FINAL

2000 NAPL FIELD INVESTIGATION REPORT

McCormick and Baxter Superfund Site Stockton, California

Volume 1 of 2

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EXECUTIVE SUMMARY

Soil, groundwater, and Old Mormon Slough sediment samples were collected and analyzed and in situ laser-induced fluorescence (LIF) and cone penetrometer testing (CPT) measurements were made during a three-month field investigation beginning in June and ending in August 2000 at the McCormick and Baxter Superfund site, located in Stockton, California. The investigation was conducted according to the guidelines and specifications described in the M*anagement Plan Addendum for the FY 2000 NAPL Field Exploration* (USACE 2000b). The purpose of this investigation was to support selection of a final groundwater remedy, including an evaluation of in situ thermal remediation technologies. The fiscal year 2000 (FY00) nonaqueous-phase liquid (NAPL) field investigation was conducted by the U.S. Army Corps of Engineers (USACE) for the U.S. Environmental Protection Agency (EPA) Region 9. The investigation activities and findings, based on the data interpretation, are presented below.

FY00 NAPL Investigation Activities

Specific tasks conducted during the FY00 field investigation included the following activities:

- Installed temporary survey control monuments on adjacent properties.
- Conducted site characterization and analysis penetrometer system (SCAPS) CPT and LIF data collection to provide geotechnical and stratigraphic information as well as estimate the extent of petroleum hydrocarbon contamination.
- Performed SCAPS soil and groundwater sampling to verify and assist with interpretation of SCAPS LIF data and to delineate contaminant extent and characterize contaminant composition.
- Installed SCAPS microwells to be used for light nonaqueous-phase liquid (LNAPL) or A-zone groundwater collection.
- Installed soil borings and monitoring wells with a rotosonic drill rig to collect physical and chemical data from deeper portion of aquifer.
- Collected shallow soil samples to look for the presence of an LNAPL and analyze for pentachlorophenol (PCP) and volatile organic compounds (VOCs) to assist with the evaluation of A-zone PCP groundwater contamination.
- Completed test pits to characterize potential subsurface obstructions near SE-3, SE-52, and SE-95.

FY00 NAPL Investigation Findings

Based on the data collected, the primary findings of the FY00 NAPL investigation are listed below.

- The SCAPS LIF data, observations made in the field, and soil data suggest four primary NAPL source areas: (1) Oily Waste Ponds Area, (2) Cellon Process Area, (3) Main Processing Area, and (4) PCP Mixing Shed. The FY00 data also suggested that NAPL has migrated away from these source areas, extending downward as well as outward to the south, west, and east. The FY00 LIF and chemical data indicates that the extent of NAPL in the eastern end of the site does not extend past push locations SE-126, SE-153, SE-124, SE/SB-154, SE-125, and SE-155. The extent of NAPL southeast of the DSW-4 wells and south of SE-97 is still uncertain but is expected to be very limited.

- LIF and chemical data suggests that NAPL is present beneath Old Mormon Slough north of the Main Processing Area, but does not extend under the Slough to the Stockton Cold Storage or The Dutra Group properties. The most significant NAPL contamination migrating from the source areas northward under the slough appears to be limited to the area adjacent to the Main Processing Area. LIF data confirms that contamination in the surficial slough sediments extends from the eastern end of the slough to west of the oily waste ponds.

- The bulk of creosote NAPL is interpreted to be present within the A- and B-zones of the upper aquifer. The volume of space within which NAPL is interpreted to be present at the site is approximately 27,000,000 ft^3 (1,000,000 yd^3). The volume of space above an elevation of –100 feet within which NAPL is interpreted to be present is approximately 24,000,000 ft^3 (900,000 yd^3). The net thickness of creosote NAPL-contaminated soil at each boring/push was determined by adding together the intervals of observed and interpreted NAPL at each sampled location to derive a net interpreted NAPL thickness for the site (Figure 5-24). The volume of soil containing creosote NAPL is approximately 7,300,000 ft^3 (270,000 yd^3). Assuming a porosity of 0.35 and values of NAPL saturation in the pore space of 4 percent (the median of NAPL saturation data) yields an estimated volume of creosote NAPL in the subsurface of 760,000 gallons.

- The Cellon Process Area is a significant PCP and diisopropyl ether source area. A gelatinous brown-purple non-creosote NAPL was encountered in the vadose zone, but did not extend to the current water table. The gelatinous NAPL was encountered only in SV-117, where the highest concentrations of PCP and diisopropyl ether were also detected. This NAPL is considered to be limited to the immediate area near SV-117 as the concentrations of PCP and diisopropyl ether significantly decreased in locations as near as 10 feet away. A previously suspected confining structure was not encountered in this area.

- Based on the LIF and soil sampling data, the PCP Mixing Shed is considered to be another source area. A colorless Sudan IV-positive noncreosote diesel NAPL was observed in one sample near the PCP Mixing Shed, which is located approximately 100 feet west of the site office building.

- A subsurface investigation conducted with a backhoe excavator was completed near SE-03, SE-52, and SE-97 to determine the nature and extent of the subsurface obstruction that prevented SCAPS penetrations greater than 16 feet in that area. The subsurface obstruction was determined to be an indurated paleosol that was thickly infiltrated with thin roots.

