Report [IT, 1991a], specifically Figure 12.4-2); however, because of their low volatility, phthalates were not contributors to the organic vapor concentrations. Other areas of contamination included the following:

- A plume was identified near the oil/water separator (Sump 25) (probable source) and gasoline tanks (numbers 33 through 41) on the southeast side of Site 9. The maximum concentration (120 ppb) of bis(2-ethylhexyl)phthalate was detected in W09-30(A1).

- On the north side of Wescoat Road (Site 18) near Building 6, bis(2-ethylhexyl)phthalate was detected in W09-17(A2) (maximum concentration of 290 ppb) (a possible source is Sump 66; however, no BNA analyses were performed on soils at this site during the removal of the sump.)

- Near Building 104, south of Wescoat Road (southwest corner of Site 9 Area 9G) at W09-38(A1), bis(2-ethylhexyl)phthalate was detected at a maximum concentration of 558 ppb. The vertical extent of this constituent was 3 to 4.5 feet bls (source unknown).

- At Area 9G, W09-19(A1) had a maximum concentration of 500 ppb. The maximum depth where this constituent was detected was 5 to 6.5 feet bls (source unknown).

- Near Building 15 in Area 9G, the maximum concentration was 1,400 ppb in W09-08(A2). The maximum depth where this constituent was detected was 5 to 6.5 feet bls. Bis(2-ethylhexyl)phthalate was also detected in W09-33(A2) in Area 9F west of Building 3. The maximum concentration here was 190 ppb, and the maximum depth where this constituent was detected was 5 to 6.5 feet (probable source was Tank 87).

- At Area 9G, W09-16(A1) had a maximum concentration of 130 ppb (probable sources were Tanks 86A and 86B).

- At Area 9A (FP09-01[A1]), the maximum concentration was 1,100 ppb. Probable sources were Tanks 47, 48, 49, and 50; however, no BNA samples were collected during the PRC activities in this area to confirm this (PRC, 1991a).

- At Area 9B (Old NEX Gas Station), the maximum concentration of bis(2-ethylhexyl)phthalate was 400 ppb in W09-07(A1). The maximum depth where this constituent was detected was 5 to 6.5 feet bls (Tanks 56A through D and associated piping were probable sources). Bis(2-ethylhexyl)phthalate and other semivolatiles were also detected in the soils relative to the removed oil/water separator (Tank 56A) according to PRC data (PRC, 1991a).

- In W09-25(A2), north of Bushnell Drive, the maximum concentration of bis(2-ethylhexyl)phthalate was 960 ppb. The maximum depth where this constituent was detected was 5 to 6.5 feet bls (source unknown).

- Two small areas of elevated concentrations of bis(2-ethylhexyl)phthalate were detected north of the site at W09-10(A1) (maximum concentration, 47 ppb), and directly north of Hangar 1 in W09-43(A2) (maximum concentration, 49 ppb). The vertical extent of the constituent at this location was 1 to 2.5 feet bls; however, these locations appeared to be isolated detections rather than a significant contaminant plume.

The remaining semivolatiles, 2,4-dimethylphenol, 4-methylphenol, chrysene, di-n-butylphthalate, di-n-octylphthalate, and diethyl phthalate were limited in areal extent.

10.2.2 Inorganics

In the Phase II sampling activities, metals were analyzed for all samples collected, except for soil borings SB09-01 through SB09-14. Phase I borings and wells were sampled for inorganics. A summary of metals detected above background (as presented in Section 3.5 and Tables 3.5-1 and 3.5-2) is presented in Table 10.2-2. The background levels are obtained from either the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) data. If the CRQL for a given parameter was above the lowest background level in Table 3.5-1 or if the element had no available background value (antimony), then the CRQL was selected as the reference level. The following metals of concern at Site 9 were detected above the background concentration:

- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium

- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Vanadium
- Zinc.

Aluminum, calcium, iron, magnesium, manganese, and potassium were detected above the background levels; however, they are not considered elements of concern in this discussion because they are naturally occurring at the levels detected.

Antimony. No background values were available for antimony. Antimony was detected above the CRQL (6 ppm) in 27 Phase II wells. Concentrations in the Phase II samples ranged from 6.2 ppm in W09-35(A1) to 90 ppm in FP09-01. Antimony was detected above the CRQL in two Phase I samples (W09-13[A2] at 9 ppm and W09-05[B3] at 11 ppm). Antimony was detected in the PRC soil borings (PRC, 1991c) at a concentration of 1.0 ppm in one sample (Table 10.2-3). In the NEX tank area (Tanks 56A, B, C, and D), concentrations ranged from below the PRC detection limit at Tanks 56B, C, and D to 39 ppm in Tank 56A (Table 10.2-4).

Arsenic. Arsenic concentrations at or above background (5.6 ppm, Hetch-Hetchy) were detected in 16 Phase II wells and ranged from 5.6 to 74.2 ppm. In the Phase I analyses, arsenic was detected above background in two wells: W09-27(A2) at 8.2 ppm maximum concentration, and W09-14(A2) at 6.3 ppm maximum concentration. Arsenic was detected in the PRC soil borings (PRC, 1991c) at concentrations ranging from 0.54 (below 1 ppm CRQL) to 15 ppm (Table 10.2-3). In the NEX tank area, arsenic concentrations ranged from 0.6 ppm (below 1 ppm CRQL) in Tanks 56C and D to 11.8 ppm in Tank 56B (Table 10.2-4; PRC, 1991a). In general, these detections were within the MV18 background range of 5.9 to 11 ppm.

Barium. Barium concentrations above background (700 ppm, USGS) were detected in soil samples from two Phase II wells/borings and ranged from 1,120 ppm in W09-24(A1) to 1,450 ppm in W09-26(A1). The only concentration detected in the Phase I samples was 795 ppm in W09-14(A2). Barium was detected above background in both the Phase I and II wells at a

maximum depth of 3 to 4.5 feet bls. Because barium was detected at low levels above background in only three samples, barium contamination does not appear to be site related at Site 9.

Beryllium. Beryllium concentrations at or above the background level (0.7 ppm, Hetch-Hetchy) in the Phase II samples ranged from 0.7 ppm in W09-23(A1) to 2.9 ppm in W09-10(A1). Beryllium was detected above background levels in two Phase I wells, W09-14(A2) at 1.2 ppm and W09-15(B2) at 0.73 ppm. Beryllium was detected in the PRC soil borings (PRC, 1991c) at concentrations ranging from 0.38 to 1.0 ppm (Table 10.2-3). This range is near the background level selected for beryllium (0.7 ppm, Hetch-Hetchy). In the NEX tank area, beryllium concentrations ranged from below the PRC detection limits in Tanks 56C and D to 1.2 ppm in Tank 56B. These detections were at or near the MV18 background range of 0.9 to 1.2 ppm. No beryllium contamination was apparent at Site 9.

Cadmium. Cadmium concentrations above background (0.7 ppm, Wahler) in Phase II soil samples ranged from 0.79 ppm in W09-43(A2) to 4 ppm in W09-19(A1). Cadmium was detected above background levels in Phase I well W09-15(B2) at 9.4 ppm. Cadmium was detected above background in the PRC soil borings (PRC, 1991c) at concentrations ranging from 1.4 to 2.05 ppm. In the NEX tank area, cadmium ranged from below PRC detection limits in Tank 56A to 0.9 ppm in Tanks 56C and D (Table 10.2-4; PRC, 1991a). This range is below the selected background level, and all detections are at or below the Hetch-Hetchy background value of 4 ppm. Because cadmium concentrations were relatively low, no cadmium anomaly could be delineated at Site 9.

Chromium. Chromium concentrations above background (17 ppm, Wahler) for the Phase II samples ranged from 19.4 to 93.4 ppm. Chromium was detected above background in nine Phase I wells with values ranging from 37.5 to 87.1 ppm. Chromium was detected in the PRC soil borings (PRC, 1991c) at concentrations ranging from 24.1 to 133 ppm (Table 10.2-3). In the NEX tank area, chromium ranged from 43.1 ppm in Tank 56A to 93.7 ppm in Tanks 56C and D (Table 10.2-4; PRC, 1991a). These detected concentrations were at or below the USGS background value of 150 ppm. Because of the relatively low concentrations and narrow concentration range of chromium encountered in the soils at Site 9, no chromium anomaly was apparent at this site.

Cobalt. Cobalt concentrations above background level (15 ppm, USGS) were detected in soil samples from 12 Phase II wells/borings installed. These concentrations ranged from 15.4

ppm in W09-19(A1) to 80.0 ppm in FP09-01. The Phase I concentrations ranged from 15.5 ppm in W09-27(A2) to 23.5 ppm in W09-05(B3). Cobalt was detected above background in both Phase I and II wells at the maximum depth sampled of 5 to 6.5 feet bls. The cobalt anomaly appears to be limited to the soils at FP09-01.

Copper. A high concentration of copper was detected in W09-12(B2) (32,900 ppm from 1 to 2.5 feet bls). W09-12(B2) is located adjacent to Building 6 on the south side of Site 9, along Wescoat Road near the dry cleaning solvent sump (Sump 66). The source of this anomaly is undetermined. Copper concentrations in adjacent wells, W09-37(A1), W09-17(A2), and W09-18(A1), were all significantly lower, indicating that the elevated copper concentrations were confined to the immediate soils around W09-12(B2). The maximum copper concentration in the Phase I data was 287 ppm (above the background value of 15 ppm, Wahler). Copper was detected in the PRC soil borings (PRC, 1991c) at concentrations ranging from 14.6 ppm to 54.7 ppm (Table 10.2-3). In the NEX tank area, copper concentrations ranged from 32.9 ppm in Tanks 56C and D to 58.1 ppm in Tank 56A (Table 10.2-4; PRC, 1991a).

Lead. Lead concentrations above background (19 ppm, Wahler) in the Phase II samples ranged from 22.8 ppm to 144 ppm. Lead was detected above background in two Phase I wells at concentrations ranging from 20.3 to 60.2 ppm. In the PRC soil borings (PRC, 1991c), lead was detected at concentrations ranging from 3 ppm (background concentration: 30 ppm, USGS) to 44.8 ppm (Table 10.2-3). In the NEX tank area, lead concentrations ranged from 3.7 ppm in Tanks 56C and D to 41.9 ppm in Tank 56A (Table 10.2-4; PRC, 1991a). Because the range of lead concentrations in the soils was relatively narrow, no lead anomaly was apparent in the soils at Site 9.

Mercury. In the Phase II wells at Site 9, mercury concentrations at or above background (0.1 ppm, Hetch-Hetchy) ranged from 0.1 ppm in W09-34(A2) to 1.1 ppm in W09-19(A1). Concentrations of mercury above background were detected in seven Phase I monitoring wells at concentrations ranging from 0.2 to 0.3 ppm. Mercury was detected in the PRC soil borings (PRC, 1991c) at concentrations ranging from 0.076 ppm (background concentration: 0.1 ppm, Hetch-Hetchy) to 0.19 ppm (Table 10.2-3). In the NEX tank area, mercury concentrations ranged from below PRC detection limits in Tank 56A to 0.1 ppm at Tanks 56B, C, and D (Table 10.2-4; PRC, 1991a). No mercury concentrations were apparent at Site 9 that would indicate mercury contamination in the soils.

Nickel. Nickel concentrations above the background level (30 ppm, USGS) in the Phase II soil samples at Site 9 ranged from 35.2 ppm in W09-21(A2) to 907 ppm in W09-12(B2). Nickel concentrations in the Phase I wells ranged from 41.8 ppm in W09-07(A1) to 91.1 ppm in W09-14(A2). An evaluation of nickel analysis in the soils indicates that the nickel concentration in W09-12(B2) may be anomalous. The sample depth of this concentration (1 to 2.5 feet) corresponded to the depth of the copper anomaly at this location discussed previously. Nickel concentrations in the adjacent wells, W09-17(A2), W09-18(A1), W09-37(A1), were all lower, thus the anomaly was confined to the soils in the immediate area around W09-12(B2). The source of this anomaly is undetermined. Nickel was detected in the PRC soil borings (PRC, 1991c) at concentrations ranging from 39.8 to 111 ppm (background concentration: 30 ppm, USGS) (Table 10.2-3). In the NEX tank area, nickel concentrations ranged from 41.3 ppm at Tank 56A to 84.0 ppm in Tank 56B (Table 10.2-4; PRC, 1991a).

Selenium. The CRQL for selenium was above the lowest background value available (see Section 3.5). In Phase II samples, concentrations of selenium at or above the CRQL (0.5 ppm) ranged from 0.50 ppm in W09-29(A1) to 0.69 ppm in W09-36(A2). No selenium was detected above the CRQL in the Phase I soil samples. Selenium was detected above the CRQL in the PRC soil borings (PRC, 1991c) at concentrations ranging from 2 to 5.7 ppm (Table 10.2-3). In the NEX tank area, selenium concentrations ranged from below PRC detection limits at Tanks 56A and B to 0.3 ppm at Tanks 56C and D (Table 10.2-4; PRC, 1991a). The concentration range for this analyte was narrow, suggesting that there was not selenium contamination at this site.

Silver. The CRQL for silver was above the lowest background value available (see Section 3.5). Silver concentrations above the CRQL (1 ppm) in the Phase II analyses ranged from 1.10 ppm in W09-20(A2) to 284 ppm in W09-12(B2) at 1 to 2.5 feet bls in the Phase II samples. Silver was also detected above the CRQL in three Phase I wells. The maximum concentration in the Phase I samples was 4.7 ppm in W09-05(B3). The elevated silver anomaly in W09-12(B2) corresponded to the nickel and copper anomaly discussed previously. Silver was detected in the PRC soil borings (PRC, 1991c) at concentrations ranging from 0.54 ppm (below the CRQL) to 18.3 ppm (Table 10.2-3). In the NEX tank area, silver concentrations ranged from below PRC detection limits at Tank 56A to 1.7 ppm at Tanks 56C and D (Table 10.2-4; PRC, 1991a). The silver appeared to be limited in extent, being confined to the soils in the immediate area of W09-12(B2).

Vanadium. No vanadium was detected above background (150 ppm, USGS) in the Phase I and Phase II samples. In the PRC soil borings (PRC, 1991c), vanadium was detected at concentrations ranging from 27.9 ppm (below background) to 171 ppm. In the NEX tank area, all vanadium values were below background (PRC, 1991a). The one elevated level of vanadium detected is most likely an indication of the natural variations within the soils.

Zinc. Zinc concentrations above the background value (31 ppm, Wahler) ranged from 36.5 ppm in W09-42(A2) to 201 ppm in FP09-01(A1) at 1 to 2.5 foot depths in the Phase II samples. The maximum zinc concentration in the Phase I samples was 160 ppm in W09-15(B2). The zinc concentration in FP09-01(A1) of 201 ppm was slightly elevated compared to the other samples. This is likely an indication of the natural variations within the soil. Zinc was detected in the PRC soil borings (PRC, 1991c) at concentrations ranging from 48.7 to 96.7 ppm (background concentration: 31 ppm, Wahler) (Table 10.2-3). In the NEX tank area, zinc concentrations ranged from 45.8 ppm at Tanks 56C and D to 88.9 ppm at Tank 56B (Table 10.2-4; PRC, 1991a). In general, the zinc detections were within the MV18 background range of 100 to 110 ppm. No additional zinc contamination could be delineated.

11.0 Nature and Extent of Contamination, Chase Park Area and Runway (Site 10)

11.1 Sources

Site 10 encompasses the runway and the Chase Park area, which is located north of the Bayshore Freeway (Highway 101) and south of the Site 9 area (Figure 2.3-8).

A primary source of potential soil contamination is the runway precipitation runoff that may carry spilled fuels and lubricants to the surrounding ditches and drains (Figure 2.3-8). No sources are known to exist in the Chase Park area, although the groundwater is known to contain chlorinated VOCs from the upgradient MEW site. Sources in the area are investigated for other sites (e.g., Sites 14, 15, and 16).

11.2 Soils and Vadose Zone

Two wells were installed in the runway area. Because no sources exist in Chase Park, no samples were collected there. All soil samples from Phase I were analyzed for VOCs, BNAs, TPHC, PCBs, pH, and metals. Figure 2.3-8 shows the location of the Site 10 wells and borings. No Phase II activities were conducted at this site. A statistical summary of the analytical data is presented in Table 11.2-1. An analytical summary of inorganics detected above background levels (Table 3.5-2) is presented in Table 11.2-2. Complete analytical results can be found in Appendix A. Plate B-3 depicts the distribution of organic compounds detected in the soils at Site 10. Previous investigative data obtained from the MEW RI Report (HLA, 1987a) indicate six soil borings were drilled in the runway area by Canonie; their locations are shown in Figure 2.3-8. The borings were sampled at depths from 3 to 11 feet bls and the samples analyzed for VOCs, BNAs, and metals.

11.2.1 Organics

VOCs. The analysis of samples collected showed that detected acetone concentrations ranged from 6 to 57 ppb. Because the quantitation limit for acetone is 10 ppb and all samples from W10-05(A1) showed acetone in association with method blank contamination, it is assumed that these low levels are a result of laboratory contamination based on the 10x rule as outlined in Chapter 2.0. Two samples from W10-06(C) had acetone detects that were not associated with laboratory contamination. Methylene chloride, another common laboratory contaminant, was detected at concentrations ranging from 10 to 26 ppb. Due to its

presence in associated laboratory method blanks in all samples and based on the 10x rule as outlined in Chapter 2.0, methylene chloride is assumed to be a result of laboratory contamination in these well borings.

A total of six VOCs with concentrations ranging from 6 to 800 ppb were detected in four of the borings. The 7- to 11-foot-bls sample from EB-37 accounts for all of the concentrations above 150 ppb. Methylene chloride, 1,1-TCA, 1,2-DCA, trichlorofluoromethane, and TCE were detected in this sample at concentrations ranging from 60 to 800 ppb. Because the higher concentrations were detected at depths (7 to 11 feet bls) presumably below the water table, contributions from groundwater contamination are possible. Three VOCs (PCE, TCE, and trichlorofluoromethane) were found at the 3- to 6.5-foot-bls depths in the borings (EB-60, EB-62, and EB-64) north of the runway at concentrations ranging from 6 to 150 ppb.

Recent sampling of the wet well contents and incoming lines of the Building 191 Lift Station was conducted as part of the North Base Area field investigation (PRC and James M. Montgomery, 1991c). The lift station receives runoff from the runway and surrounding areas as shown in Figure 3.1-2. Sample results indicated TCE concentrations ranged from 6 to 13 ppb in the wet well and incoming lines from the west and south. TCE was not detected in the Patrol/Marriage Roads ditch line, which enters the lift station from the east. These data suggest that low levels of TCE may be present in runway precipitation runoff. However, as evidenced by the Canonie soil samples, TCE soil contamination is minimal. Soil samples have not been collected during the North Base Area field investigation due to the lack of expected contamination.

BNAs. Bis(2-ethylhexyl)phthalate was detected in three samples. The 3- to 5-foot and 5- to 10-foot-bls samples from W10-05(A1) had concentrations of 190 and 730 ppb, respectively. The 5- to 10-foot-bls sample from W10-06(C) had a concentration of 110 ppb. No BNAs were detected in the Canonie samples.

TPHC. TPHC (JP-5) was detected at a concentration of 170 ppm in the 3- to 5-foot-bls sample from W10-06(C).

PCBs. No PCBs were detected in the referenced samples.

11.2.2 Inorganics

An analytical summary of inorganic concentrations detected above the background levels is presented in Table 11.2-2. The background levels were obtained from either the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) background samples as discussed in Section 3.5. The CRQL was used for comparison if the CRQL exceeded the lowest background concentration from the USGS, Hetch-Hetchy, MV18, and Wahler samples or if no background value existed (antimony). Inorganic background values are presented in Tables 3.5-1 and 3.5-2.

A number of inorganic compounds were found in each of the six samples at concentrations above the background levels. Aluminum, calcium, iron, magnesium, manganese, potassium, and sodium are major components of soil materials. Because they are naturally occurring at elevated levels in soils, they are not of concern at this site. Elements that exceeded background levels included:

- Antimony
- Barium
- Beryllium
- Chromium
- Copper
- Mercury
- Nickel
- Silver
- Zinc.

Antimony. No background values were available for antimony. Antimony was detected in one sample from W10-06(C) at a concentration (7.0 ppm) above the CRQL of 6 ppm.

Barium. Barium was detected in the 5- to 10-foot-bls sample from W10-05(A1) at a concentration (754 ppm) slightly above background (700 ppm, USGS).

Beryllium. Beryllium was detected in five samples from W10-05(A1) and W10-06(C) at concentrations slightly above background (0.7 ppm, Hetch-Hetchy). Concentrations ranged from 0.83 to 1.6 ppm. Each of the detected concentrations, with the exception of the 5- to 10-foot-bls sample from W10-06(C) (1.6 ppm), was within the MV18 background range (0.9 to 1.2 ppm).

Chromium. Chromium was found in the 1- to 3- and 3- to 5-foot-bls samples from W10-05(A1) and W10-06(C) at concentrations above background (17 ppm, Wahler). The concentrations ranged from 38.4 to 72.5 ppm. These concentrations were below the USGS background of 150 ppm, and within or slightly above the MV18 background range of 62 to 72 ppm.

Copper. Copper was detected in each of the samples from both W10-05(A1) and W10-06(C) at concentrations above background (15 ppm, Wahler). Detected concentrations ranged from 26.9 to 67.0 ppm. Only one of these concentrations was above the Hetch-Hetchy and MV18 backgrounds.

Mercury. Mercury was found in the 5- to 10-foot-bls sample from W10-06(C) at a concentration (0.8 ppm) above background (0.1 ppm, Hetch-Hetchy). The detected concentration was below the USGS background of 1.0 ppm.

Nickel. Nickel was detected above background (30 ppm, USGS) in all Site 10 soil samples. Detected concentrations ranged from 41.5 to 64.3 ppm. Only one detection (64.3 ppm) was above the MV18 background range of 52 to 58 ppm.

Silver. The CRQL for silver was greater than the lowest background value available (see Section 3.5). Silver was found in all three samples from W10-05(A1) at concentrations above the CRQL of 1 ppm. Detected concentrations ranged from 1.3 to 1.6 ppm. Silver was not detected above the CRQL in the W10-06(C) samples.

Zinc. Zinc was found in each sample from W10-05(A1) and W10-06(C) at concentrations above background (31 ppm, Wahler). Detected concentrations ranged from 44.3 to 78.1 ppm. All of these levels were below the USGS background of 110 ppm, as well as within the Wahler background range of 31 to 93 ppm.

The detected metals were reviewed for patterns, trends, or plumes, or any other indication of site-related contamination. The detected levels of these metals do not indicate site-related inorganic contamination at the Site 10 sampling locations.

12.0 Nature and Extent of Contamination, Engine Test Stand Area (Site 11)

12.1 Sources

The Engine Test Stand Area is located approximately 500 feet north of the intersection of Patrol and Zook Roads, and lies between the eastern edge of the runway and Devil's Slough (Figure 2.3-9). The site, which is used to test turbine engines, is fenced and covered by both concrete and asphalt that constitute a pad approximately 200 by 200 feet in size.

The primary source of contamination is runoff from precipitation and hydraulic cleaning of the slab, which drains to a grassy area to the south, possibly resulting in the transport of residual spilled fuel products and lubricants to local soils. Previous shallow soil samples collected by the CRWQCB from a stained area (75 by 45 feet) adjacent to the concrete slab contained 570 ppm of lead and 250 ppm of zinc, plus cadmium, copper, chromium, and nickel in the 20 to 50 ppm range (K/J/C, 1987).

12.2 Soils and Vadose Zone

All Phase I soil samples were analyzed for VOCs, BNAs, TPHC, oil and grease, PCBs, metals, and pH. No Phase II activities were conducted at this site. Monitoring well and boring locations are shown in Figure 2.3-9. Complete analytical results are included in Appendix A of this report. A statistical summary is presented in Table 12.2-1 of this report. An analytical summary of inorganics detected above background levels (Table 3.5-2) is presented in Table 12.2-2. Plate B-3 in Appendix B depicts the distribution of organic compounds detected at the site.

12.2.1 Organics

VOCs. The most frequently detected VOCs were the common laboratory contaminants acetone and methylene chloride. Each detection was associated with blank contamination. Acetone was found in 13 samples at concentrations ranging from 6 to 200 ppb with the highest concentration (200 ppb) found in W11-01(A1) at 5 to 10 feet bls. Twelve of the thirteen samples with acetone detections were collected from this depth. Methylene chloride was found in 13 samples at concentrations ranging from 17 to 80 ppb. Twelve of these samples were collected at 5 to 10 feet bls with the highest concentration (80 ppb) occurring in the 5- to 10-foot-bls sample from GSB11-10. Of the previously discussed detections, acetone appeared in only three samples at concentrations exceeding the 10x rule as discussed in

Chapter 2.0. Methylene chloride appeared in two samples at concentrations exceeding the 10x rule. Each of these five detects were found in five different borings and do not represent viable contaminant plume data.

1,1,1-TCA was detected in seven samples at 5 to 10 feet bls with concentrations ranging from 1 to 16 ppb. The highest concentration (16 ppb) occurred in SB11-08.

Carbon disulfide was found in the 5- to 10-foot-bls samples from SB11-08 and W11-01(A1) at concentrations of 3 and 5 ppb, respectively.

Toluene and 2-butanone were detected in the 5- to 10-foot-bls sample from SB11-08 at concentrations of 2 and 15 ppb, respectively.

Each of the detected VOCs was present in the 5- to 10-foot-bls sample from SB11-01. All of the acetone and methylene chloride detections were associated with blank contamination. The remaining detected VOC analytes were present in seemingly insignificant concentrations and did not indicate significant contamination.

BNAs. A total of 18 BNA compounds were detected in Site 11 soil samples. The following is a summary of the ranges for these detected analytes:

Acenaphthene	290 ppb	(1 sample)
Anthracene	300 ppb	(1 sample)
Benzo(a)anthracene	140 to 800 ppb	(3 samples)
Benzo(b)fluoranthene	120 to 1,100 ppb	(7 samples)
Benzo(g,h,i)perylene	120 to 530 ppb	(5 samples)
Benzo(k)fluoranthene	130 to 220 ppb	(2 samples)
Benzoic acid	42 ppb	(1 sample)
Bis(2-ethylhexyl)phthalate	49 to 4,500 ppb	(26 samples)
Chrysene	61 to 860 ppb	(6 samples)
Di-n-butylphthalate	33 to 840 ppb	(5 samples)
Dibenzofuran	160 ppb	(1 sample)
Fluoranthene	63 to 1,900 ppb	(8 samples)
Fluorene	240 ppb	(1 sample)
Indeno(1,2,3-c,d)pyrene	95 to 380 ppb	(4 samples)
2-Methylnaphthalene	140 ppb	(1 sample)
Naphthalene	79 ppb	(1 sample)
Phenanthrene	150 to 1,800 ppb	(3 samples)
Pyrene	56 to 1,600 ppb	(10 samples).

The most commonly detected BNA compound was bis(2-ethylhexyl)phthalate, occurring in 26 samples with concentrations ranging from 49 to 4,500 ppb. The highest concentration occurred in the 5- to 10-foot-bls sample from GSB11-11, which is located in the center of the stained area to the south of the slab. A contour map of bis(2-ethylhexyl)phthalate concentrations at 1 foot bls is shown in Figure 12.2-1.

As shown in Figure 12.2-1, bis(2-ethylhexyl)phthalate concentrations were detected at 1 foot bls throughout the sampled area to the south of the slab. Concentrations detected at 5 to 10 feet bls to the south of the slab were generally more confined to the stained area and were higher in concentration (49 to 4,500 ppb). Detected concentrations in SB11-07 (120 to 160 ppb) and W11-02(A1) (200 to 800 ppb) also indicated an area of contamination to the north of the slab. Each of these contaminated areas is immediately adjacent to the slab and is a result of precipitation and hydraulic cleaning runoff. Bis(2-ethylhexyl)phthalate concentrations in soil borings SB11-02 (88 to 120 ppb) and SB11-01 (480 ppb), located across Zook Road to the west, resulted from precipitation and contaminant runoff from the Engine Test Stand Area via Zook Road.

The remaining BNAs detected at the Engine Test Stand Area were found in each of the regions where bis(2-ethylhexyl)phthalate was detected but with less frequency and at lower concentrations. The source is assumed to be the same as that for bis(2-ethylhexyl)phthalate.

TPHC. TPHC (JP-5) was detected in two samples obtained from the area to the south of the concrete pad. The 1- to 3-foot-bls sample from GSB11-11 contained 130 ppm and the 5- to 10-foot-bls sample from W11-01(A1) contained 300 ppm.

Oil and Grease. Oil and grease were the most frequently detected organics appearing in a total of 40 samples. Twenty-five of the detects occurred at 1 to 3 feet bls with concentrations ranging from 2 ppm in SB11-01 to 9,600 ppm in GSB11-18. Thirteen samples at 5 to 10 feet bls indicated concentrations ranging from 2 ppm (SB11-07) to 530 ppm (GSB11-19). Two samples collected at greater than 10 feet bls detected oil and grease at concentrations ranging from 4 ppm (SB11-01) to 190 ppm (W11-01[A1]).

The mean concentration of the 1- to 3-foot-bls samples is 757 ppm. The mean concentration of the 5- to 10-foot-bls samples is 90 ppm. These statistics suggest that while vertical migration is present, it is limited.

Although concentrations were detected in virtually all of the samples, the significant concentrations were found in the area (grid sampling area) immediately to the south of the Engine Test Stand Area where previous studies had indicated contamination. In particular, perimeter boring samples to the southeast of the sampling grid indicated some of the higher concentrations. Figure 12.2-2 shows the areas containing oil and grease at 1 foot bls. Due to the presence of perimeter contamination, the horizontal extent of contamination cannot be defined. Runoff from the engine test stand is the apparent source of oil and grease contamination at this site. It is presumed that this runoff is also the source of the other VOCs and BNAs detected at this site.

PCBs. No PCBs were detected in the referenced samples.

12.2.2 Inorganics

An analytical summary of inorganic concentrations detected above the background levels is presented in Table 12.2-2. The background levels were obtained from the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) background samples as discussed in Section 3.5 (Tables 3.5-1 and 3.5-2). The CRQL was used for comparison if it exceeded the lowest background concentration from the USGS, Hetch-Hetchy, MV18, and Wahler samples or if no background value existed (antimony).

A review of soils data indicates that most inorganics were present above the background values. The metals aluminum, calcium, iron, magnesium, manganese, potassium, and sodium and are not of concern at this site because they are naturally occurring at elevated levels in soils. Elements that exceeded the background levels included:

- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Silver
- Vanadium
- Zinc.

Antimony. Antimony was detected in 15 samples from 14 borings/wells at concentrations (7 to 21 ppm) above the CRQL of 6 ppm. The highest level (21 ppm) was found in the 1- to 3-foot-bls sample from GSB11-07.

Arsenic. Arsenic was detected in 20 samples from 15 borings/wells at concentrations (5.7 to 25.2 ppm) above background (5.6 ppm, Hetch-Hetchy). The highest concentration (25.2 ppm) was found in the 1- to 3-foot-bls sample from GSB11-18. Only four of these samples exceeded the MV18 background range of 5.9 to 11 ppm.

Barium. Barium was detected in one sample at a concentration (1,470 ppm) above background (700 ppm, USGS).

Beryllium. Beryllium was detected in 13 samples from 6 borings/wells at concentrations (1.1 to 5.5 ppm) above background (0.7 ppm, Hetch-Hetchy). The highest concentration (5.5 ppm) occurred in the 5- to 10-foot-bls sample from W11-02(A1).

Cadmium. Cadmium was detected in 13 samples from 9 borings/wells at concentrations (1.1 to 5.1 ppm) above background (0.7 ppm, Wahler). However, only one sample was above the Hetch-Hetchy background value of 4 ppm.

Chromium. Chromium was detected in 51 samples from 30 borings/wells at concentrations (32.8 to 102 ppm) above background (17 ppm, Wahler). All detected concentrations were below the USGS background of 150 ppm.

Cobalt. Cobalt was detected in 31 samples from 26 borings/wells at concentrations (15 to 36 ppm) above background (15 ppm, USGS).

Copper. Copper was detected in 51 samples from 30 borings/wells at concentrations (26.8 to 109 ppm) above background (15 ppm, Wahler). More than half of these concentrations were below the Hetch-Hetchy background range of 44 to 47 ppm.

Lead. Lead was detected in 32 samples from 23 borings/wells at concentrations (19.4 to 126 ppm) above background (19 ppm, Wahler). The majority of these concentrations were below the MV18 background range of 49 to 54 ppm.

Mercury. Mercury was detected in 25 samples from 20 borings/wells at concentrations (0.2 to 1.4 ppm) above background (0.1 ppm, Hetch-Hetchy). The highest detection noted was just outside the MV18 background range of 0.15 to 1.3 ppm.

Nickel. Nickel was detected in 51 samples from 30 borings/wells at concentrations (36.3 to 90.9 ppm) above background (30 ppm, USGS).

Silver. The CRQL for silver was greater than the lowest background value available (see Section 3.5). Silver was detected in ten samples from eight borings/wells at concentrations (1.0 to 3.2 ppm) above the CRQL of 1 ppm.

Vanadium. Vanadium was detected in one sample at a concentration (152 ppm) above background (150 ppm, USGS).

Zinc. Zinc was detected in 51 samples from 30 borings/wells at concentrations (52.8 to 159 ppm) above background (31 ppm, Wahler). Only six of these samples exceeded the Hetch-Hetchy and MV18 background range of 100 to 110 ppm.

The majority of these elements were concentrated in different regions of the site. For example, the higher concentrations of antimony were detected in the western region of the grid sampling area, while the higher arsenic concentrations were detected in the eastern region of the grid sampling area. The highest beryllium concentrations were not detected in the grid sampling area (south of the Engine Test Stand Area) at all, but instead were found in the borings to the north and west of the Engine Test Stand Area, across Zook Road. Based on these observations, it does not appear that the Engine Test Stand Area was the common source for each of these elements. The detected inorganics were reviewed for plumes, patterns, trends, or other evidence of site-related contamination. The few elevated detections appear to be anomalous to the site, while the other detections appear to be randomly distributed. It does not appear that detections of these elements are indicative of site-related contamination.

13.0 Nature and Extent of Contamination, Equipment Parking Area (Site 13)

13.1 Sources

Site 13, the Equipment Parking Area, is a concrete/asphalt support vehicle parking lot that covers approximately 7,500 square feet and is located between the northeast side of Building 142 and Macon Road (Figure 2.3-10). Building 142 is used for repair and maintenance of aircraft ground support equipment. Waste and industrial wastewater from the repair and maintenance of aircraft equipment at the Equipment Parking Area located northeast of Building 142 are the sources of contamination at Site 13.

Fuel and lubricant spills and equipment washing wastewaters have been flushed into a surface drainage ditch adjacent to the concrete/asphalt parking area. The ditch flows into a main north-south storm drain. A sump (Sump 63) located to the southwest of Building 142 contains stripping/vehicle steam cleaning wastes. However, samples from monitoring well boring W06-10(A1) (Site 6), located approximately 40 feet to the south of Building 142 near Sump 63, typically did not contain the same constituents as found in the drainage ditch samples. Based on this information, runoff contamination is assumed to be limited to the drainage channel, and the contaminants found in W06-10(A1) are assumed to be attributable to another source. Further discussion of W06-10(A1) can be found in Chapter 7.0 (Site 6). Sump 63 is part of Site 15 and will be addressed in the OU3 RI Report.

13.2 Soils and Vadose Zone

A total of eight soil samples were collected and analyzed for VOCs, BNAs, TPHC, oil and grease, and metals during Phase I. PCB analysis was not performed. No sampling was conducted during Phase II at this site. Figure 2.3-10 shows the location of the Site 13 borings. A statistical summary compilation of the analytical data is included in Table 13.2-1 of this report. An analytical summary of inorganics detected above background levels (Table 3.5-2) is presented in Table 13.2-2. Complete analytical results are included in Appendix A. Plate B-3 in Appendix B depicts the distribution of organic compounds detected at the site.

13.2.1 Organics

VOCs. Detected VOCs included toluene, acetone, and methylene chloride. Toluene was detected in five samples at concentrations (2 to 3 ppb) below the CRQL. Methylene chloride

was detected in all eight samples. The detected concentrations ranged from 14 to 50 ppb; however, all methylene chloride detections had associated blank contamination, and based on the 10x rule, as discussed in Chapter 2.0, these detections are assumed to be a result of laboratory contamination at Site 13. Acetone was detected in three samples; however, blank contamination is associated with all detections, so that acetone is also assumed to be a laboratory contaminant in the Site 13 samples.

BNAs. The detected BNAs included bis(2-ethylhexyl)phthalate and di-n-butylphthalate. Bis(2-ethylhexyl)phthalate was found in each sample at concentrations ranging from 84 to 650 ppb. Di-n-butylphthalate was found in both samples from SB13-01 at concentrations of 64 ppb (1 foot bls) and 40 ppb (5 feet bls).

TPHC. TPHC (JP-5) was detected in the 5-foot-bls sample of SB13-04 at a concentration of 110 ppm.

Oil and Grease. Oil and grease were found in each of the eight samples from the drainage ditches surrounding Site 13. The concentrations ranged from 6 to 1,150 ppm. Figure 13.2-1 shows the concentrations of oil and grease at 1 and 5 feet bls.

The majority of the higher concentrations of oil and grease were found in the 5-foot-bls samples. The mean concentration in the 5-foot-bls samples was 379 ppm, as compared to the mean concentration of 156 ppm in the 1-foot-bls samples. These results indicate some degree of vertical migration. The extent, however, cannot be delineated with the available data.

Because the extreme upstream and downstream samples indicate the presence of oil and grease, no contamination limits have been defined. Further contaminant migration via the drainage ditch is a possibility. The presence of oil and grease in samples (SB13-03 and SB13-04) collected upstream of the east/west drainage channel suggests that oil and grease are being transported via runoff directly from the parking lot at Building 142 to the main north/south drainage channel and/or from runoff from upstream parking lots at Buildings 541 and 348.

13.2.2 Inorganics

An analytical summary of inorganic concentrations detected above the background levels is presented in Table 13.2-2. The background levels were obtained from the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) background samples as discussed in

Section 3.5. The CRQL was utilized for comparison if the CRQL exceeded the lowest background concentration from the USGS, Hetch-Hetchy, MV18, and Wahler samples or if no background value existed (antimony). Inorganic background concentrations are shown in Tables 3.5-1 and 3.5-2.

A review of soils data indicates that most of the inorganics detected are present above background levels. The metals aluminum, calcium, iron, manganese, magnesium, sodium, and potassium are not of concern at this site because they are naturally occurring at elevated levels in soils.

Elements that exceeded the lowest baseline were:

- Antimony
- Arsenic
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Silver
- Zinc.

Antimony. No background values were available for antimony. Antimony was detected in four samples from three borings at concentrations (7.0 to 9.0 ppm) above the CRQL of 6 ppm. The highest concentration was found in SB13-03.

Arsenic. Arsenic was detected in SB13-03 at a concentration (10.2 ppm) above background (5.6 ppm, Hetch-Hetchy). The detected concentration was within the MV18 baseline range of 5.9 to 11 ppm.

Cadmium. Cadmium was found in five samples from SB13-01, SB13-02, and SB13-03 at concentrations (1.1 to 6.8 ppm) above background (0.7 ppm, Wahler). The highest concentration (6.8 ppm) was found in SB13-02.

Chromium. Chromium was found in each of the eight samples at concentrations (66.9 to 116 ppm) above background (17 ppm, Wahler). The highest concentration (116 ppm) was

found in SB13-03. The detected concentrations were below the USGS background of 150 ppm.

Cobalt. Cobalt was detected in a total of six samples from all four soil borings at concentrations (15.3 to 20.3) above background (15 ppm, USGS). The highest concentration (20.3 ppm) was found in SB13-03.

Copper. Copper was found in each of the eight samples at concentrations (33 to 55.8 ppm) above background (15 ppm, Wahler). The highest concentration (55.8 ppm) was found in SB13-03. The majority of the sample concentrations did not exceed the Hetch-Hetchy background range of 44 to 47 ppm.

Lead. Lead was found in four samples from three soil borings at concentrations (76.3 to 462 ppm) above background (19 ppm, Wahler). The highest concentration (462 ppm) occurred in SB13-03.

Mercury. Mercury was found in two samples from two soil borings at concentrations (0.2 to 0.3 ppm) above background (0.1 ppm, Hetch-Hetchy). All detected concentrations were below the USGS background value of 1.0 ppm.

Nickel. Nickel was found in all eight samples at concentrations (70.7 to 92.2 ppm) above background (30 ppm, USGS). The highest concentration (92.2 ppm) was found in SB13-03.

Silver. The CRQL for silver was above the lowest background value available (see Section 3.5). Silver was detected in two samples from two soil borings at concentrations (1.2 to 1.6 ppm) above the CRQL of 1 ppm. Both of these detections were at the 5- to 6-foot-bls depth. The highest concentration (1.6 ppm) was found in SB13-04.

Zinc. Zinc was found in each of the eight samples at concentrations (57.6 to 198 ppm) above background (31 ppm, Wahler). The highest concentration (198 ppm) was found in SB13-03.

The detected inorganics were reviewed for plumes, patterns, trends, or other evidence of site-related contamination, and the detections do not indicate site-related contamination.

14.0 Nature and Extent of Contamination, Tanks 19, 20, 67, and 68 (Site 14)

14.1 Sources

Site 14 is subdivided into a southern region (Tanks 19 and 20) and a northern region (Tanks 67 and 68).

14.1.1 Tanks 19 and 20

The primary sources of contamination in the southern region are Tanks 19 and 20. These tanks were located on the corner of Macon Road and South Gate Exit in the Vehicle Ready Fuel Storage Area (Figure 2.3-11). Before removal, the 5,000-gallon tanks contained unleaded vehicle fuel. Other possible sources in the southern region include Sump 4, which is located approximately 70 feet to the northeast of Tanks 19 and 20. Sump 4 is abandoned and reportedly contained vehicle wash waste.

14.1.2 Tanks 67 and 68

Tanks 67 and 68 were located on the southwest corner of Wescoat Road and Severyns Avenue between the dry cleaners (Building 88) and the existing NEX Gas Station (Figure 2.3-12). Before its removal in May 1990, Tank 67 was used to store fuel oil for the boiler in Building 88. Tank 68, which was closed in place, was reportedly a 2,000-gallon UST used to store waste solvents.

The NEX Gas Station is an additional possible source of contamination and is located approximately 200 feet southeast of Tanks 67 and 68. The NEX Gas Station provides vehicle fuel services for military personnel and consists of two fueling areas. The west fueling area is served by four 12,000-gallon USTs containing unleaded gasoline. These tanks are single-wall fiberglass and remain in use. The four single-wall tanks and service lines that serviced the east fueling area were removed by PRC in October 1990. A field work plan that will detail the investigative tasks required to characterize the nature and extent of contamination at the NEX Gas Station is pending.

14.2 Soils and Vadose Zone

14.2.1 Tanks 19 and 20

No Phase II activities were conducted for Tanks 19 and 20. During Phase I, IT installed three soil borings and six monitoring wells within 150 feet of the former tank site. Soil

samples from the monitoring well borings and shallow soil borings at Tanks 19 and 20 were collected and analyzed from the vadose zone at 1- to 3-, 3- to 5-, and 5- to 10-foot depths. A total of 30 soil samples were analyzed for VOCs, metals, PCBs, BNAs, and TPHC. Complete analytical results are included in Appendix A. A statistical summary compilation is presented in Table 14.2-1. The locations of monitoring well borings and soil sample borings for Tanks 19 and 20 are shown in Figure 2.3-11. Plate B-4 depicts the distribution of the detected organic compounds in the area of Tanks 19 and 20. An analytical summary of inorganics detected above background levels (Table 3.5-2) is presented in Table 14.2-2.

14.2.1.1 Organics

VOCs. A total of six VOCs were detected in the area of Tanks 19 and 20. Acetone was the most frequently detected compound. Acetone was detected in 6 of the soil boring/monitoring well locations (12 samples) at concentrations ranging from 10 to 99 ppb. Methylene chloride was detected in two of the soil boring/monitoring well locations (six samples) at concentrations ranging from 10 to 39 ppb. The majority of these samples also had associated blank contamination. Applying the 10x rule as discussed in Chapter 2.0, it is assumed that the acetone and methylene chloride concentrations in these Site 14 samples are attributable to laboratory contamination.

Toluene was found in relatively small amounts (2 to 9 ppb) in eight samples taken from two soil borings and two monitoring well borings. Each sample from SB14-01 and SB14-02 contained toluene as did the 5- to 10-foot-bls sample from W14-05(A2) and the 5- to 10-foot-bls sample from W14-06(A2). These observations do not sufficiently indicate a plume of contamination.

2-Butanone was detected in each sample (1 to 3, 3 to 5, and 5 to 10 feet bls) from W14-02(A1). Concentrations ranged from 3 to 16 ppb.

1,1,1-TCA was found in the 3- to 5- and 5- to 10-foot-bls samples from W14-04(A1). The respective concentrations were 8 and 5 ppb.

PCE was found in the 5- to 10-foot-bls sample from W14-05(A2) at a concentration of 1 ppb.

VOC concentrations detected during the field testing of shallow soil (soil gas survey) ranged from 0.1 to 4.2 ppm. Sample station locations and detected concentrations are shown in

Appendix C. Six samples were collected from selected sample stations for field analysis by a portable GC. 1,1-DCA was detected in three samples at concentrations of 130, 154, and 155 ppb. GC analytical results are included in the Phase I Characterization Report (IT, 1991a). Toluene was detected in two of the samples collected for GC analysis at concentrations of 24 and 32 ppb. Because of these low concentrations and the absence of benzene and xylenes, it is unlikely that the toluene detections indicate the presence of fuel hydrocarbons.

Because VOCs were detected in such small concentrations (less than 10 ppb) and had limited areal extent, their presence does not represent any discernible site contamination.

The concentrations and distributions of organic compounds found in soil gas samples from these locations are not indicative of a groundwater plume extending to the survey area from former fuel Tanks 19 and 20.

BNAs. The most commonly detected BNA was bis(2-ethylhexyl)phthalate, which was found in six monitoring well/soil boring locations (12 samples). The detected concentrations ranged from 55 to 530 ppb with the highest concentration occurring in the 5- to 10-foot- bls sample from SB14-02. The bis(2-ethylhexyl)phthalate concentrations appeared to be randomly distributed with no apparent contamination pattern. Tanks 19 and 20 are not the suspected source.

Di-n-butylphthalate was found in the 1- to 3- and the 5- to 10-foot-bls samples from W14-03(A1) at respective concentrations of 130 and 63 ppb. The compound was also found in the 5- to 10-foot-bls sample from W14-06(A2) at a concentration of 110 ppb.

Naphthalene and phenanthrene were detected at concentrations of 59 and 47 ppb, respectively, at 1 to 3 feet bls in W14-03(A1).

TPHC. TPHC was not detected in the referenced samples.

PCBs. PCBs were not detected in the referenced samples.

14.2.1.2 Inorganics

An analytical summary of inorganic concentrations detected above the background levels is presented in Table 14.2-2. The background levels were obtained from the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) background samples as discussed in

Section 3.5. The CRQL was used for comparison if it exceeded the lowest background concentration from the USGS, Hetch-Hetchy, MV18, and Wahler samples or if no background value existed (antimony). Background concentrations are shown in Tables 3.5-1 and 3.5-2.

A review of soils data shows that several inorganics are present above background levels. The metals aluminum, calcium, iron, magnesium, manganese, potassium, and sodium are not of concern at this site because they are naturally occurring at elevated levels in soils. Elements that exceeded the referenced backgrounds included:

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Vanadium
- Zinc.

Antimony. No background values were available for antimony. Antimony was found in two samples from W14-05(A2) at concentrations (7.0 to 29.7 ppm) above the CRQL of 6 ppm.

Arsenic. Arsenic was found in eight samples from four monitoring wells/soil borings at concentrations (13.0 to 269 ppm) above background (5.6 ppm, Hetch-Hetchy). The highest concentrations were detected at 3 to 5 feet bls in SB14-03 (269 ppm) and at 3 to 5 feet bls in W14-02(A1) (241 ppm). This contamination appears to be concentrated in an area directly to the north of Tanks 19 and 20. The source of arsenic is not known.

Beryllium. Beryllium was found in 13 samples from 5 monitoring wells/soil borings at concentrations (0.79 to 5.6 ppm) above background (0.7 ppm, Hetch-Hetchy). The highest concentration (5.6 ppm) occurred in W14-01(A2).

Cadmium. Cadmium was found in four samples from two monitoring wells/soil borings at concentrations (1.6 to 5.0 ppm) above background (0.7 ppm, Wahler). The highest concentration (5.0 ppm) occurred in W14-02(A1) and is the only detection above the Hetch-Hetchy background of 4 ppm.

Chromium. Chromium was found in each of the 27 samples from 9 monitoring wells/soil borings at concentrations (39.1 to 92.5 ppm) above background (17 ppm, Wahler). The highest concentration (92.5 ppm) occurred in W14-04(A1). These detections were generally within the MV18 background range of 62 to 72 ppm and below the USGS background of 150 ppm.

Cobalt. Cobalt was found in 16 samples from 8 monitoring wells/soil borings at concentrations (15.6 to 46 ppm) above background (15 ppm, USGS). The highest concentration (46 ppm) occurred in W14-01(A2).

Copper. Copper was found in each of the 27 samples from 9 monitoring wells/soil borings at concentrations (17.9 to 133 ppm) above background (15 ppm, Wahler). The highest concentration (133 ppm) occurred in W14-04(A1).

Lead. Lead was found in the 3- to 5-foot-bls sample from SB14-02 at a concentration (19.6 ppm) above background (19 ppm, Wahler). The detected concentration was below the USGS background of 30 ppm.

Mercury. Mercury was found in ten samples from five monitoring wells/soil borings at concentrations (0.2 to 0.4 ppm) above background (0.1 ppm, Hetch-Hetchy). The highest concentration (0.4 ppm) was found in SB14-01 and W14-04(A1). All detected concentrations were below the USGS (1.0 ppm) and MV18 (0.15 to 1.3 ppm) background ranges.

Nickel. Nickel was found in each of the 27 samples at concentrations (37.2 to 117 ppm) above background (30 ppm, USGS). The highest concentration (117 ppm) occurred in W14-03(A1).

Selenium. The CRQL for selenium was above the lowest background value available (see Section 3.5). Selenium was found in three samples from two monitoring wells at concentrations (1.5 to 7.2 ppm) above the CRQL of 0.5 ppm. The three samples and their respective concentrations are as follows: 1- to 3-foot-bls sample from W14-02(A1) (1.7 ppm); 5- to 10-

foot-bls sample from W14-02(A1) (7.2 ppm); 5- to 10-foot-bls sample from W14-04(A1) (1.5 ppm).

Silver. The CRQL for silver was above the lowest background value available (see Section 3.5). Silver was found in eight samples from five monitoring wells/soil borings at concentrations (1.1 to 7.1 ppm) above the CRQL of 1.0 ppm. The two highest concentrations were seen in the same borings as the elevated arsenic and beryllium concentrations.

Vanadium. Vanadium was found in two samples at concentrations (173 to 198 ppm) above background (150 ppm, USGS). The highest concentration (198 ppm) occurred in W14-01(A2).

Zinc. Zinc was found in each of the 27 samples at concentrations (41.3 to 160 ppm) above background (31 ppm, Wahler). The highest concentration (160 ppm) occurred in W14-02(A1). Only two of the detected concentrations exceeded the Hetch-Hetchy and MV18 background ranges of 100 to 110 ppm.

The source for these elements is unknown. Although a discernible contamination configuration is not evident, the elevated detections are concentrated in an area directly to the north of Tanks 19 and 20.

14.2.2 Tanks 67 and 68

A total of 19 soil samples were obtained in the immediate vicinity of Tanks 67 and 68 by PRC Environmental Management, Inc. Sample locations and organic chemical concentrations for Tanks 67 and 68 are shown in Figure 14.2-1. IT did not conduct any Phase I or Phase II investigative activities at these tanks. An analytical summary for Tanks 67 and 68 can be found in Table 14.2-3 (organics). All samples were analyzed for VOCs, BNAs, TPHC-diesel, TPHC-kerosene, and TPHC-gasoline. No analysis was performed for oil and grease or inorganics. VOCs were found in 18 samples, BNAs were found in 2 samples, and TPHC-diesel was found in 1 sample.

14.2.2.1 VOCs

Three VOCs common to both Tank 67 and 68 soil samples were total 1,2-DCE, TCE, and toluene. Total 1,2-DCE was found in 14 samples with concentrations ranging from 3 to 55 ppb. TCE had concentrations of 2 to 100 ppb in 12 samples, and toluene was found in 6 samples with concentrations ranging from 3 to 47 ppb. In addition, PCE was found in seven

of the boring samples from Tank 68 with concentrations ranging from 11 to 140 ppb. Two boring samples from Tank 68 also had concentrations of 6 ppb of 1,1-DCA. These detected analytes are shown in Figure 14.2-1. Although these results indicate some minor contamination in and around the tank pit, there is no indication of gross contamination from these tanks.

The only common sampling depth for all samples in the area of Tanks 67 and 68 was 7.0 to 8.0 feet bls. At this depth, an inspection of total 1,2-DCE, the most commonly detected compound, indicates low, uniform, and evenly distributed concentrations. No clear horizontal migration trends were evident, except for a slight increase in 1,2-DCE concentrations moving to the north across the Tank 67 excavation area. This movement is more than likely due to groundwater transport because groundwater was encountered at 7 feet bls and the predominant groundwater flow direction is north.

A vertical extent of contamination is equally difficult to define. Samples obtained at Tank 67 with VOC concentrations extend only 8.0 feet bls. The two borings at Tank 68 extend to 25 feet bls and 25.5 feet bls, respectively, but they too indicate the presence of VOCs and BNAs at their greatest depths. The influence of groundwater is again suspect because the majority of the higher concentrations occurred within the saturated zone at depths greater than 7 feet bls.

14.2.2.2 BNAs

Both of the detected BNAs were found in Tank 68 borings. Bis(2-ethylhexyl)phthalate and di-n-butylphthalate were each detected once at concentrations of 140 ppb and 125 ppb, respectively. These compounds were also detected at depths (12.5 and 25.5 feet bls) below the suspected water table.

14.2.2.3 TPHC

TPHC-diesel was detected in one pipe trench sample at 150 ppm. The absence of TPHC compounds around the tank site indicates the probable source of the detected contaminants may be something other than Tank 67. This is further illustrated by the fact that the most commonly detected compounds (1,2-DCE and TCE) were found in roughly the same concentrations throughout adjacent Site 9. Although Tank 68 is a suspected source of solvent contamination, the levels of VOCs detected in the soils beneath the tank do not indicate a gross release. The most likely source of contamination in this area appears to be the dry cleaners (Building 88).

15.0 Nature and Extent of Contamination, Public Works Steam Cleaning Rack Sump 60 (Site 16)

15.1 Sources

The primary suspected source of contamination at Site 16 is an oil/water separator (Sump 60) located within the Public Works Vehicle Yard approximately 50 feet west of the northwest side of Building 146 (Figure 2.3-13). A concrete containment pad above the sump was utilized as a vehicle steam cleaning area. Wash water runoff was collected in two catch basins that emptied into the sump. Floating product from the sump was transferred via piping to a concrete vault to the east, which in turn drained into a 250-gallon tank west of the sump (PRC, 1991a). Effluent from the sump was reportedly discharged to a storm drain. The sump, concrete vault, tank, catch basins, and all associated piping were removed in October 1990 (PRC, 1991a).

Other possible sources of contamination include underground containment Sumps 57 and 58 (Site 15), which are not a part of this operable unit; recently removed Tanks 19 and 20 (Site 14); and Tank 89. Each of these facilities is/was located within 400 feet of the steam cleaning rack system. Tanks 19 and 20 are discussed in detail in Chapter 14.0. No information is available for Tank 89.

15.2 Soils and Vadose Zone

IT did not conduct any Phase I or II investigative activities at Site 16; however, as discussed in Chapter 2.0, several soil samples were collected during the removal of Sump 60 by PRC Environmental Management, Inc. in October 1990. All samples were analyzed for VOCs, SVOCs, BNAs, BTEX, TPHC-gasoline, TPHC-diesel, total recoverable petroleum hydrocarbons (oil and grease), and metals, with the exception of the enlarged excavation soil samples, which were not analyzed for VOCs, SVOCs, and TPHC-gasoline. In instances where benzene, toluene, ethyl benzene, and xylenes (total) analytical data were available from both the VOC analysis (EPA Method 8010, SW-846) and the BTEX analysis (EPA Method 8020, SW-846), the highest concentration was utilized in characterizing the site. Further investigation of Sump 60 by PRC in May 1992 consisted of installing monitoring well W60-02(A1) and subsequent collection of soil samples as detailed in Chapter 2.0. These samples were analyzed for VOCs, TPHC-gasoline, TPHC-diesel, and TPHC-JP5 (PRC, 1993). Analytical summaries of the referenced soil samples are presented in Table 15.2-1 (organics) and Table

15.2-2 (inorganics). The sample locations and organic chemical concentrations are shown in Figure 15.2-1.

15.2.1 Organics

VOCs. Toluene was detected in all of the soil samples collected during the sump removal and installation of W60-01(A1) ranging from 3 to 440 ppb. Toluene was also detected in the three shallowest samples (7, 10, and 15 feet bls) from W60-02(A1) at concentrations ranging from 4 to 59 ppb. Xylene was detected in two of the three excavation bottom samples at concentrations of 5 and 270 ppb as well as in three of the enlarged excavation samples ranging from 3 to 11 ppb. TCE, the only other VOC detected, was found at the 27.5-foot depth in W60-01(A1) at 6 ppb and at the 28-foot depth (6 ppb) and 34-foot depth (2 ppb) from W60-02(A1). The TCE concentrations may be from groundwater contamination.

Toluene was the most consistently detected organic constituent in the soils at Site 16. In addition, toluene was a major constituent detected in a waste sample from Sump 60. In general, the higher concentrations of toluene were found at 4 feet bls, directly under the collection system components, and decreased in relation to depth. Smaller concentrations of toluene were also found in all of the 10-foot-bls enlarged excavation samples, at the 27.5-foot depth in W60-01(A1) and at the 7-, 10-, and 15-foot depth from W60-02(A1), indicating some degree of contaminant leaching. Because toluene was detected at the greatest depth of sampling, the vertical extent of contamination cannot be defined. All site perimeter sampling indicated the presence of toluene. Based on these observations and the past utilization of the sump, it appears that Sump 60 was the source of toluene contamination.

BNAs. The only BNA detected was trichlorobenzene in an initial excavation floor sample at a concentration of 410 ppb. The enlarged excavation samples and samples from W60-02(A1) were not analyzed for BNAs.

TPHC. TPHC-diesel was detected in each of the initial excavation floor samples and one enlarged excavation sample ranging from 52 to 480 ppm. TPHC-gasoline was detected in two of the three initial excavation floor samples at concentrations of 5.6 ppm and 200 ppm. TPHC-oil and grease was detected in each of the initial excavation floor samples and in four of the enlarged excavation samples at concentrations ranging from 33 to 610 ppm. The enlarged excavation soil samples were not analyzed for TPHC-gasoline. TPHC contaminants

were not detected in W60-02(A1). Based on the site's past uses, it appears that Sump 60 was the source of this TPHC contamination.

15.2.2 Inorganics

As previously mentioned, priority pollutant metals were analyzed for in each of the three initial excavation samples and at each of the four sample depths in W60-01(A1) for a total of seven samples. A total of 10 of the 23 tested metals were detected at concentrations above background (Table 3.5-2) in at least one sample. The background levels were obtained from the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) background samples as discussed in Section 3.5. These levels are also shown in Tables 3.5-1 and 3.5-2. The CRQL was used for comparison if the CRQL exceeded the lowest background concentration from the USGS, Hetch-Hetchy, MV18, and Wahler samples. The metals aluminum, calcium, iron, magnesium, manganese, potassium, and sodium are not of concern at this site because they are naturally occurring at elevated levels in soils. Elements that exceeded the referenced background levels included:

- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Zinc.

Beryllium. Beryllium was found in each sample from W60-01(A1) at concentrations (1.0 to 1.3 ppm) above background (0.7 ppm, Hetch-Hetchy). These detections were within or just exceeded the MV18 background range of 0.9 to 1.2 ppm.

Cadmium. Cadmium was found in each of the initial excavation samples at concentrations (3.9 to 5.3 ppm) above background (0.7 ppm, Wahler). These detections were at or just above the Hetch-Hetchy background value of 4 ppm.

Chromium. Chromium was detected in each of the samples from W60-01(A1) (63.9 to 83.0 ppm) and in each of the initial excavation samples (54.1 to 71.7 ppm) at concentrations above

background (17 ppm, Wahler). All of the detected concentrations were below the USGS background of 150 ppm.

Cobalt. Cobalt was found in each of the initial excavation samples (15.3 to 20.7 ppm) and in three samples from W60-01(A1) (17.6 to 20.6 ppm) at concentrations above background (15 ppm, USGS).

Copper. Copper was found in each of the initial excavation samples (31.9 to 49.6 ppm) and in each sample from W60-01(A1) (26.3 to 63.2 ppm) at concentrations above background (15 ppm, Wahler).

Lead. Lead was detected at 10 feet bls in W60-01(A1) at a concentration (50.4 ppm) above background (19 ppm, Wahler). The concentration was within the MV18 background of 49 to 54 ppm.

Mercury. Mercury was found in each of the initial excavation samples (0.1 to 0.2 ppm) and in each sample from W60-01(A1) (0.1 to 0.3 ppm) at concentrations equal to or above background (0.1 ppm, Hetch-Hetchy). All of the detected concentrations were below the USGS background of 1.0 ppm.

Nickel. Nickel was found in each of the initial excavation samples (76.7 to 104 ppm) and in each sample from W60-01(A1) (48.9 to 104 ppm) at concentrations above background (30 ppm, USGS).

Selenium. The CRQL for selenium was above the lowest background value available (see Section 3.5). Selenium was detected in one initial excavation sample SU60-EX (5.1 ppm) and in two samples from W60-01(A1) (1.4 to 3.1 ppm) at concentrations above the CRQL (0.5 ppm).

Zinc. Zinc was found in each of the initial excavation samples (47.0 to 65.7 ppm) and in each sample from W60-01(A1) (48.1 to 95.8 ppm) at concentrations above background (31 ppm, Wahler). All of the detected concentrations were below the USGS background of 110 ppm.

The detected inorganics were reviewed for plumes, patterns, trends, or other evidence of site-related contamination. It does not appear that the detections of these elements are indicative of site-related contamination.

16.0 Nature and Extent of Contamination, Paint Shop Sump 61 (Site 17)

16.1 Sources

The Public Works Paint Shop is located in Building 45, which is on the corner of Severyns Avenue and North Akron Road (Figure 2.3-14). The site has been active since the late 1930s (NEESA, 1984) and the building is still used as a paint shop. The primary source of contamination was a concrete sump (61) located on the north side of the building. The sump received wastes from the paint shop and from Hangar 1. Wastes from the paint shop have included oil- and latex-based paints, thinners, toluene, and turpentine. The types of wastes received from Hangar 1 are unknown.

Sump 61 was removed by the Navy in October 1990. The "Final Tank and Sump Removal Summary Report" was prepared by PRC, July 15, 1991 (1991a). Sump 62, located adjacent to Sump 61, is another possible nearby source but is considered part of Site 15 and will be investigated as a separate operable unit.

16.2 Soils and Vadose Zone

A total of 14 samples were collected at or immediately adjacent to Site 17. Sample locations are shown in Figure 16.2-1. Analytical results of the five soil samples obtained by PRC during the excavation of Sump 61 and installation of monitoring well W61-01(A1) are summarized in Table 16.2-1 (organics) and Table 16.2-2 (inorganics). All soil samples collected by PRC were analyzed for VOCs, BNAs, BTEX, TPHC-diesel, TPHC-gasoline, and metals. In instances where BTEX analytical data were available from both the VOC analysis (EPA Method 8010, SW-846) and the BTEX analysis (EPA Method 8020, SW-846), the highest concentration was utilized in characterizing the site. Complete analytical data of the nine samples collected by IT from the surrounding monitoring well borings can be found in Appendix A (Site 9), and an analytical summary for inorganics detected above background levels (Table 3.5-2) is included in Table 10.2-2 (Site 9). Each of the samples collected by IT was analyzed for VOCs, BNAs, PCBs, TPHC, and metals. The locations and chemical concentrations of the detected organic compounds from the PRC and IT samples are shown in Figure 16.2-1.

16.2.1 Organics

VOCs. The only detected VOCs in the excavation samples from beneath the sump were toluene and total xylenes. Toluene was detected in both excavation samples at concentrations of 36 and 23 ppb, while xylene was detected in one excavation sample at 9 ppb. The sump samples were all taken from 9 feet bls where groundwater was first encountered. Toluene was also found at each sample depth in monitoring well W61-01(A1) at concentrations ranging from 17 to 280 ppb.

The VOCs found in the surrounding IT monitoring well borings were TCE, 1,2-DCE, and acetone. TCE was found in three of the four monitoring well borings at concentrations ranging from 2 to 100 ppb. 1,2-DCE (total) was found at a concentration of 14 ppb in the 5-foot-bls sample from monitoring well boring W09-28(A2). Acetone was detected in monitoring well boring W09-31(A1) in the 3-foot-bls (16 ppb) and the 5-foot-bls samples (20 ppb). The detections of TCE and 1,2-DCE may reflect groundwater contamination at Site 9.

A liquid sample of the Sump 61 contents was collected prior to its removal. The analysis results indicated that the primary organics detected were almost exclusively BTEX compounds. Respective concentrations were benzene (18 ppb), toluene (3,200 ppb), ethyl benzene (36 ppb), and xylenes (180 ppb). As previously mentioned, the only organics detected in the excavation area beneath Sump 61 were toluene at 36 ppb and xylene at 9 ppb. The large difference in the order of magnitude between the source and surrounding soils indicates that contaminant migration is extremely limited and the majority of contaminated soil was excavated with the sump removal. With the exception of small acetone concentrations (16 to 20 ppb), none of the organics detected in the surrounding monitoring well borings installed by IT was present in the liquid sump sample, indicating that the sump is not the source for these contaminants. Further discussion of the Site 9 monitoring well borings is presented in Chapter 10.0.

BNAs. Bis(2-ethylhexyl)phthalate, the only BNA detected, was found at each sample depth in monitoring well boring W09-23(A1) (140 to 190 ppb) and in the 3-foot-bls sample (2,000 ppb) of monitoring well boring W09-28(A2). No BNAs were detected in the sump excavation. These bis(2-ethylhexyl)phthalate concentrations from surrounding IT monitoring well borings are not thought to be attributable to Sump 61.

TPHC. No TPHC compounds were detected in the referenced samples.

PCBs. No PCBs were detected in the referenced samples.

16.2.2 Inorganics

The inorganic analysis on the two sump excavation soil samples and the three monitoring well boring (W61-01[A1]) soil samples collected by PRC detected a total of nine priority pollutant metals that exceeded background levels. The background levels were obtained from the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) background samples as discussed in Section 3.5. The CRQL was utilized for comparison if the CRQL exceeded the lowest background concentration from the USGS, Hetch-Hetchy, MV18, and Wahler samples. Background concentrations are shown in Tables 3.5-1 and 3.5-2. Sump 61 is not considered to be a source for widespread inorganic contamination; therefore, the surrounding IT monitoring well borings (Site 9) will not be discussed in this chapter. A discussion of Site 9 inorganic data is found in Chapter 10.0. The metals aluminum, calcium, iron, magnesium, manganese, potassium, and sodium are not of concern at this site because they are naturally occurring at elevated levels in soils. A summary of the inorganics detected in the PRC samples is included as Table 16.2-2. Elements that exceeded the referenced background levels included:

- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Zinc.

Beryllium. Beryllium was found in the 16-foot-bls boring sample from monitoring well boring W61-01(A1) at a concentration (1.1 ppm) above the Hetch-Hetchy background of 0.7 ppm. The detection was within the MV18 background range of 0.9 to 1.2 ppm.

Cadmium. Cadmium was detected in each of the sump excavation samples at concentrations (3.7 and 3.8 ppm) above background (0.7 ppm, Wahler). All detected concentrations were below the Hetch-Hetchy background of 4.0 ppm.

Chromium. Chromium was detected in each of the sump excavation samples and boring samples at concentrations (37.4 to 65.1 ppm) above background (17 ppm, Wahler). All detected concentrations were below the USGS background of 150 ppm.

Cobalt. Cobalt was detected in the 16-foot-bls boring sample at a concentration (24.2 ppm) above background (15 ppm, USGS).

Copper. Copper was detected in each of the sump excavation samples and boring samples at concentrations (26.2 to 66 ppm) above background (15 ppm, Wahler). Only one detected concentration (66 ppm) exceeded the Hetch-Hetchy (44 to 47 ppm) and MV18 (39 to 44 ppm) background ranges.

Lead. Lead was detected in the 16-foot-bls boring sample at a concentration (26.8 ppm) above background (19 ppm, Wahler). The detected concentration was below the USGS background of 30 ppm.

Mercury. Mercury was detected in each of the sump excavation samples and one boring sample (16 feet bls) at concentrations (0.1 to 0.2 ppm) above background (0.1 ppm, Hetch-Hetchy). All detected concentrations were below the USGS background of 1.0 ppm.

Nickel. Nickel was detected in each of the sump excavation samples and boring samples at concentrations (49.1 to 94.5 ppm) above background (30 ppm, USGS). Nickel concentrations appear to be naturally high in this area and there is no evidence that this is related to site contamination.

Zinc. Zinc was detected in each of the sump excavation samples and boring samples at concentrations (41.7 to 102.0 ppm) above background (31 ppm, Wahler). All detected concentrations were below the USGS background of 110 ppm.

Sump 61 is not considered a source of inorganic contamination at Site 17, and there is no indication that site-related (inorganic) contamination exists. The elevated detections appear to represent natural variation within the soils. No plumes or patterns exist at this site.

17.0 Nature and Extent of Contamination, Dry Cleaners' Sump 66 (Site 18)

17.1 Sources

The primary source of contamination at Site 18 is the Dry Cleaners' Sump 66, located on the north side of Building 88 (Figure 2.3-15). Previous field investigations revealed cracks in the sump and solvent contaminated soils (ERM-West, 1987). As a result of this investigation, the Navy had Sump 66 removed in May 1990. The "Final Tank and Sump Removal Summary Report" was prepared by PRC, July 15, 1991. Other possible contaminant sources include Tanks 67 and 68, located on the east side of Building 88, and Sump 91, located on the north side of Building 88. Tanks 67 and 68 have recently been removed/closed in place and are discussed in Chapter 14.0 (Site 14). Sump 91 is a 700-gallon single chamber inactive sump that reportedly contained rusty water and sludge that was contaminated with carbon tetrachloride. All material was removed from the sump in July 1991. The sump received liquids from the floor drains in Building 88. A sample of the Sump 91 contents (PRC, 1992) contained 1,2-DCE (2,400 ppb), TCE (120 ppb), TPHC (1,300 ppb), and 4-methylphenol (14 ppb). The TPHC detection was extractable as components other than diesel, JP-5, kerosene, or motor oil. PRC installed one monitoring well, W91-01(A1), directly northwest of Sump 91.

Analyses of the soil sample from the unsaturated zone in boring W91-01(A1) did not indicate the presence of significant contaminant concentrations (only TCE at a concentration of 3 ppb was detected). Analyses of soil samples collected from a saturated zone indicated low levels of chlorinated VOCs and TPHC purgeable as gasoline. PRC concluded that Sump 91 is not considered a VOC contaminant source because VOC concentrations detected in saturated soil samples are likely caused by the presence of contaminated groundwater migrating into the Building 88 area from upgradient sources, and because the unsaturated zone soil sample did not indicate contamination. PRC also stated that the low levels of TPHC purgeable as gasoline detected in soil samples from boring W91-01(A1) were attributed to laboratory contamination.

17.2 Soils and Vadose Zone

A total of 27 Phase II soil samples were collected by IT at or immediately adjacent to Site 18. All monitoring well, boring, and sample locations are shown in Figure 2.3-15. The three samples collected by PRC from the sump removal were analyzed for VOCs, TPHC-diesel, TPHC-motor oil, and TPHC-gasoline. Analytical summaries of these samples are presented

in Table 17.2-1. The 24 samples obtained by IT from the surrounding Site 9 monitoring wells and soil borings were analyzed for VOCs, BNAs, metals, PCBs, and TPHC. A discussion of the Site 9 contamination is presented in Chapter 10.0. Complete IT analytical data for Site 9 are presented in Appendix A.

17.2.1 Organics

VOCs. The primary VOCs detected during Phase II sampling were TCE, 1,2-DCE (total), and PCE. A map depicting the distribution of organic compounds is shown in Figure 17.2-1. TCE was detected in 22 of the monitoring well/soil boring samples (IT) at concentrations ranging from 2 to 130 ppb. 1,2-DCE (total) was detected in 15 samples (IT) from six monitoring well/soil borings at concentrations ranging from 1 to 86 ppb. PCE was detected in five of the monitoring well/soil boring locations. Concentrations ranging from 1 to 21 ppb were detected in a total of 11 samples. Soil sample results from monitoring well W09-46(A1) reported similar concentrations of TCE, 1,2-DCE (total), and PCE at comparable depths (0 to 10 feet bls). PCE was also detected in sample SU66-NX, a sump excavation wall sample, at 20 ppb. Toluene was detected in one sump excavation wall sample (PRC) at 28 ppb and in two monitoring well/soil boring samples (IT) at 1 ppb. Acetone and methylene chloride were detected in several samples ranging from 7 to 22 ppb but are not considered sump related. Various other VOCs were detected but with less frequency and at much lower concentrations.

Results of the shallow soil gas survey are as follows. 1,1-DCA and 1,1,1-TCA were each detected one time in a sample from the south side of the dry cleaners. Concentrations were 17,900 ppb of 1,1-DCA and 12,500 ppb of 1,1,1-TCA. Several of the soil gas samples were collected for field analysis by portable GC. 1,1-DCE was detected in eight of the GC samples at concentrations ranging from 51.5 to 12,900 ppb. The samples were collected from stations scattered throughout the Site 18 area. Concentrations ranged from 136 to 97,300 ppb for cis-1,-2 DCE, which was detected in 11 samples. TCE was detected in all 13 GC soil gas samples collected from the Site 18 area. The range of concentrations was 36 to 941,000 ppb. The latter was the highest concentration of TCE recorded from Site 9 samples by almost one order of magnitude. Its occurrence northeast of the dry cleaners indicates Site 18 as a possible source. Toluene was detected in four GC soil gas samples from the west side of Site 18. Concentrations ranged from 18 to 126 ppb. Results of the soil gas survey are included in the Phase I Characterization Report (IT, 1991a). Site 18 is contained within the boundaries of

Site 9. Figures showing the soil gas transect lines and soil gas contours for the Site 9 investigation area (adjacent to Site 18) are included in Appendix C.

The ERM-West (1987) investigation provided the following information. In boring B-13, PCE was detected in soils (at or below the water table) at concentrations up to 6,900 ppb at 12.0 to 12.5 feet bls. TCE was detected at concentrations up to 910 ppb at 19.5 to 20 feet bls. In boring B-14, PCE was detected at concentrations up to 2,100 ppb at 19.5 to 20 feet bls, and TCE was detected at concentrations up to 710 ppb at 17.0 to 17.5 feet bls. Other solvents (including 1,1-DCA, 1,1-DCE, cis-1,2-DCE, dichlorotrifluoroethane [DCTFA], TCA, and Freon-113) were also detected but in smaller concentrations. Soil sample analytical results from PRC monitoring well boring W09-46(A1) also indicated elevated concentrations of PCE and TCE at depths below the water table. PCE was detected at concentrations up to 2,800 ppb at 16.8 feet bls, and TCE was detected at concentrations up to 7,500 ppb at 16.8 feet bls.

The ERM-West study found a concentration of 18,000 ppb of PCE in a waste sample from Sump 66. PCE is a compound commonly used in dry cleaning and TCE is a common degradation product of PCE. TCE was the most commonly detected organic compound in the Site 9 IT samples (monitoring wells/borings and soil gas) surrounding Sump 66. As previously mentioned, TCE was also a main contaminant in the ERM-West (1987) and PRC borings.

This information would indicate Sump 66 is a source and the surrounding soils are contaminant recipients if the following were not true:

- IT-installed monitoring wells/borings were located 70 to 200 feet from Sump 66. Although contaminant transport in shallow soils at these horizontal distances is not impossible, it is extremely unlikely.

- TCE was consistently detected at the greatest depth (up to 11.5 feet bls) in all of the surrounding monitoring wells/borings indicating possible contributions from groundwater contamination.

- Similarly, each of the ERM-West (1987) and PRC borings was sampled at depths (up to 27 feet bls) that would have been influenced by groundwater contamination.

- The highest TCE concentration detected in the soil gas survey was approximately 250 feet to the northeast of Sump 66.
- TCE was not detected in the sump excavation samples collected directly beneath Sump 66.

Although the dry cleaners is an obvious source for the contamination seen at Site 18, Sump 66 does not appear to be the primary source for VOC contamination levels in the soils in adjacent Site 9. It is likely that the majority of any contaminated soils underlying Sump 66 was excavated during the sump removal.

BNAs. Only two BNAs were detected. Bis(2-ethylhexyl)phthalate was detected in W09-17(A2) and W09-18(A1) at concentrations ranging from 76 to 600 ppb. At 5 feet deep, 4-chloroaniline was detected in W09-37(A1) at a concentration of 400 ppb. Analysis for BNAs was not performed on the sump excavation samples; however, based on the review of VOCs, Sump 66 is not suspected as the source of any BNA contamination.

TPHC. TPHC-motor oil was detected in all three sump excavation samples ranging from 36 to 63 ppm. TPHC-diesel was found in one excavation sample at 5.4 ppm and TPHC-gasoline was found in one excavation sample at 1.3 ppm. The presence of TPHC-motor oil in all three sump excavation samples suggests that the sump once contained motor oil that leaked from the sump and contaminated the underlying soil.

PCBs. PCBs were not detected in the monitoring well/soil boring samples. The analysis was not performed on the excavation samples.

17.2.2 Inorganics

No inorganic analysis was performed on the sump excavation soil samples. There is no evidence that inorganic contamination at Site 18 or adjacent Site 9 is attributable to Sump 66. Discussion of the inorganic analysis of the surrounding monitoring well/soil borings (IT) is found in Chapter 10.0 (Site 9).

18.0 Nature and Extent of Contamination, Tanks 2, 14, 43, and 53 (Site 19)

18.1 Sources

Tanks 2, 14, 43, and 53 are the contamination sources for Site 19. Tanks 2 and 43 were located on the east side and northeast corner of Hangar 3, respectively (Figure 2.3-16). Tank 14 was located approximately 10 feet south of Building 158 and approximately 400 feet east of the intersection of Cody and Macon Roads (Figure 2.3-17). Tank 53 was located in the maintenance yard that surrounds Buildings 376 and 399, approximately 120 feet southeast of the intersection of Patrol and Marriage Roads (Figure 2.3-18). All four tanks and associated piping were removed by the Navy in May 1990 (PRC, 1991a).

Tank 2 was installed in 1979 and remained in use until January 1987 when precision testing indicated a leak. Tank 2 had a capacity of 2,000 gallons and was used as a hazardous waste storage tank for wastes from the Power Plant Shop located in Hangar 3. Waste products included oils, hydraulic fluids, MEK, JP fuels, B&B cleaner, PD-680 solvent, toluene, and Stoddard solvent (ERM-West, 1986).

Tank 14 was a 1,100-gallon unvented standby diesel tank for a backup generator in Building 158, the Line Shack. This tank was reportedly emptied before its removal.

Tank 43 was a 2,000-gallon hazardous waste collection and storage tank. Tank 43 collected rinse water from engine cleaning racks, drains, and sinks in Hangar 3. This tank contained waste oils, solvents, waste fuel, MEK, PD-680 solvent, paint waste, and battery acids. The tank was installed in 1979 and remained in use until January 1987 when precision testing indicated a leak (ERM-West, 1986).

Tank 53 was a 500-gallon unleaded gasoline tank used at the golf course physical plant. It was removed from service following discovery of a plumbing leak (ERM-West, 1987).

18.2 Soils and Vadose Zone

18.2.1 Tanks 2 and 43

A total of 28 soil samples collected by IT from the monitoring well borings and shallow soil borings were analyzed for VOCs, BNAs, PCBs, metals, and TPHC at the site of Tanks 2 and

43. Complete analytical results are included in Appendix A. A statistical summary compilation of IT data is presented in Table 18.2-1. An analytical summary of detected inorganics above background levels (Table 3.5-2) can be found in Table 18.2-2. IT monitoring well and boring locations are shown in Figure 2.3-16.

During the removal of Tanks 2 and 43 and the installation of the three monitoring wells, 43 soil samples were collected by PRC and were analyzed for VOCs, BNAs, TPHC-diesel, TPHC-gasoline, TPHC-motor oil, and metals. An analytical summary of PRC data for Tank 2 is shown in Table 18.2-3 (organics) and Table 18.2-4 (inorganics). An analytical summary of PRC data for Tank 43 is shown in Table 18.2-5 (organics) and Table 18.2-6 (inorganics). The locations and organic concentrations of all soil samples collected during the RI and removal activities at Tank 2 are presented in Figure 18.2-1. The locations of soil samples collected by PRC during the RI and removal activities at Tank 43 are shown in Figure 18.2-2.

18.2.1.1 Organics

VOCs. Acetone was detected in seven samples from borings/wells installed by IT at concentrations ranging from 18 to 120 ppb. Each acetone detection was associated with blank contamination and only one sample (3 to 5 feet bls from W19-04[A1]) exceeded the 10x rule with a concentration of 120 ppb. Methylene chloride, another common laboratory contaminant, was detected in all three samples from monitoring well boring W19-01(A1). Each of the detected concentrations (30 to 33 ppb) was below the 10x rule.

TCE was found in soil boring SB19-01 near Tank 2 at 1- to 3-, 3- to 5-, and 5- to 10-foot-bls depths at concentrations of 58, 110, and 38 ppb, respectively. TCE was also detected in one pipe trench sample from Tank 2 at 8 ppb. SB19-04, near Tank 43, contained 13 ppb of TCE at 5 feet bls, and monitoring well boring W19-01(A1), downgradient of Tank 43, contained 8 ppb of TCE at 3 feet bls. One enlarged excavation sample from Tank 43 contained TCE at 21 ppb. TCE was detected in three additional samples collected by IT at concentrations (2 ppb) below the CRQL of 5 ppb.

Toluene was detected in four samples collected by PRC from the Tank 2 area and 16 samples collected by PRC from the Tank 43 area. Concentration ranges were from 10 to 86 ppb at Tank 2 and from 16 to 6,300 ppb at Tank 43. Toluene was also detected in 14 samples from the surrounding monitoring wells and borings but were at concentrations (1 to 5 ppb) equal to or below the CRQL (5 ppb).

PCE was detected in seven samples (PRC) from the Tank 43 area including samples from the walls of the tank excavation, pipe trenches, and monitoring well borings. Concentrations ranged from 5 to 23 ppb. PCE was also detected in six samples (IT) from Tanks 2 and 43, but at concentrations (2 to 7 ppb) below or only marginally exceeding the CRQL (5 ppb).

VOCs detected in samples (PRC) from only the Tank 43 area included: total xylenes in five samples ranging from 7 to 2,000 ppb; ethyl benzene in two samples ranging from 71 to 150 ppb; and styrene in one sample at a concentration of 7 ppb.

Additional VOCs detected in samples (IT) at Tanks 2 and 43 at levels below the CRQL included 1,1-DCA (2 ppb), 2-butanone (3 to 7 ppb), and carbon disulfide (1 to 4 ppb). An analytical summary containing the detected VOCs at Tanks 2 and 43 can be found in Table 18.2-1 (IT) and Tables 18.2-3 and 18.2-5 (PRC).

BNAs. The detected BNA compounds common to both the IT and the PRC samples are bis(2-ethylhexyl)phthalate and di-n-butylphthalate. Samples from the Tank 2 area that contained bis(2-ethylhexyl)phthalate included two boring samples (IT) at concentrations of 170 ppb and 1,200 ppb and one pipe trench sample (PRC) with a concentration of 750 ppb. Samples from the Tank 43 area that contained bis(2-ethylhexyl)phthalate included 11 boring samples (IT) at concentrations ranging from 18 to 790 ppb and 3 samples (PRC) with concentrations ranging from 430 to 1,700 ppb. Di-n-butylphthalate was detected in monitoring well boring W19-01(A1), near Tank 43, at concentrations ranging from 38 to 44 ppb. Di-n-butylphthalate was also found in four samples (PRC) at Tank 43 with concentrations ranging from 560 to 26,350 ppb. Di-n-butylphthalate was detected in one pipe trench sample (TP2-1) at Tank 2 at a concentration of 600 ppb and in one sample from well boring W02-01(A1) at 130 ppb (2.5 feet bls).

The following BNA compounds were detected only in samples collected by PRC from Tank 43: anthracene in one sample (660 ppb), butylbenzylphthalate in one sample (560 ppb), dimethyl phthalate in two samples (570 ppb, 830 ppb), fluorene in one sample (600 ppb), 2-methylnaphthalene in three samples (81 to 15,900 ppb), naphthalene in three samples (1,137 to 1,780 ppb), 2-nitrophenol in one sample (506 ppb), and phenol in one sample (379 ppb).

TPHC. Monitoring well boring W07-20(A1) near Tank 2 indicated TPHC (JP-5) in the 3- to 5-foot-bls sample at a concentration of 110 ppm. TPHC-diesel was found in five samples (PRC) from Tank 2 with detected concentrations of 59 to 2,700 ppm. TPHC-diesel was also found in 26 samples (PRC) from Tank 43. Concentrations detected ranged from 1.7 to 2,000 ppm.

TPHC-gasoline was found in five samples (PRC) from Tank 2 with detected concentrations of 43 to 1,800 ppm. TPHC-gasoline was also detected in 14 samples (PRC) from Tank 43. Concentrations ranged from 1.0 to 2,000 ppm.

TPHC-motor oil was detected in one sample (PRC) from Tank 2 (120 ppm) and in five samples (PRC) from Tank 43 at detected concentrations ranging from 11 to 50 ppm.

With the exception of 48 ppm of toluene in sample TN2-NX, TPHC products were the only detected constituents in the excavation samples taken from the soils (walls) immediately adjacent to Tank 2. These data indicate some degree of horizontal migration in the north-northeast direction. The soil samples IT collected from the surrounding monitoring well/soil borings reinforce this assumption. Of the four borings, only W07-20(A1), located to the northeast of Tank 2, indicated the presence of TPHC. The absence of petroleum products in the remaining perimeter borings drilled by IT suggests that horizontal contaminant migration from the source is limited to the immediately surrounding soils. The vertical extent of contamination is unknown because TPHC concentrations were detected in several samples collected from the deepest sample depth (8 feet).

TPHC products were the most commonly detected constituents in the samples collected from the enlarged excavation of Tank 43 and its piping. Assuming that the contaminants found in the soils immediately surrounding the source indicate the possible migratory contaminants, and based on the relatively low concentrations of TPHC detected in the samples obtained after the final (enlarged) excavation, it appears as though the majority of contaminated soils were removed and the potential for further migration eliminated. One exception to this is the isolated area encompassing the south wall (2,000 ppm) and the west wall (1,400 ppm) of the tank excavation area. The absence of TPHC products in the surrounding monitoring well/soil boring soil samples to the north, east, and south indicate no extensive migration has occurred.

PCBs. No PCBs were detected at Site 19.

18.2.1.2 Inorganics

An analytical summary of inorganic concentrations detected in samples (IT) above the background levels is presented in Table 18.2-2. The background levels were obtained from the USGS (1984), Hetch-Hetchy (1987), MV18 (1987), or Wahler (1984) background samples as discussed in Section 3.5. The CRQL was used for comparison if it exceeded the lowest background concentration for the USGS, Hetch-Hetchy, MV18, and Wahler samples or if no background value existed (antimony). Background concentrations are discussed in Section 3.5 and are shown in Table 3.5-2. A review of soils data suggested that most inorganics were present above background levels. The metals aluminum, calcium, iron, magnesium, manganese, potassium, and sodium are not of concern at this site because they are naturally occurring at elevated levels in soils. Elements that exceeded the background levels included:

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Vanadium
- Zinc.

PRC inorganic data for Tanks 2 and 43 were subjected to the same background criteria as the IT data. An analytical summary of PRC inorganic data can be found in Tables 18.2-4 (Tank 2) and 18.2-6 (Tank 43), as previously mentioned.

Antimony. No background values were available for antimony. Antimony was found in 20 samples (IT) from 9 monitoring wells/soil borings at concentrations (7.0 to 50.6 ppm) above the CRQL of 6 ppm. The highest concentration (50.6 ppm) was found at 3 to 5 feet bls in W19-03(A2), northwest of Tank 43. Antimony was also detected in two samples (PRC) from Tank 43 at concentrations (6.7 to 7.0 ppm) above the CRQL.