- An LNAPL carrier for PCP and dioxin in the A-zone groundwater was not detected in the chemical data or the qualitative tests conducted on the soil samples.

- Based on the FY99 and FY00 NAPL investigations, sufficient data have been collected to support selection of a final groundwater remedy, including an evaluation of in situ thermal remediation technologies.

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FIGURES (Continued)

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ABBREVIATIONS AND ACRONYMS

API	American Petroleum Institute
ASTM	American Society for Testing and Materials
bgs	below ground surface
CADD	computer-aided drafting and design
CEC	cation exchange capacity
CLP	Contract Laboratory Program
COC	chain of custody
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPT	cone penetrometry
CSM	conceptual site model
DCQCR	Daily Chemical Quality Control Report
DNAPL	dense nonaqueous-phase liquid
DO	dissolved oxygen
DQO	data quality objective
DWR	State of California Department of Water Resources
Eh	oxidation reduction potential
EM	electromagnetic
EMLL	electromagnetic line locating
EPA	U.S. Environmental Protection Agency
FASP	Field Analytical Support Program
FID	flame ionization detector
FSP	field sampling plan
FY99	fiscal year 1999
FY00	fiscal year 2000
GC	gas chromatograph, gas chromatography
GMS	groundwater monitoring system
HCl	hydrochloric acid
IDW	investigation-derived waste
IPC	in-phase component
IS	internal standard
LCS	laboratory control samples
LIF	laser-induced fluorescence
LNAPL	light nonaqueous-phase liquid
LOD	level of detection
MCL	maximum contaminant level
MPA	Management Plan Addendum
MS	mass spectrometry
MS/MSD	matrix spike/matrix spike duplicates

ABBREVIATIONS AND ACRONYMS (Continued)

msl	mean sea level
NAD83	horizontal measurement referent, California State Coordinate System Zone 3
NAPL	nonaqueous-phase liquid
NSPC	Newark-Sierra Paper Company
NVD88	vertical measurement referent, California State Coordinate System Zone 3
PAH	polycyclic aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
%D	percent difference
PDS	postdigestion spike
PE	performance evaluation
PID	photoionization detector
POL	petroleum, oil, and lubricants
PPE	personal protective equipment
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
redox	oxidation reduction
RF	response factor
RI	Remedial Investigation
ROD	Record of Decision
RPD	relative percent difference
rpm	revolutions per minute
SAP	sampling and analysis plan
SCAPS	site characterization and analysis penetrometer system
SDG	sample delivery group
SOP	standard operating procedure
SVOC	semivolatile organic compound
TAL	target analyte list
TC	terrain conductivity
TCDD	tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorinated dibenzofuran
TEC	toxicity equivalent concentration
TFM	total field magnetometry
TIC	tentatively identified compound

ABBREVIATIONS AND ACRONYMS (Continued)

TOC	total organic carbon
TPAH	total polycyclic aromatic hydrocarbons
TPH	total petroleum hydrocarbon
TPH-Dx	total petroleum hydrocarbons–diesel range (extended)
TRPH	total recoverable petroleum hydrocarbons
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound

UNITS OF MEASURE

°C	degree Celsius
°F	degree Fahrenheit
cm	centimeter
cm/s	centimeters per second
cP	centipoise
cst	centistoke
ft/day	feet per day
ft/ft	feet per foot
ft^3	cubic foot
g	gram
g/mL	grams per milliliter
g/cc	grams per cubic centimeter
gpm	gallons per minute
L	liter
µg/L	micrograms per liter
meq/g	milliequivalents per gram
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliter
mm	millimeters
m/min	meters per minute
mS/cm	milliSiemens per centimeter
mV	millivolt
ng/kg	nanograms per kilogram
pg/L	picograms per liter
ppm	part per million
rpm	revolutions per minute
yd^3	cubic yard

1.0 INTRODUCTION

Soil, groundwater, and Old Mormon Slough sediment samples were collected and analyzed and in situ laser-induced fluorescence (LIF) and cone penetrometer testing (CPT) measurements were made during a three-month field investigation beginning in June and ending in August, 2000 at the McCormick and Baxter Superfund site, located in Stockton, California. The investigation was conducted according to the guidelines and specifications described in the M*anagement Plan Addendum for the FY 2000 NAPL Field Exploration* (USACE 2000b). The purpose of this investigation was to support selection of a final groundwater remedy, including an evaluation of in situ thermal remediation technologies. The fiscal year 2000 (FY00) nonaqueous phase liquid (NAPL) field investigation was conducted by the U.S. Army Corps of Engineers (USACE) for the U.S. Environmental Protection Agency (EPA) Region 9. This investigation report primarily addresses the nature and extent of the subsurface NAPL contamination at the site and presents technical conclusions and recommendations based on those results.

Specific tasks conducted during the 2000 field investigation included the following activities:

- Installed temporary survey control monuments on adjacent properties.
- Conducted Site Characterization and Analysis Penetrometer System (SCAPS) CPT and LIF data collection to provide geotechnical and stratigraphic information as well as estimate the extent of petroleum hydrocarbon contamination.
- Performed SCAPS soil and groundwater sampling to verify and assist with interpretation of SCAPS LIF data and to delineate contaminant extent and characterize contaminant composition.
- Installed SCAPS microwells to be used for light nonaqueous-phase liquid (LNAPL) or A-zone groundwater collection.
- Installed soil borings and monitoring wells with a rotosonic drill rig to collect physical and chemical data from deeper portion of aquifer.
- Collected shallow soil samples to look for the presence of an LNAPL and analyze for pentachlorophenol (PCP) and volatile organic compounds (VOCs) to assist with the evaluation of A-zone PCP groundwater contamination.
- Completed test pits to characterize potential subsurface obstructions near SE-3, SE-52, and SE-95.

Groundwater sampling as outlined in the FY00 Management Plan Addendum (MPA) was completed in November 2000 as part of the Remedial Design Groundwater Monitoring Program. Groundwater data will be presented in a separate report.

1.1 SITE DESCRIPTION AND HISTORY

The McCormick and Baxter Superfund site occupies approximately 32 acres in a predominantly industrial area near the Port of Stockton and the junction of Interstate 5 and State Highway 4 (Figure 1-1). Old Mormon Slough forms the boundary to the north and connects to the Stockton Deepwater Channel on the San Joaquin River. Site boundaries include Washington Street to the south, the Interstate 5 freeway to the east, and an industrial facility, which is located at the Port of Stockton Turning Basin, to the west. An 8-acre parcel in the southeastern portion of the site is owned by the Union Pacific Railroad (UPRR). The UPRR property boundaries shown in Figure 1-1 have been approximated from parcel maps.

The former processing areas and tank farm at the site are paved. The rest of the site surface is unpaved, with limited vegetative cover. A layer of gravel between 1 and 3 feet thick is found across most of the site. Railroad tracks are located on many areas of the site. Most of the former structures have been removed. The office building, two storage sheds, a stormwater collection system lift station, remnants (i.e., foundation and building, not a tank) of an old gas station, wooden tower, and building near the tower are the only remaining aboveground structures. Underground sump-like basement foundations and associated piping for the former pressure treatment units remain in the central portion of the site. Entry to the site is controlled by a perimeter fence and 24-hour security service.

The site is located on the margin of the Sacramento River–San Joaquin River Delta in the Great Valley geomorphic province of California. The site terrain is relatively flat and near sea level, ranging from 8 to 15 feet above mean sea level (msl). Surface water bodies in the vicinity of the site include Old Mormon Slough, New Mormon Slough, the Stockton Deepwater Channel, and the San Joaquin River. Old Mormon Slough is approximately 2,500 feet long and 180 feet wide. Most of the slough is approximately 10 feet deep, although the western portion near its mouth has historically been dredged for barge access. Old and New Mormon Sloughs are tidally influenced, with a maximum tidal range of approximately 3 feet. Stockton Channel, the Port of Stockton Turning Basin, and Old Mormon Slough are areas of net sediment deposition, and all but the inner portion of Old Mormon Slough are periodically dredged to maintain depths appropriate for ship traffic.

The McCormick and Baxter Creosoting Company operated at 1214 West Washington Street in Stockton, California, from 1942 until 1991. Various wood preservation processes were used at the site during its operational history. The treated wood products were used primarily by power utilities, railroads, and in construction. The preservatives included creosote, PCP, arsenic, copper, chromium, and zinc. Solvents or carriers for these preservatives included petroleum-based fuels, such as kerosene and diesel, butane, and ether. A list of wood-preserving chemicals used at the site is shown in Table 1-1.

Most treatment processes consisted of pressure impregnation of the preservative solutions in retorts. Pressure-treated wood was removed from the retorts and allowed to dry in various wood storage areas throughout the site. The primary facility areas identified as the probable sources of contamination at the site include the Main Processing Area, Oily Waste Ponds Area, and Cellon Process Area. Figure 1-2 presents the potential source areas defined at the site.

1.2 PURPOSE OF FIELD INVESTIGATION

Soil and groundwater at the McCormick and Baxter Superfund Site are contaminated primarily with creosote, dioxins, PCP, and metals that were used as wood preservatives. Free-phase product is known to exist in the subsurface, as are dissolved contaminants in groundwater and adsorbed contaminants on the solid phase. The primary objective of the field investigation was to collect the data required to determine the vertical and horizontal extent of NAPL and to determine if NAPL has migrated outside the property boundary. These data were collected to support selection of a final groundwater remedy, including an evaluation of in situ thermal treatment technologies that potentially could enhance the removal of contaminants from the subsurface. Site-specific factors that may impact the effectiveness/deployment of in situ thermal technologies include vertical and horizontal distribution of NAPL of varying compositions; physical and chemical characteristics of the NAPL; depth of NAPL penetration; type, thickness, and heterogeneity of subsurface geologic material; and the presence of manmade subsurface structures or materials. In situ thermal treatment methods under consideration include steam injection/stripping and electrical heating.