Arsenic. Arsenic was found in one sample (IT) at a concentration (7.8 ppm) above background (5.6 ppm, Hetch-Hetchy). Arsenic was also detected in 7 samples (PRC) from Tank

43 at concentrations (5.7 to 23.5 ppm) above background. The majority of the detected concentrations were within the MV18 background range of 5.9 to 11 ppm.

Beryllium. Beryllium was found in 20 samples (IT) from 8 monitoring wells/soil borings at concentrations (0.93 to 3.5 ppm) above background (0.7 ppm, Hetch-Hetchy). The highest concentration (3.5 ppm) occurred in SB19-01.

Cadmium. Cadmium was found in seven samples (IT) from four monitoring wells/soil borings at concentrations (1.1 to 9.4 ppm) above background (0.7 ppm, Wahler). The highest concentration (9.4 ppm) occurred in W19-04(A1). Cadmium was also detected in six samples (PRC) from Tank 43 and three PRC samples from Tank 2 at concentrations (1.0 to 3.0 ppm) equal to or above background. Generally, these detections were below the Hetch-Hetchy background of 4 ppm.

Chromium. Chromium was found in 26 samples (IT) from 9 monitoring wells/soil borings at concentrations (30.9 to 88.2 ppm) above background (17 ppm, Wahler). The highest concentration (88.2 ppm) occurred in SB19-01. Chromium was also detected in each of the PRC samples from Tanks 2 and 43 at concentrations (24.3 to 67.9 ppm) above background. All of the detected concentrations were below the USGS background (150 ppm) and were generally within the MV18 background range (62 to 72 ppm).

Cobalt. Cobalt was found in 12 samples (IT) from 8 monitoring wells/soil borings at concentrations (15.2 to 21.6 ppm) above background (15 ppm, USGS). The highest concentration (21.6 ppm) occurred in W19-03(A2). Cobalt was detected in seven samples (PRC) from Tank 43 and two samples (PRC) from Tank 2 at concentrations (15.3 to 18.6 ppm) above background.

Copper. Copper was found in 26 samples (IT) from 9 monitoring wells/soil borings at concentrations (27.8 to 98.9 ppm) above background (15 ppm, Wahler). The highest concentration (98.9 ppm) occurred in SB19-04. Copper was detected in each of the samples (PRC) from Tank 43 and Tank 2 at concentrations (19.4 to 132.0 ppm) above background.

Lead. Lead was found in three samples (IT) from two monitoring wells/soil borings at concentrations (22.4 to 75.8 ppm) above background (19 ppm, Wahler). Lead was detected in one sample (PRC) from Tank 43 at a concentration (92.4 ppm) above background. All of the detected concentrations were within the Wahler background range of 19 to 110 ppm.

Mercury. Mercury was found in seven samples (IT) from four monitoring wells/soil borings at concentrations (0.2 to 0.5 ppm) above background (0.1 ppm, Hetch-Hetchy). The highest concentration (0.5 ppm) occurred in W19-04(A1). Mercury was also detected in six samples (PRC) from Tank 43 and two samples (PRC) from Tank 2 at concentrations (0.1 to 3.6 ppm) equal to or above background.

Nickel. Nickel was found in 26 samples (IT) from 9 monitoring wells/soil borings at concentrations (33.3 to 203 ppm) above background (30 ppm, USGS). The highest concentration (203 ppm) occurred in W19-04(A1). Nickel was also detected in 34 samples (PRC) from Tank 43 and 5 samples (PRC) from Tank 2 at concentrations (35.9 to 77.4 ppm) above background.

Selenium. The CRQL for selenium was above the lowest background value available (see Section 3.5). Selenium was detected in one sample (PRC) from Tank 2 at a concentration (0.7 ppm) above the CRQL of 0.5 ppm.

Silver. The CRQL for silver was above the lowest background value available (see Section 3.5). Silver was found in four samples (IT) from W19-03(A2) and W19-04(A1) at concentrations (2.0 to 7.7 ppm) above the CRQL of 1.0 ppm. The highest concentration (7.7 ppm) occurred in W19-04(A1).

Vanadium. Vanadium was found in one sample (IT) at a concentration (169 ppm) above background (150 ppm, USGS).

Zinc. Zinc was found in 26 samples (IT) from 9 monitoring wells/soil borings at concentrations (50.7 to 122 ppm) above background (31 ppm, Wahler). The highest concentration (122 ppm) occurred in W19-03(A2) and W19-04(A1). Zinc was also detected in 34 samples (PRC) from Tank 43 and 3 samples (PRC) from Tank 2 at concentrations (38.4 to 268.0 ppm) above background. The majority of the detected concentrations were within the Hetch-Hetchy and MV18 background range of 100 to 110 ppm.

The detected inorganics were reviewed for plumes, patterns, trends, or other evidence of site-related contamination. It does not appear that these detections are indicative of site-related contamination.

18.2.2 Tank 14

IT did not perform any soil investigative activities at or immediately adjacent to Tank 14. PRC collected ten soil samples at Tank 14. Seven samples were collected during the excavation of Tank 14 and its piping, while three soil samples were collected during the installation of an adjacent monitoring well (WT14-01[A1]). All of the soil samples collected by PRC were analyzed for BTEX, TPHC-diesel, TPHC-motor oil, and TPHC-gasoline. An analytical summary is provided in Table 18.2-7 (organics). Sample locations and organic chemical concentrations are shown in Figure 18.2-3. Further investigation of Tank 14 by PRC Environmental Management, Inc. in May 1992 included six Geoprobe® soil samples collected from an area immediately north of the initial tank excavation. The Geoprobe soil samples were collected by driving a 1-inch diameter steel tube to the specified depth and collecting the sample. Soil samples were collected at two depths from each of these locations. Each of the samples was analyzed for TPHC-diesel.

18.2.2.1 Organics

BTEX. Toluene was detected in both of the initial excavation samples at concentrations of 130 and 123 ppb. Toluene was also found in the 7.5-foot-bls sample collected from monitoring well WT14-01(A1) at a concentration of 5.7 ppb. Benzene, ethyl benzene, and xylene were not detected in the PRC samples at Tank 14.

TPHC. TPHC-diesel was detected in seven excavation samples ranging in concentration from 3.0 to 4,440 ppm. TPHC-gasoline was detected in both of the initial excavation samples at concentrations of 340 ppm and 350 ppm. TPHC-motor oil was detected in four samples at concentrations ranging from 15 to 48 ppm. TPHC-diesel was not detected in the analysis of the Geoprobe soil samples collected to the north of the tank excavation.

Samples obtained from the walls of the enlarged excavation indicated that TPHC products were the only organic constituents detected. Of these TPHC products, TPHC-diesel had the highest concentrations and was the most frequently detected. Based on the extremely small TPHC-diesel concentrations (0 to 3.9 ppm) detected in the east, south, and west walls of the excavation, it appears that the majority of any contaminated soil has been removed during tank excavation and that no contaminants exceeded the horizontal or vertical excavation limits. The 1,700-ppm concentration of TPHC-diesel found in the north wall sample appears to be isolated because the additional Geoprobe sampling analysis did not detect TPHC-diesel.

Tank 14 is the apparent source of contamination; however, all contamination appears to have been localized in or around the tank pit.

18.2.2.2 Inorganics

There were no inorganic analyses performed on samples from the Tank 14 excavation.

18.2.3 Tank 53

The nine soil samples (IT) from the monitoring well/soil borings in adjacent Site 3 (within 130 feet of Tank 53) were analyzed for VOCs, BNAs, TPHC, PCBs, and metals. Complete IT analytical data are presented in Appendix A (Site 3).

PRC collected seven soil samples at Tank 53 in May 1990. Five samples were collected from the excavation of Tank 53 and two samples were collected during the installation of a monitoring well. All PRC soil samples were analyzed for VOCs, BTEX, and TPHC-gasoline. In instances where BTEX analytical data were available from both the VOC analysis (EPA Method 8010, SW-846) and the BTEX analysis (EPA Method 8020, SW-846), the highest concentration was utilized in characterizing the site. An analytical summary of the PRC data is located in Table 18.2-8. Soil sample locations and organic chemical concentrations from the PRC tank excavation samples and monitoring well samples are shown in Figure 18.2-4. Further investigation of Tank 53 by PRC in May 1992 (PRC, 1992) included 24 Geoprobe soil samples collected from areas to the south, east, and west of the tank excavation area and three soil samples collected during the installation of monitoring well W53-02(A1). The Geoprobe soil samples were collected by driving a 1-inch diameter steel tube to the specified depth and collecting the sample. The 24 Geoprobe samples and the samples from W53-02(A1) were analyzed for TPHC-gasoline and BTEX compounds.

Geoprobe soil sample locations are shown in Figure 2.3-18. Geoprobe soil sample analytical results are shown in Tables 18.2-9 and 18.2-10. Sample location and analytical results for W53-02(A1) are included in Figure 18.2-4.

18.2.3.1 Organics

VOCs. The only VOCs detected in samples (IT) were acetone and 2-butanone found in W03-16(C) at concentrations of 54 ppb and 5 ppb, respectively.

Each of the BTEX constituents was detected in the PRC samples collected in May 1990. Benzene and ethyl benzene were found in all seven samples with detected concentration ranges of 14 to 4,160 ppb and 7.6 to 14,950 ppb, respectively. Toluene was detected in six samples (50.4 through 6,810 ppb), and total xylenes were detected in four samples (9 to 77,710 ppb). Samples obtained from the walls of the enlarged excavation indicated significant levels of BTEX were present. The highest concentrations of any single BTEX constituent in each wall sample were as follows: north wall (ethyl benzene - 77 ppb), south wall (total xylenes - 77,710 ppb), east wall (ethyl benzene - 1,430 ppb), west wall (total xylenes - 4,955).

BTEX constituents were also detected in several of the 24 Geoprobe soil samples collected by PRC in May 1992. On-site field screening of these samples by the mobile laboratory detected benzene in 20 samples at concentrations ranging from 5,000 to 457,000 ppb; toluene in 16 samples at concentrations ranging from 37 to 2,650 ppb; ethyl benzene in 20 samples at concentrations ranging from 34 to 9,490 ppb; and xylene in 18 samples at concentrations ranging from 12 to 10,700 ppb. The laboratory analysis of 13 of the Geoprobe soil samples did not detect benzene. However, toluene was detected in four samples (200 to 2,900 ppb), ethyl benzene was detected in nine samples (100 to 20,000 ppb) and xylene was detected in eight samples (800 to 79,000 ppb). BTEX constituents were not detected in soil borings from W53-02(A1).

Based on these data, it appears as though BTEX contamination is isolated to the area within the tank pit with the exception of some migration of contaminants to the southeast. PRC concluded that the distribution of contaminants and the local topography suggests fuel leakage from Tank 53 may have migrated toward a drain near the center of the golf course maintenance yard.

BNAs. Bis(2-ethylhexyl)phthalate was detected in one sample from soil boring SB03-02 (11,000 ppb) and in all three samples from W03-23(A1) (53 to 130 ppb). The samples collected by PRC were not analyzed for BNAs. There does not appear to be a link between BNAs detected in Site 3 samples and Tank 53.

TPHC. No TPHC was detected in the samples collected by IT. TPHC-gasoline was found in all of the samples collected by PRC in May 1990 at concentrations ranging from 1.0 to 1,600 ppm. Tank 53 was the apparent source for this TPHC contamination. TPHC-gasoline was also detected in 20 of the 24 Geoprobe samples collected by PRC in May 1992 and screened

on site with the mobile laboratory. The concentrations ranged from 5 to 457 ppm. The 13 Geoprobe samples sent to the laboratory also indicated TPHC-gasoline in nine samples at concentrations ranging from 35 to 1,160 ppm. Each of these sampling rounds confirmed the presence of fuel-related contamination in the soils surrounding Tank 53. Detected concentrations were the highest to the south and east of the tank excavation. As previously mentioned, PRC concluded that the distribution of contaminants and the local topography suggest fuel leakage from Tank 53 may have migrated toward a drain near the center of the golf course maintenance yard. Additional sampling may be required to determine the extent of contamination to the southeast of the tank pit area.

PCBs. No PCBs were detected in the IT samples. PRC samples were not analyzed for PCBs.

18.2.3.2 Inorganics

Inorganic analysis was not performed on the PRC samples. An inorganic summary including the monitoring well/soil boring samples (IT) is found in Table 4.2-2 (Site 3). This table indicates each detect exceeding the background value. No evidence indicates Tank 53 is a possible inorganic contaminant source for surrounding Site 3 soils or that inorganic contamination exists at this site.

19.0 Chemical Fate and Transport

19.1 Chemical Persistence

The fate of chemicals in the environment depends on a variety of chemical, physical, and biological processes. This section describes some of the processes that may occur for the compounds identified at Moffett Field OU2. The major processes at work in the natural environment include hydrolysis, volatilization, sorption, oxidation/reduction, and biodegradation. Of these processes, volatilization and sorption appear to dominate in the classes of compounds of interest at Moffett Field OU2. Chemicals can be divided into two broad categories: organics and inorganics (metals).

The following discussion describes the behavior and persistence of these classes of chemicals. Examples are used to discuss typical chemical fate processes that may occur in the environment.

19.1.1 Organics

Primary sources of organics at Moffett Field originate from on- and off-site derived chlorinated solvents leaking from sumps and tanks or from spills. These hydrocarbon solvents are composed of halogenated aliphatic or linear bonded structures and aromatic or ring-type structures. Chlorinated aromatics tend to be among the most environmentally persistent chemicals.

The transport and fate of many of the halogenated aliphatic hydrocarbons detected in the surface and near-surface environment at Moffett Field are dominated by volatilization. Recent studies have demonstrated that biodegradation occurs for some components (including TCE, PCE, and TCA) under both aerobic and anaerobic conditions. Sorption processes, particularly on suspended natural organic polymers or humic material, may also affect the mobility of organic compounds in the near-surface environment.

The mobility of organic compounds within the soil/groundwater system is affected by chemical processes that depend, in part, on their volatility, octanol-water partition coefficient (K_{ow}), water solubility, and concentration. In general, the more water insoluble an organic compound is, the more hydrophobic it is and the more likely it is to be adsorbed on a soil or organic surface. These compounds also have a tendency toward self-association in a polar medium such as water. Hydrophobic compounds tend to have a higher K_{ow} and a greater

affinity for organic matter contained within the soil matrix. Table 19.1-1 contains physical and chemical characteristics of organic compounds detected in the soil at OU2. The values in this table were taken from two primary sources: ***The Installation Restoration Program (IRP) Toxicology Guide Vols. 1-5***, (Biomedical and Environmental Information Analysis [BEIA], 1989) published for the U.S. Air Force (USAF) for use in the implementation of the IRP at USAF installations, and the ***Handbook of Environmental Degradation Rates*** (Howard et al., 1991), published for EPA. These values for physical and chemical characteristics are measured or estimated values and may vary depending on the measurement or estimation method used. Therefore, different sources may cite different values. For example, one source gives the soil adsorption coefficient (K_{oc}) for benzene as 65 and a K_{oc} of 1,160 for 1,2-dichlorobenzene (BEIA, 1988), while another source (Dragun, 1988) gives a K_{oc} for benzene of 85 and a K_{oc} for 1,2-dichlorobenzene of 377. For this reason, the values in Table 19.1-1 should be considered representative but should not be viewed as the only possible value for these parameters.

Compounds such as acetone, benzene, and the chlorinated aliphatic hydrocarbons with high aqueous solubilities also have a relatively low K_{ow}. When present in the soil/groundwater system at low concentrations, migration of these compounds tends to be more rapid than migration of compounds such as the phthalates, PCBs, or large aromatic compounds such as polycyclic aromatic hydrocarbons (PAH) that have low solubilities and high K_{ow}s.

Even compounds with a relatively low K_{ow} will exhibit some attenuation within the system if the organic carbon content of the matrix is high.

In addition to volatilization and sorption, other chemical processes may occur under certain conditions to alter the composition of various organic compounds. Some of the more important processes include:

- Hydrolysis
- Oxidation
- Reduction
- Hydration.

Under favorable conditions and kinetics, PCE has been reported to undergo hydrolysis in the presence of oxygen to form trichloroacetic acid and hydrochloric acid. Parsons et al. (1984) reported the presence of cis- and trans-1,2-DCE as degradation products from a TCE spill. The abiotic transformation of TCA has been reported by Vogel and McCarty (1987) under

methanogenic conditions. The results of laboratory experiments, particularly measured rate constants, are heavily dependent on laboratory conditions; however, they do indicate that such chemical transformations are thermodynamically and kinetically possible.

Biological processes may also alter the composition of various compounds into less or more toxic daughter products. Nelson et al., (1986) reported the biodegradation of TCE in the presence of phenol, toluene, 2-methylphenol, or 4-methylphenol under aerobic conditions. The resulting products were carbon dioxide and hydrogen chloride. Other researchers (Vogel and McCarty, 1985; Kleopfer et al., 1985) have reported the biotransformation of this same compound under anaerobic conditions, with vinyl chloride among the resulting metabolites.

The behavior and potential persistence of the organic chemicals found at Moffett Field OU2 are discussed in the following sections. These discussions include estimated degradation rates for these chemicals in soil systems. These degradation rates are generally based on laboratory studies and are intended only to be used on a relative measure of each chemical's ability to degrade in the subsurface. Actual degradation will vary under natural conditions.

Acetone. Because it is infinitely soluble in water and has a negative log K_{ow} and a low K_{oc}, acetone is expected to migrate freely through the soil/groundwater system with little or no retardation. Acetone has been shown to permeate materials generally considered relatively impervious to organic solvents (e.g., clays). Acetone is highly volatile; however, the potential for volatilization of acetone from soils is reduced by its high aqueous solubility (BEIA, 1989).

Acetone is highly susceptible to microbial biodegradation. In actual soil/groundwater systems, the concentration of microorganisms capable of biodegrading acetone may be low and is expected to drop off sharply with increasing depth. Therefore, the prediction of actual biodegradation rates is not possible; however, acetone is not expected to persist in the environment (BEIA, 1989). A scientific judgement of acetone's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 1 to 7 days (Howard et al., 1991).

Benzene. Benzene is weakly sorbed onto soils and is, therefore, fairly mobile in the soil/groundwater system. Benzene's high volatility makes vapor-phase transport an important mechanism in near-surface soils (BEIA, 1989).

Benzene is not susceptible to hydrolysis but may undergo aerobic or anaerobic biodegradation. Benzene may persist in soils for months to years (BEIA, 1989). A scientific judgement

of benzene's half-life, based upon unacclimated aqueous aerobic biodegradation, is 5 to 16 days (aerobic) in soil and 10 (aerobic) to 730 (anaerobic) days in groundwater (Howard et al., 1991).

Benzoic Acid. Benzoic acid has been studied extensively and shown to be biodegradable in aerobic and anaerobic conditions. If released on land, benzoic acid should leach into the ground and, due to its slow soil adsorption, readily biodegrade. It did not adsorb appreciably to two different sandy soils, a clayey subsoil, or a montmorillonite clay. Benzoic acid has a half-life in soil of less than 1 week (Hazardous Substances Data Banks [HSDB], 1992)

Bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate is relatively immobile in the soil/groundwater system due to strong soil sorption, low water solubility, and low vapor pressure. Bis(2-ethylhexyl)phthalate may undergo slow hydrolysis or biodegradation and will persist in the environment for months to years (BEIA, 1989). A scientific judgement of bis(2-ethylhexyl)phthalate's half-life in soil, based upon unacclimated aqueous aerobic biodegradation, is 15 to 23 days (aerobic) in soil and 10 (aerobic) to 389 (anaerobic) days in groundwater (Howard et al., 1991).

Bromodichloromethane. If bromodichloromethane is released to soil, volatilization is likely to be the dominant removal process where exposure to air is possible. Bromodichloromethane is moderately to highly mobile in soil and can therefore leach into groundwater and subsurface regions. In soils where exposure to the atmosphere can occur, volatilization is likely to be the dominant environmental fate process due to the high vapor pressure of bromodichloromethane. Laboratory studies have indicated that significant biodegradation can occur under anaerobic conditions; therefore, in soil regions where volatilization is not viable, biodegradation may be the major removal process (HSDB, 1992).

Bromoform. Bromoform is a slightly volatile liquid and tends to exist primarily as vapor in the atmosphere. It has a minor tendency to be absorbed by soils and sediments. The relatively low K_{oc} of bromoform implies that it will exhibit only a minor affinity for soil materials and will tend to be highly mobile. Bromoform may be slightly bioconcentrated by aquatic organisms. No studies have been located regarding the biodegradation rates of bromoform in soil, but it is expected that bromoform undergoes only limited biodegradation under aerobic conditions but is readily biodegraded under anaerobic conditions in the presence of methane-producing bacteria (Agency for Toxic Substances and Disease Registry [ATSDR], 1990a). A scientific judgement of bromoform's half-life in soil, based upon estimated

unacclimated aqueous aerobic biodegradation, is 28 to 182.5 days (Howard et al., 1991). In near surface soils, however, volatilization will be the primary loss mechanism.

Bromomethane. Decomposition of bromomethane in soil results in production of the bromide ion. The rate of bromide production is influenced by soil type; it is greatest in peaty manure, intermediate in loam (clay soil), and least in sand. The bromide ion in soil can be absorbed and concentrated by plants and may be ingested subsequently by humans and animals. After fumigation with methyl bromide, retention of the bromide ion in soil is related to the organic content of the soil; an increase in organic content increases retention (HSDB, 1992).

2-Butanone. 2-Butanone is expected to migrate easily through the soil/groundwater system with very little retardation due to soil sorption. 2-Butanone may volatilize from near surface soils but the potential for volatilization is reduced by the presence of water due to its high solubility. 2-Butanone is very susceptible to microbial decay and is not expected to persist in soils with active microbial populations (BEIA, 1989). A scientific judgement of 2-butanone's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 1 to 7 days (Howard et al., 1991).

Carbon Disulfide. If released on land, carbon disulfide will be primarily lost by volatilization. Because it has a low adsorptivity to soil, it should also readily leach into the ground where there is some evidence that it may biodegrade. The action of soil in adsorbing and degrading gaseous carbon disulfide demonstrates that soil may be a natural sink for the chemical. Carbon disulfide has a suggested persistence in unadapted soil of 3 months to a year. Due to its high vapor pressure and low adsorption to soil, carbon disulfide would be expected to volatilize readily from soil (HSDB, 1992).

Carbon Tetrachloride. Carbon tetrachloride is expected to be strongly sorbed onto surface soils and less strongly sorbed onto deep or sandy soils. Volatilization from surface soils may occur. Neither hydrolysis nor biodegradation is expected to be important for carbon tetrachloride in natural soils and it may persist for months to years or more (BEIA, 1989). A scientific judgement of carbon tetrachloride's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 182.4 to 365 days (Howard et al., 1991).

Chlorobenzene. Chlorobenzene is moderately absorbed by soil, and has a low potential for bioaccumulation. This compound may volatilize from soil surfaces. Chlorobenzene's

sorption on soil particles increases with increasing soil organic content (BEIA, 1989). A scientific judgement of chlorobenzene's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 68 to 150 days (Howard et al., 1991).

Chloroethane. Chloroethane is weakly adsorbed and has no significant potential for bioaccumulation. Chloroethane on soil surfaces is likely to volatilize, but that portion not subject to volatilization is likely to be mobile in groundwater. The potential for food chain bioaccumulation is considered to be zero and biodegradation should be assumed to be of minimal importance. In most cases, it should be assumed that chloroethane will persist for months to years (BEIA, 1989). A scientific judgment of chloroethane's half-life, based upon estimated unacclimated aerobic aqueous biodegradation, is 7 to 28 days in soil and 14 to 56 days in groundwater (Howard et al., 1991).

Chloroform. Chloroform in the environment is weakly adsorbed to soil and has no significant potential for bioaccumulation. Chloroform on the soil surface is likely to volatilize, but that portion not removed by volatilization may eventually migrate to groundwater. Chloroform may be relatively mobile in the soil/groundwater system when present at low concentrations (dissolved in water and sorbed on soil) or as a separate organic phase (resulting from a spill of significant quantities of the chemical). Chloroform is expected to be highly mobile in soils and transport to groundwater is likely. Volatilization of near surface material or material in the soil-air compartment may also be important. Transformation processes (e.g., hydrolysis, biodegradation) are not expected to be significant in natural soils. Diffusion through the soil-air pores up to the ground surface, and subsequent removal by wind, may be a significant loss pathway in unsaturated soils. Groundwater underlying chloroform-contaminated soils with low organic content is particularly vulnerable to pollution. Sorption of chloroform on soil particles is expected to increase with increasing soil organic matter content. In most cases, it should be assumed that chloroform will persist for months to years (BEIA, 1989). A scientific judgment of chloroform's half-life, based upon estimated unacclimated aerobic aqueous biodegradation, is 28 to 182.5 days in soil and 56 to 1,825 days in groundwater (Howard et al., 1991).

Chloromethane. Chloromethane will be rapidly lost from soil by volatilization although there is a potential for it to leach into groundwater where it may very slowly biodegrade and hydrolyze (half-life may exceed a year). Chloromethane has a very low log K_{ow} indicating that it would not have a significant tendency to adsorb to soil (HSDB, 1992).

1,1-DCA. The physicochemical properties of 1,1-DCA suggest that it is weakly absorbed by soil and has a low potential for bioaccumulation. This compound may volatilize from soil surfaces, but that portion not subject to volatilization is likely to be mobile in groundwater. 1,1-DCA is expected to be highly mobile in the soil/groundwater system. Limited sorption on soils, particularly soils of low organic content, is expected. Sorption on soils is expected to increase with increasing soil organics matter content. Volatilization and migration with soil pore water are thought to be significant transport pathways. Degradation in natural soil/groundwater systems is not expected to be significant. In most cases, it should be assumed that 1,1-DCA will persist for months to years. Biodegradation should be assumed to be of minimal importance (BEIA, 1989). A scientific judgement of 1,1-DCA's half-life in soil, based upon soil grab sample data, is 32 to 154 days (Howard et al., 1991).

1,2-DCA. 1,2-DCA is weakly sorbed by soil and has no significant potential for bioaccumulation. This compound may volatilize from soil surfaces, but that portion not removed by volatilization may eventually migrate to groundwater. Biodegradation in the soil/groundwater system should be assumed to be of minimal importance. 1,2-DCA is expected to be highly mobile in the soil/groundwater system. Adsorption onto soil, particularly soil of less than 1 percent organic content, is low. Volatilization from surface soils and through soil-air may be important transport processes. Microbial biodegradation in soil is not expected to be significant. The persistence of 1,2-DCA in soil/groundwater systems is not well documented. In most cases, it should be assumed that 1,2-DCA will persist for months to years. The mobility of 1,2-DCA in the soil/groundwater system (and its eventual migration into aquifers) is strongly affected by the extent of its sorption on soil particles. Sorption on soils is generally expected to increase with increasing soil organic matter content. Presence of other materials in the soil may significantly affect the volatilization of 1,2-DCA from surface soils (BEIA, 1989). A scientific judgement of 1,2-DCA's half-life in soil, based upon estimated unacclimated aerobic aqueous biodegradation, is 100 to 182.5 days (Howard et al., 1991).

1,1-DCE. 1,1-DCE is weakly absorbed by soil and has a low potential for bioaccumulation. This compound may volatilize from soil surfaces, but that portion not subject to volatilization is likely to be mobile in groundwater. 1,1-DCE is expected to be highly mobile in the soil/groundwater system; sorption of 1,1-DCE onto soils is weak. Volatilization of material near the surface or in the soil-air compartment is expected to be significant. Transformation processes are not expected to be significant in natural soils. 1,1-DCE may move through the soil/groundwater system when present at low concentrations or as a separate organic phase. The 1,1-DCE associated with the water and air phases of the soil are more mobile than the

adsorbed portion. In saturated, deep soil (containing no soil-air and negligible soil organic carbon), a much higher fraction (78 percent) of the 1,1-DCE is likely to be present in the soil-groundwater phase and transported with flowing groundwater. In most cases, it should be assumed that the chemical will persist for months to years (BEIA, 1989). A scientific judgement of 1,1-DCE's half-life in soils, based upon estimated unacclimated aerobic biodegradation, is 28 to 182.5 days (Howard et al., 1991).

1,2-DCE (Total). 1,2-DCE is weakly absorbed by soil and has no significant potential for bioaccumulation. These compounds may volatilize from soil surfaces, but that portion not subject to volatilization is likely to be mobile in groundwater. 1,2-DCE is expected to be highly mobile in soil/groundwater systems, particularly in deep or sandy soils. Volatilization may be important for 1,2-DCE near the surface or in the soil-air compartment. Transformation processes such as hydrolysis or biodegradation are not expected to be significant in natural soils. In saturated, deep soil (containing no soil-air and negligible soil organic carbon), a much higher fraction (80 to 90 percent) of the 1,2-DCE is likely to be present in the soil-groundwater phase and transported with flowing groundwater. It should be assumed that the chemical will persist for months to years (BEIA, 1989). A scientific judgement of 1,2-DCE's half-life in soil, based upon estimated unacclimated aerobic aqueous biodegradation, is 28 to 182.5 days (Howard et al., 1991).

Dibenzofuran. If released to soil, dibenzofuran is not expected to leach significantly in most soil types. Dibenzofuran is biodegraded readily by adapted microbes from subsurface regions in the presence of sufficient oxygen. In groundwater regions where oxygen may be limited or lacking, however, biodegradation may occur very slowly, resulting in long periods of persistence. Dibenzofuran should have very low to no soil mobility; however, leaching may occur several times faster than predicted by its log K_{ow}, depending on soil chemistry. No data are available to suggest that dibenzofuran is chemically degraded in soil (HSDB, 1992).

Dibromochloromethane. The physical properties and fate characteristics of dibromochloromethane in the environment suggest it is moderately volatile in aqueous solutions, weakly adsorbed to soil, and has a low potential for bioaccumulation. Dibromochloromethane on the soil surface may volatilize, but that portion not removed by volatilization may eventually migrate to groundwater. Dibromochloromethane is expected to be somewhat mobile in surface soils and highly mobile in deep soils or sandy soils. Biodegradation in natural soils is not expected to be significant. In most soil/groundwater systems, the concentration of

microorganisms capable of biodegrading chemicals such as dibromochloromethane is very low and drops off sharply with increasing depth. It may be relatively mobile in the soil/ groundwater system when present at low concentrations or as a separate organic phase. Its sorption on soil particles generally increases with increasing soil organic matter content. Neither hydrolysis, photolysis, nor oxidation is expected to occur in the environment at rates significant enough to compete with volatilization (BEIA, 1989). A scientific judgement of dibromochloromethane's half-life in soil, based upon estimated unacclimated aerobic aqueous biodegradation, is 28 to 182.5 days (Howard et al., 1991).

m-, o-, and p-Dichlorobenzene. Dichlorobenzenes are moderately to strongly absorbed by soil and have a moderate potential for bioaccumulation. Only a small fraction may volatilize from soil surfaces and their biodegradation ability is not significant. Dichlorobenzenes are expected to have limited mobility in soils, particularly soils with 1 to 2 percent organic carbon content; some migration with soil-groundwater may be observed in deep or sandy soils (BEIA, 1989). A scientific judgement of dichlorobenzene's half-life in soil, based upon unacclimated aerobic screening test data and aerobic soil grab sample data, is 28 to 182 days (Howard et al., 1991).

1,2-Dichloropropane. 1,2-Dichloropropane is weakly absorbed by soil and has no significant potential for bioaccumulation. This compartment may volatilize from soil surfaces, but that portion not removed by volatilization is likely to become mobile in groundwater once it reaches the saturated zone. It may move through the soil/groundwater system when present at low concentrations (dissolved in water and sorbed on soil) or as a separate organic phase. The 1,2-dichloropropane associated with the water and air phase of the soil is more mobile than that which is adsorbed. In saturated, deep soil (containing no soil air and negligible soil organic carbon), a much higher fraction (82 percent) of the 1,2-dichloropropane is likely to be present in the soil-groundwater phase and transported with flowing groundwater. Groundwater underlying 1,2-dichloropropane-contaminated soils with low organic content is highly vulnerable to pollution. 1,2-Dichloropropane is expected to be somewhat mobile in surface soils and highly mobile in deep or sandy soils. Volatilization may be important for the near surface material or the small portion expected to be in the soil-air phase. Transformation processes (hydrolysis, biodegradation) are not expected to be significant in natural soils. In surface soils, biodegradation is expected to be very slow in comparison to volatilization. Volatilization appears to be the major mechanism in determining the fate of 1,2-dichloropropane in soil. Bioaccumulation in aquatic organisms and adsorption in sediment are not significant (BEIA, 1989). A scientific judgement of 1,2-dichloropropane's half-life in soil,

based on estimated unacclimated aerobic aqueous biodegradation, is 167 to 1277.5 days (Howard et al., 1991).

cis-1,3-Dichloropropene. When injected into the soil during its use as a soil fumigant, volatilization of cis-1,3-dichloropropene occurs from the soil surface that decreases to insignificant levels after approximately 4 weeks. Low temperature and heavy rains will lengthen the volatilization period. Most cis-1,3-dichloropropene is degraded rather than lost by volatilization. Rapid soil disappearance will be associated with moist soil content that promotes hydrolysis and porous soil that promotes volatilization. When applied as a fumigant, it readily disperses in soil; its movement is a function of temperature, soil type, and moisture. It will bind to the soil, degrade, be leached with the soil-groundwater, or be vented into the atmosphere. Adsorption is higher in dry soils than in moist soils; however, water-saturated soils have air passageways blocked and fumigant movement is decreased (HSDB, 1992).

trans-1,3-Dichloropropene. When injected into the soil, most of the trans-1,3-dichloropropene will be lost through volatilization over the course of approximately 4 weeks. Adsorption to sediment and bioconcentration in fish are not expected to be important processes. When applied as a fumigant, trans-1,3-dichloropropene will readily disperse in soil; its movement is a function of temperature, soil type, and moisture as well as the chemical properties of the fumigant. The fumigant will bind to the soil, degrade, be leached with the soil-groundwater, or be vented into the atmosphere. An increase in temperature increases the Henry's Law constant and diffusion of 1,3-dichloropropene through soil and shortens the volatilization time. Adsorption is higher in dry soil than in moist soil. An investigation estimates that the half-life of trans-1,3-dichloropropene in soil at $20^{o}C$ ranges from 3 to 25 days (HSDB, 1992).

2,4-Dimethylphenol. If spilled on soil, 2,4-dimethylphenol will probably adsorb moderately to the soil and biodegrade in several days. No experimental data on the adsorption of 2,4-dimethylphenol are available; however, based on an estimated K_{oc} of 425, a moderate adsorption to soil is indicated (HSDB, 1992). A scientific judgement of 2,4-dimethylphenol's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 1 to 7 days (Howard et al., 1991).

4,6-Dinitro-2-Methylphenol. Biodegradation is probably the main removal process of 4,6-dinitro-2-methylphenol from agricultural soils. Estimated K_{oc} values suggest that 4,6-dinitro-

2-methylphenol will have medium to low soil mobility. The greatest mobility can be expected in coarse-textured sandy soils and the least mobility in fine-textured clay and organic soils (HSDB, 1992). The estimated half-life of 4,6-dinitro-2-methylphenol is 7 to 21 days based on soil tests (Howard et al., 1991).

2,4-Dinitrophenol. If released to soil, 2,4-dinitrophenol is expected to be highly mobile, although there is the possibility that some of this compound will adsorb to clay minerals. 2,4-Dinitrophenol may inhibit microbial growth in some aerobic microbes, but there are other microorganisms that degrade this compound in the environment. 2,4-Dinitrophenol is not expected to volatilize significantly from wet or dry soil surfaces (HSDB, 1992). The estimated half-life in soil is 68 to 263 days based on soil tests (Howard et al., 1991).

Di-n-Butylphthalate and Diethyl Phthalate. Both phthalates are somewhat mobile in aqueous solution in wet soils; however, they are fairly immobile in dry soils with little or no vapor-phase transport. They are resistant to hydrolysis and photolysis but biodegradation may be significant (BEIA, 1989). A scientific judgement of di-n-butylphthalate's half-life in soil, based upon unacclimated aqueous aerobic soil grab sample data, is 2 to 23 days (Howard et al., 1991). A scientific judgement of diethyl phthalate's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 3 to 56 days (Howard et al., 1991).

Di-n-Octylphthalate. Bioconcentration of di-n-octylphthalate is probably important in species where little or no metabolism occurs. If spilled on land, di-n-octylphthalate will sorb strongly to soil and therefore should not readily leach into the groundwater. However, it has been found in drinking water whose source is groundwater. Although di-n-octylphthalate is biodegradable, no experimental data could be found containing rates of degradation in soil. Phthalates will slowly leach or volatilize from plastics whether in normal use or in landfills. Higher temperatures will increase both rates. The presence of organics in water can appreciably increase the rate of leaching (HSDB, 1992). A scientific judgement of di-n-octylphthalate's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 7 to 28 days (Howard et al., 1991).

Ethyl Benzene. Ethyl benzene may be moderately absorbed by soil and has a moderate potential for bioaccumulation. This compound may volatilize from soil surfaces. The portion of the compound not removed by volatilization may be absorbed, but some of the ethyl benzene may migrate to groundwater. Ethyl benzene is somewhat mobile in soil/groundwater systems, especially in aqueous phase if sufficient water is present. Volatilization losses

through air-filled pores may be a minor loss pathway. This chemical is resistant to hydrolysis, but will probably biodegrade easily if microbiological populations are sufficiently numerous and active. It may persist for months to years if biodegradation is not possible. Ethyl benzene associated with the water and air phases of the soil is more mobile than the adsorbed portion. In saturated, deep soil (containing no soil-air and negligible soil organic carbon), a much higher fraction (26 percent) of the ethyl benzene is likely to be present in the soil-groundwater phase and transported with flowing groundwater. In most cases, it should be assumed that the chemical will persist for months to years in soil/groundwater systems (BEIA, 1989). A scientific judgement of ethyl benzene's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 3 to 10 days (Howard et al., 1991).

2-Hexanone. If released to soil, 2-hexanone is expected to display high mobility, and is capable of undergoing rapid biodegradation. If spilled onto soil, 2-hexanone should readily leach through soil, as an estimated K_{oc} of 134 suggests high mobility. The vapor pressure for 2-hexanone combined with the Henry's Law constant and low K_{oc} suggests that volatilization from soil should be an important fate process (HSDB, 1992).

Methylene Chloride. Methylene chloride is highly mobile in the soil/groundwater system with little or no retardation, especially in deep or sandy soils. Volatilization may be important in near surface soils due to its relatively high vapor pressure. Methylene chloride is expected to be persistent in the environment as transformation processes such as hydrolysis and biodegradation are expected to be very limited (BEIA, 1989). A scientific judgement of methylene chloride's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 7 to 28 days (Howard et al., 1991).

2-Methylnaphthalene. 2-Methylnaphthalene should biodegrade rapidly in the environment where microorganisms have acclimated to PAHs and at a moderate rate in unacclimated soils. Hydrolysis and bioconcentration of 2-methylnaphthalene should not be important fate processes in the environment. A measured K_{oc} of 8,500 indicates 2-methylnaphthalene will be immobile in soil. 2-Methylnaphthalene may undergo direct photolysis in sunlit surface soils. Volatilization of 2-methylnaphthalene from moist soils with a low organic matter content may be an important fate process (HSDB, 1992). In general, 2-methylnaphthalene should be considered to be very persistent in soils.

4-Methyl-2-Pentanone. If released to soil, 4-methyl-2-pentanone may be removed by direct photolysis on soil surfaces, volatilization, or aerobic biodegradation. This compound is

also susceptible to extensive leaching and has been detected in landfill leachate. Chemical hydrolysis is not expected to be environmentally significant. The K_{oc} of 19 to 106 suggests that it would be highly mobile in soil and would not adsorb significantly to suspended solids and sediments in water bodies. Volatility from water and expected lack of adsorption to soil suggest that 4-methyl-2-pentanone would be susceptible to volatilization from moist soil surfaces. The relatively high vapor pressure of 4-methyl-2-pentanone suggests that this compound would volatilize rapidly from dry surfaces (HSDB, 1992).

4-Methylphenol. 4-Methylphenol's fate in soil has not been extensively studied; it is mobile and will probably biodegrade. It is poorly adsorbed to soil and, therefore, should leach extensively. It biodegrades rapidly in water and although there is evidence that it also biodegrades in soil, rate data are lacking. In subsurface soils, the levels of free iron and pH were key factors in determining adsorption capacity (HSDB, 1992). A scientific judgement of 4-methylphenol's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 0.04 to 0.67 days (Howard et al., 1991).

Naphthalene. Naphthalene is fairly mobile in the soil/groundwater system being moderately volatile, moderately absorbed by soil, and having a moderate potential for bioaccumulation. In sandy soil and soils of low organic content, naphthalene is transported with infiltrating water. Biodegradation in natural soils and groundwater is not expected to be significant (BEIA, 1989). Naphthalene's half-life in soil, based upon soil test data, is 16.6 to 48 days (Howard et al., 1991).

PAHs. Some of the transport and partitioning characteristics (Henry's Law constant, K_{oc} values, and K_{ow} values) of PAHs are roughly correlated to their molecular weights:

- Low molecular weight compounds (152 to 178 g/mol) - acenaphthylene, anthracene, fluorene, and phenanthrene
- Medium molecular weight compounds (202 g/mol) - fluoranthene and pyrene
- High molecular weight compounds (228 to 278 g/mol) - benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene, chrysene, and indeno(1,2,3-cd)pyrene.

In general, PAHs have low water solubilities. PAHs with low molecular weights are associated with significant volatilization from soil, while high molecular weight PAHs volatilize from soil only to a limited extent. High molecular weight PAHs have a stronger

tendency to adsorb to organic carbon. Sorption of PAHs to soil and sediments increases with increasing organic carbon content and is also directly dependent on particle size. In general, bioconcentration is greater for the higher molecular weight compounds than for the lower molecular weight compounds (ATSDR, 1990b). The estimated half-life in soil of PAHs ranges from 32 to 2,139 days (Howard et al., 1991).

PCBs (Aroclor-1260). The sorption of Aroclor-1260 onto soil materials will be rapid and strong. In the absence of organic solvents, leaching is not expected to be important, and PCBs are expected to be immobile in the soil/groundwater system. PCBs will be much more mobile in the presence of organic solvents. In the case of large spills of PCB/solvent mixtures, the soil and aqueous phases may become saturated, resulting in a separate oily phase that may be more mobile (BEIA, 1989).

Transport of PCB vapors through the air-filled pores of unsaturated soils is not expected to be a rapid transport pathway. Sorption to organic matter has been shown to compete strongly with volatilization. Aroclor-1260 is resistant to biodegradation. In saturated, deep soils (containing no soil-air nor negligible soil organic carbon), sorption is still expected to be the most significant fate process (BEIA, 1989).

PCE. PCE is moderately absorbed by soil and has a low potential for bioaccumulation. It is relatively mobile in soil/groundwater systems, including transport of vapor through air-filled pores as well as transport in solution. PCE is resistant to hydrolysis and to biodegradation and may persist for months to years (BEIA, 1989). A scientific judgement of PCE's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 182.5 to 365 days (Howard et al., 1991).

Styrene. Styrene released to soils is subject to biodegradation. Styrene may exhibit low to moderate soil mobility depending on soil conditions. It has been demonstrated that styrene buried in soil can leach into underlying groundwater. Styrene that leaked into surrounding soil from buried drums persisted in the soil for up to 2 years. Styrene is not expected to bioaccumulate or bioconcentrate in organisms and food chains to any measurable extent (HSDB, 1992). A scientific judgement of styrene's half-life in soil, based upon unacclimated grab samples of aerobic soil and acclimated aqueous screening test data, is 14 to 28 days (Howard et al., 1991).

1,1,1-TCA. The mobility of 1,1,1-TCA in the soil/groundwater system is strongly affected by its sorption on soil particles. In soils of low organic carbon, adsorption is low; therefore, mobility is high. A significant loss pathway is diffusion through the soil-air pathways up to the ground surface and subsequent transport by wind. Biodegradation in natural soils is not expected to be significant except in landfills with active microbiological populations (BEIA, 1989). A scientific judgement of 1,1,1-TCA's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 140 to 273 days (Howard et al., 1991).

1,1,2-TCA. 1,1,2-TCA has a low soil partition coefficient and as such will not partition into sediment and will readily pass through soil into the groundwater where biodegradation may be very slow. Bioconcentration is not a significant process. When released to land, 1,1,2-TCA should partially volatilize and partially leach into the groundwater. Experimentally determined K_{oc} values of 83 to 209 indicate that 1,1,2-TCA will be moderately to highly mobile in soil. Several studies have shown that 1,1,2-TCA is resistant to biodegradation. Due to its moderate vapor pressure, volatilization from soil will occur (HSDB, 1992). A scientific judgement of 1,1,2-TCA's half-life in soil is based upon estimated hydrolysis half-life at pH 9 and 25°C (low half-life time [low $t_{1/2}$]), data from the estimated unacclimated aerobic aqueous biodegradation of half-life (low $t_{1/2}$), and a soil column test in which no biodegradation was observed. This half-life is 135 to 365 days (Howard et al., 1991).