Secondary objectives of this project were to determine the general extent of surface and subsurface PCP contamination near SCAPS push SE-8 in the Cellon Process Area; determine whether a light NAPL (LNAPL) is responsible for transporting PCP in A-zone groundwater; and determine the nature and extent of the subsurface anomaly identified during the fiscal year 1999 (FY99) NAPL investigation near SE-3, SE-52, and SE-95, which prevented SCAPS penetration beyond 16 feet bgs.

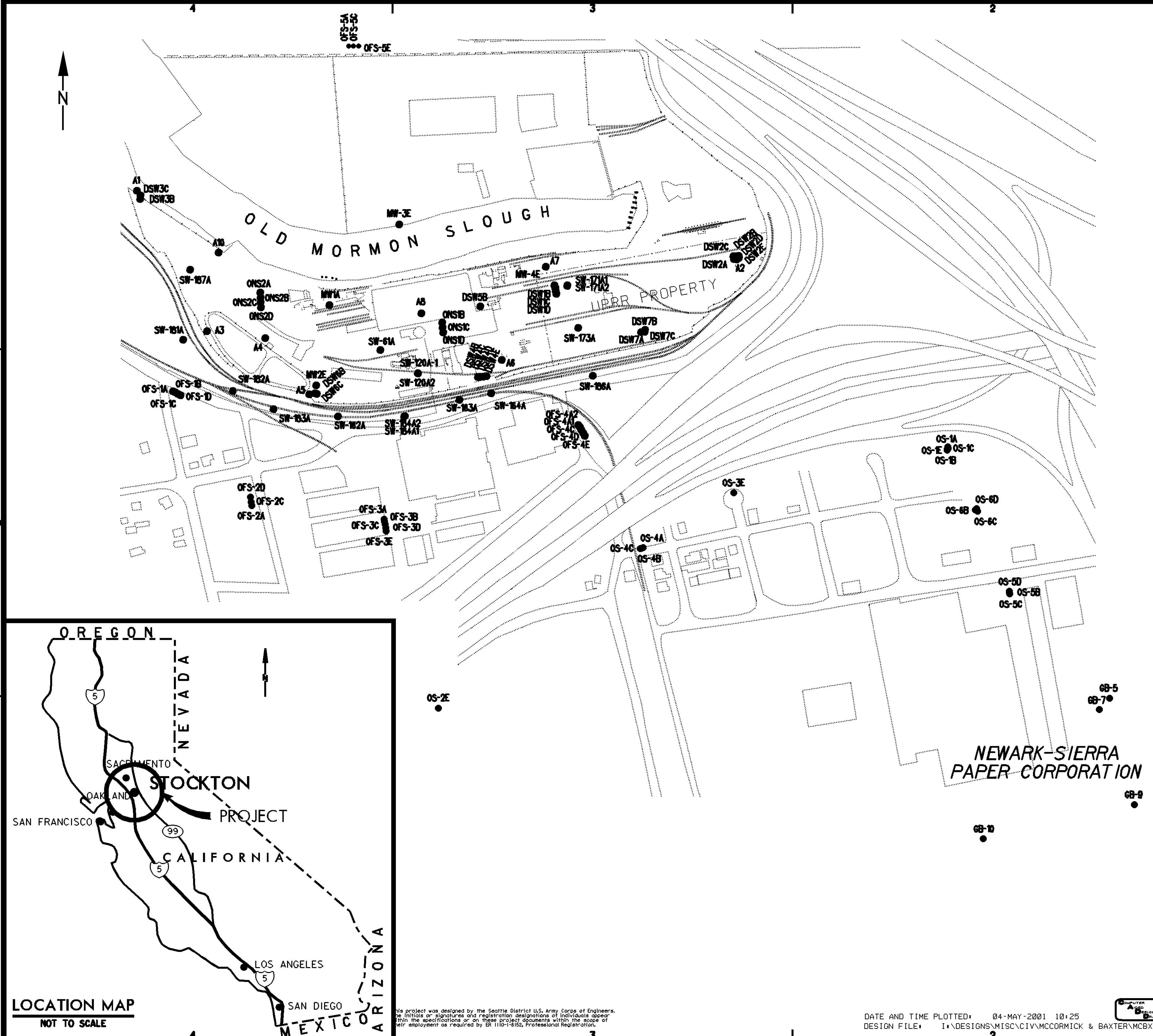
1.3 FIELD INVESTIGATION REPORT CONTENTS AND ORGANIZATION

The purpose of this report is to present the FY00 subsurface soil, Old Mormon Slough, and preliminary groundwater investigation results and the technical recommendations based on those results. To support the report objectives, this field investigation report contains:

- A detailed description of the subsurface soil, Old Mormon Slough sediment, and preliminary groundwater investigation
- Presentation and interpretation of analytical results
- Analysis of contamination source areas
- Estimates of the extent of lateral and vertical NAPL contamination
- Calculations of NAPL volume
- Discussion of dissolved phase contaminant plume migration
- Data gap identification
- Update of the conceptual site model
- Conclusions and recommendations

Tables and figures are presented at the end of the section in which they are first cited. Oversized plates are inserted in plastic sleeves at the end of this document.

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY



LEGEND

OS-3E ● WELL LOCATION

1" = 400'   0 — 400'

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

MC CORMICK & BAXTER SUPERFUND SITE
FY00 NAPL INVESTIGATION

SITE LOCATION AND WELLS

STOCKTON				CALIFORNIA
SIZE D	INVITATION NO.	FILE NO.	DATE:	FIGURE 1-1
DSGN. SMITH		CHK. LYNCH	SHEET	

SCALE: 1" = 200'

This project was designed by the Seattle District U.S. Army Corps of Engineers. The initials or signatures and registration designations of individuals appear within the specifications or on these project documents within the scope of their employment as required by ER 1110-1-8152, Professional Registration.

DATE AND TIME PLOTTED: 04-MAY-2001 10:25
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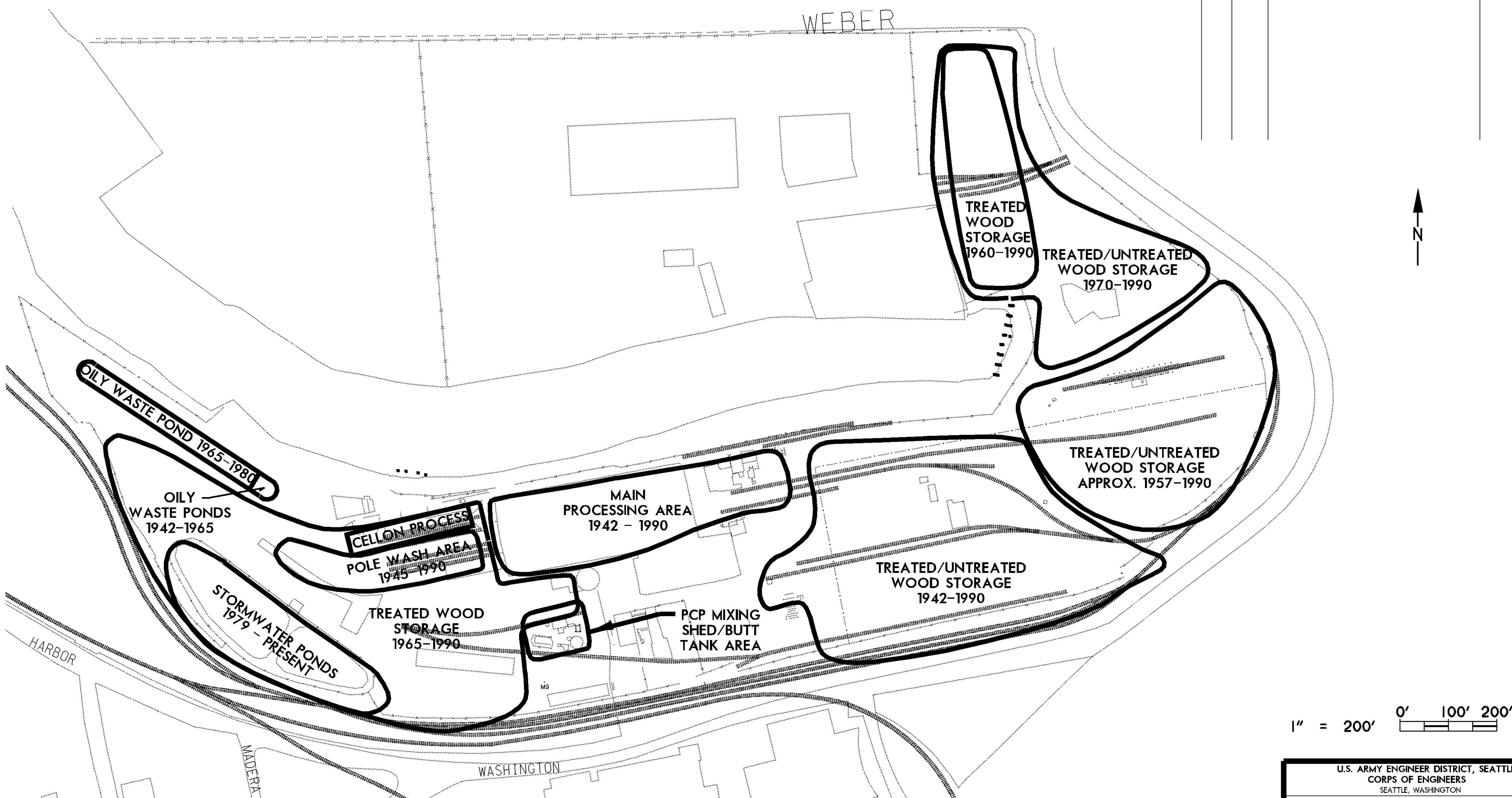

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

MC CORMICK & BAXTER SUPERFUND SITE
FY00 NAPL INVESTIGATION

PROCESS/SOURCE AREAS
IDENTIFIED IN THE RI

STOCKTON CALIFORNIA

SIZE D | INVITATION NO. | FILE NO. | DATE: | FIGURE I-2

DSGN. SMITH | CHK. LYNCH | SHEET

This project was designed by the Seattle District U.S. Army Corps of Engineers. The initials or signatures and registration designations of individuals appear within the specifications or on these project documents within the scope of their employment as required by ER 1110-1-8152, Professional Registration.