TCE. The mobility of TCE in the soil/groundwater system is inversely related to sorption on the soil phase. Soil sorption increases with increasing soil organic matter content. Organic matter also contributes to retardation of TCE when percolating through the soil column. TCE under normal environmental conditions does not undergo rapid hydrolysis and supports only minimal biodegradation. TCE will volatilize when applied to surface soils (BEIA, 1989). A scientific judgement of TCE's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation, is 182.5 to 365 days (Howard et al., 1991).

1,1,2,2-Tetrachloroethane. 1,1,2,2-Tetrachloroethane is expected to have limited mobility in surface soils with 1 to 2 percent organic carbon; mobility in deep soils is expected to be higher due to migration with the soil pore water. In the soil/groundwater system, 1,1,2,2-tetrachloroethane is expected to be persistent. In the environment it is moderately volatile from aqueous solutions, moderately adsorbed to soil, and has a low potential for bioaccumulation. This compound may volatilize from the soil surface, but that portion not subject to volatilization will be somewhat mobile in groundwater. In most cases, it should be assumed that 1,1,2,2-tetrachloroethane will persist for months to years. Biodegradation should be

assumed to be of minimal importance. Some sorption of 1,1,2,2-tetrachloroethane is expected to occur in surface soils; however, in deep soils, sorption is not expected to be particularly significant. The presence of other materials in the soil may significantly affect the volatilization of 1,1,2,2-tetrachloroethane from surface soils. Its mobility in the soil/groundwater system is strongly affected by the extent of its sorption on soil particles, which is expected to increase with increasing soil organic matter content (BEIA, 1989). A scientific judgement of 1,1,2,2-tetrachloroethane's half-life in soil, based on hydrolysis half-lives at pH 7 and 9, is 45 days (Howard et al., 1991).

Toluene. Toluene is relatively mobile in soil/groundwater systems, including transport of vapor through air-filled pores as well as transport in solution. Toluene is moderately absorbed by soil and has a low potential for bioaccumulation. Toluene is resistant to hydrolysis but will probably biodegrade easily if microbiological populations are sufficiently numerous and active. It may persist for months to years if biodegradation is not possible (BEIA, 1989). Where biodegradation is possible, a scientific judgement of toluene's half-life in soil is 4 to 22 days based upon estimated aqueous aerobic biodegradation (Howard et al., 1991).

2,4,6-Trichlorophenol. Release to soil of 2,4,6-trichlorophenol may decrease in concentration due to biodegradation, depending upon the temperature, availability of oxygen, and the presence of appropriate organisms. Adsorption to soil will be significant in soils with high organic content; leaching to groundwater will be significant in sandy soils and in soils where biodegradation is not rapid. Volatilization and photomineralization may contribute to losses at the surface of the soil (HSDB, 1992). A scientific judgement of 2,4,6-trichlorophenol's half-life in soil, based upon estimated unacclimated aqueous aerobic biodegradation and grab sample data, is 7 to 70 days (Howard et al., 1991).

Vinyl Acetate. If released to soil, hydrolysis will occur in the presence of moisture. Evaporation from dry surfaces will occur. It is susceptible to biodegradation. Hydrolysis should be a significant process for vinyl acetate in moist soils. Hydrolysis rates will increase as the soils become more alkaline. Significant biodegradation may occur in soil. An estimated K_{oc} value of 19 to 59 indicates very high to high soil mobility, suggesting significant leaching is possible; however, concurrent hydrolysis should decrease the environmental importance of leaching. Vinyl acetate readily polymerizes; therefore, if vinyl acetate is released to the environment in a spill situation, significant polymerization may occur (HSDB, 1992).

Vinyl Chloride. Vinyl chloride is very weakly absorbed by soil and has no significant potential for bioaccumulation. This compound will volatilize from soil surfaces, but that portion not removed by volatilization is likely to be mobile in groundwater. The portions of vinyl chloride associated with the water and air phases of the soil are more mobile than the adsorbed portion. Vinyl chloride is expected to be highly mobile in soil/groundwater systems. In surface soils, most of the vinyl chloride will be in the soil-air phase and removal by volatilization will be important. In deep soils, transport with soil-groundwater is important. Transformation processes such as hydrolysis and biodegradation are not expected to be significant in natural soils. Transport of vinyl chloride vapors through the air-filled pores of unsaturated soils will be the most important transport mechanisms for near-surface soils. It should be assumed that vinyl chloride will persist for months to years once it enters the saturated soil zone (BEIA, 1989). A scientific judgement of vinyl chloride's half-life in soil, based upon estimated aqueous aerobic biodegradation, is 28 to 182.5 days (Howard et al., 1991).

Xylenes. Xylene isomers are relatively mobile in soil/groundwater systems, especially in the aqueous phase, and can volatilize from surface soil through air-filled pores. Xylenes are resistant to hydrolysis but are probably biodegradable. It should be assumed that xylenes could persist in the soil for months to years. Xylene isomers are highly volatile from aqueous solutions, moderately absorbed by soil, and have a moderate potential for bioaccumulation (BEIA, 1989). A scientific judgement of xylene's half-life in soil, based upon estimated aqueous aerobic biodegradation, is 7 to 28 days and 14 to 365 days in groundwater based upon estimated aqueous aerobic and anaerobic degradation (Howard et al., 1991).

19.1.2 Inorganics

Metals react with soil and aquifer components in a variety of ways. These reactions can generally be classified as ion exchange, adsorption, precipitation, and complexation. The reaction mechanisms and rates, both in soils and the water column, are dependent upon the type and amount of organic matter, clay, and hydrous oxides present in the soil. Additional factors are the pH, exchangeable cations, oxidation-reduction potential (Eh), and the composition and concentration of soil-groundwater and groundwater. Physical properties of soil collected in and around Moffett Field are discussed in Chapter 3.0.

Metal ions may be bound to soil particulates by a combination of forces ranging from electrostatic to covalent. Layer silicates or clay minerals such as smectite, illite, and kaolinite tend to bind soluble species by ion exchange reactions due to electrostatic attractions. Ion

exchange tends to be reversible but highly dependent on the type of clay mineral present, the composition of ions occupying exchange sites, the pH, and the composition of the groundwater.

Not only do the presence of various ligands affect the sorption of a metal, but the type of surface will also determine the extent of sorption. Clay minerals have different affinities for the adsorption of charged species due to geometric and chemical factors. This affinity is expressed as the cation exchange capacity (CEC), and it relates to the molecular structure and chemical composition of the mineral lattice and the particle size distribution of the sample. Kaolinite minerals have lower exchange capacities than do illites, which in turn are lower than smectites under similar conditions. In the bay environment of Moffett Field, the types of clay minerals expected to be present would reflect the weathered source area and thus be dominated by illite and kaolinite with minor montmorillonite and chlorite.

Hydrous metal oxides such as manganese and iron hydroxides have the ability to attenuate metals by both adsorption and coprecipitation reactives. These minerals are ubiquitous in nonreducing environments and occur not only as discrete oxide grains, but also as coatings on silicate minerals and weathering products in rock fragments. These phases tend to have extremely high CECs and their importance in concentrating heavy metals in the environment has been well documented (Murray, 1975; Suarez and Langmuir, 1976; Jenne, 1977; Means et al., 1978).

Hydrous oxides also attenuate metals by coprecipitation reactions. As the oxides form, various heavy metals of appropriate size, such as zinc and cadmium, will substitute within the mineral lattice and become a covalently bonded trace component of the oxide. This is a nonreversible reaction. Metals will be liberated only with the destruction of the mineral phase due to changes in the pH-Eh regime of the system. In addition, coprecipitation reactions with the hydrous oxides are effective in immobilizing the negatively charged chromate and selenite species that are stable under oxidizing conditions. The high concentrations of iron, and in many cases manganese, detected in shallow aquifer soils suggest that these phases are present throughout Moffett Field.

In addition to sorption and coprecipitation, most heavy metals are attenuated at increasing pH by the direct precipitation of mineral phases. Cadmium, zinc, and lead are effectively attenuated by the formation of carbonate, oxide, and hydroxide minerals at neutral to basic

(high) pH. Soil pH varies across the facility from a low of 3.9 (acid) in bay marsh soils to a high of 9.8 (basic) in the upland soils.

Metals are generally very persistent in the soil/groundwater systems because they do not degrade. A few metals are susceptible to biotransformation (e.g., mercury to methyl mercury).

19.2 Potential Routes of Migration

Chemicals in soil may migrate via five pathways:

- Volatilization to the surface and transport by wind
- Leaching to saturated zone and transport with groundwater
- Adsorption to surface soil particulates and transport by wind as fugitive dust
- Erosion and transport with surface runoff
- "Tracking" of chemicals at the surface by foot and equipment traffic.

For all but the most volatile compounds, all of these pathways except leaching are important only for surface soils. Chemicals will volatilize at any depth but generally only those at the surface or near surface escape to the atmosphere in significant amounts.

The most important potential migration pathway for chemicals in soil at OU2 is leaching to groundwater. To evaluate the potential significance of leaching, a simple vadose zone model has been applied to several of the sites at OU2.

19.2.1 Description of the Vadose Zone Model

The concentration of a chemical in groundwater is a function of the amount of the chemical infiltrating through the soil column and the sorption potential of the chemical. The chemical concentration is also affected by the volume of water into which it is dissolved.

Chemical concentrations in groundwater as a result of leaching from soil were estimated using the Summer's Model (EPA, 1989a). Twelve of the chemicals detected in soils at OU2 have been modeled. These 12 represent the chemicals found most commonly at OU2 and provide an example of potential chemical transport for compounds having a wide range of chemical properties. This model is designed to provide an estimate of the concentration of a chemical in soil that will not result in an unacceptable concentration in the groundwater directly below. This is a conservative model designed to be protective of groundwater quality. The equations and assumptions used in the model are:

$$Cgw = \frac{(QpCp) + (QaCa)}{Qp + Qa} \quad (1)$$

where:

Cgw = Target contaminant concentration in groundwater (µg/L)
Qp = Volumetric flow rate of infiltration into the aquifer (ft^3/day); VdzAp
Vdz = Darcy velocity in downward direction (ft/day)
Ap = Horizontal area of spill (ft^2)
Cp = Concentrations of chemicals in the infiltration at the unsaturated-saturated zone interface (µg/L)
Qa = Volumetric flow rate of groundwater (ft^3/day); $V_d$hw
V_d = Darcy velocity in aquifer (ft/day)
h = Aquifer thickness (ft)
w = Width of spill perpendicular to flow direction in aquifer (ft)
Ca = Initial or background concentration of pollutant in aquifer (µg/L).

Vdz can be estimated by the difference between average annual precipitation and annual evapotranspiration potential (both in units of depth/year)

The Darcy velocity in an aquifer (Vd) is estimated by:

$$V_d = KI \quad (2)$$

where:

K = Hydraulic conductivity (ft/day)
I = Hydraulic gradient (unitless).

At equilibrium, the ratio of the concentrations of contaminant in soil and water is described by:

$$Cs = KdCp \quad (3)$$

where:

Cs = Soil concentration (μg/kg)
Kd = Soil-groundwater equilibrium partitioning coefficient (mL/g)
Cp = Dissolved concentration in infiltration (μg/L).

If the Kd for a chemical is not available, it can be estimated by:

$$Kd = (K_{oc})(foc) \tag{4}$$

where:

K_{oc} = Water/organic carbon equilibrium partitioning coefficient (mL/g)
foc = Fraction organic carbon on soils (unitless).

Assuming that the background concentration of the chemical (Ca) equals zero, equations (1) and (3) are rearranged to solve for Cs, the concentration in soil:

$$Cs = \frac{Cgw(Qp + Qa)Kd}{Qp} \tag{5}$$

The following simplifying assumptions are utilized by the model:

- The soil/groundwater system is at equilibrium.
- No chemical degradation is occurring.
- The unsaturated soil zone is homogeneous down to the aquifer.
- Chemicals are mixed throughout the depth of the aquifer beneath the contaminant source.

The model does not account for any contaminant dilution or attenuation due to horizontal transport within the aquifer. Soil concentrations are therefore estimated based on the assumption that groundwater must meet acceptable levels within the aquifer directly beneath the source.

The site-specific parameters used in the model are listed in Table 19.2-1. The potential mass of a chemical available to leach to groundwater and the potential for dilution are dependent upon the area of contaminated soil and the orientation of this area relative to the direction of groundwater flow as well as the chemical concentration. The sites at OU2 range in size from approximately 100 square feet (Site 18) to approximately 19,602,000 square feet (450 acres,

Site 10). This range of site areas has been modeled to provide a range of soil concentrations associated with chemical-specific groundwater concentrations for the constituents of interest. These concentrations are based on protecting the groundwater to MCLs; however, the A aquifer is not potable at much of Moffett Field due to its naturally high salinity, and all domestic wells in the area are completed in the C aquifer or below. These soil concentrations, therefore, are given only as an example of the leaching potential at Moffett Field.

19.2.2 Results of Vadose Zone Model

The results of this modeling are presented in Table 19.2-2. The effect of a chemical's potential for adsorption onto soil (as estimated by the K_{oc} or Kd) is obvious from these results. Chemicals with a high affinity for soils such as bis(2-ethylhexyl)phthalate can be present in the soil at high concentrations without adversely impacting the groundwater (i.e., a soil concentration of 3.0 [Site 10] to 425 [Site 18] mg/kg could result in a groundwater concentration of 0.004 mg/L). Chemicals with a low affinity for soil such as methylene chloride readily leach to the groundwater (i.e., a soil concentration of 0.00052 [Site 10] to 0.075 [Site 18] mg/kg could result in a groundwater concentration of 0.005 mg/L). As discussed previously (Section 19.1.1), the K_{oc} value for a chemical can vary depending upon its source. Variations from 10 to 100 percent are not uncommon; however, it is highly unusual for reported K_{oc} values to vary by an order of magnitude or more. The results of this model should be evaluated with this potential for error in mind.

A large portion of the land at Moffett Field has been created during past reclamation programs by building dikes and adding fill materials to marsh areas. Elevations at Moffett Field range from about 36 feet above msl to 2 feet below msl. All of these elevations contribute to a very shallow water table. This shallow groundwater is contaminated with a variety of organic solvents and petroleum hydrocarbons and may be contributing to the soil contamination at OU2. Chemicals may be transported upward from the groundwater via vapor-phase transport, capillary action, or during the normal rise and fall of the water table. Therefore, the groundwater below OU2 may be acting as a source of contamination to the soil. This makes the use of a vadose zone leaching model highly uncertain.

20.0 Baseline Risk Assessment

20.1 Introduction

This baseline risk assessment has been conducted for Moffett Field in compliance with CERCLA, as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (EPA, 1990).

20.1.1 Scope and Organization of the Baseline Risk Assessment

This baseline risk assessment evaluates the potential current and future adverse impacts from OU2 Moffett Field on human health and the environment in the absence of remedial action. OU2 is defined as the soils at 15 sites at Moffett Field. Some of these sites (8, 9, 10 [Chase Park area only], 14, 16, 17, 18, and 19 west [Tank 14] overlie the regional groundwater plume. A ROD is currently in place for this groundwater plume and the soils above it. The OU2 sites that overlie the regional plume primarily contain chemicals that have been addressed by this ROD. Therefore, these sites are not addressed further in this baseline risk assessment. This baseline risk assessment evaluates the soils at Sites 3 through 7, 10 (runway area only), 11, 13, and 19 east (Tanks 2, 43, and 53).

This baseline risk assessment is organized to follow the format recommended by the EPA (EPA, 1989b). Section 20.1 provides an overview of OU2 and the organization of the baseline risk assessment. Section 20.2 describes the selection of the chemicals of potential concern at OU2. The exposure assessment is described in Section 20.3. This assessment includes a description of OU2 and the human and environmental populations potentially affected by site-related chemicals now and in the future (Section 20.3.1). Potential exposure pathways are evaluated in Section 20.3.2, which includes a discussion of the sources, fate and transport potential of each potentially site-related chemical, and the possible routes of exposure. Finally potential human exposures are quantified in Section 20.3.3. Section 20.4 discusses the potential toxicity of the chemicals of potential concern at Moffett Field OU2, and in Section 20.5 this toxicity information and the exposure assessment are integrated to provide an estimate of potential adverse health effects associated with site-related chemicals. Section 20.6 summarizes the results and conclusions of the human health baseline risk assessment. An environmental assessment is provided in Section 20.7. The uncertainties associated with each step of the risk assessment are discussed at the end of each section.

In each section of the risk assessment, the risk assessment step being performed (e.g., selection of chemicals of potential concern) is described in general, followed by site-specific discussions for each of the nine sites addressed in this baseline risk assessment for OU2.

20.1.2 Overview

To facilitate the RI/FS process at Moffett Field, the investigation has been divided into five operable units. A brief description of all operable units is given in Section 1.3 of this report. This baseline risk assessment focuses on OU2 (east), which is defined as the soil investigations for Sites 3, 4, 5, 6, 7, 10 (runway area only), 11, 13, and 19 (Tanks 2, 43, and 53). Due to differences in location and types of available data, Site 19 will be evaluated in two parts. The data for Tanks 2 and 43 will be evaluated together. Tank 53 data will be addressed separately.

This baseline risk assessment estimates the potential risks to human health and the environment from potential exposures of current and future receptors to site-related chemicals. This assessment of the human and environmental risk will help form a basis for determining the need for immediate remedial action and for establishing a time frame to develop a long-term remedial alternative. Based on the currently available information, the tasks involved are:

- Identification of the chemicals present at OU2 and estimation of the quantity of these chemicals in the soil
- Identification of possible human and environmental receptor populations that could be exposed to site-related chemicals
- Estimation of the potential exposure levels, if any, of chemicals in soil, groundwater, and air to identified populations
- Evaluation of possible adverse effects of chemical exposure to the identified receptor populations.

The information obtained from these tasks is integrated in the baseline risk assessment. The approach is based on current EPA guidance for conducting risk assessments found in: ***Risk Assessment Guidance for Superfund, Human Health Evaluation Manual*** (EPA, 1989b), ***Risk Assessment Guidance for Superfund, Human Health Risk Assessment: EPA Region IX Recommendations*** (EPA, 1989c), ***Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"*** (EPA, 1991a), ***Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual*** (EPA, 1988e), ***Draft Risk***

Assessment Guidance for Superfund Ecological Assessments/Region IX (EPA, 1989d), and other EPA guidance as cited in this report.

20.1.3 Site Background

The complete site description and history for Moffett Field are given in Section 1.4 of this report. A brief summary is given here.

Moffett Field is located in the Santa Clara Valley near the southern end of San Francisco Bay, 35 miles southeast of San Francisco, California, and 10 miles northwest of San Jose, California. The installation encompasses approximately 2,200 acres in Santa Clara County. Moffett Field is bordered by the cities of Mountain View on the west and Sunnyvale on the south (Figure 20.1-1).

The facility is bounded by salt evaporation ponds to the north, Stevens Creek to the west, U.S. Highway 101 to the south, and Lockheed Missile and Space Company's Lockheed Aerospace Center to the east. Since the 1950s, the area surrounding the facility has become increasingly populated, and very little land is now available that is not committed to urban land uses or tidelands.

A sizeable portion of Moffett Field is situated on previously submerged land or marsh lands that have been filled to their existing elevations. Much of the area north of the middle of the airfield has been filled to present elevations with materials of unknown composition. The original shoreline ran northwest through what is now the NASA-ARC (Figure 20.1-2).

Moffett Field is essentially divided in half by the runway system that is oriented northwest-southeast. Most of the aircraft and flight training operations are on the east side of the runway. The administrative support operations and functions are on the west side (Figure 20.1-2).

Moffett Field has been in continuous operation by the military since it was commissioned in 1933. A variety of national defense missions have been executed by Moffett Field, including the present support of the Pacific Fleet Air Patrol Forces. The current mission of Moffett Field is to support antisubmarine warfare training and patrol squadrons. Although no heavy manufacturing or major aircraft maintenance is performed at Moffett Field, a significant amount of intermediate level maintenance is accomplished. Moffett Field supports more than 70 tenants - the most important being the Commander Patrol Wings, U.S. Pacific Fleet.

Additionally, Moffett Field supports the California Air National Guard. Other groups supported by Moffett Field include:

- Naval Air Maintenance Training Detachment 1012, Moffett Field
- Naval Aviation Engineering Service Unit, Moffett Field
- Fleet Aviation Specialized Operation Training Group, Pacific Detachment, Moffett Field
- Explosive Ordnance Disposal Unit Detachment, Moffett Field
- Branch Dispensary, Naval Regional Medical Center, Oakland
- Branch Facility, Naval Regional Dental Center, San Francisco
- Department of Defense, ARPA, Moffett Field
- Defense Property Disposal Office, Alameda.

Minor support is provided to the Naval Academy, Flying Club, printing office, and communications/training/research and development. Minor support is also provided to other military installations for vehicle maintenance and to private companies engaged in electronics.

Since the early 1930s wastes have been generated at Moffett Field through maintenance operations, fuel management, and fire training. The primary contaminants at Moffett Field are waste oils and jet fuels, solvents and cleaners, washing compounds, and minor amounts of gasoline, hydraulic fluids, asbestos, paints, pesticides, battery acid, and PCBs. Surrounding industries have significantly contributed to the solvent contamination of the groundwater in the region. Groundwater flows north toward San Francisco Bay and has transported these contaminated waters into areas of Moffett Field.

In 1981 the Navy developed a priority list of contaminated installations and facilities requiring remedial action. This provided the impetus for the start of IRP activities at Moffett Field. The WESTDIV is responsible for implementing the Navy IRP at Moffett Field. In July 1983, an investigation under the IRP was initiated at Moffett Field. In July 1987, Moffett Field was placed on the EPA NPL as a result of an area-wide groundwater plume. At approximately the same time, the Navy initiated plans to conduct the current RI/FS at Moffett Field.

The first phase of the IRP, the IAS, was completed in 1984. This was followed by Phase II (Confirmation Study), which is composed of four steps. Step I, the Verification Step, was completed in 1986. Step II, the Characterization Step, was modified to conform with the EPA RI/FS guidance under SARA in 1987. From 1988 to 1991, Phase I and II RI field activities were conducted to identify and characterize the point sources on Moffett Field.

The results of the Phase I RI field activities and summaries of previous field investigations are presented in the Phase I Characterization Report (IT, 1991a). Based on these data, the quality of soil and groundwater at each of the 19 sites was evaluated and data gaps identified for consideration during the Phase II field investigation. The combined data obtained from both Phase I and II field investigations are presented and integrated in this OU2 RI Report.

20.1.4 Sites Investigated as Part of OU2

Nine sites are included in the baseline risk assessment for OU2 (east) at Moffett Field (Figure 20.1-3). The sites under investigation are identified as follows:

- Site 3 - Marriage Road Ditch
- Site 4 - Former Wastewater Holding Pond
- Site 5 - Fuel Farm French Drains and Bulk Tanks
- Site 6 - Runway Apron
- Site 7 - Hangars 2 and 3
- Site 10 - Runway Area
- Site 11 - Engine Test Stand Area
- Site 13 - Equipment Parking Area (Building 142)
- Site 19 - Tanks 2, 43, and 53

Some of the sites are discrete, individual locations, while other sites are composed of multiple locations. A brief description of each site follows.

Site 3 - Marriage Road Ditch. Site 3 runs northward along the east side of Marriage Road, carrying surface drainage from the intersection of Marriage and Macon Roads to the northern boundary of Moffett Field. At that point, the drainage water is pumped to a perimeter canal south of the evaporation ponds that leads to Guadalupe Slough. The ditch was constructed prior to 1947 and originally extended across Macon Road to the aprons of Hangars 2 and 3. Storm drains in and around Hangars 1, 2, and 3 discharge into the ditch. An estimated 150,000 to 750,000 gallons of mixed hazardous waste containing waste oils, solvents, fuels, detergents, paints, paint strippers, and hydraulic fluids were disposed of in the storm drains from the 1940s to the 1970s.

Site 4 - Former Wastewater Holding Pond. Site 4 is the area encompassing and surrounding the former wastewater holding pond, located north of Hangars 2 and 3 and west of the existing ponds. The former pond was unlined and received about 15 million gallons of wastewater from aircraft washing, equipment maintenance, and operations in Hangars 2 and 3 from 1968 to 1978 (NEESA, 1984). The wastewater was held in the pond, treated, and dis-

charged to the sanitary sewers. As many as 35,000 gallons of hazardous materials, including toluene, MEK, dry cleaning solvent, paint sludge, paint stripper, Freon-113, TCE, TCA, carbon remover, ethylene glycol, fuel, and oil, may have been discharged to the pond either directly or as components of wastewater.

Site 5 - Fuel Farm French Drains and Bulk Tanks. Site 5 is separated into a northern and a southern area. The northern area is located in the triangular area bordered by Macon Road, Patrol Road, and the golf course. The southern area is bounded by Macon Road on the east, runway aprons to the south and west, and Hangar 3 to the north. These tanks were the main fuel facilities for Moffett Field since the 1950s. As a standard operating procedure from the 1950s to 1960s, water and fuel were pumped into French drains during routine tank drainage. The exact locations of the drains and the quantities of fuel dumped into the drains are unknown, although two open vertical pipes have been located at the site. In the IAS, NEESA estimated that as many as 28,000 gallons of fuel could be present on top of the groundwater at the site, based on observations of fuel levels in wells. The fuel farm continues to be the main storage facility.

Site 6 - Runway Apron. Site 6 is designated the Runway Apron disposal site and was located adjacent to the former aprons northeast of Hangars 2 and 3. The site was paved over in 1979 during enlargement of the apron. An estimated 120,000 to 600,000 gallons of hazardous waste from aircraft maintenance, including solvents, oils, fuels, paints, and paint strippers, were disposed of at this site from the 1940s to the 1970s (NEESA, 1984).

Site 7 - Hangars 2 and 3. Site 7 consists of Hangars 2 and 3 and the paved area surrounding the hangars, which were constructed in 1942. From 1942 until 1978, hazardous waste that accumulated in the unpaved area surrounding the hangars flowed through deck drains to the Marriage Road Ditch. Unpaved areas at each corner of Hangars 2 and 3 were used to dispose of an estimated 120,000 to 600,000 gallons of paint, paint strippers, oils, solvents, fuels, hydraulic fuels, and other hazardous wastes. A power plant shop in the northeast corner of Hangar 3 disposed of chlorinated solvents, including TCE, into down-deck drains and on unpaved areas around Hangar 3 (NEESA, 1984).

Site 10 - Runway Area. Site 10 encompasses the runway and the Chase Park area; however, only the runway area is included in this baseline risk assessment. Chase Park is upgradient of known Moffett Field sources. No sources are known to exist in the runway area, although it is presumed that fuels, oils, and hydraulic fluids may have been spilled there.

Site 11 - Engine Test Stand Area. The Engine Test Stand Area is located approximately 500 feet north of the intersection of Patrol Road and Zook Road, and lies between the eastern edge of the runway and Devil's Slough. The site, which is used to test turbine engines, is fenced and underlain by both concrete and asphalt that constitute a pad approximately 200 by 200 feet in size. A small drainage depression drains waste oils, hydraulic fluids, and fuels from the center of the pad to the southern edge of the pad. During past tests, fluids may have run onto the adjacent soils. An area approximately 75 feet by 45 feet appears to be "oil-stained" south of the pad. It is unknown how long the Engine Test Stand Area has been in use, how frequently it has been used, or the quantity of fluids that has run off the pad.

Site 13 - Equipment Parking Area (Building 142). The Equipment Parking Area is located northeast of Building 142, approximately 600 feet east of Hangar 3. Building 142 is used for repair and maintenance of aircraft ground support equipment. Waste and industrial wastewater from spills, leaks, and washing have resulted in surface wash and drainage onto a concrete/asphalt parking area east of and adjacent to Building 142. This runoff flows into a main north-south trending, unlined storm drain channel. Runoff also discharges into a small secondary east-west trending, asphalt-lined drainage channel along the north sides of the parking area. A 20- to 25-foot-long portion of the north-south trending storm drain has apparently been excavated and back-filled with clean fill material. The gradient of the channel appears to be nearly flat.

Site 19 - Tanks 2, 43, and 53. Tank 2 was a leaking UST located on the east side of Hangar 3. The tank, which was in use from 1979 to January 1987, had a capacity of 2,000 gallons. The tank had been used as a hazardous waste storage tank for wastes from the Power Plant Shop located in Hangar 3. Waste products that have been stored in the tank include oils, hydraulic fluids, MEK, JP fuels, B&B cleaner, PD-680 solvent, toluene, and Stoddard solvent. The tank was unmetered; therefore, no inventory could be calculated. The tank was reportedly emptied every 90 days (ERM-West, 1986). Tank 2 was removed in May 1990.

Tank 43 was located on the northeast corner of Hangar 3. Tank 43 was a 2,000-gallon UST that collected rinse water from engine cleaning racks, drains, and sinks in Hangar 3. The tank contained waste oils, solvents, waste fuel, MEK, Solvent PD-680, paint waste, and battery acids. The tank was emptied every 90 days, and the wastes were hauled off site (ERM-West, 1986). The tank, which had been in use since 1980, was removed in May 1990.

Tank 53, which was removed in May 1990, was a UST located on the southeast corner of the intersection of Patrol Road and Marriage Road. The 500-gallon tank was used to store unleaded gasoline for use at the golf course physical plant.

20.2 Selection of Chemicals of Potential Concern

20.2.1 Data Collection and Evaluation

Past hazardous materials handling practices at Moffett Field generated waste oils, solvents, detergents, paints, strippers, hydraulic fluids, and other chemicals. Consequently, in 1983 the Navy initiated an environmental study to determine if past practices caused any contamination at the site. The data evaluated in this report were collected in the characterization portion of the two-phase study. Results of the Phase I RI field activities are presented in the Phase I Characterization Report (IT, 1991a). Based on the Phase I data, additional sampling was conducted in Phase II to further assess the quality of soil and groundwater and to address data gaps identified in the Phase I effort. Results of the Phase II RI field activities are presented in this report.

Both Phase I and Phase II data were collected and analyzed in accordance with CLP QA/QC procedures and in accordance with the methods and approaches described in the Work Plan for Moffett Field (IT, 1988a). Complete explanations of the RI tasks and approaches can be found in the main text of this report: the operable unit definition is provided in Section 1.3; site descriptions and histories are provided in Section 1.4; and possible on-site sources are described in Sections 1.5 and 2.3.1.

20.2.1.1 Data Collection

Soil samples were collected to fulfill the following RI objectives:

- Confirm, characterize, and define the lateral and vertical extent of contamination at each site known or suspected to be a source of contaminant release
- Supplement and refine the existing geologic, geochemical, hydrogeologic, and chemical database for the study sites
- Evaluate the chemical migration pathways, site hydrogeology, and specifics of groundwater movement that influence the migration of site-related chemicals

- Evaluate potential risks and hazards to public health and the environment
- Provide sufficient data for assessing the need for interim remedial actions and for adequately designing such actions.

To accomplish these objectives, data used for this assessment were generated under two phases of the RI. Details of the approach used can be found in the approved project Work Plan's SAP and QAPP (IT, 1988a) and summarized in Chapter 2.0 of this report. In addition, conclusions and approaches with respect to the nature and extent of contamination of the sites can be found in the Phase I Characterization Report (IT, 1991a) and Chapters 4.0 through 19.0 of this report.

20.2.1.2 Data Evaluation and Validation

Analytical data used in this report were generated by CLP and CLP-like methods during the Phase I and Phase II RI sampling efforts conducted by Energy Systems and IT. These investigations were conducted in accordance with the QA/QC requirements presented in the RI's QAPP and SAP (IT, 1988a). Data were subsequently validated by third-party reviewers. Discussed thoroughly in Section 2.2 of the text, the CLP program, third party validation, and specific approaches and conclusions of the third party validation are summarized in this section.

Both phases utilized EPA CLP methods, or in the absence of a CLP method, a CLP-like method. CLP methods provide data of EPA analytical Levels III and IV as defined by the EPA's DQOs for Remedial Response Activities (EPA, 1987a). For data generated by CLP methods, the difference between Levels III and IV is based on the deliverable, not on laboratory QA/QC or technical quality; data generated by CLP methods have been produced under the most rigorous analytical QA/QC conditions specified by EPA.

Prior to reporting, internal validation of data was performed by the contract laboratory to ensure QA/QC standards were met. In addition, all analytical data were subjected to third party validation. Systematic approaches undertaken in the third party validation effort varied with laboratory deliverables and primary project needs. The detail of laboratory documentation contained in the data packages differed between Phase I and Phase II because they had different primary objectives.

Guidance for review of CLP analytical results is provided by the EPA guidance documents "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" (EPA,

1988a) and "Laboratory Data Validation Functional Guidelines for Inorganic Analyses" (EPA, 1988b) and where applicable by the HAZWRAP document "Requirements for Quality Control of Analytical Data" (HAZWRAP, 1990). These documents are designed to aid in technical review of field and laboratory performance. Yet, as pointed out in the EPA guidelines, "some areas of overlap between technical review and Contract Compliance Screening exist." Because each project is different, the contract requirements may need to be incorporated by the validator to ensure data usability, particularly for the CLP-like EPA Level V data.

Complete CLP packages were not necessary to meet the objectives of the Phase I effort. Thus, validation of Phase I data emphasized meeting contract/Work Plan requirements for data quality, while validation of Phase II data included review of raw data. These approaches overlapped to the extent that QA/QC data were provided by the laboratory. Findings from the validation effort were incorporated into the project's database and are reflected in the qualifiers assigned to the validated data.

Hence, although the intensity of third party validation varied between Phase I and Phase II, all CLP and CLP-like data generated under the Phase I and Phase II RIs are considered valid for the purpose of risk assessment.

Phase I Validation. QA sampling and analysis activities included collecting and analyzing field and laboratory QC samples. Field QC samples included trip blanks, equipment blanks, and field duplicates. Split samples, split with Energy Systems, were also taken. Reported laboratory QC samples included laboratory blanks, matrix spikes, and matrix spike duplicates.

Split samples were particularly scrutinized with respect to common laboratory contaminants. As both laboratories had method blanks containing common laboratory contaminants, methylene chloride or acetone concentrations could not be dismissed for all sites solely on the basis of laboratory contamination.

Following data review, data quality is considered good. Analytical precision and accuracy were good with more than 90 percent of duplicate, spike, and split analyses being within the CLP method limits. Data are complete because more than 95 percent of the data are usable. Data are representative because the accepted and prescribed methods presented in the IT Moffett Field Work Plan were followed.

Phase II Validation. QA sampling and analysis activities included collecting and analyzing field and laboratory QC samples. Field QC samples included trip blanks, equipment blanks, and field duplicates. Laboratory QC samples included laboratory blanks, matrix spikes, matrix spike duplicates, and blank spikes. Other QC procedures performed by the laboratory included instrument tuning, calibration checks, surrogate recovery monitoring, ICP spectrometer interference checks, laboratory control checks, and serial dilution checks.

Data were rejected or qualified as estimated when performance criteria were not met. Due to the volume of data, specific reasons for qualification must be obtained from the validation report. However, the conclusions of the validation have been incorporated into the project's database. Data qualified as estimated were used quantitatively in the site characterization and risk assessment statistics along with nonestimated data. Rejected data were used for qualitative insights only.

Following data review, data quality is considered good. Analytical precision and accuracy were good with more than 90 percent of duplicate and spike analyses being within the CLP method limits. Data are complete because more than 95 percent of the data are usable. Data are representative because the accepted and prescribed methods presented in the IT Moffett Field Work Plan were followed.

Site 19 (Tank 53) Data. Two sets of data were available for use in the risk assessment of the Site 19 (Tank 53) area. The first source was the "Final Tank and Sump Removal Summary Report" (PRC, 1991a), which consisted of an investigation of Tank 53, its subsequent removal, and the excavation of associated soils. Samples were collected at the tank-soil interface (5/11/90), from the residual soils at each of the four walls of the excavation, (5/24/90) and from the borings of two monitoring wells (8/30/90). The results are summarized in Table 18.2-8.

The draft report "Additional Tank and Sump Field Investigation Technical Memorandum" (PRC, 1993) was also reviewed. Twenty-four soil samples were collected and analyzed using the Geoprobe method. This method consists of headspace analyses and is used for screening purposes. These data are summarized in Table 18.2-9. Due to the preliminary nature of these analyses, these data were not subjected to CLP or equivalent validation procedures.

Thirteen of the twenty-four samples were submitted for laboratory confirmation. Although benzene was detected in both the original investigation and with the Geoprobe method, it was

not detected in the confirmation process. The analytical results for the confirmation samples are summarized in Table 18.2-10. The quantitative evaluation of these data was limited to validated data from the 1990 and 1992 EPA Method 8020 analyses. Although there is a difference in time frame between the sampling events, these data were combined to represent potential contamination at the tank site.

20.2.2 General Selection Process for Chemicals of Potential Concern

All chemicals detected at OU2 were screened to determine if they met the given criteria for chemicals of potential concern. Only original samples (no duplicates) were used. Data reported with a "J" or "J"-equivalent qualifier (indicating an estimated concentration) were included with other positive detections. Data with an "R" or "R"-equivalent qualifier (indicating rejected data) were not included in the data set. Data from the Phase I and II investigations were used. For this baseline risk assessment, samples taken from a depth of 0 to 10 feet below the surface were evaluated together unless the water table was encountered above 10 feet. Contamination is not expected at the ground surface because most sites are paved and/or the potential source of contamination is underground (e.g. underground storage tanks). Therefore, exposure will require excavation to expose the subsurface soil at the surface. An excavation depth of 10 feet was selected as representative for California. As noted previously, less than 10 feet of soil was used if the water table was encountered at a shallower depth. Complete data are contained in Appendix A of this report.

The following criteria, from EPA's ***Risk Assessment Guidance for Superfund: Human Health Evaluation Manual*** (1989b), were applied to select the chemicals of potential concern for OU2:

- Blank (QC) Contamination. Because of the presence of several laboratory contaminants in virtually all environmental sampling efforts, EPA has developed guidance for eliminating these contaminants from consideration as chemicals of potential concern. As part of the data validation process, a chemical was not considered further if the maximum sample concentration did not exceed ten times the highest blank for all common laboratory contaminants (2-butanone, acetone, methylene chloride, toluene, and phthalates) or five times the highest blank for other chemicals. This criterion was developed by EPA to prevent the inclusion of chemicals that are most likely sampling or analytical artifacts.

- Comparison with Background. Inorganic chemicals are naturally present in soils. If inorganic constituents were present at naturally-occurring background levels, they were eliminated from the risk assessment. Specifically, a chemical was not considered further if the upper 95 percent confidence limit of the sample concentrations was within the range of background concentrations reported for

this area. A complete discussion of the background sources used is given in Section 3.5 of this RI Report.

- Frequency of Detection. Chemicals that are infrequently detected may be artifacts in the data due to sampling, analytical, or other problems. Chemicals were eliminated if they were detected in 5 percent or less of the on-site samples.

- Essential Nutrients. Iron, magnesium, calcium, sodium, and potassium are essential and are generally toxic only at very high doses. These constituents were, therefore, eliminated as chemicals of potential concern. A discussion of the potential toxicity of these constituents is given in Appendix E. Other essential nutrients, such as selenium and zinc, that have a greater potential for toxicity were carried through the risk assessment unless eliminated by the aforementioned criteria. The general soil parameters phosphorus, sulfate, and carbonate are also generally toxic only at very high doses and have not been carried through the risk assessment. The potential toxicity of these constituents is also described in Appendix E.

In addition to the above criteria, the weight-of-evidence of carcinogens as classified by EPA (EPA, 1991b and 1992b) was also considered. Chemicals classified as Class A (known human carcinogens) were not eliminated from the final list of chemicals of potential concern regardless of their frequency of detection. Class A carcinogens were eliminated if they were present within naturally occurring background concentrations.

JP-5 was analyzed as a TPHC. The potentially toxic components of JP-5 (e.g. naphthalene, benzene, ethyl benzene, toluene, xylene) were also analyzed separately. Therefore, the individual components have been considered for this risk assessment. Total JP-5 is not one distinct chemical and has not been carried through the risk assessment as a chemical of potential concern. The data used for this baseline risk assessment are summarized in Tables 20.2-1 through 20.2-9.

20.2.3 Chemicals of Potential Concern at Site 3

All constituents detected in the soil at Site 3 are listed in Table 20.2-1. A total of 43 constituents were detected in the soil at Site 3 including 23 organics and 21 metals. Constituents were excluded from the list of chemicals of potential concern for the following reasons:

- Benzo(g,h,i)perylene, carbon disulfide, carbon tetrachloride, chrysene, di-n-butylphthalate, 1,2-DCE, trans-1,3-dichloropropene, fluoranthene, hexanone, phenanthrene, indeno(1,2,3-c,d)pyrene, methylene chloride, n-nitroso-di-n-dipropylamine, pyrene, and TCE were each detected in 5 percent or less of the samples analyzed.

- Aluminum, arsenic, barium, cadmium, chromium, copper, lead, mercury, vanadium, and zinc were all detected within naturally occurring background levels.

- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are 14 chemicals of potential concern identified at Site 3:

Organics		
Acetone	2-Butanone	PCE
Aroclor-1260	Butylbenzylphthalate	Toluene
Bis(2-ethylhexyl)phthalate	Diethyl phthalate	
Metals		
Antimony	Cobalt	Nickel
Beryllium	Manganese	Silver

These metals may also be present as a result of natural background; however, the limited background data do not allow for their elimination on this basis. Past practices at OU2 do not suggest that these metals are site related.

20.2.4 Chemicals of Potential Concern at Site 4

All constituents detected in the soil at Site 4 are listed in Table 20.2-2. A total of 55 constituents have been detected in the soil at Site 4 including 32 organics and 23 metals. Constituents have been excluded from the list of chemicals of potential concern for the following reasons:

- 1,1,1-TCA, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2-hexanone, 4-methylphenol, acenaphthalene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chlorobenzene, chrysene, fluorene, indeno(1,2,3-cd)pyrene, methylene chloride, Aroclor-1260, thallium, cadmium, selenium, and TCE were each detected in 5 percent or less of the samples analyzed.

- Aluminum, arsenic, barium, fluoranthene, pyrene, chromium, lead, mercury, vanadium, and zinc were all detected within background levels.

- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are 18 chemicals of potential concern identified at Site 4:

Organics

Acetone	Diethyl phthalate	Phenanthrene
Bis(2-ethylhexyl)phthalate	2-Methylnaphthalene	Toluene
2-Butanone	Naphthalene	Xylenes (total)
1,2-Dichlorobenzene	PCE	

Metals

Antimony	Copper	Silver
Beryllium	Nickel	Manganese
Cobalt		

These metals may also be present as a result of natural background; however, the limited background data do not allow for their elimination on this basis. Past practices at OU2 do not suggest that these metals are site related.

20.2.5 Chemicals of Potential Concern at Site 5

All constituents detected in the soil at Site 5 are listed in Table 20.2-3. A total of 53 constituents have been detected in the soil at Site 5 including 30 organics and 23 metals. Constituents were excluded from the list of chemicals of potential concern for the following reasons:

- 1,1,1-TCA, 2-butanone, benzo(a)anthracene, benzo(k)fluoranthene, carbon disulfide, chlorobenzene, chloroform, chrysene, di-n-butylphthalate, di-n-octyl-phthalate, ethyl benzene, fluoranthene, fluorene, naphthalene, phenanthrene, pyrene, PCE, xylenes (total), 2-methylnaphthalene, Aroclor-1016, -1221, -1232, -1242, -1248, -1254, -1260, selenium, and thallium were each detected in 5 percent or less of the samples analyzed.

- Aluminum, arsenic, barium, cadmium, chromium, copper, lead, mercury, vanadium, and zinc were all detected within naturally occurring background levels.

- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are ten chemicals of potential concern at Site 5:

Organics

Acetone	Diethyl phthalate	Toluene
Bis(2-ethylhexyl)phthalate		

Metals

Antimony	Cobalt	Nickel
Beryllium	Manganese	Silver

These metals may also be present as a result of natural background; however, the limited background data do not allow for their elimination on this basis. Past practices at OU2 do not suggest that these metals are site related.