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COMPUTER AIDED DESIGN & DRAFTING

DATE AND TIME PLOTTED: 04-MAY-2001 10:23 DESIGN FILE: I:#designs#misc#civ#McCormick & Baxter#mcbx#mcbxcs0b.dgn

Table 1-1
Wood-Preserving Chemicals Used at McCormick and Baxter

Common Name	Chemical Components	Period of Use
Creosote	Creosote and fuel oil	1942 to 1990
Pentachlorophenol	Pentachlorophenol and oil	1946 to 1990
Bouliden salts	Chromium, copper, and arsenic	1949 to 1952
CCA	Chromated copper and arsenic	1952 to 1970
Cellon	Pentachlorophenol, butane, and ether	1965 to 1988
ACA	Ammoniacal copper arsenate	1970 to 1986
Flamescape	Diammonium phosphate, ammonium sulfate, and boric acid	1976 to 1988
ACZA	Ammoniacal copper-zinc aresenate	1986 to 1990

2.0 INVESTIGATION ACTIVITIES SUMMARY

2.1 OVERVIEW OF THE FY00 NAPL INVESTIGATION

Final resolution of the comments on the FY00 Management Plan Addendum (USACE 2000b) and approval to proceed with the McCormick and Baxter FY00 predesign characterization was received on June 2, 2000. The final FY00 Management Plan Addendum was distributed on July 7, 2000. The FY00 NAPL investigation, which began on June 5, 2000, was conducted in phases, as presented below:

- Phase I was conducted using SCAPS LIF/CPT pushes, SCAPS soil sample collection and analysis, soil borings and soil sample collection and analysis, and installation of new monitoring wells, to determine whether creosote NAPL had migrated under Old Mormon Slough.

- Phase I also was conducted in Old Mormon Slough using SCAPS LIF/CPT pushes and sediment sample collection and analysis to determine the lateral and vertical extent of creosote NAPL migration below the slough.

- Phase II was conducted on the Union Pacific Rail Road (UPRR) property east and south of the McCormick and Baxter property to characterize the horizontal and vertical extent of NAPL east of SE-79, southeast of the DSW-4 wells, and south of SE-97.

- Phase III was conducted in three events to determine the areal extent of LNAPL and PCP contamination outside areas where the A-zone is known to be contaminated with creosote NAPL and along the southern property boundary (Event One); identify PCP and LNAPL contamination in the subsurface soils around the PCP mixing shed (Event Two); and determine the presence of a subsurface confining structure and the lateral and vertical extent of PCP contamination in the PCP disposal area (Event Three).

- Phase IV was conducted using a backhoe to characterize the subsurface feature near SE-3, SE-52, and SE-95, where during the FY99 NAPL investigation, SCAPS encountered refusal at 16 feet bgs.

The investigation objectives are presented in Section 1. The field investigation data quality objectives (DQO) process is summarized in Table 2-1. The activities associated with this investigation are detailed in the FY00 Management Plan Addendum (USACE 2000b).

2.1.1 Phase I: Evaluate NAPL Migration North of or in Old Mormon Slough

Phase I was conducted on The Dutra Group and Stockton Cold Storage properties north of Old Mormon Slough and in Old Mormon Slough. Seven SCAPS LIF/CPT pushes each were made on The Dutra Group and Stockton Cold Storage properties. Two rotosonic borings (i.e., SB-101 and SB-112) were completed on the Stockton Cold Storage property. Four soil samples were collected at three SCAPS locations (i.e., SE-102, SE-106, and SE-109), and analyzed for TPH. Seventeen soil boring samples (not including field quality control [QC] samples) were collected from SB-101 and SB-112 and analyzed for total petroleum hydrocarbons (TPH). TPH was not detected and the samples were not analyzed for polynuclear aromatic hydrocarbons/ pentachlorophenol (PAHs/PCP). Eight soil samples, not including field QC samples, were collected at SE-113 and SE-105 on The Dutra Group property to characterize semivolatile organic compounds (SVOCs) and trace metals in suspected 1997 dredge spoils. All soil samples were analyzed as described by the FY00 Management Plan Addendum (USACE 2000). One monitoring well (i.e., MW-3E) was installed on the Stockton Cold Storage property. Specific field investigation procedures are described in Section 2.2. All FY00 investigation locations are presented in Plate 1.

Based on the results of the initial investigation north of the slough, Phase One continued in Old Mormon Slough. The SCAPS truck and support vehicles were place onto a 110-foot spud barge and barged to the slough. SCAPS LIF/CPT was used to investigate the subsurface underneath Old Mormon Slough along an east-west line approximately 20 to 75 feet north of the McCormick and Baxter shoreline. Twenty-four SCAPS LIF/CPT pushes were made in the slough from the eastern end to the western extent of the McCormick and Baxter property (approximately 250 feet west of the sheet pile wall). Eleven sediment samples (not including field QC samples) were collected and analyzed for VOCs, TPH, and PAHs/PCP at three locations (i.e., SE-127, SE-133, SE-137).