20.2.6 Chemicals of Potential Concern at Site 6

All constituents detected in the soil at Site 6 are listed in Table 20.2-4. A total of 34 constituents have been detected in the soil at Site 6 including 14 organics and 20 metals. Constituents were excluded from the list of chemicals of potential concern for the following reason:

- Aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, vanadium, zinc, and pyrene were all detected within background levels.
- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are 17 chemicals of potential concern at Site 6:

Organics

Acetone	Ethyl benzene	Naphthalene
Bis(2-ethylhexyl)phthalate	Fluorene	Phenanthrene
2-Butanone	2-Methylnaphthalene	Toluene
1,2-DCE	4-Methylphenol	Xylenes (total)
Diethyl phthalate		

Metals

Antimony	Nickel	Silver
Cobalt		

These metals may also be present as a result of natural background; however, the limited background data do not allow for their elimination on this basis. Past practices at OU2 do not suggest that these metals are site related.

20.2.7 Chemicals of Potential Concern at Site 7

All constituents detected in the soil at Site 7 are listed in Table 20.2-5. A total of 32 constituents have been detected in the soil at Site 7 including 11 organics and 21 metals.

Constituents were excluded from the list of chemicals of potential concern for the following reasons:

- Butylbenzylphthalate, carbon disulfide, di-n-butylphthalate, phenanthrene, and 1,1,2,2-tetrachloroethane were each detected in less than 5 percent of the samples analyzed.
- Aluminum, arsenic, barium, chromium, cobalt, lead, mercury, and vanadium were all detected within naturally occurring background levels.
- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are 14 chemicals of potential concern identified at Site 7:

Organics		
Acetone	2-Butanone	Toluene
Bis(2-ethylhexyl)phthalate	Ethyl benzene	Xylenes (total)
Metals		
Antimony	Manganese	Thallium
Beryllium	Nickel	Zinc
Copper	Silver	

These metals may also be present as a result of natural background; however, the limited background data do not allow for their elimination on this basis. Past practices at OU2 do not suggest that these metals are site related.

20.2.8 Chemicals of Potential Concern at Site 10 (Runway Area)

All constituents detected in the soil at Site 10 are listed in Table 20.2-6. A total of 23 constituents have been detected in the soil at Site 10 (Runway Area) including 2 organics and 21 metals. Constituents were excluded from the list of chemicals of potential concern for the following reasons:

- Aluminum, arsenic, barium, chromium, cobalt, lead, mercury, vanadium, and zinc were all detected within naturally occurring background levels.
- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are nine chemicals of potential concern identified at Site 10:

Organics	
Acetone	Bis(2-ethylhexyl)phthalate

Metals

Antimony	Manganese	Silver
Beryllium	Nickel	Thallium
Copper		

These metals may also be present as a result of natural background; however, the limited background data do not allow for their elimination on this basis. Past practices at OU2 do not suggest that these metals are site related.

20.2.9 Chemicals of Potential Concern at Site 11

All constituents detected in the soil at Site 11 are listed in Table 20.2-7. A total of 42 constituents have been detected in the soil at Site 11 including 20 organics and 22 metals. Constituents were excluded from the list of chemicals of potential concern for the following reasons:

- 2-Butanone, 1,3-dichlorobenzene, benzo(a)anthracene, benzo(k)fluoranthene, benzoic acid, phenanthrene, thallium, and toluene were each detected in 5 percent or less of the samples analyzed.

- Benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, pyrene, aluminum, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, vanadium, and zinc were all detected within naturally occurring background levels.

- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are 12 chemicals of potential concern identified at Site 11:

Organics

Acetone	Carbon disulfide	n-nitrosodiphenylamine
Bis(2-ethylhexyl)phthalate	di-n-butylphthalate	1,1,1-TCA

Metals

Antimony	Cobalt	Manganese
Copper	Nickel	Silver

These metals may also be present as a result of natural background; however, the limited background data do not allow for their elimination on this basis. Past practices at OU2 do not suggest that these metals are site related.

20.2.10 Chemicals of Potential Concern at Site 13

All constituents detected in the soil at Site 13 are listed in Table 20.2-8. A total of 23 constituents have been detected in the soil at Site 13 including 3 organics and 20 metals. Constituents were excluded from the list of chemicals of potential concern for the following reasons:

- Aluminum, arsenic, barium, chromium, mercury, and vanadium were all detected within naturally occurring background levels.
- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are 12 chemicals of concern identified at Site 13:

<u>Organics</u>		
Bis(2-ethylhexyl)phthalate	di-n-butylphthalate	Toluene
<u>Metals</u>		
Antimony	Copper	Nickel
Cadmium	Lead	Silver
Cobalt	Manganese	Zinc

These metals may also be present as a result of natural background; however, the limited background data do not allow for their elimination on this basis. Past practices at OU2 do not suggest that these metals are site related.

20.2.11 Chemicals of Potential Concern at Site 19

All constituents detected in the soil at Site 19 are listed in Table 20.2-9. A total of 37 constituents have been detected in the soil at Site 19 including 14 organics and 23 metals. This includes detections from all the tank sites. Constituents were excluded from the list of chemicals of potential concern for the following reasons:

- 1,1-DCA and pyrene were detected in less than 5 percent of the samples analyzed.
- Aluminum, arsenic, barium, cadmium, chromium, lead, mercury, vanadium, and zinc were all detected within naturally occurring background levels.
- Calcium, iron, magnesium, potassium, and sodium are all essential nutrients.

There are 21 chemicals of potential concern at Site 19.

Organics

Acetone	Butylbenzylphthalate	PCE
Benzene	Carbon disulfide	TCE
Bis(2-ethylhexyl)phthalate	1,2-DCE	Toluene
2-Butanone	Ethyl benzene	Xylenes

Metals

Antimony	Copper	Nickel
Beryllium	Lead	Silver
Cobalt	Manganese	Thallium

20.2.12 Summary of Chemicals of Potential Concern

Chemicals of potential concern have been selected for OU2 using EPA (1989b) selection criteria. Solvents and fuel-related constituents are the primary types of chemicals of potential concern, as expected. Metals were also found in most samples. The majority of these metals are related to natural background and are most likely due to the proximity of Moffett Field to the San Francisco Bay and the salt evaporation ponds. The chemicals selected in this section will be quantitatively evaluated in the exposure assessment.

For reference purposes, risk was estimated on the basis of background soil concentrations for Moffett Field as listed in Table 3.5-2. Potential risks and hazard quotients associated with soil ingestion and inhalation of fugitive dusts were calculated for both occupational and residential scenarios. The results of this assessment are presented in Section 20.6.

20.2.13 Uncertainties

Uncertainties associated with the collection and laboratory analysis of the sampling data may impact the results of the selection process. These uncertainties result from contamination of samples during collection, preparation, or analysis, and normal error in analytical techniques. Uncertainties are addressed by the selection process for chemicals of potential concern. Compounds detected infrequently (5 percent of the time or less) or at levels close to those in the associated blanks were assumed to be artifacts produced during sample collection or analysis and were deleted from the final list of chemicals of potential concern. This results in a list of chemicals of potential concern that have been found most consistently and at the highest concentrations. This selection process is consistent with current EPA guidance (EPA, 1989b).

Due to analytical constraints, it is possible for chemicals that have been detected only sporadically to contribute significantly to potential risks if they are actually present in samples

below the CRQL. Chemicals that have CRQLs associated with potential risks above the lower limit of acceptable risk have been carried through the risk assessment separately. The results of this assessment of potential false negatives (PFN) are presented in Section 20.6 along with the results for the chemicals of potential concern. Naturally occurring (background) concentrations of metals may present a risk at some sites. Therefore, background metals have also been carried through the risk assessment separately from the chemicals of potential concern. These "background risks" are also presented in Section 20.6.

20.3 Exposure Assessment

The estimation of potential exposures of human and environmental receptors to chemicals found at the site is presented in this section. Exposure is defined as the contact of a receptor with a chemical. Exposure assessment is the estimation of the magnitude, frequency, duration, and route of exposure. The magnitude of an exposure is determined by estimating the amount of a chemical available at the receptor exchange boundaries (lungs, gastrointestinal [GI] tract, or skin) during a specified time period. The general procedure for conducting an exposure assessment is (EPA, 1989b):

- Characterization of exposure setting
- Identification of exposure pathways
- Estimation of exposure.

20.3.1 Characterization of Exposure Setting

This section summarizes the physical characteristics of OU2 as well as the populations, both human and environmental, living on or near OU2 that may be affected by the site. A complete physical description of OU2 is given in Chapter 3.0 of this report.

20.3.1.1 Physical Setting

Moffett Field's proximity to the San Francisco Bay and the Pacific Ocean is a major component in the climatology, hydrology, biota, and, to a lesser degree, physiography of the area. Figures 1.4-1 and 1.4-2 show the location of Moffett Field. The physical setting for Moffett Field is briefly described in the following paragraphs.

Surface Features. Moffett Field is situated on a nearly flat interfluvial basin deposit of Holocene and Pleistocene ages. Elevations at Moffett Field range from about 36 feet above msl to 2 feet below msl.

No natural surface water features exist on Moffett Field. To the north, Moffett Field abuts the Cargill Salt Company evaporation ponds and the San Francisco Bay. The Coyote River and Guadalupe River drain into San Francisco Bay to the east of Moffett Field and Stevens Creek drains into the Bay to the west.

San Francisco Bay, California's largest estuary, forms the northern boundary of Moffett Field. Historically, tidal salt marsh and mud flats covered extensive areas of the southern portion of the Bay; however, most have been eliminated or greatly altered. The large area to the north and northeast of Moffett Field was diked and is now bordered by commercial salt evaporation ponds. There are no streams on Moffett Field, although several streams are present to the east and west. With the exception of several small ponds maintained on the Moffett Field golf course as water hazards, no other surface water features, except for standing water after flooding or heavy rainfall, are present at Moffett Field.

Meteorology. Moffett Field has a Mediterranean-type climate. It is subtropical with relatively dry summers and cool winters. Temperature extremes are modified by the influence of the Pacific Ocean and the San Francisco Bay. Cool valley breezes help keep the average annual temperature at 58°F. September has an average high of 65°F, and January has a mean low temperature of 45°F. Maximum temperatures have been recorded above 100°F in June and September, and minimum temperatures have been as low as 22°F in December and January. Humidity averages 74 percent, with daily highs of 85 percent and lows of 60 percent. Winds are usually moderate from the north and southwest during the day and westerly during the evening. The average annual wind velocity is 7 miles per hour. Precipitation is seasonal. The maximum monthly average precipitation of 2.5 inches occurs during December and January and decreases during the spring and fall to between 1 and 2 inches per month. The summer dry period starts in May and extends through September. The average annual rainfall is 13.2 inches (WESTDIV, 1985).

Soil Characteristics. The U.S. Soil Conservation Service (1967 and 1968) has identified two different soil associations on Moffett Field: the Reyes-Alviso Association and the Sunnyvale-Castro Association. The Reyes-Alviso Association consists of very poorly drained, fine-textured soil developed in gleyed, fine-textured alluvium; the association occupies the level tidal flats of the Bay. The Alviso soils constitute about 85 percent of the association and are dark gray to gray silty clay subsoils. Underlying alluvium is stratified with thin, discontinuous lenses of organic matter.

The Sunnyvale-Castro Association consists of poorly drained, fine-textured soils developed on gleyed, noncalcareous, fine-textured alluvium. The association occupies nearly level, topographically low positions of interfluvial basin deposits. These soils are very deep, slightly permeable, and are saturated at depth. Sunnyvale soils, which constitute about 50 percent of the association, have calcareous, dark gray, granular, silty clay surface soils and have strongly calcareous, gray silty clay subsoils. Castro soils, which make up about 35 percent of the association, have very dark gray, calcareous, clay surface layers and gray, partially lime-cemented subsoils. Underlying alluvium is gleyed, noncalcareous, and fine grained.

Vegetation. Moffett Field is situated on a gently sloping tidal basin area of old mud flats once covered by tidal marsh plants. This scene is still typical of some of the areas north of Moffett Field; however, diking, construction of salt evaporation ponds, and filling activities have considerably decreased the marsh habitat and has limited it to narrow buffer zones along the fringes of sloughs. Typically, cordgrass resides in the low tidal zones and gives way to pickleweed, salt grass, and other salt-tolerant plants on drier ground. This vegetation occurs mainly along Stevens Creek and Guadalupe Slough. The brackish water marsh vegetation occurs abundantly along the northern portion of Moffett Field, and where salt concentrations are low, the vegetation gives way to cattails and sedges. Where salt concentrations are low and sites are relatively dry, opportunistic (ruderal) vegetation invades. Common plants that occur on these sites are cranesbill, sweet clover, vetch, mustard, thistle, and sweet fennel along with a variety of grasses.

Regional Geology. Moffett Field is located in a large northwest-trending trough (Santa Clara Valley) formed predominantly during the Pliocene age (5 million years ago) and is associated with the Coast Range of California (ESA, 1986b). The valley is bordered on the west by the Santa Cruz Mountains and on the east by the Diablo Range. The valley gently slopes to the northwest and is filled with unconsolidated to semiconsolidated sediments. Near the center of the valley the sediments are more than 1,500 feet thick and thin near the margins (Iwamura, 1980). The northwestern portion of the trough has been intermittently inundated by seawater over the past million years and now forms the southern area of San Francisco Bay, which includes Moffett Field (Helley et al., 1979).

During the colder periods of the Pleistocene age, ice accumulated in the polar regions, resulting in a sea level that was as much as 400 feet below the present day levels in the San Francisco Bay area. During these periods of low water, the alluvial deposits from the

mountain ranges to the east and west of the trough moved downslope. The alluvial deposits, consisting of gravel, sand, and silt, were interbedded with marine sediments consisting of fine-grained clays and silt. The average rate of alluvial deposition near Sunnyvale, California was about 5 inches per 1,000 years (Meade, 1967). About 10,000 years ago the sea reentered the Bay and gradually rose to its present elevation, which has been maintained for the past 6,000 years.

Local Geology. The local geology represents the events that occurred during the Pleistocene (1,800,000 years to present) and Holocene (10,000 years to present) ages, but on a limited areal scale. The area underlying Moffett Field consists of interfingering of alluvial sediments and estuary deposits. The most recent alluvial-estuary sediments are coarse to fine grained and are derived from the Santa Cruz Mountains, southwest of Moffett Field. The gently sloping alluvial fans merge with the basin, tidal, and shallow marine deposits in and around the location of Moffett Field.

Surface geologic maps generated by Helley and Brabb in 1971 and modified by Iwamura in 1980 show alluvial fan deposits extending toward the basin (northeasterly) approximately to the Bayshore Freeway (Highway 101). North of Highway 101, interfluvial finer-grained deposits predominate with the San Francisco Bay being fringed by bay mud. The southward change near Highway 101 is from finer interfluvial deposits to coarser fan sediments and is approximately coincident with a steepening of the topographic slope toward the highlands. The topographic profile at and around Moffett Field is typical of bayland and alluvial fan interfingering systems. Drilling at Moffett Field did not penetrate the total thickness of the alluvial fan material (1,000 feet bls), but it is assumed to be more than 1,500 feet thick (Iwamura, 1980).

Regional Hydrogeology. The Santa Clara Valley groundwater basin occupies one of the large, northwest-trending valleys in the Coast Range of California (ESA, 1986b). The Santa Clara Valley is a gently northward-sloping trough and is filled with unconsolidated to semiconsolidated sediments as much as 1,500 feet thick near the center of the valley (Iwamura, 1980), then thins to feather edges along the margins. The Santa Cruz Mountains and the Diablo Range form the western and eastern boundaries of the valley and its corresponding groundwater basin.

The unconsolidated basin-fill deposits consist of interbedded layers, tongues, and lenses of gravel, sand, silt, and clay. The coarser-grained sands and gravels that readily transmit

groundwater (aquifers) were deposited in the channels of streams and in estuarine channels by relatively fast-moving water. The finer-grained clay and silt that restrain or restrict groundwater flow (aquitards) were deposited in slow-moving or still water in the open bay as well as in relatively flat estuarine and interfluvial marsh areas. Individual beds generally are thin and of limited areal extent as a result of lateral shifts of channels on the alluvial fans in estuaries in deltas along the margins of the San Francisco Bay. Major transgressions of the Bay resulted in more regionally extensive fine-grained deposits.

As a result of the ingress and egress of salt water and the continual erosion of the nearby hills and mountains, three distinctive sequences containing several aquifers developed. For ease of understanding, an alphanumeric aquifer nomenclature was introduced by HLA (1987b). The upper sequence contains two definable aquifers: A and B. This subdivision is further supported by Helley (1990) when he states that a nonconformity exists at the depth between the A and B aquifers. The A aquifer may be further divided into the A1- and A2-aquifer zones and an A1/A2 aquitard. The A-aquifer zones are generally thin and discontinuous and are made up of material ranging from silty sand to coarse gravel. The B aquifer contains three distinct zones, which are called the B1, B2, and B3, with the B3 being the lowest in relative elevations (HLA, 1987a). Each of these aquifer zones also has a distinct aquitard between them. The B1-aquifer zone appears to grade into the A2-aquifer zone as the geologic environment changes from alluvial to estuarine. The B-aquifer zones also consist of material ranging from silty sand to coarse gravel. In certain areas of the alluvial fans the lower aquifer sequence is denoted as the C aquifer, and although it contains many alternating coarse- and fine-grained layers and extends to greater than 1,000 feet in depth, because of limited data, it has not been subdivided into individual water-bearing units.

Local Hydrogeology. The hydrogeologic setting in the vicinity of Moffett Field consists of alluvial sand aquifers or sand and gravel aquifers, which are separated by low permeability silt and clay aquitards. These aquifers and aquitards are defined as highly complex braided and meandering stream systems (paleochannels) within estuarine and deltaic environments.

In the interior of the Santa Clara Valley, the aquifers defined by Iwamura (1980) are further divided into zones and sequences: the upper aquifers (A and B) and the lower aquifer (C). The distinction between the two aquifer sequences is that the upper aquifer is generally unconfined, although in places it acts as semiconfined, and the lower aquifer is semiconfined under a laterally extensive clay aquitard at depths of 140 to 200 feet bls.

The upper aquifer has been subdivided into four zones: A1, A2, B2, and B3, and into three aquitards: A1/A2, A2/B2, and B2/B3. The lower aquifer is composed of the C aquifer and the B/C aquitard.

Aquifers in the upper zone (A and B) are generally thin and discontinuous. Materials range from silty, to fine sand, to coarse gravel. The A and B aquifers are not pumped for beneficial uses because they produce only brackish water over most of Moffett Field.

Lower Aquifer. The aquitard between the B and C aquifers is the most laterally extensive and correlatable unit in the area. The B/C aquitard material is generally 20 to 100 feet thick and consists of blue and yellow clay (Navy Department, Bureau of Yards and Docks, Drawing 112,977, January 27, 1932). The extensive amount of aquitard material and consolidation due to loading contribute to the flowing artesian condition of the aquifer. Wells that were used for water supplies at Moffett Field were drilled to a total depth of 1,000 feet bls.

The C aquifer has historically been the primary source of groundwater in and around Moffett Field for agricultural and drinking water. Today, Moffett Field receives its drinking water from a public source (Hetch-Hetchy). Only one well is used for agricultural water on Moffett Field.

20.3.1.2 Receptor Assessment

The objective of this receptor assessment is to identify potential human populations that may be exposed to site-related chemicals at Moffett Field under current and future land-use conditions. The assessment considered both residential and occupational populations and their relationship to the potential migration pathways for site-related chemicals.

Off-Site Demography and Land Use. For the past several thousand years, the Santa Clara Valley has been influenced by four sequential cultures: Indian, Spanish, Mexican, and American. The area evolved from a grassland/forest wilderness environment populated by Indians, through an agricultural era during the Spanish mission and land grant period, followed by the Mexican mission period after Spanish withdrawal, to the current "modern" times of intense light industrial and urban development.

Presently, more than 1.3 million people reside in Santa Clara County and the population is continuing to grow. Moffett Field is bordered by the cities of Mountain View and Sunnyvale, California. The city of Mountain View is located on the west side of Moffett Field.

Mountain View was primarily an agricultural community until the 1930s. Since the U.S. Navy commissioned Moffett Field in 1933, Moffett Field and the NASA-ARC have been two of the largest employers in the area; the other main industry is electronics. During the past 15 years, many electronics firms have established themselves in and around Mountain View. Presently, Mountain View's residential population of 61,000 increases to 120,000 during business hours when "Silicon Valley" workers commute into the area.

The city of Sunnyvale is located east of Mountain View and is adjacent to the southern border of Moffett Field. The population of Sunnyvale is more than 114,000, and like Mountain View, the population increases during working hours. There are more than 525 manufacturers/wholesalers in Sunnyvale. The leading types of industry are research and development, high technology, and aerospace. Lockheed is the largest employer, with a work force of approximately 25,000 persons.

Lockheed is the eastern neighbor to Moffett Field. The firm is involved in designing and manufacturing missile and space systems. It has designed and built several submarine-launched missile systems and has worked with Moffett Field on various electronic systems installations in patrol aircraft.

The salt evaporation ponds located to the north of Moffett Field are anticipated to continue operations for the foreseeable future (WESTDIV, 1985). The present industrial and research parks are also expected to continue operations into the foreseeable future (WESTDIV, 1985). Undeveloped lands located near Moffett Field are currently zoned for industrial and research park development (WESTDIV, 1985). The air traffic into Moffett Field has limited area land use in the past; this limitation is expected to remain until Moffett Field is decommissioned because the runway will remain open for NASA use.

On-Site Demography and Land Use. The current mission of Moffett Field is to support antisubmarine warfare training and patrol squadrons. Today more than 5,500 military, 1,500 civilian, and 1,000 reservist personnel support nearly 100 P-3C Orion patrol aircraft assigned to nine squadrons (WESTDIV, 1985). Although no heavy manufacturing or major aircraft maintenance is performed at Moffett Field, a significant amount of unit and intermediate level maintenance is accomplished (WESTDIV, 1985).

Approximately 1,500 acres of land at Moffett Field are used for operations, training, ordnance storage, maintenance facilities, personnel support facilities, and single-person and family

housing (WESTDIV, 1985). An additional 160 acres is leased for agricultural use as part of Moffett Field's ongoing land management planning program. Land uses at Moffett Field are divided in half by the runway system. The aircraft and flight operations are on the east side of the runway, and the personnel support operations and housing are on the west side (WESTDIV, 1985).

Moffett Field has been listed for closure in the future; therefore, future land use will differ from the current military use. The most likely future use is as an expanded facility for NASA-ARC. Potential future uses include use as an airport with aircraft maintenance, industrial development, or residential development. Because definitive information does not exist to indicate that future development will not be residential, a residential scenario has been used as a worst-case assumption for future land use at OU2.

20.3.2 Identification of Potential Exposure Pathways

For exposures to occur, complete exposure pathways must exist. A complete exposure pathway requires (EPA, 1989b):

- A source and mechanism for release of the chemical
- A transport medium
- A point of potential human or environmental contact
- An exposure route at the exposure point.

If any one of these four components is missing, the pathway is generally not complete. The transport medium may be missing and the pathway still be complete if the point of contact is directly at the release of the chemical.

20.3.2.1 Sources and Receiving Media

The potential source areas that make up OU2 at Moffett Field are described in Section 20.1-4. OU2 is defined as the soils (above the water table) at these sites. The primary release mechanisms for chemicals in soil are:

- Fugitive dust generation and deposition
- Tracking of soils by foot or vehicle traffic
- Volatilization
- Surface runoff following precipitation
- Leaching to groundwater
- Uptake by biota.

Fugitive dust generation and deposition, tracking, and surface runoff all contribute to the movement of chemicals from the source areas to nearby surface soils. A discussion of the extent of contamination from each source area is given in Chapters 4.0 through 18.0 of this RI.

In some cases, if the complete extent of contamination has not been determined, and the risk assessment shows significant risks associated with a source area, it may be necessary to further characterize the extent to which the contaminated soils have been carried. For those sources that represent significant risks, remediation of the source will prevent further soil movement.

Chemicals may be released to the air via volatilization or fugitive dust. The potential for these releases to adversely impact potential receptors is discussed in Section 20.3.2.3. Chemicals in soil may act as a source for releases to groundwater as a result of leaching. The presence of a large regional groundwater contaminant plume at Moffett Field makes the evaluation of possible past leaching from OU2 soils difficult. Future leaching may be evaluated through the use of mathematical models as described in Section 20.3.2.2.

Chemicals in soil may be released to surrounding biota as a result of direct contact/dermal absorption (especially for plants and soil dwelling fauna such as earthworms), ingestion of the soil or plants growing in the soil, or inhalation of fugitive dust or volatiles. Directly exposed plants and animals may then act as a source to other biota.

20.3.2.2 Fate and Transport

After a chemical is released to the environment, it may be:

- Transported
- Physically transformed (e.g., volatilization, precipitation)
- Chemically transformed (e.g., photolysis, hydrolysis, oxidation, reduction, etc.)
- Biologically transformed (e.g., biodegradation)
- Accumulated in one or more media.

The potential fate and transport of the chemicals of potential concern identified at Moffett Field OU2 is described in Chapter 19.0 of this RI Report. The most important transport mechanism for the chemicals in the soil at OU2 is leaching to groundwater as a result of rainfall and percolation through the soil. The potential for chemicals to leach to groundwater may be estimated through the use of mathematical models. These models range from simple

screening level models, which require very little site-specific data and give "worst-case" estimates of leaching potential, to sophisticated numerical simulations that require large amounts of site-specific data and provide more realistic estimates of leaching potential. All mathematical models have varying levels of concentrations associated with their use.

For the soils at Moffett OU2, a screening level approach was used. The Summer's model described in Chapter 19.0 was used to estimate an acceptable soil concentration (that would not result in groundwater contamination above California state or federal MCLs) at each site. This model is designed to overestimate leaching potential by disregarding loss mechanisms such as chemical/biological decay and volatilization and by assuming that 100 percent of the local precipitation is available for chemical transport (none is lost to evapotranspiration, plant uptake, or surface runoff). Leaching potential is further overestimated by assuming that the entire area of each site is contaminated at the upper 95 percent confidence limit concentration for each chemical of potential concern. The purpose of this overestimation is to compensate for the uncertainties inherent in the modeling and to provide a screening level for chemicals in soil that is sufficiently health-protective. By using this conservative model, it can be assumed that any site that has estimated soil concentrations below the screening level set by the model will not result in significant risks as a result of groundwater contamination.

20.3.2.3 Potential Exposure Pathways

Once all potential exposure pathways have been identified, the potentially significant ones are selected for a more detailed evaluation. EPA guidance for performing risk assessments (EPA, 1989b) suggests eliminating an exposure pathway from detailed analysis when there is sound justification for elimination (e.g., based on the results of a screening analysis). EPA risk assessment guidance (EPA, 1989b) offers examples of justification for eliminating exposure pathways, including:

- "The exposure resulting from the pathway is much less than that from another pathway involving the same medium at the same exposure point."
- "The potential magnitude of exposure from a pathway is low."
- "The probability of the exposure occurring is very low and the risks associated with the occurrence are not high."

Potentially complete exposure pathways depend on a large number of site-specific circumstances including:

- The types of chemicals detected at the site - for example, if the chemicals of potential concern at a site do not include any volatile compounds, inhalation of VOCs is not applicable at that site.

- The type of groundcover present at the site - if the site is covered with asphalt or concrete, there may be no completed pathways. If the site is grass covered (or heavily vegetated with some other cover), fugitive dust may not be applicable because fugitive dust emissions are greatly dependent on the type and quantity of vegetative groundcover. Gravel cover will also inhibit the release of fugitive dust and generally prevents direct contact but will not prevent VOC emissions.

- The type of activities at the site - for example, even if an area has vegetative or gravel groundcover, if heavy equipment (e.g. tanks) is used, fugitive dust may be an important pathway.

All of these factors have been taken into account in selecting the exposure pathways which may be complete at each site. As recommended by EPA (1989b), some pathways may be complete but their contribution to total exposure is negligible compared to other pathways. These pathways are discussed in the risk assessment but not quantified.

Fugitive dust comprises particulates of different aerodynamic diameters, some of which are respirable (generally less 10 μm in diameter). The larger particulate fraction is not considered to be respirable into the deep lung. In this risk assessment, the conservative assumption was made that all fugitive dust is of a respirable size.

There are two types of exposure pathways for chemicals in soil:

- Direct Pathways - Receptors may be exposed to chemicals in surface soils via incidental ingestion of contaminated soil or direct external contact with contaminated soil.

- Secondary Pathways - Receptors may be exposed to airborne constituents from soil. The transport of chemicals from soil to the air begins with either the resuspension of contaminated particulates or the emission of volatile chemicals from the soil. Airborne chemicals are subsequently dispersed in the environment by winds.

  Exposure may also occur via consumption of produce grown on contaminated soil, and meat and milk from livestock that ingest contaminated soil, or crops grown in this soil. In addition, exposures may occur via contact with other media contaminated through erosive forces (i.e., surface water) or water percolation and leaching of contaminants from the soil to groundwater.

The direct pathways are important only for surface or near-surface soils. Near-surface soils available for contact may be defined as being up to 10 feet deep. This includes soils that may be contacted during construction activities. The incidental ingestion pathway is especially important for children under the age of 6 years because they have the greatest tendency to ingest soil. This juvenile exposure pathway is only expected to involve soils down to 1 foot deep because young children are not expected to be present at construction sites.

The food chain pathways are also applicable only for surface or near surface soils. Volatile chemicals may migrate to the surface from any soil depth; however, the emission rate at the surface drops off sharply with the depth of the contaminated soil and becomes negligible for contaminated soil more than 1 to 3 feet deep. Leaching of chemicals to groundwater may occur regardless of the depth of contamination.

There are currently no livestock at Moffett Field OU2; therefore, this pathway will not be considered further for current exposures at any of the sites. There are also no crops currently being grown for human consumption at OU2; therefore, this pathway will not be considered further. Vegetable ingestion is considered as a possibility if there is future residential development; however, current residential land-use development around Moffett Field tends toward condominiums and other multiple occupancy dwellings. These types of housing generally do not have gardening plots available. This assumption is based on inspections of the area and aerial photographs.

All identified potential exposure pathways for OU2 are summarized in Tables 20.3-1 through 20.3-9. Additionally, a conceptual model for potential exposures at Moffett Field is included as Figure 20.3-1. A brief explanation of the rationale for the inclusion or exclusion of each pathway in the quantitative risk assessment for each site is given in the following sections.

Site 3 - Marriage Road Ditch. The potential exposure pathways at Site 3 are summarized in Table 20.3-1. Given the present conditions at the site, potentially exposed populations may include occupational populations such as personnel working in the Marriage Road Ditch and construction crews working within an excavation at the site. Marriage Road Ditch transects a golf course; therefore, older children (more than 6 years old) or adults may be in the area and may be exposed to site-related chemicals (recreational exposure).

Exposure pathways for occupational populations include dermal contact and incidental ingestion of the soils as the result of hand-to-mouth activity. Personnel working in the ditch or within an excavation may come in direct contact with sediments or chemical-bearing soils. Recreational receptors may also be exposed via these pathways.

Potential exposure via dermal exposure with the water in the ditch may occur at this site; however, the chemicals present in the water would consist primarily of inorganics because the primary organic compounds present in the soils are not readily soluble in water. Inorganics are not readily absorbed through the skin; therefore, potential exposure via dermal contact to chemicals in the water is not considered to be significant relative to uptake via other pathways. The water in the ditch is not deep enough to allow swimming; therefore, children are not likely to be exposed via inadvertent ingestion of water while swimming.

The grass and water present in the ditch is expected to prevent wind erosion from occurring; therefore, potential exposure via inhalation of windborne particulates is not considered to be a viable pathway. Potential exposure via inhalation would be limited to inhalation of organic compounds by individuals working within an excavation. Persons working within an excavation may be exposed to organic chemicals vaporizing from the surrounding soils. Inhalation of fugitive dust has historically been an insignificant exposure pathway for a limited excavation scenario.

Future land use at this site is not likely to include development as a residential area or for industrial use; however, as a conservative measure, future residential and industrial uses are assumed in this assessment. Exposure pathways that may be present under a residential exposure scenario include dermal contact with soils, inadvertent ingestion of soils, and potential exposure via consumption of foods grown at the site. Adults or children living in the area of the site may come in direct contact with the soils located in their yard or near their residence. This would result in exposure via dermal uptake of chemicals and inadvertent ingestion of the soils. If a garden is planted at this site, fruits and vegetables may bioaccumulate site-related compounds, resulting in exposure via consumption of the homegrown food. If the site is developed for residential use, the area would be covered either by structures or grass. Vegetative groundcover reduces the potential for fugitive dust emissions from soils for several reasons:

- The root structure stabilizes the soil making greater wind force necessary for emissions.

- Vegetation reduces the wind velocity at the ground surface.
- Vegetation reduces evaporative water loss from the soil. Increased moisture decreases the potential for fugitive dust emissions.

For these reasons, fugitive dust is not considered a significant exposure pathway where groundcover is present. A solid cover (such as grass) has been proven to profoundly reduce fugitive dust emissions (GRI, 1986).

Emissions of VOCs are dependent on the volatility of the individual chemicals, the absorption of the chemicals to the soil, and the air and soil temperature. Soil moisture can affect the absorption of chemicals to the soil particles and chemicals may absorb or be taken up by plant roots; therefore, vegetative groundcover may also have some effect on VOC emissions. The magnitude of this effect is unknown. Because of this uncertainty, exposure via inhalation of windborne particulates is unlikely for a future residential scenario; however, inhalation of VOCs may occur where significant VOC contamination is present.

Chemicals present in the soils may leach into groundwater. If the groundwater in the A aquifer underlying the site is used as a residential water source, inhabitants may be exposed to site-related chemicals via drinking water.

Site 4 - Former Wastewater Holding Pond. The potential exposure pathways at Site 4 are summarized in Table 20.3-2. Current potentially exposed populations at this site would be restricted to occupational populations. Individuals working at the site may be exposed via dermal contact with the soils, inadvertent ingestion of soils, inhalation of organics volatilized from the soils, or inhalation of chemicals absorbed onto windborne particulates. Given the distance of the site from residential areas on the site and the type of operations in the area, it is unlikely that a nonmilitary resident at Moffett Field would be exposed to site-related chemicals.

Individuals working at the site may come in direct contact with chemicals in the surficial soils, resulting in exposure via dermal contact or inadvertent ingestion of soils. Organic compounds vaporizing from the soils may result in the exposure via inhalation of these organic vapors. Chemicals bound to soils may become airborne as the result of wind erosion. This may result in exposure through inhalation of these airborne particulates.

This site may be used as a residential development in the future. Should this occur, potential receptors may be exposed via dermal contact with soils, inadvertent ingestion of soils, inhalation of organic vapors, and ingestion of site-related chemicals bioaccumulated in homegrown foods. Residential development of the site would result in the area being covered by either structures or grass; therefore, exposure via inhalation of windborne particulates is unlikely.

Chemicals present in the soils may leach into groundwater. If the groundwater in the A aquifer underlying the site is used as a residential water source, inhabitants may be exposed to site-related chemicals via drinking water.

Site 5 - Fuel Farm French Drains and Bulk Tanks. The potential exposure pathways at Site 5 are summarized in Table 20.3-3. This facility consists of eight USTs and an abandoned network of French drains that were used to dispose of water and solvents used in cleaning the storage tanks. Chemicals of potential concern have been introduced via either the French drains or leaking USTs; therefore, these chemicals would be limited to subsurface soils. A potential receptor would be limited to an individual working within an excavation. Construction or maintenance personnel working within an excavation may be exposed via dermal contact with the soils, inadvertent ingestion of the soils, or inhalation of organic vapors resulting from volatilization of organic compounds.

Should this site be developed as a residential area, chemicals in the soils would remain isolated and the potential for exposure via direct contact, etc. would be unlikely. Chemicals in the soils, however, may leach into groundwater. If the A aquifer at this site is used as a drinking water source, inhabitants of the area may be exposed to site-related chemicals via drinking water.

Site 6 - Runway Apron. The potential exposure pathways at Site 6 are summarized in Table 20.3-4. The site was paved over in 1979 during enlargement of the apron; therefore, site-related chemicals are effectively isolated from all potential receptors with the exception of individuals working within an excavation. Construction or maintenance personnel working within an excavation may be exposed via dermal contact with the soils, inadvertent ingestion of soils, and inhalation of organic vapors resulting from volatilization of organic compounds.

Future use of this site may include development of the area as a residential area. Soils underlying the pavement may become exposed; therefore, residential receptors may be

exposed via direct contact with the soils (dermal uptake and inadvertent ingestion of soils), ingestion of chemicals that have bioaccumulated into homegrown foods, and inhalation of organic compounds that are vaporizing from the soil. If the site is developed for residential use, the area would be covered either by structures or grass; therefore, exposure via inhalation of windborne particulates is unlikely.

Chemicals in the soils may leach into groundwater. If the groundwater at this site is used as a drinking water source, inhabitants of the area may be exposed to site-related chemicals via drinking water.

Site 7 - Hangars 2 and 3. The potential exposure pathways at Site 7 are summarized in Table 20.3-5. This site is presently paved; therefore, site-related chemicals are effectively isolated from all potential receptors with the exception of individuals working within an excavation. Construction or maintenance personnel working within an excavation may be exposed via dermal contact with the soils, inadvertent ingestion of the soils, or inhalation of organic vapors resulting from volatilization of organic compounds.

Future use of this site may include development of the area as a residential area. Soils underlying the pavement may become exposed; therefore, residential receptors may be exposed via direct contact with the soils (dermal uptake and inadvertent ingestion of soils), ingestion of chemicals that have bioaccumulated into homegrown foods, and inhalation of organic compounds that are vaporizing from the soil. If the site is developed for residential use, the area would be covered either by structures or grass; therefore, exposure via inhalation of windborne particulates is unlikely.

Chemicals in the soils may leach into groundwater. If the groundwater at this site is used as a drinking water source, inhabitants of the area may be exposed to site-related chemicals via drinking water.

Site 10 - Runway Area. The potential exposure pathways at Site 10 are summarized in Table 20.3-6. The primary source of site-related chemicals in the runway area is the precipitation runoff.

Site-related chemicals in the runway area are present in the surface soils. Occupational populations that may be exposed include individuals working in the area and construction workers or contractors. Exposure routes would include direct dermal exposure, inadvertent

ingestion of soils, and inhalation of VOCs. A person working in the area may also be exposed via inhalation of chemical-bearing particulates that have become suspended as a result of wind erosion.

Residential receptors may be exposed to site-related chemicals that are absorbed onto windborne particulates; however, it is unlikely that such a receptor would be in the area of the runway. Both areas may be used for housing developments in the future.

Individuals living in the area of the runway in the future may be exposed to site-related chemicals via dermal contact with the soils, inadvertent ingestion of soils, inhalation of volatile organics, and potential consumption of homegrown foods from this site. If the site is developed for residential use, the area would be covered either by structures or grass; therefore, exposure via inhalation of windborne particulates is unlikely. Chemicals in the soils may leach into groundwater, resulting in exposure via drinking water should the A or B aquifer be used as a drinking water source.

Site 11 - Engine Test Stand Area. The potential exposure pathways at Site 11 are summarized in Table 20.3-7. Given the present conditions at the site, potentially exposed populations may include occupational populations such as personnel working at the area and construction crews working within an excavation at the site. Potential exposure pathways include dermal contact with the soils and inadvertent ingestion of soils and inhalation of VOCs. The size of the area impacted is approximately 75 feet by 45 feet; therefore, the contribution of particulate material to the atmosphere resulting from wind erosion at this site is not expected to be significant.

Should this site be developed as a residential area, future potential exposure pathways may include dermal contact with soils, inadvertent ingestion of soils, inhalation of VOCs, and ingestion of site-related chemicals via bioaccumulation into homegrown fruits and vegetables. If the site is developed for residential use, the area would be covered either by structures or grass; therefore, exposure via inhalation of windborne particulates is unlikely. The total dissolved solids (TDS) concentrations in monitoring wells at Site 11 exceeded the upper detection limit of 20,000 ppm. Potable water is defined as having less than 3,000 ppm TDS by the California State Water Resources Control Board (CSWRCB) (Resolution No. 88-63); therefore, potential exposure resulting from chemicals leaching into groundwater is not likely to occur at this site.

Site 13 - Equipment Parking Area (Building 142). The potential exposure pathways at Site 13 are summarized in Table 20.3-8. Given the industrial nature of the activities occurring in the area surrounding this site, potential receptors would be limited to occupational populations. These individuals may be exposed as a result of dermal contact with soils, inadvertent ingestion of soils, and inhalation of VOCs and windborne particulates bearing site-related chemicals.

Future land use at this site may include development as a residential area. Should this occur, potential receptors may be exposed via dermal contact with soils, inadvertent ingestion of soils, ingestion of homegrown produce, and inhalation of volatile organics. If the site is developed for residential use, the area would be covered either by structures or grass; therefore, exposure via inhalation of windborne particulates is unlikely.

Chemicals present in the soils may leach into groundwater. If the A aquifer underlying the site is used as a residential water source, receptors may be exposed to site-related chemicals via drinking water.

Site 19 - Underground Storage Tanks (2, 43 and 43). The potential exposure pathways at Site 19 are summarized in Tables 20.3-9a and 20.3-9b. A potential receptor for this site would be limited to an individual working within an excavation. The depth of all soil samples is given in Appendix A. The source of contamination at this site is underground. Construction or maintenance personnel working within an excavation may be exposed via dermal contact with the soils, inadvertent ingestion of the soils, or inhalation of organic vapors resulting from volatilization of organic compounds.

Should this area be developed as a residential community, chemicals in the subsurface soils would be isolated and the potential for exposure via direct contact and inhalation of volatiles would be unlikely; however, chemicals in the soils may leach into groundwater. If the A aquifer at the sites associated with Tanks 2 and 43 is used as a drinking water source, inhabitants of the area may be exposed to site-related chemicals via drinking water.

The drinking water pathway will not be considered a complete exposure pathway for the Tank 53 area. Due to the high TDS values in this area (approximately 20,000 ppm), the aquifer is not expected to constitute a potable water source.

Background Metals and PFNs. All potential occupational and residential exposure pathways evaluated for at least one site for current or potential future land use were included in the quantitative evaluation of background metals and PFNs.

20.3.3 Estimation of Exposure

This section describes the estimation of exposures for each of the site-related chemicals of potential concern that may be contacted by human receptors. The process involves:

- Determining the concentration of each chemical in the identified environmental medium at the point of human exposure
- Identifying applicable human exposure models and input parameters
- Estimating human intakes.

For each identified pathway, a reasonable maximum exposure (RME) scenario has been developed to give a reasonable upper-bound estimate of the potential magnitude of an individual exposure to chemicals from the site. The intent of the RME as defined by EPA (1989b) is to estimate a conservative exposure case (i.e., well above the average case) that is still within the possible range of exposures. This RME approach supersedes the previous EPA recommendation for evaluating an average and worst-case scenario. This RME is estimated from a combination of average and upper-bound exposure assumptions to result in a reasonable maximum. In addition to this RME scenario, an average exposure case has been evaluated.

20.3.3.1 Exposure Models

Three exposure routes were evaluated in this risk assessment: ingestion, inhalation, and dermal contact. The exposure models used are from the ***Risk Assessment Guidance for Superfund - Volume I: Human Health Evaluation Manual*** (EPA, 1989b) and are shown as follows.

<u>Ingestion (of soil, water, or produce)</u>

$$\text{Intake} = [(C_i)(IR)(F)(EF)(ED)]/[(BW)(AT)]$$

where:

Intake	=	Intake of chemical; through ingestion of medium (mg/kg-day)
C_i	=	Chemical concentration in medium i (mg/kg or mg/L)
IR	=	Ingestion rate for medium i (kg/day or L/day)
F	=	Fraction of ingested medium from contaminated source (unitless)

EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time, period over which exposure is averaged (days)

Inhalation

$$\text{Intake} = (C_i)(BA)(IR)(ET)(EF)(ED)/(BW)(AT)$$

where:

C_i	=	Chemical specific air concentration (mg/m^3)
BA	=	Bioavailability factor (unitless)
IR	=	Inhalation rate (m^3)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time, period over which exposure is averaged (days)

Dermal Absorption

$$AD = (C_i)(AdF)(Abs)(CF)(SA)(EF)(ED)/(BW)(AT)$$

where:

AD	=	Absorbed dose (mg/kg-day)
C_i	=	Chemical specific soil concentration (mg/kg)
AdF	=	Soil to skin adherence factor (mg/cm^2)
Abs	=	Chemical specific skin absorption factor (unitless)
CF	=	Conversion factor (kg/mg)
SA	=	Skin surface area available for contact (cm^2/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time, period over which exposure is averaged (days)

20.3.3.2 Exposure Parameters

There are three types of parameters that are used to estimate intake (EPA, 1989b):

- Chemical-related parameters (i.e., exposure concentrations)
- Parameters that describe the exposed population (e.g., contact rate, exposure frequency and duration, and body weight)
- Toxicity-related parameters (i.e., averaging time).