2.1.2 Phase II: Define Eastern and Southeastern Limits of NAPL Contamination

Phase II was conducted on UPRR property inside the McCormick and Baxter property perimeter fence and along the railroad tracks outside (south of) the perimeter fence. SCAPS LIF/CPT pushes were made at 11 and 13 locations east (inside the fence) of the McCormick and Baxter property and along the railroad tracks (outside the fence), respectively. Eight soil samples (not including field QC samples) were collected at four locations (SE-153, SE-156, SE-173, and SE-176). Rotosonic soil borings were completed at four locations (i.e., SB-126, SB-154, SB-165, and SB-179) and 23 samples were collected. One monitoring well (MW-4E) was installed on UPRR property east of the McCormick and Baxter perimeter fence. All soil samples were screened for NAPL using Sudan IV and analyzed for TPH and PAHs/PCP.

2.1.3 Phase III: Characterize PCP Contamination in Cellon Process Area and A-Zone Groundwater

Event One was conducted in the A-zone near monitoring wells A-3, A-4, A-5, and A-6. Preliminary groundwater samples were collected from these locations to initially focus the Phase III investigation. Four preliminary groundwater samples (not including field QC samples) were collected from these wells and analyzed for floating product, SVOCs, and VOCs, including diisopropyl ether. Forty-nine SCAPS soil samples were collected from four locations co-located with A-zone monitoring wells, including SV-114 (A-6), SV-115 (A-5), SV-116 (A-3), and SV-121 (A-4). Soil samples were collected from the top of the current water table (approximately 16 feet bgs) to the lowest historical water table (approximately 40 feet bgs) to determine whether PCP, diisopropyl ether, or an LNAPL were present. All soil samples were screened with Sudan IV to determine whether an LNAPL was present. No LIF/CPT pushes were planned or conducted here.

Ten SCAPS microwells were installed on UPRR property along the railroad tracks outside the McCormick and Baxter property fence and two microwells were installed on UPRR property inside the McCormick and Baxter perimeter fence. CPT data were collected at these locations and used to select an acceptable A-zone horizon for the well screen. No LIF pushes were conducted. All microwells were screened in the uppermost A-zone sand. Groundwater samples will be collected from these wells and analyzed as part of the ongoing remedial design groundwater monitoring program. The groundwater monitoring results will be contained in a separate report.

Event Two was conducted around the PCP Mixing Shed. Nine SCAPS LIF/CPT pushes were made around the PCP Mixing Shed. Seventeen SCAPS soil samples were collected at three locations (i.e., SV-120, SV-122, and SV-123), and analyzed for VOCs, PCP, and TPH. Four soil samples were collected and also analyzed for PAHs/PCP, including SV0122-9-11, SV0122-11-13, SV0122-31-33, and SV0123-10-12. All soil samples were first screened for NAPL using Sudan IV. Microwells were installed and screened in the A-zone at four locations, including SW-120A1, SW-120A2, SW-61A, and SW-187A. Groundwater samples will be collected from these wells and analyzed as part of the ongoing remedial design groundwater monitoring program. The groundwater monitoring results will be contained in a separate report.

Event Three was conducted in the Cellon Process Area in a location where excavation work activities were suspended by the EPA On-Scene Coordinators due to vapors from an unknown compound. Thirty SCAPS soil samples (not including field QC samples) were collected from four locations (i.e., SV-117, SV-118, SV-119, and SV-152) and analyzed for VOCs, PCP, PAHs/PCP, and TPH.

2.1.4 Phase IV: Characterize Subsurface Features Near SE-3, SE-52, and SE-95

Three trenches 40 inches wide, 18 feet long, and approximately 18 feet deep were excavated with a backhoe in the area in question. The subsurface feature, which is suspected as causing SCAPS refusal during the FY99 field investigation, is a relatively thin, very hard, natural soil horizon, but not manmade. This layer was light brown in color and thickly infiltrated with very thin roots. The lateral extent was not investigated and is unknown; however, SCAPS penetrations were refused at 16 feet bgs at SE 160 and SE-161, which are located outside the McCormick and Baxter perimeter fence and approximately 100 feet southwest of SE-03.

2.2 SUMMARY OF FIELD INVESTIGATION METHODS

2.2.1 Survey of Exploration and New Well Locations

SCAPS exploration locations were surveyed during field activities using a portable GPS unit and a hand level to measure horizontal and vertical position of each exploration location, respectively. Elevations were measured relative to existing site control monuments using the hand level.

Prior to the beginning of SCAPS exploration work in Old Mormon Slough, a Sacramento District (SPK) survey team surveyed the SCAPS exploration locations north of the slough (i.e., SE-101–SE-113) and surveyed the elevation of a marked point on the east end of the sheetpile wall. The sheetpile wall elevation mark was subsequently used by the SCAPS team to determine the elevations of the slough exploration locations. The Sacramento District survey team returned at the conclusion of investigation activities and surveyed the horizontal and vertical positions of the SCAPS exploration locations (except SE-101–SE-113 and the slough locations), rotosonic soil borings, monitoring wells and microwells.