The exposure parameters are summarized in Tables 20.3-10 through 20.3-13. The selection of average or upper-bound values is explained in the following sections. Upper-bound values are generally 90th or 95th percentile values depending on data availability for that parameter. A combination of RME and average exposure parameters has been used in each scenario to result in a combined RME. Average or 50th percentile values are available for only a few exposure parameters.

Occupational Exposure Parameters. Four occupational scenarios were evaluated for this baseline risk assessment. These scenarios are based on potential current and future worker exposures at Moffett Field. These exposure pathways are: incidental ingestion of soil, dermal exposure to soil, inhalation of volatiles, and inhalation of fugitive dust.

Exposure concentrations are chemical-related parameters for the constituents of potential concern. The concentrations for chemicals detected in the OU2 soils are listed in Tables 20.2-1 through 20.2-9. An RME concentration was estimated as the upper 95th percent confidence limit of the arithmetic mean of the sampling data for each chemical of potential concern unless the upper 95th percent confidence limit value was greater than the maximum detected value. In this case, the maximum detected value was used for the RME. The average concentration was used for the average exposure case. For samples with no detectable concentration of a chemical, a value of one-half the detection limit was used to estimate the mean and upper 95th percent confidence limit. Concentrations in air due to volatilization and fugitive dust were modeled from soil concentrations as shown in Appendix E of this report. The upper 95th percent confidence limit or mean of the soil concentrations was used as the starting concentration in these models.

The population-specific parameters for all scenarios were based on EPA guidance (EPA, 1989b, 1989c, and 1991a). Population-specific exposure parameters are shown in Tables 20.3-10 and 20.3-11. For soil ingestion, an occupational soil ingestion rate of 50 mg/day was used for general occupational activities. Where construction activities occur, ingestion may be higher. Therefore, the occupational excavation scenario is a soil ingestion rate of 480 mg/day. The exposure frequency and exposure duration were site-dependent because of the different exposure scenarios at each site (Section 20.3.2.1). For current exposures at Sites 3, 5, 6, 7, and 19, an exposure frequency of 5 days/week was combined with an exposure duration of 4 weeks. The only exposures anticipated at these sites are a result of excavation activities, which are expected to be short-term (e.g., laying utility lines). An exposure frequency of 250 days/year and a duration of 25 years was assumed for Sites 4, 10, 11, and

13. Occupational exposures at these sites could occur as a result of routine, long-term occupational activities; therefore, these standard worker exposure parameters were used.

The estimated average body weight for an adult (70 kg; EPA, 1991a) was used for all sites.

For dermal contact, an occupational exposure area of 3,120 cm^2 representing the average adult's hands and arms was used for all sites where dermal soil exposure was an applicable pathway. This was combined with a soil-to-skin adherence factor of 1.05 mg/cm^2 (Driver et al., 1989), and a chemical-specific absorption factor (EPA, 1992b; McKone, 1990). Dermal absorption values for inorganics were estimated from a measured value for cadmium by applying a safety factor of 10. The measured value for cadmium was used for cadmium. Dermal absorption values were estimated for organics using the K_{ow} and Henry's Law constant for each chemical using a model developed by McKone (1990). The method of estimation is described in Appendix E; the dermal absorption values are listed in Table 20.3-10a. The exposure frequency and exposure duration are site-dependent. The same values were used for dermal exposure as described for soil ingestion. A body weight of 70 kg was used for all sites.

Inhalation exposures were estimated assuming an inhalation rate of 1.4 m^3/hour. This assumes that the worker spends half his/her time engaged in heavy activity and half his/her time engaged in moderate activity (EPA, 1989c). Workers were assumed to be present at the site 8 hours/day. All other exposure parameters were the same as those described for soil ingestion.

The toxicity-related parameters are averaging times, which depend on the toxic endpoint of the chemical of concern. For chemicals that are associated with noncarcinogenic effects, intakes were averaged over the duration of exposure. For chemicals that are associated with potential carcinogenic effects, intakes were averaged over the estimated lifetime of the receptor (70 years; EPA, 1991a).

Residential Exposure Scenarios. Five residential scenarios were evaluated for this baseline risk assessment. These pathways are based upon the potential for residential development of Moffett Field property in the future and include: ingestion of contaminated soil, dermal contact with soil, inhalation of volatiles, ingestion of homegrown crops raised in contaminated soil, and domestic use of groundwater contaminated by the leaching of site-related chemicals.

The concentrations for chemicals detected in the OU2 soils are listed in Tables 20.2-1 through 20.2-9. The residential RME concentration was estimated as the upper 95th percent confidence limit of the arithmetic mean of the sampling data for each chemical of potential concern, unless the upper 95th percent confidence limit value was greater than the maximum detected value. The mean exposure concentration was estimated as the arithmetic mean of the sampling data for each chemical of potential concern. Concentrations in air due to volatilization and crops grown in contaminated soil were modeled from concentrations in soil, as shown in Appendix E in this report. The upper 95th percent confidence limit of the mean or maximum detected concentration (whichever was lowest) in the soil was used as the starting concentration for the RME scenario. The average concentration in the soil was used as the starting concentration for the average exposure scenario in these models.

The population-specific parameters for the ingestion scenarios were based on EPA guidance (EPA, 1989b, 1989c, and 1991a). For soil ingestion, an ingestion rate of 100 mg/day was used with a diet fraction of 100 percent for adults. For children age 0 to 6 years, an ingestion rate of 200 mg/day with a diet fraction of 100 percent was used. Children were considered separately in developing exposure parameters due to their higher affinity for soil ingestion. Average body weights for children (age 0 to 6 years) of 16 kg (EPA, 1989c) and adults of 70 kg (EPA, 1991a) were used for this scenario.

For dermal contact, an exposed surface area of 8,170 cm^2, representing the average adult's hands, arms, and legs (EPA, 1989c), was used. This was combined with a soil to skin adherence factor of 1.05 mg/cm^2 (Driver et al., 1989) and chemical-specific skin absorption factors.

Values for consumption of homegrown produce have been estimated as 140 g/day for fruits and 200 g/day for vegetables with the "reasonable worst case" proportion of produce that is homegrown as 30 and 40 percent, respectively (EPA, 1991a). This results in ingestion rates of 42 g/day for fruit and 80 g/day for vegetables. Because home gardens more often contain vegetables than fruits, 80 g/day was used. The exposure frequency for all residential exposure scenarios is 350 days per year (EPA, 1991a). This value represents the number of days during the year that the resident spends at home. It is assumed that the resident leaves home for approximately 2 weeks of vacation per year. The exposure duration expresses the number of years that the resident lives in the same home. The 90th percentile value of 30 years was used for the exposure duration parameter (EPA, 1991a). The estimated average

body weight for an adult of 70 kg was used for all exposure scenarios except soil ingestion (EPA, 1991a).

The toxicity-related parameters are averaging times that depend upon the toxic endpoint of the chemical of concern. For chemicals associated with noncarcinogenic effects, intakes were averaged over the duration of exposure (30 years). For chemicals associated with potential carcinogenic effects, intakes were averaged over the estimated lifetime of the receptor (70 years; EPA, 1991a).

The existing groundwater contamination on the east side of Moffett Field has been addressed as OU5. Some of this groundwater contamination is due to sources other than Moffett Field; however, the contaminated soil at the OU2 sites may leach to the groundwater. There are three known aquifers (A [shallowest], B, and C) at Moffett Field. There are currently no wells in the area in the A or B aquifers and the completion of a well in these zones is unlikely. For these reasons, and because the high level of uncertainty involved in modeling vadose zone transport where the A aquifer is very shallow and soil may actually be contaminated by groundwater in some areas, the risks associated with groundwater use were not quantified. A vadose zone model was used to estimate acceptable soil concentration based on acceptable groundwater concentrations (MCLs) (Table 20.3-14). This model and the associated parameters are described in Appendix E of this report.

Recreational Exposure Scenario. One recreational scenario was evaluated for this baseline risk assessment. The pathways are based on the potential for a child to be playing in Marriage Road Ditch (Site 3) and include ingestion of contaminated soils. It is assumed that the potential receptor is a child age 5 to 10 years. Adults were not considered for this scenario because they are not expected to play in the ditch (adult workers are considered in the occupational scenario). Very young children (less than 5 years old) are not assumed to play this far from home.

The concentrations for chemicals detected in the Site 3 soils are listed in Table 20.2-1. The recreational RME concentration was estimated as the upper 95th percent confidence limit of the arithmetic mean of the sampling data for each chemical of potential concern unless the upper 95th percent confidence limit value was greater than the maximum detected value. The recreational average exposure concentration was estimated as the arithmetic mean of the sampling data for each chemical of potential concern.

The population-specific parameters for the ingestion scenario were based on EPA guidance (EPA, 1989b, 1989c, and 1991a). For soil ingestion, an ingestion rate of 140 mg/day was used along with a diet fraction of 100 percent. This assumes that the receptor consumes 200 mg/day for 2 years (ages 5 and 6) and 100 mg/day thereafter (EPA, 1991a). The bioavailability of constituents in soils is assumed to be 100 percent. An average body weight for children age 5 to 10 years is 25 kg (EPA, 1989c).

For this risk assessment, it was assumed that a child visited the site once a week for 50 weeks. A 2-week family vacation was assumed (EPA, 1991a). An exposure duration of 5 years was used, assuming that military personnel would be transferred to another assignment after 5 years based on proposed base closure.

20.3.4 Results

The results of the quantitative exposure assessment are shown in Tables 20.3-15 through 20.3-110. In general, the highest predicted exposures for current land use are associated with inhalation of VOCs where highly volatile compounds are present. For less volatile constituents, incidental ingestion of soil represents the greatest contribution to predicted intakes. Ingestion at construction sites involving earth moving may result in higher intakes. The estimated intakes for dermal exposure are similar to those predicted for ingestion but in most cases are slightly lower. When inhalation of fugitive dust is a complete exposure pathway, its contribution to total intake is negligible compared to the other exposure routes.

The highest predicted exposures for future land use are associated with ingestion of vegetables grown in contaminated soil. This is due, in large part, to the conservative nature of the uptake model used. The relative contribution to total intake from the other exposure pathways (inhalation of VOCs, soil ingestion, dermal contact, and inhalation of fugitive dust) is similar to those described previously for current land use.

20.3.5 Uncertainties

Three major types of uncertainties should be considered when reviewing the results of the exposure assessment: uncertainties associated with predicting future land use, uncertainties associated with estimating chemical concentrations at receptor locations, and uncertainties associated with assumptions used in the exposure models. Physiological (e.g., body weight, inhalation rate, etc.) and behavioral (e.g., average time spent in one place, amount of soil ingested) values used to model the RME are a combination of average and upper-bound levels

taken from reliable sources. The use of upper-bound estimates will tend to overestimate exposure. This provides a conservative health-protective approach for the risk assessment.

20.4 Toxicity Assessment

To understand the potential health risk associated with a potentially hazardous chemical, information on chemical-specific toxicity is required. Toxicity information is used in conjunction with the results of the exposure assessment to characterize potential health risks at OU2. EPA provides information on the toxicity of chemicals in two forms: for carcinogens, a cancer slope factor (CSF) is used to describe the dose-response relationship; for noncarcinogenic toxicants a threshold dose, or reference dose (RfD), is used to describe the dose above which adverse health effects may be observed. For carcinogens the endpoint of concern is always cancer. For noncarcinogens, the toxic endpoint (e.g., kidney effects) may vary among chemicals and routes of exposure (e.g., ingestion and inhalation).

The process used by EPA to evaluate potential chemical carcinogens assumes that no threshold levels exist below which a carcinogen will not cause cancer; that is, any exposure to a carcinogen results in the possibility of cancer. This is a conservative assumption because many potential human carcinogens, especially chlorinated solvents, appear to be cancer promoters and will increase the possibility of developing cancer in the presence of a cancer initiator. Using the no-threshold linearized multistage model, EPA determines slope factors to describe the potency of a carcinogen. A larger slope factor indicates a greater potency. In addition, EPA qualitatively evaluates potential carcinogens according to weight-of-evidence from epidemiological studies and animal studies. The classes are:

- Class A - Human carcinogen
- Class B1 - Probable human carcinogen, limited evidence of carcinogenicity in animals
- Class B2 - Probable human carcinogen, sufficient evidence in animals, inadequate evidence in humans
- Class C - Possible human carcinogen, limited evidence in animals
- Class D - Not classifiable.

In general, it is assumed that for noncancer-causing toxicants, a threshold intake exists below which no toxic effects can be observed. This intake, or dose, can be determined by reviewing data from human exposures (usually in occupational settings) or animal exposures to

chemicals. From these studies, a no-observed-adverse-effect-level (NOAEL) or lowest-observed-adverse-effect-level (LOAEL) can be determined. Once an NOAEL or LOAEL dose has been established, EPA applies uncertainty factors to ensure the safety of human health. Uncertainty factors of 10 each may be applied (1) if the NOAEL study was an animal study, (2) if a subchronic study is used to estimate chronic exposures, (3) to protect sensitive human populations, and (4) if an LOAEL is used in lieu of an NOAEL.

This section provides information on the toxicity of the chemicals of potential concern at Moffett Field. EPA has evaluated available dose-response data and results are provided on the ***Integrated Risk Information System*** on-line database (EPA, 1992b), and in the ***Health Effects Assessment Summary Tables*** (EPA, 1991b). CSFs and RfDs are taken from these databases. Chemical-specific chronic and acute toxicity values from these sources, along with the critical effect or target organ, carcinogenic weight of evidence, uncertainty factors, and tested species are listed in Tables 20.4-1 and 20.4-2 for all chemicals of potential concern. Solubility, vapor pressure, and log K_{ow} are also provided in these tables. None of the chemicals of concern has any known toxic effect via the dermal route, which is different from the oral; thus the oral and inhalation values only are shown. Dermal values are derived from the oral values as recommended by EPA (1989b) using oral absorption factors from Jones and Owen (1989). For those chemicals for which no RfD was available from EPA, an evaluation of their possible toxicity is described in the following sections. Chemicals that lacked data on carcinogenicity were assumed not to be carcinogenic.

20.4.1 Lead

EPA has published no oral or inhalation RfDs for lead because its toxicity is not thought to demonstrate a threshold. The California Department of Toxic Substances Control (DTSC) (1992) model (the California lead model) for estimating blood lead concentration has therefore been used for assessing the potential health risks from inorganic lead in the soil at Moffett OU2. The DTSC (1992) established a blood lead concentration in children or adults of 10 µg/dl as the concentration of concern, and further specified that a 0.01 risk of exceeding this value is the point of departure for risk management.

20.4.1.1 Overview of the Model

The California lead model is a set of equations that have been formatted to a computer spreadsheet. The equations estimate the contribution to blood lead concentration resulting from exposure to lead by five separate pathways, each of which is discussed in Section 20.4.1.2. The output of the model, total blood lead concentration, is computed as the sum of

the contributions from each of the five pathways. Three receptors are considered: an adult, a one-year-old child, and a one-year-old child whose lead intake is increased by pica.

The output of the model is the 50th and the upper 90th, 95th, 98th, and 99th percentile blood lead levels for these three receptors. The distributional presentation is consistent with the observation that blood lead concentrations are generally log-normally distributed, with a geometric standard deviation of approximately 1.42 (EPA, 1989a). To protect the most sensitive members of the population, DTSC (1992) uses the blood lead concentration of the upper 99th percentile as the basis for initiating risk management. DTSC (1992) notes that the distribution reflects the variation in all the parameters (presumably including the default parameters), and that it is inappropriate to choose upper-bound or reasonable maximum values because doing so would distort the distribution.

20.4.1.2 Exposure Pathways

Dietary Uptake Pathway. The contribution to total blood lead concentration of the GI uptake of dietary lead is computed as the product of the concentration of lead in the diet, the contact (or diet ingestion) rate, and dietary constants (different values for adults and children) that represent the contribution to blood lead concentration resulting from the daily ingestion of 1 μg of lead in the diet. The model provides default values for dietary lead concentration, diet ingestion rate, and the dietary constant. It also provides the opportunity to model a contribution from produce grown on contaminated soils. In this case it is assumed that home-grown produce constitutes 5.5 percent of the diet, and that the lead concentration in home-grown produce is 0.045 percent of the lead concentration in the soil on which it is grown.

The default dietary intake of 1.3 kg/day for a 1-year-old child, who would weigh approximately 10 kg (EPA, 1987), seems unusually high. It may include ingestion of approximately 0.4 L of drinking water, which is also considered in a separate pathway (see drinking water uptake pathway).

Drinking Water Uptake Pathway. The contribution to total blood lead concentration of GI lead uptake from drinking water is computed as the product of the concentration of lead in drinking water, the contact (or water ingestion) rate, and the dietary constants described previously. The model provides default values for drinking water intake, and permits input of the concentration of lead in drinking water.

In the absence of site-specific drinking water lead concentration data, however, DTSC (1992) recommends defaulting to 15 µg/L, which is the EPA (1992b) action level at the tap for lead in drinking water. This federal action level, however, represents a worst-case or maximum exposure scenario. As discussed previously, DTSC (1992) notes that the distributional approach provides for variation in the model parameters, and that choosing worst-case or maximum values is inappropriate.

Analytical studies of lead in water supplies showed that concentrations generally have not exceeded 50 to 60 µg/L (Tsuchiya, 1986; van der Leeden et al., 1991). Concentrations for the 100 largest cities in the United States ranged from not detected to 62 µg/L, with a median of 3.7 µg/L. The median lead concentration of 3.7 µg/L is a more appropriate default value than the federal action level of 15 µg/L.

Soil and Dust Ingestion Uptake Pathway. The model treats soil and dust as a single entity, known as soil. The contribution to total blood lead concentration of GI lead uptake from ingested soil is computed as the product of the concentration of lead in soil, the contact (or soil ingestion) rate, and a soil constant that represents the contribution to blood lead concentration resulting from the daily ingestion of 1 µg of lead in the soil. The model permits entry of a site-specific value for soil lead concentration and provides default values for soil ingestion. The default soil ingestion rates for an adult and a normal 1-year-old child, 25 and 55 mg/day, respectively, are consistent with guidance provided by EPA (1989b, 1989c).

The model also estimates blood lead levels for a 1-year-old child with soil pica, which is defined as deliberate soil ingestion. For this receptor, which differs from the normal child only in the amount of soil ingested, soil ingestion defaults to 790 mg/day.

Data evaluated by EPA (1989c) suggest that the 1-year-old child is an inappropriate receptor for which to model pica. EPA (1989c) notes that all children mouth or ingest non-food substances. This behavior is a normal, but temporary, phase of childhood development. When this behavior persists beyond 18 months of age, which is uncommon, the child is said to be practicing pica. The condition usually does not persist beyond 6 to 7 years of age. A more defensible receptor for which to model pica would be a child of 18 months to 7 years of age; a 4-year-old (arithmetic average of 1.5 and 6.5 years) child might be a reasonable choice. The GI uptake and fate kinetics of lead are expected to be quite different in a 1-year-old compared with a 4-year-old child.

Inhalation Uptake Pathway. The contribution to total blood lead concentration of respiratory tract lead uptake from inhalation of contaminated air is computed as the product of the concentration of lead in air and an inhalation constant that represents the contribution to blood lead concentration resulting from the daily inhalation of 1 μg of lead in air. Presumably the inhalation constant contains a factor for contact (or inhalation) rate, because a separate term for contact rate is not provided. The term for lead concentration in air may be input as a measured site-specific value (the concentration of lead in air from all sources), or may be input as the sum of local or regional ambient air lead concentration (background) and lead in airborne dust arising from the soil on the site. In the latter case, the model multiplies the concentration of lead in soil by the concentration of dust in air. The concentration of dust in air may be input (input zero if site-specific air lead concentrations are available) or allowed to default to 50 $\mu g/m^3$.

Dermal Contact Uptake Pathway. The contribution to total blood lead concentration of lead uptake from dermal contact with contaminated soil is computed as the product of the soil concentration of lead, the contact rate, and a soil constant that represents the contribution to blood lead concentration resulting from dermal contact with 1 μg of soil-borne lead. Dermal contact is the least important pathway in the model, accounting for ≤2 percent of the total blood lead concentration.

20.4.1.3 Application of the Model

Several runs of the model were performed. Figure 20.4-1 presents the run using the measured soil lead concentration of 257.61 μg/g and the recommended default values for the other parameters: 0.18 μg lead/m^3 in air, 15 μg lead/L in water and 50 μg of airborne soil (dust)/m^3 in air.

20.4.2 Copper

The EPA-approved MCL for copper in water is 1.3 mg/L. This was converted to a risk-based acceptable exposure as shown:

$$AE = \frac{(MCL)(IR)}{(BW)}$$

where:

AE = Acceptable exposure (mg/kg-day)
MCL = Maximum contaminant level in drinking water (mg/L)
IR = Ingestion rate for water (L/day)
= 2 L/day for adults (IEM/4/98)
BW = Body weight (kg)
= 70 kg for adults (IEM/4/50).

The resulting acceptable exposure is 0.037 mg/kg-day for both the oral and inhalation routes. Data are not currently available to determine a separate acceptable exposure for inhalation.

20.4.3 2-Methylnaphthalene

Adequate data do not currently exist to characterize the potential toxicity of 2-methylnaphthalene (ATSDR, 1989). Due to its structural similarity, the toxicity of 2-methylnaphthalene is assumed to be similar to that of naphthalene, and this chemical will be evaluated qualitatively in the risk assessment.

20.4.4 4-Methylphenol

Due to a lack of toxicity data, this chemical was not included in the quantitative risk assessment.

20.4.5 Phenanthrene

Due to a lack of toxicity data, this chemical was not included in the quantitative risk assessment.

20.4.6 Cobalt

Due to a lack of toxicity data, this chemical was not included in the quantitative risk assessment.

20.4.7 Uncertainties

The toxicological parameters used to quantify potential risk to a receptor include cancer potency factors (CPF) and RfDs. These values are often derived from laboratory animal studies. The overriding uncertainties associated with the use of laboratory animal studies are:

- The extrapolation of toxic effects observed at the high doses necessary to conduct animal studies to predict effects that might occur at the much lower, environmentally relevant doses

- The extrapolation from toxic effects in animals to toxic effects in man (i.e., responses of animals may be different from responses of man).

EPA has derived CPFs using a weight-of-evidence approach to studies in the scientific literature. The CPFs represent the upper 95 percent confidence limits on the slope of the dose-response curve for carcinogenic responses. Because CPFs represent the upper limits of the slope of the line, the use of the CPF is more likely to overestimate the actual risk rather than underestimate it.

Uncertainties also arise in the development of the RfDs used to characterize noncarcinogenic effects. These reference values are derived using studies in humans or animals by identifying the NOAEL. Two basic types of uncertainty arise. The first is related to the extrapolation from toxic effects seen at high doses to predict effects at the low doses usually encountered in the environment. The second involves extrapolation from effects in animals to effects in man. Each of these is offset by an uncertainty factor, which is actually a product of as many as five separate factors, each intended to account for one type of uncertainty (EPA, 1989b). The LOAEL or NOAEL is then divided by this composite uncertainty factor. The uncertainty factors usually range from 10 to 10,000. The five types of uncertainty included in the assignment of the uncertainty factor are (each representing an uncertainty factor of 5 to 10):

- Sensitive subpopulations in the general population
- Extrapolation from animals to humans
- Extrapolation from a subchronic study to a chronic estimate
- Extrapolation from an LOAEL to an NOAEL
- Additional uncertainties in the critical study used in setting the RfD.

20.5 Risk Characterization

This section provides a characterization of the potential health risks associated with the intake of chemicals at Moffett Field OU2. The risk characterization compares estimated potential cancer risks with reasonable levels of risk for potential carcinogens, and the estimated daily intake with reference levels for noncarcinogens. Some carcinogenic chemicals may also pose a systemic (noncarcinogenic) hazard, and these potential hazards are characterized as for other noncarcinogens.

The approach used to estimate the potential risks associated with exposure to the site contaminants in the soils and groundwater is based on the ***Risk Assessment Guidance for Superfund - Volume I: Human Health Evaluation Manual (Part A)*** (EPA, 1989b). This assessment employs a health-protective bias that leads to the overestimation of risks rather than an underestimation. Reasonable scenarios for maximally exposed individuals in specific receptor populations were developed in Section 20.3.2. These were evaluated in Section

20.3.3 to provide estimates of daily intakes. These estimated intakes are evaluated to determine the potential carcinogenic risks and the potential for toxic (systemic) impacts on human health.

20.5.1 Known or Suspected Carcinogens

20.5.1.1 Selection of a Reasonable Probability of Risk of Cancer

In weighing residential exposures to potentially carcinogenic compounds, a reasonable level of risk must be selected. In the United States, the incidence of cancer occurrence is 3×10^{-1} (American Cancer Society, 1990). Approximately 80 percent of these cases result in death directly attributable to the disease. Incremental lifetime cancer risk (ILCR, also referred to as excess cancer risk) is defined as the estimated increased risk that occurs over an assumed average life span of 70 years as the result of exposure to a specific known carcinogen. Thus, an ILCR of one in one million (1×10^{-6}) may be interpreted as an increase in the baseline cancer incidence from 300,000 per million population to 300,001 per million population.

EPA uses an incremental lifetime risk level of one in one million as the lower bound of an acceptable range for developing drinking water standards (EPA, 1987b). The upper bound for an acceptable ILCR recommended by EPA for drinking water is 1 in 10,000 (1×10^{-4}) (EPA, 1987b). In addition, in the NCP (EPA, 1990) the agency specifies a risk range of 1×10^{-6} to 1×10^{-4} associated with the consideration and selection of remedial alternatives for contaminated land. The U.S. Food and Drug Administration (U.S. FDA) considers an ILCR of one in one million to be *de minimis* or insignificant risk (U.S. FDA 1985a, 1985b).

Based on the scientific and regulatory precedents cited above, a reasonable and appropriate ILCR range for Moffett Field would be from 10^{-6} to 10^{-4} with 10^{-6} as the point of departure.

20.5.1.2 Estimation of Carcinogenic Risk

This cancer risk is estimated as the probability of an additional incidence of cancer above background. Probability is given by:

$$\text{ILCR} = (\text{CPF})(\text{Intake})$$

where:

ILCR = Incremental lifetime cancer risk (unitless)
CPF = Cancer potency factor [$(\text{mg/kg-day})^{-1}$]
Intake = Chronic daily intake averaged over a 70-year lifetime (mg/kg-day).

The CPFs for the site-specific chemicals are given in Table 20.4-1. These are the most recent values cited in EPA's ***Integrated Risk Information System*** (EPA, 1992b) and ***Health Effects Assessment Summary Tables*** (EPA, 1991b).

For a given pathway with potential exposure to several carcinogens, the following equation was used to sum cancer risks:

$$Risk_{T,P} = Risk_P(chem_1) + Risk_P(chem_2) + ...Risk_P(chem_i)$$

where:

$Risk_{T,P}$	=	Total cancer risk for pathway *p* (unitless)
$Risk_P(chem_i)$	=	Individual cancer risk for constituent *i* through exposure pathway *p* (unitless).

Estimates of incremental lifetime carcinogenic risk are provided for each exposure scenario and pathway based on the associated exposure estimates. The estimated chemical-specific ILCRs for each site are given in Tables 20.3-63 through 20.3-110. The estimated chemical-specific ILCRs for background metals and PFNs are listed in Tables 20.5-1 through 20.5-8.

Cancer risk may also be expressed as a potential population risk. Population risk is estimated as the ILCR times the number of people potentially exposed. Because the ILCR is expressed as a probability, this results in an estimate of the number of additional cancers predicted for the exposed population. For example, a site with an estimated ILCR of 2×10^{-6} and a potentially exposed receptor population of one million people has a population risk of two people. If the potentially exposed population is only 500,000 people, the estimated population risk is one person affected.

The current potentially exposed population at each of the OU2 sites is limited to a few people. Therefore, population risks will be negligible. A future residential scenario has been included in this risk assessment to provide an upper-bound estimate of potential future risk. However, no future residential development is currently planned; therefore, any estimate of the number of future receptors would be extremely tenuous.

20.5.2 Noncarcinogens

Chemicals that pose a health threat other than cancer were evaluated by comparing an exposure level or intake to an acceptable level or RfD. The ratio of estimated daily intake to the RfD is termed the hazard quotient (HQ) and is defined as:

$$HQ_{i,p} = I_{i,p}/RfD_i$$

where:

$HQ_{i,p}$ = Individual hazard index for exposure to constituent *i* through exposure pathway *p*
$I_{i,p}$ = Daily intake via a specific pathway *p* for constituent *i* (mg/kg-day)
RfD_i = Reference dose for exposure by the specific pathway for *i* (mg/kg-day).

The RfD is an estimate of an intake level to which a human population, including sensitive subpopulations, may be chronically exposed without a significant risk of adverse health effects (EPA, 1989b). The RfDs for the chemicals of concern are listed in Table 20.4-2.

Because the HQ does not define intake-response relationships, its numerical value should not be construed as a direct estimate of risk. It is a numerical indication of the fraction of acceptable limits of exposure or the degree to which acceptable exposure levels are exceeded. As this quotient approaches unity, concern for the potential hazard of the constituent increases. It does suggest that a given situation should be more closely scrutinized. The estimated HQs for each potential exposure pathway are given in Tables 20.3-15 through 20.3-62.

EPA advocates the use of a total hazard index (HI) for a mixture of components based on the assumption of additive toxic effects. In the case of simultaneous exposure to several chemicals, an HI may be calculated to evaluate the potential risk associated with exposure to a mixture by summing the HQs for each chemical and pathway. The hazard index formula is (EPA, 1989b):

$$HI = (HQ)_1 + (HQ)_2 + (HQ_i) + ... + (HQ)_n$$

where:

HI = Hazard index (unitless)
HQ_i = Hazard quotient for exposure to constituent *i* (unitless), *i* = 1, ... n.

Summation of the individual HQs could result in an HI that exceeds one, even if no single chemical exceeds its acceptable level. Mechanistically, it is not appropriate to sum HQs unless the constituents that make up the mixture have similar modes of action on the identical organ. Consequently, the summing of HQs for a mixture of compounds that are not expected to induce the same type of effects could overestimate the potential risk. EPA recommends that if the total HI is greater than unity, the components of the mixture should be grouped by critical effect and separate HIs derived for each effect.

Estimates of hazards associated with site-related noncarcinogenic chemicals are provided for each exposure scenario and pathway based on the associated exposure estimates. The estimated chemical-specific HIs for each pathway are given in Tables 20.3-15 through 20.3-62.

The estimated chemical-specific HQs for background metals and PFNs are listed in Tables 20.5-1 through 20.5-8.

20.5.3 Uncertainties

The overriding uncertainties associated with the risk characterization are:

- The extrapolation of toxic effects observed at high doses necessary to conduct animal studies to effects that might occur at much lower, "real-world" doses
- The extrapolation from toxic effects in animals to toxic effects in man (i.e., responses of animals may be different from responses of man).

These extrapolations form the basis for derivation of the factors used to estimate risks. Uncertainties are taken into account when deriving RfDs and other similar human response factor standards. This risk assessment minimizes the uncertainties by using published EPA standards and criteria to evaluate the risks posed by the source units.

A risk assessment of a site is ultimately an integrated evaluation of historical, chemical, analytical, environmental, demographic, and toxicological data that are as site-specific as possible. To minimize the effect of uncertainties in the evaluation, each step is biased toward health protective estimations. Because each step builds on the previous one, this biased approach should more than compensate for risk assessment uncertainties. In addition, these calculations do not represent currently existing or expected future exposure or health risks. Rather, they are estimates of potential risk only if all of the conservative assumptions are realized.

20.6 Summary and Conclusions

Chemicals present in OU2 soils were evaluated to determine if a potential risk associated with exposure to site-related chemicals exists. The potential health risks associated with exposure of current and future populations are summarized as follows.

Site 3 - Marriage Road Ditch. The ILCRs for exposure of children via soil ingestion and dermal contact under the current land-use scenario are 1.3×10^{-7} and 5.0×10^{-6} for the average case and 6.4×10^{-7} and 1.2×10^{-5} for the RME case. The total average case ILCR for the child is 5.1×10^{-6}, and the total RME case ILCR for the child is 1.3×10^{-5}. These values fall within the range of 10^{-6} to 10^{-4} specified in the NCP.

The average and RME case HIs for juvenile soil ingestion are 3.7×10^{-3} and 1.6×10^{-2}, respectively. For juvenile dermal contact, the HQs are 3.9×10^{-3} and 9.5×10^{-3}. The total HI for the average case is 7.6×10^{-3}, and for the RME case, 2.6×10^{-2}. These values are more than two orders of magnitude below the target value of unity. It is unlikely that chemicals in the soils at this site will have an adverse effect upon the health of this receptor.

Occupational exposures could include soil ingestion, dermal contact, and inhalation of VOCs. The ILCRs for each of these pathways are 5.1×10^{-8}, 3.2×10^{-6}, and 5.0×10^{-16} for the average exposure case. The principal contributor is beryllium, which has an ILCR of 3.2×10^{-6} for the dermal pathway. The next highest ILCR was 4.2×10^{-9} for ingestion of Aroclor-1260. The total ILCR for all pathways is 3.3×10^{-6}. This value is within the range (10^{-6} to 10^{-4}) specified in the NCP. The ILCRs for soil ingestion, dermal contact, and inhalation of VOCs for the RME case are 6.3×10^{-8}, 3.9×10^{-6}, and 5.2×10^{-16}, respectively. The total ILCR for the RME case is 4.0×10^{-6}. As in the average case beryllium is the principal contributor to risk with an ILCR of 3.9×10^{-6}. The values fall within the range specified in the NCP.

The HIs for soil ingestion, dermal contact, and inhalation of VOCs are 7.2×10^{-3}, 1.3×10^{-2}, and 3.8×10^{-8} for the average case scenario, and 8.1×10^{-3}, 1.5×10^{-2}, and 5.2×10^{-9} for the RME case scenario. The average case total HI for all pathways is 2.0×10^{-2} and the RME case total HI is 2.3×10^{-2}. These values are more than two orders of magnitude below the target value of unity. It is not likely that chemicals at this site will have an unacceptable effect upon the health of a worker.

The ILCRs for potential residents under average case, future land-use scenarios are 9.8×10^{-6} for incidental juvenile soil ingestion, 5.6×10^{-7} for incidental adult soil ingestion, 1.3×10^{-3} for dermal contact, 3.1×10^{-6} for ingestion of homegrown vegetables, and 1.0×10^{-13} for inhalation of VOCs. The total ILCR for all exposure pathways is 1.3×10^{-3}. The major contributor to the ILCRs at this site is beryllium. The ILCRs for beryllium are 1.3×10^{-3} and 9.0×10^{-6} for dermal absorption and juvenile soil ingestion, respectively. The ILCRs for potential residents under the RME case, future land-use scenarios are 1.2×10^{-5} for incidental juvenile soil ingestion, 5.5×10^{-6} for incidental adult soil ingestion, 5.4×10^{-3} for dermal contact, 1.9×10^{-5} for ingestion of homegrown vegetables, and 3.5×10^{-13} for inhalation of VOCs. The total ILCR for all RME scenarios is 5.4×10^{-3}. The major contributor to the ILCRs in the RME case, as with the average case, is beryllium. The dermal ILCR for beryllium is 5.4×10^{-3}. The next highest ILCR is beryllium in the juvenile soil ingestion pathway with an ILCR of 1.1×10^{-5}. Beryllium occurs at widespread low levels at Moffett Field and is considered to be reflective of naturally occurring background levels.

The HIs for dermal contact, juvenile ingestion of soil, adult ingestion of soil, consumption of homegrown vegetables, and inhalation of VOCs are 5.8×10^{-1}, 2.3×10^{-1}, 2.6×10^{-2}, 8.5×10^{-1}, and 8.4×10^{-8}, respectively, for the average case, and 7.0×10^{-1}, 2.6×10^{-1}, 2.9×10^{-2}, 1.4×10^{0}, and 1.2×10^{-7}, respectively, for the RME case. The total HI for the average case is 1.7×10^{0}, and the total RME case HI is 2.4×10^{0}. These values are only slightly greater than unity. Furthermore, the target organs for each of the individual chemicals are different; therefore, it is assumed that effects are not additive. The systemic toxicity of chemicals in the soil does not present an unacceptable effect to human health given a future residential exposure scenario.

Future receptor populations may be exposed to chemicals in soils as a result of leaching into groundwater. The maximum acceptable soil concentrations for selected chemicals of concern are given in Table 20.3-14. The concentration of all chemicals evaluated in soils was less than the maximum acceptable concentration by an order of magnitude or more.

Based on the analysis of the available data, chemicals present in soils at Site 3 are not expected to have a significant long-term adverse health impact on the identified receptors. All ILCRs fall within the range specified in the NCP with the exception of dermal exposure to beryllium by future residents, and no HQ exceeds unity. The highest estimated ILCRs are associated with potential future residents and result from ingestion of beryllium in soils and

vegetables and dermal contact; however, beryllium occurs at widespread low levels at Moffett Field and is considered to be reflective of naturally occurring background levels.

Site 4 - Former Wastewater Holding Pond. The estimated ILCRs for dermal contact, ingestion of soils, inhalation of VOCs, and fugitive dust are 3.8×10^{-4}, 5.9×10^{-7}, 1.0×10^{-13}, and 1.2×10^{-6}, respectively, for the average case, and 6.2×10^{-4}, 9.4×10^{-7}, 1.4×10^{-13}, and 1.7×10^{-6}, respectively, for the RME case. The total ILCRs for all pathways in the average case and the RME case scenarios are 3.9×10^{-4} and 6.2×10^{-4}, respectively.

The HIs for the previously discussed pathways are 1.6×10^{-2} for soil ingestion; 2.1×10^{-7} for inhalation of volatile organic vapors; 9.5×10^{-2} for dermal contact; and 2.7×10^{-1} for inhalation of fugitive dust for the average case. The total HI is 3.9×10^{-1}. This value is more than an order of magnitude below the target value of unity. In the RME case, the HIs for soil ingestion, dermal contact, inhalation of fugitive dust, and inhalation of VOCs are 2.4×10^{-2}, 1.2×10^{-1}, 3.1×10^{-1}, and 5.4×10^{-7}, respectively. The total HI for these pathways is 4.6×10^{-1}. This value is also more than an order of magnitude lower than the target value of unity.

Future potential receptor populations may be exposed via incidental juvenile soil ingestion, incidental adult soil ingestion, dermal contact, inhalation of VOCs, and consumption of homegrown vegetables. The ILCR for each of these respective pathways is 4.6×10^{-6}, 2.6×10^{-7}, 6.8×10^{-4}, 8.7×10^{-14}, and 1.1×10^{-6}, respectively, for the average case; and 5.6×10^{-6}, 2.5×10^{-6}, 2.7×10^{-3}, 3.0×10^{-13}, and 6.6×10^{-6}, respectively, for the RME case. The total average case ILCR for all pathways is 6.8×10^{-4}, and for the RME case, the total ILCR for all pathways is 2.7×10^{-3}. The major contributor in both the average and RME case is beryllium in the dermal pathways with ILCRs of 6.8×10^{-4} and 2.7×10^{-3}, respectively. All other ILCRs fall within or below the range specified in the NCP. The beryllium results are considered reflective of naturally occurring beryllium levels found at Moffett Field.

The HIs for incidental juvenile soil ingestion, incidental adult soil ingestion, dermal contact, consumption of homegrown vegetables, and inhalation of VOCs are 4.3×10^{-1}, 4.9×10^{-2}, 3.7×10^{-1}, 1.7×10^{0}, and 4.0×10^{-7}, respectively, for the average case, and 5.8×10^{-1}, 6.6×10^{-2}, 4.6×10^{-1}, 3.2×10^{0}, and 9.6×10^{-7}, respectively, for the RME case. The total HI for the average case is 2.5×10^{0}. The total HI for the RME case is 4.3×10^{0}. Vegetable consumption was the only exposure pathway that exceeded the target value of unity. Given, however, the type of development in the area, it is unlikely that sufficient land will be available for

development of a garden that will supply the daily quantities of produce assumed in the exposure assessment. Exposure via other pathways was more than an order of magnitude below the target value of unity.

Future receptor populations may be exposed to chemicals in soils as a result of leaching into groundwater. The maximum acceptable soil concentrations for selected chemicals of concern are given in Table 20.3-14. The upper 95th percentile soil concentrations at this site are below their respective acceptable concentrations; therefore, chemicals at this site are not a potential threat to groundwater.

Chemicals at the site do not present a significant risk to health of receptors identified for both current and future land-use scenarios. Although the total HQ resulting from vegetable ingestion exceeds unity, the hypothetical future land-use scenario is inconsistent with current residential development for the area. Other chemicals present in the soil do not present an unacceptable risk to human health or the groundwater aquifer.

Site 5 - Fuel Farm French Drains and Bulk Tanks. The estimated total ILCRs for incidental soil ingestion, dermal contact, and inhalation of VOCs are for workers currently working at the site 3.9×10^{-8}, 2.6×10^{-6}, and zero, respectively, for the average case; and 4.4×10^{-8}, 3.0×10^{-6}, and zero, respectively, for the RME case. The total ILCR for all pathways is 2.7×10^{-6} for the average case and 3.0×10^{-6} for the RME case. The total ILCR for all exposure pathways falls within the range specified in the NCP; therefore, chemical carcinogens present at the site do not present an unacceptable cancer risk to current receptors.

The HIs for soil ingestion, dermal contact, and inhalation of VOCs are 1.2×10^{-2}, 1.1×10^{-2}, and 1.0×10^{-7}, respectively, for the average case; and 1.4×10^{-2}, 1.3×10^{-2}, and 1.8×10^{-7}, respectively, for the RME case. The total HI is 2.3×10^{-2} for the average case and 2.7×10^{-2} for the RME case. These values are more than an order of magnitude below the target value of unity; therefore, it is unlikely that exposure at this site would present an unacceptable risk to human health.

Future receptor populations may be exposed to chemicals in soils as a result of leaching into groundwater. The maximum acceptable soil concentrations for selected chemicals of concern are given in Table 20.3-14. The chemicals evaluated were more than three orders of magnitude below the maximum acceptable limits.

Based on the analysis of the available data, chemicals present in soils at this site do not present an unacceptable risk to human receptors. ILCRs and HIs fall within ranges deemed acceptable based on scientific and regulatory precedent.

Site 6 - Runway Apron. The ILCRs for incidental soil ingestion, dermal contact, and inhalation of VOCs are 1.9×10^{-11}, 1.3×10^{-10}, and zero, respectively, for the average case; and 3.8×10^{-11}, 2.6×10^{-10}, and zero, respectively, for the RME case. The total ILCR for all the pathways in the average case is 1.5×10^{-10}, and in the RME case 3.0×10^{-10}. These values are more than four orders of magnitude below the lower bound of the range specified by the NCP. The potential receptors currently present at the site are not exposed to unacceptable levels of risk from exposure to chemical carcinogens at the site.

The HIs for this site are 5.3×10^{-3}, 2.0×10^{-3}, and 2.6×10^{-8} for the average case and 7.4×10^{-3}, 2.4×10^{-3}, and 4.2×10^{-8} for the RME case for soil ingestion, dermal contact, and inhalation of VOCs, respectively. The total HI for all of the pathways is 7.3×10^{-3} for the average case and 9.7×10^{-3} for the RME case. These values are more than three orders of magnitude below the target value of one. Based on the evaluation of the available data, it is unlikely that chemicals present at this site will have an unacceptable impact upon the public health of current potentially exposed populations.

Potential future receptor populations may be exposed via juvenile ingestion of soil, adult ingestion of soil, dermal contact, inhalation of VOCs, and consumption of vegetables. The ILCRs for each of these pathways are 3.7×10^{-9}, 2.1×10^{-10}, 5.4×10^{-8}, zero, and 1.2×10^{-8}, respectively, for the average case, and 7.2×10^{-9}, 3.3×10^{-9}, 3.5×10^{-7}, zero, and 1.1×10^{-7}, respectively, for the RME case. No carcinogenic VOCs were present at this site. The total ILCR for the average case is 7.0×10^{-8}. The total ILCR for the RME case is 4.8×10^{-7}. These values fall below the lower limit of the range specified by the NCP.

The HIs for the average case are 1.7×10^{-1}, 1.9×10^{-2}, 9.2×10^{-2}, 6.1×10^{-1}, and 5.8×10^{-7}. The HIs for the RME case are 2.4×10^{-1}, 2.7×10^{-2}, 1.1×10^{-1}, 1.2×10^{0}, and 9.4×10^{-7} for juvenile soil ingestion, adult soil ingestion, dermal absorption, ingestion of homegrown vegetables, and inhalation of VOCs, respectively. The total average case HI is 7.4×10^{-1}, and for the RME case, 1.6×10^{0}. The two major contributors to the high HI for vegetable consumption in the RME is antimony with an HI of 8.6×10^{-1} and nickel with an HI of 2.4×10^{-1}. Given that no individual chemicals HI exceeds the value of unity, and the vegetable

model is a very conservative model, it is doubtful that there is any significant risk to human health.

Future receptor populations may be exposed to chemicals in soils as a result of leaching into groundwater. The maximum acceptable soil concentrations for selected chemicals of concern are given in Table 20.3-14. The upper-bound concentrations of chemicals at Site 6 were below the maximum acceptable limits; therefore, it is unlikely that chemicals in soils will affect groundwater.

Based on the analysis of the available data, chemicals of concern at this site do not present an unacceptable risk for current human receptors. In addition, these chemicals are not likely to have systemic (noncarcinogenic) health effects upon current or future residential receptors. Chemical concentrations in soils should not have an impact upon groundwater.

Site 7 - Hangars 2 and 3. The respective ILCRs for incidental soil ingestion, dermal contact, and inhalation of VOCs are 2.7×10^{-8}, 1.9×10^{-6}, and zero, respectively, for the average case and 3.7×10^{-8}, 2.5×10^{-6}, and zero, respectively, for the RME. The total ILCR for all the exposure pathways is 1.9×10^{-6} for the average case and 2.6×10^{-6} for the RME. These values are within the range specified in the NCP.

The HIs for soil ingestion, dermal contact, and inhalation of VOCs are 2.0×10^{-2}, 9.6×10^{-3}, and 1.4×10^{-8}, respectively, for the average case; and 4.0×10^{-2}, 1.5×10^{-2}, and 2.3×10^{-8}, respectively, for the RME case. The total HIs for all pathways in the average case and the RME case are 3.0×10^{-2} and 5.5×10^{-2}, respectively. These values are more than two orders of magnitude below unity; therefore, chemicals present at the site are unlikely to have an adverse effect upon human health.

Future potentially exposed populations include individuals living at the site. These receptors may be exposed via juvenile soil ingestion, adult soil ingestion, dermal contact, inhalation of VOCs, and consumption of vegetables. The respective ILCRs for these pathways are 5.2×10^{-6}, 3.0×10^{-7}, 7.7×10^{-4}, zero, and 1.2×10^{-6}, respectively, for the average case, and 7.1×10^{-6}, 3.2×10^{-6}, 3.5×10^{-3}, zero, and 8.3×10^{-6}, respectively, for the RME case. The total average case ILCR is 7.7×10^{-4}. The total RME case ILCR is 3.5×10^{-3}. The major contributor in the average case and the RME case in the dermal pathway is beryllium with ILCRs of 7.7×10^{-4} and 3.5×10^{-3}, respectively. All other ILCRs fall within or below the

range specified by the NCP. Beryllium occurs at widespread low levels at Moffett Field and is considered to be reflective of naturally occurring beryllium levels.

The HIs for juvenile soil consumption, adult soil consumption, dermal contact, inhalation of VOCs, and consumption of vegetables are 6.4×10^{-1}, 7.3×10^{-2}, 4.4×10^{-1}, 3.2×10^{-7}, and 6.9×10^{0}, respectively, for the average case, and 1.3×10^{0}, 1.5×10^{-1}, 6.6×10^{-1}, 5.0×10^{-7}, and 2.7×10^{1}, respectively, for the RME case. Copper is the dominant chemical of concern for vegetable consumption with an HQ of 4.5 for the average case and 19.4 for the RME. Zinc also contributes with an average case HI of 1.4 and an RME case HI of 5.7. The total HIs for the remaining chemicals are 9.5×10^{-1} for the average case and 1.8×10^{0} for the RME case. The model used for this pathway does not consider bioavailability. In addition, the RfD is based on a secondary drinking water standard, which assumes a soluble form of copper and zinc. Given that it is unlikely that food consumption will be a major route of exposure for this site, it is unlikely that this exposure pathway will have an adverse impact on human health. The remaining exposure pathways are below unity with the exception of the RME case juvenile soil ingestion, which had a total HI of 1.3×10^{0}. Because this value slightly exceeds unity and the target organs for the individual chemicals differ, it is assumed that the health effects are not additive.

Future receptor populations may be exposed to chemicals in soils as a result of leaching into groundwater. The maximum acceptable soil concentrations for selected chemicals of concern are given in Table 20.3-14. The concentrations of all compounds are more than three orders of magnitude below the maximum acceptable limits. It is unlikely that chemicals in soils will affect groundwater.

Based on the analysis of the available data, chemicals of concern at this site do not present a significant risk to health for current human receptors. For future use scenarios, intake of copper via ingestion of homegrown vegetables exceeded acceptable intake levels. However, as previously discussed, homegrown vegetable consumption at these levels is not considered to be a likely exposure pathway for future residential use. Additionally, future residential use of this site is considered very unlikely; therefore, chemicals in soils should not have an impact on groundwater.

Site 10 - Runway Area. Current potential receptors at this site include individuals working at the site in the runway area. These receptors may be exposed via soil ingestion, dermal contact, inhalation of VOCs, and inhalation of fugitive dust. The ILCRs for these pathways

are 6.0×10^{-7}, 4.0×10^{-4}, zero, and 1.0×10^{-6} for the mean exposure. Beryllium is the dominant contributor to risk with a total ILCR of 4.0×10^{-4} due to dermal exposure. The remaining compounds and pathways have ILCRs that are at least two orders of magnitude less than beryllium levels. For the RME scenario, the ILCRs for these pathways are 1.0×10^{-6}, 6.9×10^{-4}, zero, and 1.6×10^{-6}, respectively. Again, beryllium is the dominant contributor to risk with a dermal ILCR of 6.9×10^{-4}. All other chemicals are at least two orders of magnitude less than beryllium levels.

The HIs for soil ingestion, dermal contact, inhalation of VOCs, and inhalation of fugitive dust are 1.3×10^{-2}, 8.8×10^{-2}, 4.6×10^{-8}, and 2.2×10^{-1}, respectively, for the average case. The RME case HIs are 1.7×10^{-2}, 1.2×10^{-1}, 7.4×10^{-8}, and 2.9×10^{-1}, respectively, for the previously listed pathways. The total HIs are 3.3×10^{-1} and 4.3×10^{-1} for the average and RME cases, respectively. These HIs are all less than 1. The total HI for all pathways for both the average and RME cases are less than 1. Based on this analysis of the available data, chemicals present in soils will not cause an adverse effect on human health of current exposure populations.

Future exposure populations include individuals living at the site. These receptors may be exposed via juvenile soil ingestion, adult soil ingestion, dermal contact, inhalation of VOCs, and consumption of homegrown vegetables. The ILCRs for these pathways are 4.7×10^{-6}, 2.7×10^{-7}, 6.9×10^{-4}, zero, and 1.1×10^{-6} for the average case. The total average case ILCR is 7.0×10^{-4}. Beryllium is the primary contributor with a total ILCR of 7.0×10^{-4}. This value is more than three orders of magnitude greater than the total ILCR for other chemicals. The potential risks for the RME scenarios are 6.2×10^{-6}, 2.8×10^{-6}, 3.0×10^{-3}, zero, and 7.2×10^{-6} for these same pathways. Again, the primary contributor to risk is beryllium and all other risks are three orders of magnitude less than beryllium levels. The risks are within the range specified in the NCP. It is estimated that the runway area will remain in use as a runway and this scenario of residential use is unlikely.

Future receptors may be exposed to contamination via juvenile soil ingestion, adult soil ingestion, dermal contact, inhalation of VOCs, and consumption of homegrown vegetables. The average case HIs for these pathways are 3.3×10^{-1}, 3.8×10^{-2}, 3.4×10^{-1}, 8.8×10^{-8}, and 1.1×10^{0}. The RME case HIs were 4.2×10^{-1}, 4.8×10^{-2}, 4.4×10^{-1}, 1.3×10^{-7}, and 2.1×10^{0} for the respective pathways. The total HIs were 1.8×10^{0} and 3.0×10^{0} for the average and RME cases, respectively. Ingestion of homegrown vegetables was the major pathway contributing to the HIs. The metals antimony, copper, manganese, and nickel were

the major contributors in both the average and RME cases. No individual chemical was above unity. Because the ingestion of homegrown vegetables is a very conservative model, and no one chemical is above unity in any pathway, it is unlikely that chemicals in the soil at this site will have an adverse impact upon human health.

Future receptor populations may be exposed to chemicals in soils as a result of leaching into groundwater. The maximum acceptable soil concentrations for selected chemicals of concern are given in Table 20.3-14. The upper concentrations of chemicals detected are below the maximum acceptable concentration; therefore, chemicals at this site are not a potential threat to groundwater.

ILCRs for chemicals of concern at the Site 10 runway area generally fall within the range deemed acceptable based on scientific and regulatory precedent. High ILCRs are associated with potential dermal exposures to beryllium. However, similarly high risks are associated with background levels of this metal. Background concentrations of beryllium range from 0.7 to 1.2 ppm. The average and RME exposure concentrations are 1.1 and 1.4 ppm. Based on the analysis of the available data, these chemicals of concern are not likely to have a systemic (noncarcinogenic) health effect upon occupational receptors. Future exposure scenarios also had ILCRs within the acceptable range. Potential systemic toxicity to humans resulting from intake of site-related chemicals is unlikely.

Site 11 - Engine Test Stand Area. The current average case ILCR for soil ingestion is 7.7×10^{-10} and the ILCR for dermal contact is 5.0×10^{-8}. The RME case ILCR for soil ingestion is 1.5×10^{-9}, and the ILCR for dermal absorption is 9.7×10^{-8}. The ILCR for inhalation of VOCs is zero for both the RME and average cases. The total ILCRs for the average and RME cases are 5.1×10^{-8} and 9.9×10^{-8}, respectively. These values are two orders of magnitude less than the lower end of the range specified by the NCP.

The HIs for soil ingestion, dermal absorption, and inhalation of VOCs are 1.1×10^{-2}, 2.8×10^{-2}, and 2.4×10^{-7}, respectively, for the average case; and 1.4×10^{-2}, 3.2×10^{-2}, and 4.1×10^{-7}, respectively, for the RME case. The total average case HI is 2.8×10^{-2}. The total RME case HI is 4.7×10^{-2}. The values are more than two orders of magnitude lower than the value of unity; therefore, chemicals at this site are unlikely to have an adverse effect upon the health of current receptors.

Future land use at the site includes possible residential development. These receptors may be exposed via juvenile soil ingestion, adult soil ingestion, dermal contact, inhalation of VOCs, and consumption of homegrown vegetables. The ILCRs for these pathways are 6.0×10^{-9}, 3.4×10^{-10}, 8.8×10^{-8}, zero, and 9.9×10^{-8}, respectively, for the average case; and 8.7×10^{-9}, 4.0×10^{-9}, 4.3×10^{-7}, zero, and 5.3×10^{-7}, respectively, for the RME case. The total ILCR for the average case is 1.9×10^{-7}, and the total ILCR for the RME case is 9.7×10^{-7}. Both of these values are less than the lower value of the range specified by the NCP.

The HIs for juvenile soil ingestion, adult soil ingestion, dermal contact, consumption of homegrown vegetables, and inhalation of VOCs are 3.0×10^{-1}, 3.4×10^{-2}, 1.1×10^{-1}, 1.3×10^{0}, and 4.5×10^{-7}, respectively, for the average case, and 3.5×10^{-1}, 4.0×10^{-2}, 1.2×10^{-1}, 2.2×10^{0}, and 7.3×10^{-7}, respectively, for the RME case. The total HI for the average case is 1.7×10^{0}. The total HI for the RME case is 2.7×10^{0}. Vegetable consumption is the only exposure pathway that exceeds the target value of unity. Given, however, the small size of the area, it is unlikely that sufficient land will be available for development of a garden that will supply daily the quantities of produce assumed in the assessment.

The chemicals at the site do not present an unacceptable risk to current populations at Moffett Field. Future exposure scenarios had ILCRs within acceptable ranges. Based on the analysis of the available data, these chemicals are not likely to have a systemic (noncarcinogenic) health effect upon potential future receptors.

Site 13 - Equipment Parking Area (Building 142). Current potential receptor populations include people working at the site. These individuals may be exposed via soil ingestion, dermal contact, inhalation of fugitive dust, and inhalation of VOCs. The ILCRs for these exposure pathways are 4.8×10^{-10}, 3.1×10^{-8}, 2.0×10^{-6}, and zero, respectively, for the average case, and 1.0×10^{-9}, 6.7×10^{-8}, 3.6×10^{-6}, and zero, respectively, for the RME case. The total ILCRs for the average and RME cases are 2.0×10^{-6} and 3.6×10^{-6}, respectively. These values are within the range of 10^{-6} to 10^{-4} specified by the NCP.

The HIs for the previously listed pathways are 1.3×10^{-2}, 3.3×10^{-2}, 3.1×10^{-1}, and 1.6×10^{-10}, respectively, for the average case, and 1.8×10^{-2}, 4.0×10^{-2}, 3.8×10^{-1}, and 1.9×10^{-10}, respectively, for the RME case. The total HI for all the exposure pathways in the average case scenario is 3.6×10^{-1}, and is 4.4×10^{-1} for the RME case scenario. These

values fall below the target value of unity; therefore, it is unlikely that chemicals present in soils at this site will have an impact upon human health.

Potential future receptor populations include people living on the site. Juveniles may be exposed via soil ingestion. Adults may be exposed via soil ingestion, dermal contact, consumption of homegrown vegetables, and inhalation of VOCs. For the average case, the respective ILCRs for these pathways are 3.7×10^{-9}, 2.1×10^{-10}, 5.5×10^{-8}, 1.2×10^{-8}, and zero. The total average case ILCR is 7.0×10^{-8}. For the RME case, the respective ILCRs for these pathways are 6.0×10^{-9}, 2.7×10^{-9}, 2.9×10^{-7}, 9.2×10^{-8}, and zero. The total RME case ILCR is 3.9×10^{-7}. These totals fall below the lower bound of the risk range specified by the NCP.

The HIs for juvenile soil ingestion, adult soil ingestion, dermal contact, consumption of homegrown vegetables, and inhalation of VOCs are 3.4×10^{-1}, 3.9×10^{-2}, 1.3×10^{-1}, 2.1×10^{0}, and 3.0×10^{-10}, respectively, for the average case, and 4.5×10^{-1}, 5.2×10^{-2}, 1.5×10^{-1}, 4.2×10^{0}, and 3.4×10^{-10}, respectively, for the RME case. This HI for vegetable ingestion is based on an extremely conservative vegetable uptake model and assumes that a potential future receptor maintains a well-stocked vegetable garden at this site for 30 years. The total average case HI and RME HI for all other pathways are 5.1×10^{-1} and 6.5×10^{-1}, respectively. These values are below the target value of unity; therefore, chemicals present in soils are not likely to have a significant impact upon human health.

Blood lead concentrations have been estimated using the California lead model. Several runs of the model were performed. Figure 20.4-1 presents the run using the measured soil lead concentration of 257.61 µg/g and the recommended default values for the other parameters: 0.18 µg lead/m^3 in air, 15 µg lead/L in water and 50 µg of airborne soil (dust)/m^3 in air. Ingestion of lead through homegrown produce was not considered a likely pathway. As shown, the only valid receptor showing an unacceptable blood lead level (99th percentile >10.0 µg/dl) was the normal child, for which the 99th percentile blood lead concentration was 10.1 µg/dl. The pica child showed unacceptable blood lead concentrations at all distributions (50th through 99th percentile). As discussed in Section 2.4, however, the pica condition imposed on a 1-year-old child is inappropriate. Figure 20.6-1 shows that reducing soil lead concentration from 257.61 to 256 µg/g, with no changes in any of the other parameters, results in acceptable blood lead concentrations in all receptors except the pica child. In Figure 20.6-2, all of the parameters were as described in Figure 20.4-1, except a drinking

water lead concentration of 3.7 μg/L was used, as discussed in Section 2.3. Blood lead levels were acceptable for all receptors except the pica child.

Further evidence that the pica condition imposed on a 1-year-old is inappropriate is provided by the model itself. Figure 20.6-3, generated using the default values recommended by DTSC (1992) (except that ingestion of lead in homegrown produce was not considered) shows that soil lead concentration would need to be ≤18 μg/g to obtain acceptable blood lead concentrations. This is considerably below the background concentration of 110 μg/g measured at the site, and is below the concentrations (30 and 70 μg/g) for two samples in Santa Clara County obtained by the USGS (1984). The alternative interpretation, equally valid and far more practical, is to acknowledge that the environment cannot be made safe for the pica child, probably also for many reasons unrelated to lead ingestion. Safety for the pica child depends on limited and supervised contact with his environment and behavioral modification until the condition is outgrown. These results indicate that the lead detected in soils at Site 13 is not likely to have a significant impact upon human health.

Future receptor populations may be exposed to chemicals in soils as a result of leaching into groundwater. The maximum acceptable soil concentrations for selected chemicals of concern are given in Table 20.3-14. The upper concentrations were below the maximum acceptable limits. The chemicals at the site do not present unacceptable risks to current and future populations.

Site 19 - Tanks 2, 43 and 53. The evaluation for Site 19 was performed in two parts. Tanks 2 and 43 were evaluated together, and data from Tank 53 were evaluated separately.

Potential current receptor populations for Tanks 2 and 43 include individuals working within an excavation. These individuals may be exposed via soil ingestion, dermal contact, and inhalation of VOCs. The ILCRs for soil ingestion, dermal contact, and inhalation of VOCs are 4.1×10^{-8}, 2.8×10^{-6}, and 2.3×10^{-15}, respectively, for the average case; and 5.1×10^{-8}, 3.5×10^{-6}, and 4.2×10^{-15}, respectively, for the RME case. The total ILCR for the average case is 2.8×10^{-6}. The total ILCR for the RME case is 3.5×10^{-6}. Both values fall within the range specified by the NCP.

The HIs for soil ingestion, dermal contact, and inhalation of VOCs are 1.7×10^{-2}, 1.2×10^{-2}, and 4.8×10^{-9}, respectively, for the average case; and 2.2×10^{-2}, 1.5×10^{-2}, and 6.7×10^{-9}, respectively, for the RME case. The total HIs for the average case and RME case are 2.9 x

10^{-2} and 3.7×10^{-2}, respectively. These values are more than an order of magnitude below the target value of unity; therefore, it is unlikely that chemicals at this site present an unacceptable potential risk to human health given the present receptor populations.

Potential exposure of future receptor populations is limited to individuals exposed to compounds that have leached into drinking water. The maximum acceptable soil concentrations for selected chemicals of concern are given in Table 20.3-14. The upper-bound concentrations of chemicals at Site 19 (Tanks 2 and 43) were below the maximum acceptable limits; therefore, it is unlikely that chemicals in soils at Tanks 2 and 43 will impact groundwater. The chemicals at the Tanks 2 and 43 site do not present unacceptable risks to current and future populations.

Occupational exposures associated with Tank 53 were also evaluated separately based on data that were collected during tank and sump field investigations during 1990 and 1992 (PRC, 1991a; 1993). Current receptor populations were limited to individuals working within excavations. These individuals may be exposed via soil ingestion, dermal contact, and inhalation of VOCs. The ILCRs for these pathways are 1.8×10^{-4}, 3.7×10^{-11}, and 6.1×10^{-13}, respectively, for the average case; the values were 3.4×10^{-4}, 7.0×10^{-11}, and 1.2×10^{-12}, respectively, for the RME case. The total ILCR for the average case is 1.8×10^{-4}; the total ILCR for the RME case is 3.4×10^{-4}.

The ILCR values reflect the sole contribution of benzene to carcinogenic risk at the site. The dominant exposure pathway is incidental soil ingestion. It is noted that the ILCR values from the Tank 53 evaluation are based on detections from the 1990 data set; benzene was reported as undetected in the 1992 data set. Furthermore, the seven benzene concentrations ranged from 38.3 to 4,160 ppb. The wide concentration range and the relatively small number of samples may skew the average and RME estimates.

The HIs for soil ingestion, dermal contact, and inhalation of VOCs were 5.8×10^{-5}, 1.3×10^{-5}, and 8.7×10^{-9}, respectively, for the average case; and 1.1×10^{-4}, 2.4×10^{-5}, and 1.5×10^{-8}, respectively, for the RME case. The total HI for the average case is 7.1×10^{-5}; the total HI for the RME case is 1.3×10^{-4}. None of these values exceeds the acceptable value of one.

Total TPHC and gasoline data were also available from the 1990 and 1992 data sets. These materials were analyzed based on individual components (i.e., benzene, toluene, ethyl benzene, and xylenes), which are represented in the results in the previous paragraphs. Lead

was not evaluated from the Tank 53 data set because the evaluation is limited to occupational receptors.

Due to the high concentrations of TDS in groundwater associated with the Tank 53 area, pathways associated with use of groundwater were considered to be incomplete. The high concentrations (approximately 20,000 ppm) are expected to preclude the use of the aquifer in this area as a potential potable water source.

Background and PFNs. All potential occupational and residential exposure pathways evaluated for at least one site for current or potential future land use were included in the quantitative evaluation of background metals and PFNs.

Potential risks to current occupational and future residents receptors at Moffett OU2 sites may occur due to exposure to background metals via incidental soil ingestion, dermal contact, and/or inhalation of fugitive dust. There is no acceptable range available for background risk. The acceptable risk range specified by EPA in the NCP refers to incremental risks above background. The total background cancer risk averages 3×10^{-1} (30 percent) (American Cancer Society, 1990). This includes the risk presented by naturally occurring carcinogens such as the aflatoxins present in many legumes.

Potential HQs associated with occupational exposure to background metals in soils at OU2 are provided in Table 20.5-1. None of the HQs for the individual metals for either incidental soil ingestion or fugitive dust inhalation exceeds the acceptable level of one. Potential ILCRs associated with occupational exposures to background metals in soils are addressed in Table 20.5-2. The ILCR for exposure to arsenic via incidental soil ingestion is 2.0×10^{-6}. This value is within the acceptable risk range of 10^{-6} to 10^{-4} as specified in the NCP.

Potential HQs associated with residential exposures to background metals in soils at OU2 are presented in Table 20.5-3. All HQs are below the accepted value with the exception of lead. The HQ for lead via the incidental soil ingestion pathway is 1.0. The health effects of lead have also been addressed in detail by using the DTSC (1992) lead model as discussed in Section 20.4.1. The evaluation of ILCRs associated with the residential exposures to background metals appears in Table 20.5-4. The ILCR for arsenic is 9.6×10^{-6} under the incidental soil ingestion scenario for residents. This ILCR value is within the acceptable risk range of 10^{-6} to 10^{-4}.

Due to analytical restraints, it is possible for chemicals that have not been detected to contribute significantly to potential risks. Potential ILCRs associated with occupational exposure to chemicals at the CRQL are summarized in Table 20.5-5. Under the incidental soil ingestion scenario, 15 compounds have detection limits associated with potential risks at or above 10^{-4}:

- Aroclor-1016
- Aroclor-1221
- Aroclor-1232
- Aroclor-1242
- Aroclor-1248
- Aroclor-1254
- Aroclor-1260
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Chrysene
- Dibenzo(a,h)anthracene
- Indeno(1,2,3-cd)pyrene

An additional 18 compounds have detection limits associated with risks at or above 10^{-6}:

- Aldrin
- Alpha-hexachlorocyclohexane (BHC)
- Alpha-chlordane
- Beta-BHC
- Bis(2-chloroethyl)ether
- 1,4-Dichlorobenzene
- 3,3'-Dichlorobenzidine
- Dieldrin
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- Gamma-chlordane
- Heptachlor
- Heptachlor epoxide
- Hexachlorobenzene
- Hexachlorobutadiene
- Pentachlorophenol
- Toxaphene
- Vinyl chloride

Potential HQs associated with the occupational exposure are given in Table 20.5-6. None of these values exceeds one at the CRQL.

Potential ILCRs associated with residential exposure to chemicals in the soil at the CRQL are listed in Table 20.5-7. Under the incidental soil ingestion scenario, 24 compounds have detection limits at or above 10^{-4}:

- Aldrin
- Aroclor-1060
- Aroclor-1221
- Aroclor-1232
- Aroclor-1242
- Aroclor-1248
- Aroclor-1254
- Aroclor-1260
- Benzo(a)anthracene
- Benzo(k)fluoranthene
- Bis(2-chloroethyl)ether
- Chrysene
- Dibenzo(a,h)anthracene
- Dieldrin
- 3,3'-Dichlorobenzidine
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- Hexachlorobenzene

- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Indeno(1,2,3-cd)pyrene
- Pentachlorophenol
- Toxaphene

An additional 15 compounds have detection limits associated with potential risks at or above 10^{-6}:

- Alpha-BHC
- Alpha-chlordane
- Beta-BHC
- Bis(2-ethylhexyl)phthalate
- 1,1-DCE
- 1,4-Dichlorobenzene
- 4,4'-DDD
- 4,4'-DDE
- 4,4'-DDT
- Gamma-chlordane
- Heptachlor
- Heptachlor epoxide
- Hexachlorobutadiene
- n-nitrosodiphenylamine
- 2,4,6-Trichlorophenol

Furthermore, 24 compounds had detection limits associated with potential risks at or above 10^{-6} under the dermal contact scenario:

- Aldrin
- Aroclor-1016
- Aroclor-1221
- Aroclor-1232
- Aroclor-1242
- Aroclor-1248
- Aroclor-1254
- Aroclor-1260
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Bis(2-chloroethyl)ether
- Chrysene
- Dibenzo(a,h)anthracene
- 3,3'-Dichlorobenzidine
- Dieldrin
- 2,4-Dinitrotoluene
- 2,6-Dinitrotoluene
- Hexachlorobenzene
- Indeno(1,2,3-cd)pyrene
- Pentachlorophenol
- Toxaphene

Potential HQs associated with residential exposure are provided in Table 20.5-8. Values representing the incidental soil ingestion pathway for juveniles exceeded unity for three chemicals:

- Alpha-chlordane
- 2,4-Dinitrophenol
- Gamma-chlordane.

If any of these chemicals are present at Moffett Field OU2 at or near the CRQL, these chemicals could require remediation. Chemicals are often detected below the CRQL;

therefore, if any of these chemicals were actually present at Moffett Field OU2, it is likely that they would be detected (possibly below the CRQL) in a few samples.

Conclusions. ILCRs and HIs have been estimated for potential current and future exposure to chemicals in soil at Moffett Field OU2 (east). The upper acceptable risk range recommended by EPA is 10^{-6} to 10^{-4} (EPA, 1990). The total ILCR at Site 15 is 1.8×10^{-4} for the average case and 3.4×10^{-4} for the RME case. The ILCR values reflect the sole contribution of benzene to carcinogenic risk at the site. The dominant exposure pathway is incidental soil ingestion. It is noted that the ILCR values from the Tank 53 evaluation are based on detection from the 1990 data set and further samples (PRC, 1993) did not confirm the presence of benzene in the soil. Furthermore, the seven benzene concentrations ranged from 38.3 to 4,160 ppb. The wide concentration range and the relatively small number of samples may skew the average and RME estimates.

Estimated ILCRs for beryllium are within this risk range at Sites 3, 5, and 19 and exceed this range for the RME future residential exposure scenario at Sites 4, 7, and 10. There are no known sources of beryllium at Moffett Field; this metal is not site related. The higher risks are associated with the RME future residential exposure scenario at Site 7, which is a very unlikely scenario for Moffett Field; therefore, the estimated risks associated with this metal are likely to be due to naturally occurring background and the conservative assumptions used in the assessment of this metal.

The predicted potential HI exceeded one for future land use at Site 7. This is due to the predicted accumulation of metals in homegrown vegetables. It is unlikely that these metals are site related; they are more likely to be naturally occurring. These metals have been included as chemicals of potential concern in this baseline risk assessment because of uncertainty caused by the limited amount of available background data from unimpacted areas. Additionally, the hypothetical future land-use scenario is inconsistent with current projected development of the area. Even in a residential scenario, it is unlikely that sufficient land use would be available for development of a garden that could supply the daily quantities of produce assumed in the exposure assessment. Furthermore, the future residential scenario for this site is very unlikely.

This risk assessment integrates toxicological, physiological, exposure assumptions, and environmental sampling data. All of the uncertainties associated with each step of the risk

assessment process impact the risk characterization. Each step in the assessment is biased to overestimate the potential health hazards to compensate for this uncertainty.

20.7 Environmental Assessment

An environmental assessment evaluates the potential for site-related contamination to adversely affect environmental receptors.

The soils that make up OU2 at Moffett Field are located at isolated sites (e.g., Site 9, the Old Fuel Farm and Old NEX Gas Station). With the possible exception of rare plants (which are not present at any of the OU2 sites), environmental receptors are rarely confined to a single site. For this reason, the environmental assessment for OU2 is limited to a review of potential receptors and a qualitative assessment of the potential for adverse impacts. A more complete environmental assessment will be included in the stationwide RI and ecological assessment. The stationwide RI is the most appropriate form for a comprehensive environmental assessment because it covers the entire area, including the marshlands and bay, and includes all potentially contaminated media.

20.7.1 Chemicals of Potential Concern - Environmental

Specific chemicals of potential concern will be selected stationwide in the ecological assessment. In general, the chemicals of potential concern for the soils will be the same as those selected for the human health risk assessment. Some metals that were eliminated because they are essential nutrients and/or have very low toxicity for human receptors may be included in the environmental assessment.

20.7.2 Receptor Assessment - Environmental

This environmental receptor assessment identifies potential environmental populations that may be exposed to site-related chemicals at Moffett Field OU2 under current and future land-use conditions.

20.7.2.1 ~~2.7.2.1~~ Flora

Most of Moffett Field that is not covered by buildings or other structures is either paved or planted with typical urban ornamental plants. Approximately 160 acres of land is under agricultural cultivation. The northwestern portion of Moffett Field contains some areas where vegetation grows in a wild state (ENVIRON, 1981).

The area just north of Moffett Field is within the historical margin of San Francisco Bay and was once open to tidal action. Because the area is now bordered by commercial salt evaporation ponds and dikes on the bayside and contains no open slough channels, regular tidal action has been eliminated.

The absence of tidal inflow and the use of the site for storm water storage has resulted in changes to the plant community. Present vegetation types are distributed according to residual salt concentrations in the bay mud spoils, hydrologic conditions, and the level and salinity of drainage water. Plant distribution as a result of dikes and roads reflect man-made alterations to the area (ENVIRON, 1981).

Major vegetation types found just north of Moffett Field include salt marsh, brackish marsh, fresh-water marsh, and ruderal vegetation (ENVIRON, 1981). A description of each of the vegetation types is given in the following paragraphs.

Salt marsh communities are found in estuaries, bays, and other areas that are protected from wave action and strong winds from the open coast. The soil, which is protected from wave action and strong winds from the open coast, is generally very wet; in some areas it is periodically inundated with salt water by tidal action (Ornduff, 1974). Salt marsh vegetation closest to Moffett Field is found within the edges of Stevens Creek and Guadalupe Slough. Cordgrass, pickleweed (Salicornia sp.), and salt grass (Distichlis spicata) grow at different elevations along with other holophytic species (ENVIRON, 1981).

Brackish marsh vegetation covers a large portion of the area immediately north of Moffett Field. During the winter, this area, which is bordered by wetland vegetation, functions as a storage pond. In the summer and fall months, lower water levels present different conditions, and vegetation such as annual species might cover a larger area of the basin (ENVIRON, 1981).

Fresh-water marsh vegetation grows along the southeastern margin of the brackish marsh where salinity levels are lower. Clumps of cattails (Typha sp.), sedges (Carex sp.), and rushes (Juncus sp.) are distributed over a 100-foot-wide corridor crossed by several water channels (ENVIRON, 1981).

Ruderal vegetation, which consists of transitional opportunistic plant species, is evident along the perimeter drainage ditch and Stevens Creek, but becomes sparse to nonexistent on the

northern border of the brackish marsh where high soil salinity and fluctuating water levels may prohibit establishment of a ruderal margin. Ruderal vegetation occurs on all levees and roads around the perimeter of the brackish marsh. Low forms such as cranesbill (Geranium dissectum), sweet clover (Melilotous sp.), and vetch (Vicia sp.) subtend to the hardy annuals (such as mustard [Brassica sp.], thistle [Cirsium sp.], and sweet fennel [Foeniculum vulgare]) that provide a thick border along most levee roads. Other abundant species include various grasses (Gramineae sp.), curly-leaved dock (Rumex cirpus), and the rare marsh gum plant (Grindelia humilus) (ENVIRON, 1981).

20.7.2.2

~~2.7.2.2~~ *Fauna*

Wildlife in the area consists of a variety of migratory and wintering birds, visiting birds from nearby bayfront and open water habitats, and several resident species of birds and small animals. A variety of waterfowl species frequent both the brackish marsh and the adjacent fresh-water pond. Local duck clubs report that wintering duck species are abundant on the salt ponds immediately adjacent to Moffett Field. Other than in a small section of Stevens Creek, fresh-water marshes are uncommon in this region of the South Bay, and this marsh may be of importance as a nesting habitat to local waterfowl (ENVIRON, 1981).

The brackish marsh provides habitat for shorebirds. The black-necked stilt (Himantopus mexicana), killdeer (Charadrius vaciferus), least sandpiper (Erolia minutilla), and the American avocet (Recurvirostra american) feed in the ponded areas. Other local species associated with the salt marshes include the great blue heron (Ardea herodias), the great egret (Casmerodius albus), cinnamon teal (Anas cyanoptera), the American coot (Fulica americana), and the song sparrow (Melospiza melodia). The ring-billed gull (Larus delawarenis), Bonaparte's gull (Larus philadelphia), western grebe (Aechmorphorus occidentalis), eared grebe (Podiceps caspicus), and the Forester's tern (Sterna forsteri) would be expected to be present occasionally near the brackish marsh (ENVIRON, 1981). Burrowing owls and their burrows have been observed in the northeastern section of Moffett Field.

The numerous salt evaporation ponds lining the South Bay provide significant habitat for several species of birds. The endangered California least tern and other birds prefer to nest on levees bordering salt ponds. A large colony of eared grebes bred in the salt ponds at Moffett Field in 1983. It is the only known nesting ground of the eared grebes in San Francisco Bay (ENVIRON, 1981).

The most conspicuous mammal near Moffett Field is the California ground squirrel (Spermophilus beecheyi), whose burrows are numerous along the wetland levees. Other mammals include the gray fox (Urocyon cinereoargentus), raccoon (Prycyon lotor), black-tailed hare (Lepus californicus), striped skunk (Metphous mephitus), feral cat (Felis domestica), and California vole (Microtus californicus).

20.7.2.3

~~2.7.2.3~~ *Endangered, Threatened, and Rare Species*

The Endangered Species Act (16 U.S.C. 1531 et seq.) provides that all federal agencies shall carry out programs for the conservation of listed endangered, threatened, and rare species. These programs ensure that actions authorized, funded, or carried out by the agencies are not likely to either jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat of these species that are determined by the U.S. Secretary of the Interior to be critical.

The California Native Plant Protection Act of 1978 assigns primary responsibility to the Department of Fish and Game for determining California plants that are to be listed as endangered or rare. A species is endangered when its prospects of survival and reproduction are in immediate jeopardy. A species is rare when (although not presently threatened with extinction) it is present in such small numbers throughout its range that it may become endangered if its present environment worsens. As of November 20, 1979, the State of California has listed 75 endangered and 49 rare plants (California Native Plant Society, 1980).

The California Department of Fish and Game uses the California Native Plant Society's "Inventory of Rare and Endangered Vascular Plants of California" (1980) as their species-of-concern list.

The list of endangered and threatened animal and plant species is published in the ***Federal Register*** 50 CFR 17.11-17.12. The official State of California listing of endangered and rare animals is contained in the CCR, Title 14, Section 670.5 (California Department of Water Resources [DWR], 1983).

The following list presents information about the endangered, threatened, and rare species that may inhabit areas near Moffett Field:

- California least tern (Sterna albifrons browni)

  - Federal status: endangered

  - State of California status: endangered

  - Habitat: beaches, bays, oceans, and estuaries

  - Food: small fish, marine life, and large insects (Peterson, 1961)

  - Preferred prey: anchovy, shiner perch, topsmelt, killifish, jacksmelt, California grunion, and mosquito fish (Naval Facilities Engineering Command [NAVFACENGCOM], 1982)

  - Comments: This species has been observed nesting on levees in Fremont, which is approximately 5 miles northeast of Moffett Field, and at other locations in south San Francisco Bay (ENVIRON, 1981).

- California clapper rail (Rallus longirostris obsoletus)

  - Federal status: endangered

  - State of California status: endangered

  - Habitat: small marshes and salicornia beds among the Pacific coast (Peterson, 1961)

  - Food: aquatic plants, insects, frogs, crustaceans, mollusks, seeds, and buds (Peterson, 1961).

- California black rail (Laterallus jamaicensis coturniculus)

  - Federal status: not listed

  - State of California status: rare

  - Habitat: salt marshes and salicornia beds along the Pacific coast (Peterson, 1961)

  - Food: aquatic plants, insects, frogs, crustaceans, mollusks, seeds, and buds (Peterson, 1961)

  - Comments: Both California clapper rails and California black rails may be present in the salt marsh corridors of Stevens Creek and have been sighted at Guadalupe Slough; both species may occasionally visit the wetlands adjacent to Moffett Field to forage in the areas of dense tidal marsh vegetation (ENVIRON, 1981).

- Brown pelican (Pelecanus occidentalis)

  - Federal status: endangered

  - State of California status: endangered

  - Habitat: salt bays and oceans (Peterson, 1961)

  - Food: mainly fish and crustaceans (Peterson, 1961); feeds mostly on anchovies (NAVFACENGCOM, 1982)

  - Comments: Abundant in Jagel Slough near Moffett Field from August to October (ENVIRON, 1981).

- Salt marsh harvest mouse (Reithrodontomys raviventris)

  - Federal status: endangered

  - State of California status: endangered

  - Habitat: coastal salt marsh; found only in the San Francisco Bay area (Ingles, 1965); prefers dense salt marsh vegetation consisting of pickleweed or a combination of pickleweed and alkali heath, with a border of ruderal habitat

  - Food: seeds and fruit, prefers wild plants (Ingles, 1965)

  - Comments: The salt marsh along Stevens Creek is a potential habitat area; during periods of inundation, mice from the Stevens Creek wetlands may invade the nearby ruderal vegetation area (ENVIRON, 1981).

- San Francisco forktail damselfly (Ischnura gemina)

  - Federal status: Category I candidate

  - State of California status: not listed

  - Habitat: Small seepages, shallow ponds, and sluggish streams (Hafernik, 1988)

  - Food: Small aquatic organisms

  - Comments: Has been found in Marriage Road Ditch (Haas, 1992).

- Marsh gum plant (Grindelia humilus)

  - Federal status: not listed

  - State of California status: candidate rare species (ENVIRON, 1981)

- California Native Plant Society status: rare

- Habitat: salt marsh

- Comments: Two specimens were located on the Stevens Creek levee bordering the brackish marsh (ENVIRON, 1981).

These species have been identified in the Moffett Field area. Most are not present at specific OU2 sites.

20.7.3 Potential Exposure Pathways

Potential environmental exposure pathways include:

- Dermal contact with contaminated soils or sediments
- Ingestion of contaminated soils
- Inhalation of organic vapors
- Inhalation of windborne particulates bearing chemicals
- Ingestion of chemicals that have bioaccumulated into foods.

Environmental receptors may be exposed to chemicals in soils via direct or secondary exposure pathways. Direct exposure pathways include dermal contact, soil ingestion, inhalation of organic vapors, and/or chemicals adsorbed to fugitive dust. Significant exposure via dermal contact would be limited to organic chemicals that are lipophilic and can cross the epidermis of the exposed organism. Mammals are less susceptible to exposure via dermal contact with soils because their fur prevents all of the soil from coming into contact with the skin. However, the animal may ingest the soil during grooming.

Ingestion of soils may result from a number of different behaviors. An organism may inadvertently ingest the soil while grooming; burrowing; or consuming plants, insects, or burrowing invertebrates found in the soil. Some organisms, such as deer, deliberately ingest soil as a source of minerals.

Inhalation of organic vapors would be limited to those chemicals with relatively high vapor pressures. The potential for significant exposure of an organism to occur via vaporization of organics into the atmosphere is low, unless a recent spill involving large quantities of the chemical had occurred. However, the potential of a burrowing animal to be exposed to organic vapors from the surrounding soils is significant, given the limited amount of air

present by which to dilute the vapors and the absence of winds or breezes that would disperse the gases.

Exposure via inhalation of fugitive dust would be limited to chemicals present in surface soils at a site devoid of either vegetation or hardscape that would prevent erosion of soil particles. Intake via this mechanism is probably minimal relative to the other pathways; however, the off-site transport of soils may result in the exposure of organisms that are not present on site.

Chemicals present in sediment may be the result of erosion from a site or the absorption of waterborne chemicals onto the sediment particles. If the sediments are present in an area that is periodically inundated with water, the previous exposure pathways for soils would be applicable during dry periods. The presence of water over the sediments would prevent chemicals from either volatilizing or being carried by wind erosion. The presence of water would involve some different types of receptors from terrestrial sites, i.e. the presence of aquatic organisms, and the potential increased presence of amphibians and some reptiles. Exposure via dermal contact may occur especially for benthic organisms. Some aquatic organisms consume sediment and ingest the organic material from the sediment (e.g. Chironomids). Inadvertent ingestion of sediments may occur as the result of feeding on benthic organisms and plants.

Secondary exposure pathways would be limited to chemicals that bioaccumulate within the food chain. This may include chemicals bioaccumulated from the soil into plants or bio-accumulating into animals that ingest the soil. These plants and/or animals may be consumed by higher animals; thus, these chemicals may be passed up the food chain or impact organisms within the next ecological tier.

20.7.4 Conclusions

Conclusions concerning the ecological impacts of site-related chemicals will require a comprehensive ecological risk assessment. This type of risk assessment has been proposed as part of the stationwide RI and ecological assessment because environmental receptors are not likely to be limited to a single site. Conclusions concerning the ecological impacts of these chemicals will not be addressed under this study but will be addressed as part of the basewide comprehensive ecological risk assessment.

21.0 Summary and Conclusions

This chapter presents a summary of the nature and extent of contamination for each OU2 site and the risk assessment for each site discussed as part of OU2 (east). In addition, any conclusions that can be made as a result of the RI activities will be presented in these sections.

21.1 Marriage Road Ditch - Site 3

21.1.1 Nature and Extent of Contamination

The Marriage Road Ditch runs northward along the east side of Marriage Road, carrying surface drainage from the intersection of Marriage and Macon Roads to the northern boundary of Moffett Field. The probable source for contamination at this site is the surface runoff that flows into the storm drains adjacent to the ditch.

Soil samples were collected from monitoring well borings and soil borings. In addition, a soil gas survey was conducted at the site. The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC.

From the Phase I and II sampling efforts, slightly elevated levels of methylene chloride, phthalates, TPHC, PCBs, lead, and zinc appear to be concentrated at various locations within the Marriage Road Ditch. In general, these concentrations are all in shallow subsurface samples, which support the presumption that runoff into and through the ditch is the source of contamination at Site 3. The analytes detected are scattered in frequency and areal extent, and there is no evidence of gross site contamination.

21.1.2 Risk Assessment

Based on the analysis of the available data, chemicals present in soils at Site 3 are not expected to have a significant long-term adverse health impact on the identified receptors. All ILCRs fall within the range specified in the NCP, with the exception of dermal exposure to beryllium by future residents, and no HQ exceeds unity. The highest estimated ILCRs are for potential future residents and resulted from ingestion of beryllium in soils and vegetables and dermal contact. Beryllium, however, occurs at widespread low levels at Moffett Field and is considered to be reflective of naturally occurring beryllium levels.

21.2 Former Wastewater Holding Pond - Site 4

21.2.1 Nature and Extent of Contamination

Site 4 is located north of Hangar 3 and west of the existing ponds. The former pond was unlined and, during its useful life, received approximately 15 million gallons of wastewater from aircraft washing, equipment maintenance, and operations in Hangars 2 and 3.

RI activities at this site consisted of drilling soil borings and groundwater monitoring wells and collecting soil samples from these borings. The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC.

A number of VOC and BNA compounds were detected in all the Phase II borings; however, the majority of these were detected within the area of the former holding pond, although some were detected in W04-13(B2) across Macon Road. TPHC (JP-5) was also detected within the area of the former pond. The highest readings of the detected analytes within these groups were at the depth (7.5 feet bls) where groundwater was first detected at this site. The extent of soils contamination outside the former holding pond was not fully delineated, and no distribution trends could be delineated for any of the other analytes detected outside the area of the former holding pond.

Several inorganics were detected at or above the various background levels. Of those detected, arsenic and chromium were found in all borings. The arsenic concentrations were below 10 ppm in all borings, and there did not appear to be a distribution pattern in the soils sampled. Chromium was detected above background at concentrations ranging from 56.1 to 86.7 ppm; however, no obvious distribution trend could be delineated. Metals detected do not appear to indicate site-related contamination. It should be noted that the soils in the area of the former pond are likely to represent fill material brought in to close the pond.

21.2.2 Risk Assessment

Chemicals at the site do not present a significant risk to health of receptors identified for both current and future use scenarios. Although the total HQ resulting from vegetable ingestion exceeded unity, the hypothetical future land-use scenario is inconsistent with current residential development for the area. Other chemicals present in the soil did not present an unacceptable risk to human health or the groundwater aquifer.

21.3 Fuel Farm French Drains and Bulk Tanks - Site 5

21.3.1 Nature and Extent of Contamination

The Fuel Farm has been the main fuel facility since the 1950s. This site is separated into a northern and a southern area.

RI activities consisted of drilling and sampling soil and monitoring well borings in both the northern and southern areas. In addition, an SOV survey was also conducted and four organic vapor plume areas were defined. Soil samples collected were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC.

A number of VOCs were detected at Site 5, acetone being the most prevalent; however, except for acetone, these VOCs were either limited in areal extent (detected in only one or two boreholes) or detected at low concentrations. A number of BNA compounds were also detected at this site with bis(2-ethylhexyl)phthalate, diethyl phthalate, and 2-methylnaphthalene being the most common and most widespread. Four plumes of bis(2-ethylhexyl)phthalate and five plumes of diethyl phthalate were delineated, and these corresponded approximately to the plumes noted in the SOV activities.

TPHC (JP-5) was detected in several of the well and soil borings with concentrations ranging from 10 to 1,460 ppm. Four areas were delineated that show TPHC contamination and these areas roughly corresponded to the four plumes defined in the SOV activities. Due to the nature of this site, TPHC contamination is expected, and the various fuel tanks located throughout this site are the candidate sources for the contamination found. Contaminant migration at this site is likely through surface leaks and spills followed by vertical and horizontal migration through the soil.

PCBs were detected in only one boring (SB05-31), which is located near Tank 26. This suggests that Tank 26 may have contained PCB oil at one time. Further investigation of the Tank 26 usage may be warranted.

A number of inorganics (metals) were detected in the soil samples from this site, the majority of which fell within the background ranges noted in Table 3.5-1. Some elevated lead concentrations were detected at one location; however, no obvious trends or plumes could be delineated from the available data, and metals do not appear to indicate site-related contamination.

21.3.2 Risk Assessment

Based on the analysis of the available data, chemicals present in soils at this site do not present an unacceptable risk to human receptors. ILCRs and HIs fall within ranges deemed acceptable based on scientific and regulatory precedent.

21.4 Runway Apron - Site 6

21.4.1 Nature and Extent of Contamination

The site was located adjacent to the former apron northeast of Hangar 3. This site was paved over in 1979 during enlargement of the apron. An estimated 120,000 to 600,000 gallons of hazardous waste from aircraft maintenance was disposed of at this site from the 1940s to the 1970s.

Three monitoring wells were drilled during RI activities and soil samples were collected from these three borings. The collected soil samples were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC.

A number of VOCs were detected in the soil samples from these wells at concentrations ranging from 1 to 290 ppb. Several BNA compounds were also detected at concentrations ranging from 69 to 2,000 ppb. TPHC was only detected in two samples at 14 and 420 ppm. Volatile and semivolatile organics and JP-5 appear to be localized around W06-10(A1). Organics appear to be confined to the top 2 to 3 feet in W06-09(A1), but extend to 4.5 feet in depth at W06-10(A1). The linear distance between W06-09(A1) and W06-10(A1) is approximately 800 feet. Because of this great distance, it is not apparent if the organic concentrations in these soils represent a continuous area of contamination or two discrete areas of contamination. Well W06-10(A1) is also adjacent to Site 13 (Equipment Parking Area) and Sump 63, which are both potential sources for the contamination detected in this well. The vertical depth of contamination by organic constituents at this site coincides closely to the depth at which saturated soils were encountered during drilling activities (6.5 feet bls). VOCs detected in the well borings at the north end of the Runway Apron were at concentrations of 10 ppb or less (ESA, 1986b). It was determined that these soils did not have an impact on the underlying groundwater.

The metals of concern detected in the soils above background at Site 6 include arsenic, beryllium, cadmium, chromium, copper, nickel, silver, and zinc. The range of concentrations for each analyte is narrow, and no obvious metals contamination was delineated. The metals

detected in these soils could be naturally occurring rather than as a result of contamination. Metals detected do not indicate site-related contamination.

21.4.2 Risk Assessment

Based on the analysis of the available data, chemicals of concern at this site do not present an unacceptable risk for current human receptors. In addition, these chemicals are not likely to have systemic (noncarcinogenic) health effects upon current or future residential receptors. Chemical concentrations in soils should not have an impact upon groundwater.

21.5 Hangars 2 and 3 - Site 7

21.5.1 Nature and Extent of Contamination

Site 7 consists of Hangars 2 and 3 and the paved area surrounding the hangars. The suspected sources of contamination at this site are spilled fuels and lubricants from aircraft and ground support vehicles and maintenance activities as well as shop operations chemicals that were disposed of in unpaved areas around the hangars. USTs were also located on the east side of Hangar 3.

A number of monitoring wells and soil borings were drilled at this site and soil samples were collected from the borings. The soil samples collected were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC.

The only VOCs detected in the samples from this site were acetone and toluene as well as minor concentrations of 2-butanone, ethyl benzene, xylenes, carbon disulfide, and TCE. Acetone and toluene were limited in areal extent. Bis(2-ethylhexyl)phthalate was the only BNA detected in the Site 7 soil samples, but it is widespread at Site 7 having been detected in the majority of the borings. Bis(2-ethylhexyl)phthalate appears to be the only semivolatile compound of concern at this site. Although runoff from maintenance activities is the likely source of the contamination detected at this site, the source of the bis(2-ethylhexyl)phthalate is not clear.

TPHC was also detected in two wells/soil borings (SB07-01, W07-20[A1]) at a maximum concentration of 160 ppm.

Metals analyses from the Phase I and II site characterization activities showed elevated concentrations of antimony, copper, and zinc in SB07-02. This has been attributed to the

effects of the laboratory acid extraction process on metal shavings seen in the soils and not to metal contamination within the soil matrix. Shop operations are a potential source of the metal shavings seen in the soils of this site. Other metals detected in the soils above the lowest background value were arsenic, cadmium, chromium, and nickel. The relatively small range of concentrations for these other metals and their low concentrations indicate that there are no anomalous values for these constituents that would suggest soil or site-related contamination.

21.5.2 Risk Assessment

Based on the analysis of the available data, chemicals of concern at this site do not present a significant risk to health for current human receptors. For future use scenarios, intake of copper and zinc via ingestion of homegrown vegetables exceeded acceptable intake levels. However, the model used for this pathway does not consider bioavailability. In addition, the RfD is based on a secondary drinking water standard, which assumes a soluble form of copper and zinc. Given that it is unlikely that food consumption will be a major route of exposure for this site, it is unlikely that this exposure pathway will have an adverse impact on human health. Chemical concentrations in soils should have a minimal effect on groundwater.

21.6 Waste Oil Transfer Area - Site 8

Nature and Extent of Contamination. Site 8 is located near Building 127 where DRMO maintained a 5,000-gallon waste oil tank from the 1940s until 1980. Waste oil was discharged from trucks into a sump and then transferred into the tank. The probable source of contamination was from spillage during transfer activities. The tank has been removed from this site.

A number of soil borings and monitoring wells were drilled at this site and soil samples were collected from the borings. The soil samples collected were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC.

The Phase I and II data were evaluated to determine the extent of soil contamination by VOCs. The major VOCs detected at this site were acetone, methylene chloride, xylenes, 2-butanone, and carbon disulfide in concentrations ranging from below detection levels to 900 ppb. There does appear to be a VOC (acetone) contamination plume at this site.

Diethyl phthalate and bis(2-ethylhexyl)phthalate, the major semivolatile compounds, were detected in the soil samples from this site. The semivolatile constituents appeared to be located around two borings. Semivolatile contamination extends along the southern perimeter of the site.

Although the waste oil transfer sump is a candidate as a source for the contamination detected at the site, the area adjacent to Site 8 has been used for equipment parking; spillage and runoff from this parking area is also a potential source of contamination.

Other than high concentrations of zinc and copper detected in a single boring from the Phase I investigation, no concentrations were significantly above background values for metals at Site 8. For the metals detected, no contamination plume could be delineated in the soils at Site 8, although anomalous zinc and copper concentrations appear to be localized around that boring.

21.7 Old Fuel Farm and Old NEX Gas Station - Site 9

Nature and Extent of Contamination. Site 9 was used for fuel storage from the 1940s until 1964. AVGAS was stored in six 10,000-gallon steel USTs and four 25,000-gallon USTs near Building 29. A 25,000-gallon aboveground tank at Building 29 was used to store AVGAS before removal. Three 5,000-gallon steel USTs located near Building 31 contained motor vehicle fuel, and a 500-gallon UST contained waste oil (Old NEX Gas Station).

A number of other tanks and sumps located within the Site 9 investigation area were identified during RI activities.

RI activities consisted of drilling a large number of soil borings and groundwater monitoring wells throughout the site. Soil samples collected from these borings were analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC.

Multiple VOCs were detected in the soil samples at the Site 9 investigation area. Several areas of 1,2-DCE contamination were delineated within the Site 9 investigation area. Concentrations ranged from 1 to 110 ppb. Sample results from around the Old NEX Gas Station indicated several contaminated areas containing 2-butanone, acetone, BTEX, and methylene chloride. TCE was also detected throughout the site and several small plumes

were delineated. These plumes generally corresponded to the plumes of 1,2-DCE that were seen. PCE was detected in the northeast corner of Site 9 and at Hanger 1.

Several BNAs were detected in the soil samples from this site. Bis(2-ethylhexyl)phthalate was the most common BNA detected. Several plumes of this compound were delineated at Site 9, as well as high concentrations (up to 1,400 ppb at W09-08[A2]) within individual samples/borings throughout the rest of the site. Other BNA compounds detected were limited in extent and did not indicate obvious contamination plumes.

TPHC (JP-5) was detected at minimal levels throughout the Site 9 area and is not thought to be a problem in the shallow soils. TPHC products (gasoline, diesel, motor oil) were detected in the soils at the Old NEX Gas Station area and the Old Fuel Farm Area. The tanks at the Old NEX Gas Station have been removed (as well as contaminated tank pit soils) and additional source control work is planned. The tanks at the Old Fuel Farm are being investigated for source control measures at this time. These tanks are located at or below the saturated zone and the contribution to contamination in the shallow soils is considered minimal. Contamination from these tanks in the groundwater (saturated zone) is addressed in the West Side Groundwater Site Characterization Report (IT, 1993).

There are a number of contamination sources at this site including the Old NEX Gas Station, various USTs, the adjacent Site 18 (Dry Cleaners), Site 14 (Tanks 67 and 68), and Site 17. In some instances, the contamination was found at or adjacent to a source, while in other cases, contamination was found in areas seemingly unrelated to a contamination source. It is probable that much of the VOC contamination is from contaminated groundwater rather than a nearby surface source. The TCE contamination seen at the groundwater interface averaged an order of magnitude higher than the values seen in the shallow soils. In addition, similar observations have been made at other sites at Moffett Field. In a memo dated February 26, 1992 by IT Corporation (recommendation for further investigation/remedial design for the shallow soils and groundwater around Site 5: the Northern Fuel Farm), page 2, paragraph 3 (soil/groundwater contamination), it was noted that all field-detected contaminants were encountered in close proximity to the water table, and clean soils were found above this zone. The memo states, "This suggests that the areas explored were impacted by contaminants transported in the groundwater from another source, and did not percolate down through the soil or originate from contaminated soil."

A number of metals were detected at this site. With the exception of copper, all were within established background levels and did not indicate site-related contamination. Copper was detected in W09-12(B2) (adjacent to Building 6) at 32,900 ppm. Copper concentrations in adjacent well borings were less than 100 ppm. The source of this anomaly is undetermined, but it appears to be confined to the soils at monitoring well boring W09-12(B2).

21.8 Chase Park Area and Runway - Site 10

21.8.1 Nature and Extent of Contamination

Site 10 encompasses the runway and the Chase Park area, which is located north of the Bayshore Freeway and south of the Site 9 area. Each of the samples taken in the runway area was analyzed for VOCs, pH, metals, PCBs, BNAs, and TPHC. Detected VOCs included acetone and methylene chloride, but these were considered laboratory contaminants based on laboratory method blank analyses. Bis(2-ethylhexyl)phthalate was detected in three samples (110 to 730 ppb) and TPHC JP-5 was detected in one sample (170 ppm). The specific source for these contaminants is not clear. There are no sources in Chase Park and no samples were taken there.

A number of wells were also drilled in the runway area for the MEW RI. Several VOCs were detected at the 3- to 6.5-foot-bls and 7- to 11-foot-bls sampling depths. Recent sampling of the wet well contents from the Building 191 Lift Station, which receives runoff from the runway, indicated TCE concentrations ranging from 6 to 13 ppb. However, the soil samples from the MEW wells showed only two TCE detections in different borings from different depths. Although the suspected source of contamination is runoff from the runway and migration into the soil, the contamination seen in the deeper (7 to 11 feet bls) samples is at or below the groundwater table and may be contributed by the groundwater.

The levels, patterns, and trends of the detected metals did not indicate site-related contamination.

21.8.2 Risk Assessment (Runway Area Only)

ILCRs for chemicals of concern at the Site 10 runway area fall within the range deemed acceptable based on scientific and regulatory precedent. Higher ILCRs are associated with potential dermal exposures to beryllium; however, similarly high risks are associated with background levels of this metal. Based on the analysis of the available data, these chemicals of concern are not likely to have a systemic (noncarcinogenic) health effect upon occupational

receptors. Future exposure scenarios also had ILCRs within the acceptable range. Potential systemic toxicity to humans resulting from intake of site-related chemicals is unlikely.

21.9 Engine Test Stand Area - Site 11

21.9.1 Nature and Extent of Contamination

The Engine Test Stand Area is used to test turbine engines. The site is fenced and underlain by both concrete and asphalt, which constitute a pad approximately 200 by 200 feet. The primary source of contamination is runoff from precipitation and hydraulic cleaning of the slab, possibly resulting in the transport of residual spilled fuel products and lubricants to local soils. Previous investigations and drainage patterns indicate that the primary recipient of the runoff is an adjacent area to the south of the slab.

Soil samples were collected from two monitoring well borings, ten surface, and ten shallow soil borings located on 20-foot centers to the south of the concrete slab, and from an additional eight shallow soil borings around the perimeter of the slab. A total of 54 soil samples were collected from 1-, 3-, 5-, and greater than 5-foot depths and analyzed for VOCs, BNAs, TPHC, oil and grease, PCBs, metals, and pH.

Detected constituents included six VOCs, of which two, acetone and methylene chloride, were associated with blank contamination. The remaining detected VOC analytes (1,1,1-TCA, carbon disulfide, toluene, and 2-butanone) were infrequently detected, present in low concentrations (1 to 16 ppb), and did not indicate a contamination plume.

A total of 18 BNAs were detected in Site 11 soil samples. The most commonly detected BNA, bis(2-ethylhexyl)phthalate, occurred in 26 samples ranging from 49 to 4,500 ppb. The highest concentration occurred in the 5- to 10-foot-bls sample from GSB11-11, which is located in the center of the stained area to the south of the slab. Discernible contamination plumes were found in the areas south of the slab and, to a lesser degree, north of the slab.

Each of the contaminated areas is immediately adjacent to the slab and is a suspected result of precipitation and hydraulic cleaning runoff. Bis(2-ethylhexyl)phthalate concentrations (88 to 480 ppb) located across Zook Road to the west possibly resulted from precipitation and contaminant runoff from the Engine Test Stand Area via Zook Road.

The remaining BNAs detected at the Engine Test Stand Area were found in each of the regions where bis(2-ethylhexyl)phthalate was detected, but with less frequency and at lower concentrations. The suspected source is assumed to be the same as that for bis(2-ethylhexyl)phthalate.

TPHC (JP-5) was detected in two samples (130 to 300 ppm) obtained from the area south of the concrete pad.

Oil and grease were the most frequently detected analytes, appearing in 40 samples at concentrations ranging from 2 to 9,600 ppm. The mean concentration of the 1- to 3-foot-bls samples was 757 ppm. The mean concentration of the 5- to 10-foot-bls samples was 90 ppm. These facts suggest that while vertical migration is present, it is limited.

Although concentrations were detected in virtually all of the samples, the significant concentrations were found in the area (grid sampling area) immediately to the south of the Engine Test Stand Area where previous studies indicated contamination. In particular, perimeter boring samples to the southeast of the sampling grid indicated some of the higher concentrations. The areas containing oil and grease are at 1 foot bls. Due to the presence of perimeter contamination, the horizontal extent of contamination cannot be completely defined. Runoff from the Engine Test Stand Area is the apparent source of oil and grease contamination at this site.

The majority of the detected metals were concentrated in different regions of the site. For example, the higher concentrations of antimony were detected in the western region of the grid sampling area, while the higher arsenic concentrations were detected in the eastern region of the grid sampling area. The highest beryllium concentrations were not detected in the grid sampling area (south of the Engine Test Stand Area) at all, but instead were found in the borings to the north and west of the Engine Test Stand Area, across Zook Road. Based on these observations, it does not appear that the Engine Test Stand Area was the common source for each of these elements. The detected inorganics were reviewed for plumes, patterns, trends, or other evidence of site-related contamination. The few elevated detections appear to be anomalous to the site, while the other detections appear to be randomly distributed. However, it does not appear that these elements are indicative of site-related contamination.

21.9.2 Risk Assessment

The chemicals at the site do not present an unacceptable risk to current populations at Moffett Field. Future exposure scenarios had ILCRs within acceptable ranges. Based on the analysis of the available data, these chemicals are not likely to have a systemic (noncarcinogenic) health effect upon potential future receptors. The oil and grease seen at this site indicate petroleum spillage, but the hazardous constituents assessed do not present an unacceptable risk to current populations at Moffett Field.

21.10 Equipment Parking Area (Building 142) - Site 13

21.10.1 Nature and Extent of Contamination

The Equipment Parking Area is a concrete/asphalt support vehicle parking lot. Water and wastewater runoff from the repair and maintenance of aircraft ground support equipment are potential sources of contamination to the surrounding drainage ditch soils. Three shallow soil borings were installed in the north-south trending storm drain, and a fourth boring was installed in the center of the east-west trending drainage channel. Soil borings were sampled at approximate depths of 1 and 5 feet. A total of eight soil samples were collected and analyzed for VOCs, BNAs, TPHC, oil and grease, and metals.

Detected VOCs included toluene, acetone, and methylene chloride. Toluene was detected in five samples at concentrations (2 to 3 ppb) below the CRQL of 5 ppb. Methylene chloride was detected in all eight samples and acetone was detected in three samples. The detected concentrations ranged from 3.1 to 50 ppb; however, all methylene chloride and acetone detections had associated blank contamination, and based on the 10x rule discussed in Chapter 2.0, they are assumed to be the result of laboratory contamination.

The detected BNAs included bis(2-ethylhexyl)phthalate, found in each sample at concentrations ranging from 84 to 650 ppb, and di-n-butylphthalate, found in both samples from SB13-01 at concentrations ranging from 40 to 64 ppb.

Oil and grease were found in each of the eight samples at concentrations ranging from 6 to 1,150 ppm in the drainage ditches surrounding Site 13 and were considered the primary site contaminants. The majority of the higher concentrations of oil and grease were found in the 5-foot-bls samples. The mean concentration of 5-foot-bls samples was 379 ppm, as compared to the mean concentration of the 1-foot-bls samples at 156 ppm. These results indicate some

degree of vertical migration. The extent, however, cannot be delineated with the available data.

Because the extreme upstream and downstream samples indicate the presence of oil and grease, the extent of contamination has not been completely defined. Further contaminant migration via the drainage ditch is a possibility. The presence of oil and grease in samples collected upstream of the east/west drainage channel suggests that oil and grease are being transported via runoff directly from the parking lot at Building 142 to the main north/south drainage channel and/or from runoff from upstream parking lots at Buildings 541 and 348.

Well W06-10(A1) (Site 6) is located just west of the Equipment Parking Area and adjacent to Building 142. A number of contaminants were detected in the soil samples from this well, which suggests that contamination might be migrating through the soil from the parking area or that another contaminant source may be in this area.

The detected inorganics were reviewed for plumes, patterns, trends, or other evidence of site-related contamination. It does not appear that the detections of these elements indicate site-related contamination.

21.10.2 Risk Assessment

The chemicals at the site do not present unacceptable risks to current and future populations. The oil and grease seen is an indicator of petroleum product spillage, but the assessment of the hazardous constituents contained within petroleum products did not present an unacceptable risk.

21.11 Tanks 19, 20, 67, and 68 - Site 14

Nature and Extent of Contamination. Site 14 is subdivided into a southern region (Tanks 19 and 20) and a northern region (Tanks 67 and 68).

Tanks 19 and 20. The primary sources of contamination in the southern region were recently removed Tanks 19 and 20. Each tank had a capacity of 5,000 gallons and contained unleaded vehicle fuel. These tanks were removed prior to any RI activities.

IT installed three soil borings and six monitoring wells within 150 feet of the tank site. Soil samples from the monitoring well borings and shallow soil borings at Tanks 19 and 20 were collected and analyzed for VOCs, metals, PCBs, BNAs, and TPHC.

A total of six VOCs were detected in the area of Tanks 19 and 20; however, acetone (the most frequently detected compound) and methylene chloride had associated blank contamination. Based on the 10x rule as discussed in Chapter 2.0, it is assumed that detections of these compounds are attributable to laboratory contamination. The remaining VOCs (toluene, 2-butanone, 1,1,1-TCA, and tetrachloroethane) were detected in small concentrations (less than 10 ppb) and at limited areal extent, and their presence does not represent any discernible site contamination plumes. The results of the soil gas survey, conducted approximately 200 to 300 feet north of Tanks 19 and 20, did not indicate the presence of fuel hydrocarbons or the extension of a contamination plume from the tank site.

Detected BNAs included bis(2-ethylhexyl)phthalate (55 to 530 ppb), di-n-butylphthalate (63 to 130 ppb), naphthalene (59 ppb), and phenanthrene (47 ppb). There is no apparent contamination pattern for BNA compounds detected at Tanks 19 and 20, and these tanks are not a suspected source of BNA contamination.

Although a discernible contamination plume was not evident, the elevated levels of inorganics detected were concentrated in an area directly north of Tanks 19 and 20. The source of these elements is unknown. However, these levels of inorganics are thought to represent natural variations within the soil and are not indicative of site contamination.

Tanks 67 and 68. The primary sources of contamination in the northern region were Tanks 67 (removed) and 68 (abandoned). Tank 67 was used to store fuel oil and had a capacity of 20,000 gallons. Tank 68 is reportedly a 2,000-gallon tank that was used to store waste solvents. PRC Environmental Management, Inc., collected a total of 19 soil samples during the removal of Tank 67 and an in situ soil investigation of abandoned Tank 68. All samples were analyzed for VOCs, BNAs, TPHC-diesel, TPHC-kerosene, and TPHC-gasoline (PRC, 1991a).

The VOCs common to both Tanks 67 and 68 soil samples were total 1,2-DCE (3 to 55 ppb), TCE (2 to 100 ppb), and toluene (3 to 47 ppb). Also detected were PCE (11 to 140 ppb) and 1,1-DCA (6 ppb). Although these results indicate some minor contamination in and around the tank pit, there is no indication of gross contamination from these tanks. The only

common sampling depth for all samples in the area of Tanks 67 and 68 was 7.0 to 8.0 feet bls. At this depth, an inspection of total 1,2-DCE, the most commonly detected VOC, indicated low, uniform, and evenly distributed concentrations. No clear horizontal migration trends were evident with the exception of a slight increase in 1,2-DCE concentrations moving north across the Tank 67 excavation area. This activity is more than likely due to groundwater transport because groundwater was encountered at 7 feet bls and the predominant groundwater flow direction is north.

Both of the detected BNAs were found in Tank 68 borings. Bis(2-ethylhexyl)phthalate and di-n-butylphthalate were detected once each at concentrations of 140 ppb and 125 ppb, respectively.

TPHC-diesel was detected in one pipe trench sample at 150 ppm. The absence of TPHC compounds around the tank site indicates the probable source of the detected TPHC contaminants may be something other than Tanks 67 or 68. This is further illustrated by the fact that the most commonly detected compounds (1,2-DCE and TCE) were found in roughly the same concentrations throughout adjacent Site 9. Although Tank 68 cannot be dismissed as a source of VOC contamination, the results of the testing do not indicate any gross contamination at or around the tank. The most likely source of contamination in this area appears to be the dry cleaners (Building 88), although much of the VOC contamination may be from an area with a groundwater contamination plume.

21.12 Public Works Steam Cleaning Rack Sump 60 - Site 16

Nature and Extent of Contamination. Site 16 was an oil/water separator (Sump 60) utilized to collect wash water runoff from a vehicle steam cleaning area.

During the removal of Sump 60, PRC Environmental Management, Inc., collected a total of 14 soil samples from the sump excavation and the installation of a monitoring well (PRC, 1991a). Detected contaminants included three VOCs, toluene, xylene, and TCE, at concentrations ranging from 3 to 440 ppb. Toluene was the most consistently analyzed and detected organic constituent in the soils as well as the major constituent detected in a waste sample from Sump 60. Toluene was found at each sample location's greatest depth and in all site perimeter samples; therefore, the extent of contamination could not be defined. Based on these observations and the past utilization of the sump, it appears that Sump 60 was the source of this VOC contamination. One BNA compound, trichlorobenzene, was detected at

410 ppb. TPHC (diesel, gasoline) and oil and grease were detected at concentrations ranging from 5.6 to 610 ppm. The detected inorganics were reviewed for plumes, patterns, trends, or other evidence of site-related contamination. It does not appear that these elements are indicative of site-related contamination.

An additional investigation at Sump 60 by PRC in May 1992 consisted of the installation of an adjacent monitoring well and subsequent collection of seven soil samples. The samples were analyzed for VOCs, TPHC-gasoline, TPHC-diesel, and TPHC-JP5. Toluene was detected in the three shallowest (7.0, 10.0, and 15.0 ft. bls) samples at concentrations ranging from 4 to 59 ppb. TCE was detected at the two greatest depths (28.0 and 34.0 ft. bls) at concentrations of 6 ppb and 2 ppb, respectively. TPHC contaminants were not detected.

21.13 Paint Shop Sump 61 - Site 17

Nature and Extent of Contamination. Sump 61 received paint waste (paints, thinners, toluene, turpentine, etc.) from Building 45 and unknown wastes from Hangar 1. During the removal of Sump 61, PRC collected five soil samples from the sump excavation and a nearby monitoring well installation (PRC, 1991a). IT collected nine soil samples from three monitoring well borings (Site 9) near the sump. All PRC soil samples were analyzed for VOCs, BNAs, BTEX, TPHC-diesel, TPHC-gasoline, and metals, while the IT soil samples were analyzed for VOCs, BNAs, PCBs, TPHC, and metals.

The only detected VOCs in the excavation samples from beneath the sump were toluene and total xylenes. Toluene was detected in both excavation samples at concentrations of 36 ppb and 23 ppb, while xylene was detected in one excavation sample at 9 ppb. The VOCs found in the surrounding IT monitoring well borings were TCE (2 to 100 ppb), 1,2-DCE (14 ppb), and acetone (16 to 20 ppb).

A liquid sample of the Sump 61 contents was collected before the sump was removed. The analysis results indicated that the primary organics detected were almost exclusively BTEX compounds. Respective concentrations were benzene (18 ppb), toluene (3,200 ppb), ethyl benzene (36 ppb), and xylene (180 ppb). As previously mentioned, the only organics detected in the excavation area beneath Sump 61 were toluene at 36 ppb and xylene at 9 ppb. The large difference in the order of magnitude between the source and surrounding soils indicates that contaminant migration is extremely limited, if existent, and the majority of contaminated soil was excavated with the sump removal. With the exception of small acetone concentrations (16 to 20 ppb), none of the organics detected in the surrounding IT monitoring well

borings was present in the liquid sump sample indicating no gross or area-wide contamination had occurred near Sump 61.

Bis(2-ethylhexyl)phthalate, the only BNA compound detected, was found at each sample depth in IT monitoring well boring W09-23(A1) (140 to 190 ppb) and in the 3-foot-bls sample (2,000 ppb) of IT monitoring well boring W09-28(A2). No BNAs were detected in the sump excavation. The bis(2-ethylhexyl)phthalate concentrations from surrounding IT monitoring well borings are not thought to be attributable to Sump 61.

Sump 61 is not considered a source of inorganic contamination at Site 17, and there is no indication that site-related (inorganic) contamination exists. The elevated detections appear to be an indication of natural variation within the soils. No plumes or patterns exist at this site.

21.14 Dry Cleaners' Sump 66 - Site 18

Nature and Extent of Contamination. The primary source of contamination at Site 18 is the Dry Cleaners' Sump 66, located on the north side of Building 88. Field investigations by ERM-West in 1987 revealed cracks in the sump and VOC concentrations (primarily PCE and TCE) up to 6,900 ppb in the surrounding soils. The ERM-West study also found a concentration of 18,000 ppb of PCE in a waste sample from Sump 66 (1987). PCE is a compound commonly used in dry cleaning; TCE is a common degradation product of PCE.

Other possible contaminant sources include Tanks 67 and 68, located on the east side of Building 88, and Sump 91, located on the north side of Building 88. Tanks 67 and 68 have recently been removed/closed in place and are included in the Site 14 discussion.

Sump 91 is a 700-gallon single-chamber inactive sump that reportedly contained rusty water and sludge that was contaminated with carbon tetrachloride. All material was removed from the sump in July 1991. The sump received liquids from the floor drains in Building 88. A sample of the Sump 91 contents contained 1,2-DCE (2,400 ppb), TCE (120 ppb), TPHC (1,300 ppb), and 4-methylphenol (14 ppb) (PRC, 1992). The TPHC detection was extractable as components other than diesel, JP-5, kerosene, or motor oil. PRC installed one monitoring well, W91-01(A1), directly northwest of Sump 91. Analyses of the soil sample from the unsaturated zone in boring W91-01(A1) did not indicated the presence of significant contaminant concentrations (only TCE at a concentration of 3 ppb was detected). Analyses of soil samples collected from a saturated zone indicated low levels of chlorinated VOCs and

TPHC purgeable as gasoline. PRC concluded that Sump 91 is not considered a VOC contaminant source because VOC concentrations detected in saturated soil samples are likely caused by the presence of contaminated groundwater migrating into the Building 88 area from upgradient sources, and because the unsaturated zone soil sample did not indicate contamination. PRC also stated that the low levels of TPHC purgeable as gasoline detected in soil samples from boring W91-01(A1) were attributed to laboratory contamination.

A Phase I IT soil gas survey revealed total ionizable compound concentrations ranging from 0.2 to 216.3 ppm during field testing. Samples collected for GC analysis revealed several VOC compounds with TCE, at 941,000 ppb, having the highest concentration. The soil gas plume indicated the concentration of TCE to be at its highest near the southwest corner of Building 126, approximately 250 feet northeast of Sump 66. During the removal of Sump 66 in May 1990, PRC collected three soil samples from the sump excavation. PRC soil samples were analyzed for VOCs, TPHC-diesel, TPHC-motor oil, and TPHC-gasoline. IT collected 24 soil samples from four monitoring wells and three soil borings located at Site 9 within approximately 200 feet of Sump 66. IT soil samples were analyzed for VOCs, BNAs, metals, PCBs, and TPHC (JP-5). The majority of the VOC compounds detected were in the surrounding monitoring well/soil boring IT samples. The primary VOCs detected were TCE (2 to 130 ppb), 1,2-DCE (total) (1 to 86 ppb), and PCE (1 to 21 ppb). Although the dry cleaners is an obvious source for the contamination detected at Site 18, Sump 66 does not appear to be the only source for VOC contamination levels in the soils at Site 18 due to the following observations:

- IT monitoring wells/borings were located from 70 to 200 feet from Sump 66. Although contaminant transport in shallow soils at these horizontal distances is not impossible, it is extremely unlikely.

- TCE was consistently detected at the greatest depth (up to 11.5 feet bls) in all of the surrounding IT monitoring wells/borings indicating possible contributions from groundwater contamination.

- Similarly, each of the ERM-West (1987) borings was sampled at depths (up to 20 feet bls) that would have been influenced by groundwater contamination.

- TCE was not detected in the PRC sump excavation samples collected directly beneath Sump 66.

Two BNAs (76 to 600 ppb) were detected in the IT samples. Analysis for BNAs was not performed on the sump excavation samples; however, based on the review of VOCs, Sump 66

is not suspected as the source of any BNA contamination. TPHC products were found in each sump excavation sample (1.3 to 63 ppm) suggesting the sump may have contained TPHC products at one time and leaked these products into the underlying soil.

Although it appeared that there was some minimal contamination within the sump pit, the majority of the contaminated material was localized around the sump and was excavated. Contamination detected within the Site 9 monitoring well and soil borings did not appear to be related to this sump. No inorganic analysis was performed on the sump excavation soil samples. There is no evidence that inorganic contamination at Site 18 is attributable to Sump 66.

21.15 Tanks 2, 14, 43, and 53 - Site 19

21.15.1 Nature and Extent of Contamination

Tanks 2, 14, 43, and 53 are the suspected contamination sources for Site 19. Tank 2 had a capacity of 2,000 gallons and was used as a hazardous waste storage tank for wastes from the Power Plant Shop located in Hangar 3. Tank 14 was a 1,100-gallon unvented standby diesel tank for a backup generator in Building 158, the Operations Building. Tank 14 is located on the west side of OU2 and has not been evaluated in the risk assessment. Tank 43 was a 2,000-gallon hazardous waste collection and storage tank. Tank 43 collected rinse water from engine cleaning racks, drains, and sinks in Hangar 3. Tank 53 was a 500-gallon unleaded gasoline tank for use at the golf course physical plant.

Tanks 2 and 43. Prior to the removal of Tanks 2 and 43, IT collected a total of 28 soil samples from four monitoring wells and five shallow soil borings surrounding the tank sites. IT soil samples were analyzed for VOCs, BNAs, PCBs, metals, and TPHC. During the removal of Tanks 2 and 43, PRC collected a total of 43 soil samples from the tank excavation area and three adjacent monitoring wells. All PRC soil samples were analyzed for VOCs, BNAs, TPHC-diesel, TPHC-gasoline, and TPHC-motor oil. The PRC samples from Tank 43 were also analyzed for metals (PRC, 1991a).

Two of the detected VOCs at Tanks 2 and 43 were methylene chloride (10 to 46 ppb) and acetone (18 to 120 ppb); however, each sample was associated with blank contamination with only one acetone concentration exceeding the 10x rule discussed in Chapter 2.0. VOCs detected in soils at both Tanks 2 and 43 included TCE (2 to 110 ppb), toluene (1 to 6,300 ppb), and PCE (2 to 23 ppb). VOCs limited to Tank 43 soils only include xylenes (7 to

2,000 ppb), ethyl benzene (71 to 150 ppb), and styrene (7 ppb). Detected BNAs common to soils at both Tanks 2 and 43 in the excavation samples and the surrounding boring samples were bis(2-ethylhexyl)phthalate (18 to 1,700 ppb) and di-n-butylphthalate (38 to 26,350 ppb). Eight other BNAs (81 to 15,900 ppb) were found in soils surrounding Tank 43 only. TPHC products were detected in the majority of the excavation samples from Tanks 2 and 43. With the exception of 48 ppm of toluene in sample TN2-NX, TPHC products were the only detected constituents in the PRC excavation samples taken from the soils (walls) immediately adjacent to Tank 2. These data indicate some degree of horizontal migration in the north-northeast direction. The IT soil samples collected from the surrounding monitoring wells/soil borings reinforces this assumption. Of the four borings, only W07-20(A1) located to the northeast of Tank 2 indicated the presence of TPHC. The absence of petroleum products in the remaining perimeter IT borings suggests that horizontal contaminant migration from the source is limited to the immediately surrounding soils. The vertical extent of contamination is unknown because TPHC concentrations were detected in several samples collected from the deepest sample depth (8 feet bls).

TPHC products were the most commonly detected constituents in the samples collected from the enlarged excavation of Tank 43 and its piping. Based on the relatively low concentration of TPHC detected in the samples obtained after the final (enlarged) excavation, it appears as though the majority of contaminated soils was removed during tank excavation.

One exception to this is the isolated area encompassing the south wall (2,000 ppm) and the west wall (1,400 ppm) of the tank excavation area; however, the absence of TPHC products in the surrounding IT monitoring well/soil boring soil samples to the north, east, and south indicate no extensive migration has occurred.

The detected inorganics were reviewed for plumes, patterns, trends, or other evidence of site-related contamination. It does not appear that these detections are indicative of site-related contamination.

Tank 14. During the removal of Tank 14 in May 1990, PRC collected ten soil samples from the tank excavation area and an adjacent monitoring well. All soil samples were analyzed for BTEX, TPHC-diesel, TPHC-motor oil, and TPHC-gasoline. The only detected BTEX compound was toluene (5.7 to 130 ppb). Detected TPHC compounds ranged in concentration from 3 to 4,440 ppm (PRC, 1991a).

An additional investigation of Tank 14 by PRC was conducted in May 1992. Six Geoprobe soil samples were collected from an area immediately north of the initial tank excavation. The samples were analyzed for TPHC-diesel, but it was not detected.

Samples obtained from the walls of the enlarged excavation in May 1990 indicated that TPHC products were the only organic constituents detected. Of these TPHC products, TPHC-diesel possessed the highest concentrations and was the most frequently detected. Based on the extremely small concentrations of TPHC-diesel (0 to 3.9 ppm) detected in the east, south, and west walls of the excavation, it appears that the majority of any contaminated soil was removed during tank excavation and that no contaminants exceeded the horizontal or vertical excavation limits. A TPHC-diesel concentration of 1,700 ppm found in the north wall sample appears to be isolated because the additional Geoprobe sampling did not detect TPHC-diesel in this region.

Tank 53. IT collected a total of nine soil samples from two monitoring wells and two soil borings from Site 3, which is adjacent to Tank 53. IT soil samples were analyzed for VOCs, BNAs, TPHC, PCBs, and metals. During the removal of Tank 53 in May 1990, PRC collected seven soil samples from the tank excavation area and an adjacent monitoring well. All PRC soil samples were analyzed for VOCs, BTEX, and TPHC-gasoline (PRC, 1991a). An additional investigation at Tank 53 by PRC in May 1992 included 24 Geoprobe soil samples collected from areas to the south, east, and west of the tank excavation area and 3 soil samples collected during the installation of an adjacent monitoring well. Each of these samples were analyzed for TPHC-gasoline and BTEX compounds.

The only detected VOCs from IT samples were acetone and 2-butanone. Each of the BTEX constituents was detected in the PRC samples collected in May 1990. Samples obtained from the walls of the enlarged excavation indicated significant levels of BTEX were present. The highest concentrations of any single BTEX constituent in each wall sample are as follows: north wall (ethyl benzene - 1,430 ppb), south wall (total xylenes - 77,710 ppb), east wall (ethyl benzene - 1,430 ppb), west wall (total xylenes - 4,955).

BTEX constituents were also detected in several of the 24 Geoprobe soil samples collected in May 1992. On-site field screening of the Geoprobe samples detected each of the BTEX constituents ranging from 12 ppb (xylene) to 457,000 ppb (benzene). Thirteen of the soil samples collected by Geoprobe were sent to the laboratory for confirmatory analysis. Laboratory analysis of the Geoprobe samples detected toluene, ethyl benzene, and xylene at

concentrations ranging from 100 to 79,000 ppb. Laboratory analysis did not confirm the presence of benzene detected in the field screening analysis. BTEX contamination appears to be isolated to the tank area with the exception of an area to the southeast. BTEX distribution and local topography to the southeast suggested contaminants from Tank 53 may have migrated toward a drain near the center of the maintenance yard. It can be assumed that no extensive migration has occurred because the outerlying (120 feet from Tank 53) IT monitoring well/soil boring soil samples did not detect any BTEX constituents.

The BNA compound bis(2-ethylhexyl)phthalate was detected in two IT borings. The PRC samples were not analyzed for BNA compounds. There does not appear to be a link between BNA compounds detected in Site 3 samples and Tank 53.

Tank 53 is the apparent source for the TPHC contamination found in the PRC soil samples. Detected concentrations and local topography suggest TPHC contaminants from Tank 53 may have migrated toward a drain near the center of the maintenance yard.

Inorganic analysis was not performed on the PRC samples. No evidence indicates Tank 53 is a possible inorganic contaminant source for surrounding Site 3 soils.

21.15.2 Risk Assessment (Tanks 2, 43, and 53)

The chemicals at the site do not present unacceptable risks to current and future populations. In general, ILCRs are within the range specified by the NCP at this site and all HIs are at least an order of magnitude less than the target value of unity. The ILCR values at Tank 53 reflect the sole contribution of benzene to carcinogenic risk at the site, and the ILCR values are based on detections from a small sample set taken by PRC in 1990. Further soil sampling at this site did not confirm the presence of benzene in the soil (PRC, 1993). It is unlikely that chemicals in the soils at the Tanks 2 and 43 area will impact groundwater. Due to high TDS levels in the Tank 53 area, the groundwater is not considered a potential potable source.

21.16 RI Conclusions

As noted previously, EPA determined that the OU2 sites (west) that overlie the regional groundwater plume or are within the MEW regional study area have been addressed by EPA in the 1989 ROD for the MEW study area. Because the MEW ROD also addresses soils in the regional study area, those OU2 sites (west) that overlap with the MEW ROD have not proceeded through the baseline risk assessment and will not proceed through the FS or ROD phases. However, the Navy will provide expanded source controls and remedial designs for

the OU2 (west) soils following guidance in the MEW ROD. The other sites in OU2 (east) have been carried through the baseline risk assessment and will proceed through the FS and ROD phases as appropriate. If other sites are identified during the completion of the IRP, these sites will be included in the stationwide RI.

ILCRs and HIs have been estimated for potential current and future exposure to organic chemicals in soil at Moffett Field OU2 (east). The upper acceptable risk range recommended by EPA is 10^{-6} to 10^{-4} (EPA, 1990). At Site 19 (Tank 53), the total ILCR for the average case is 1.8×10^{-4} and for the RME case is 3.4×10^{-4}. The ILCR values reflect the sole contribution of benzene to carcinogenic risk at the site. The dominant exposure pathway is incidental soil ingestion. It is noted that the ILCR values from the Tank 53 evaluation are based on detections from the 1990 data set, yet further sampling (PRC, 1993) did not confirm the presence of benzene in the soil at this site and indicated considerable reduction in all other contaminant levels. Additionally, the Navy and the EPA agreed to exclude IRP sites containing only petroleum and petroleum-related constituents from the CERCLA process. Accordingly, petroleum contamination at Site 19 will be addressed through separate corrective action, which is outlined in the Federal Facility Agreement revisions.

ILCRs and HIs have been estimated for potential current and future exposure to inorganic chemicals in soil at Moffett Field OU2 (east). Estimated ILCRs for beryllium are at the upper limit of the EPA risk range for the RME future residential exposure scenario at Sites 3, 4, 7, and 10. However, there are no known sources of beryllium at Moffett Field and this metal is not site related. The higher risks are associated with the RME future residential exposure scenario at Site 7, which is a very unlikely scenario for Moffett Field. The estimated risks associated with this metal are likely to be due to naturally occurring background and the conservative assumptions used in the assessment of this metal.

The predicted potential HI exceeded one for future land use at Site 7. This is due to the predicted accumulation of metals in homegrown vegetables. It is unlikely that these metals are site related; they are more likely to be naturally occurring. These metals have been included as chemicals of potential concern in the baseline risk assessment because of uncertainty caused by the limited amount of available background data from unimpacted areas. Additionally, the hypothetical future land-use scenario is inconsistent with current projected development of the area. Even in a residential scenario, it is unlikely that sufficient land use would be available for development of a garden that could supply the daily quanti-

ties of produce assumed in the exposure assessment. Further, the residential scenario for Moffett Field is very unlikely.

In conclusion, for the OU2 (east) sites, it is recommended that no FS be required and that the process should move directly to a ROD. The OU2 (west) sites that overlie the regional groundwater plume or are within the MEW regional study area have been addressed by EPA in the 1989 MEW ROD; therefore, an FS or ROD is not required for these sites.

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N00296.001720
MOFFETT FIELD
SSIC NO. 5090.3

REMEDIAL INVESTIGATION REPORT
OPERABLE UNIT 2: SITES 3-11, 13, 14, 16-19, SOILS

DATED 01 MAY 1993

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