2.2.2 Preliminary PCP and VOC Groundwater Sample Collection

Preliminary groundwater samples were collected from four A-zone monitoring wells (A-3, A-4, A-5, and A-6) on March 28 (A-4 and A-5), April 13 (A-3), and May 10, 2000 (A-6) and analyzed for VOCs (including diisopropyl ether) and SVOCs. Preliminary groundwater samples were collected to satisfy the following objectives:

- To determine whether diisopropyl ether is present and migrating in the A-zone groundwater where PCP also is detected

- To collect data to focus Phase III of the FY00 field investigation

- To evaluate the groundwater quality in monitoring wells where PCP has been detected in the past

A summary of the rationale for the groundwater sample collected from each monitoring well is presented in Table 2-2.

All groundwater samples, except A-6, were collected using a low-flow purging technique. A low-flow sampling technique was used for this sampling event because it provides data that is more reproducible and representative than a higher flow method and also generates less investigation-derived waste (IDW) than the higher flow method. Grundfos Rediflo 2 pumps were used for the low-flow sampling in all wells, except A-6. The discharge pipe in A-6 was broken, and three well volumes were purged using a high-flow pump. The groundwater sample was then collected using a Teflon® bailer. Purge water generated during groundwater sampling of A-6 was contained in a 5-gallon drum approved by the U.S. Department of Transportation and then allowed to evaporate in the decontamination pad on site. Purge water collected from A-3, A-4, and A-5 initially was contained in 5-gallon buckets and allowed to evaporate on site. Groundwater sampling procedures are described in detail in the Field Sampling Plan (FSP), which is included in the FY00 Management Plan Addendum (USACE 2000b).

Additional details from the groundwater sampling event can be found in Appendix B.

2.2.3 SCAPS LIF and CPT

The general objectives of the SCAPS LIF/CPT investigation are presented below:

- Determine whether NAPL contamination has migrated north of Old Mormon Slough (Phase I).

- Determine the nature and extent of NAPL migration under Old Mormon Slough (Phase I).

- Determine the nature and extent of NAPL contamination migration southeast of the McCormick and Baxter property, namely onto the UPRR property (Phase II).

- Determine the nature and extent of petroleum fuel hydrocarbon contamination around the PCP Mixing Shed (Phase III).

The vertical and horizontal extent of the petroleum hydrocarbon plume was characterized using the SCAPS, equipped with an LIF sensor. Continuous fluorescence measurements and CPT measurements were collected for the entire length of each of the SCAPS pushes to provide an indication of relative concentrations of suspected contaminants. The SCAPS fluorescence intensity is generally proportional to in situ concentration of contaminants. The proportional feature of the SCAPS LIF can be used to pinpoint the zones of highest contaminant concentration and screen the variation in concentration across the site. SCAPS LIF and cone penetrometry measurements, soil sampling, and microwell installation started on June 5, 2000, and ended on August 17, 2000. Four final LIF pushes (i.e., SE-188, SE-189, SE-190, and SE-191) were completed on October 12 and 13, 2000.

A total of 75 SCAPS LIF/CPT pushes were placed at the site. SCAPS LIF and CPT locations were denoted with “SE” and a number, beginning with SE-100 on the Stockton Cold Storage property. The maximum depth of each push varied from 13.6 to 144.2 feet bgs, with an average push depth of 65.9 feet bgs. A summary of the SCAPS LIF and CPT activities is presented below. Further details can be found in the SCAPS FY00 supplemental field investigation report (USACE 2000a).

The SCAPS LIF/CPT push locations are shown on Plate 1. Salient information regarding the SCAPS penetrations, including location, dates, wavelength signature depth, and comments, was recorded on a push-probe penetration log form.

Initial SCAPS penetration locations were preselected based on the FY99 field investigation results. The initial SCAPS locations on The Dutra Group and Stockton Cold Storage properties were positioned at locations likely to intercept creosote NAPL contamination potentially migrating northward from the McCormick and Baxter property. The SCAPS locations in the Slough were pre-selected to provide the same data density as that collected during the uplands investigation. The Phase II locations on UPRR property were based on the FY99 field investigation data, which suggested that NAPL was migrating to the southeast in deep stringers. The Phase III locations around the PCP Mixing Shed on the McCormick and Baxter property were pre-selected based on suspected source area locations (i.e., PCP Mixing Shed). The remaining locations for SCAPS LIF pushes were selected in the field based on the following:

- SCAPS LIF borings were spaced to provide area-wide information on NAPL occurrence and stratigraphy. Data on extent of NAPL contamination is required to identify the area of interest for potential in situ thermal treatment.
- Areas of highest contamination and different petroleum, oil, and lubricant (POL) contaminant types were further defined to evaluate whether more than one contaminant type might require treatment.
- The depth of POL contamination above the LIF threshold concentration was defined.
- Data were collected to fill in gaps for the conceptual site model.

During installation of the SCAPS probes, continuous geotechnical and stratigraphic data were collected to help interpret contaminant distribution and to delineate the continuity of subsurface materials that may influence contaminant movement, such as clay, silt, and sand and gravel zones. The SCAPS data were also used to optimize the placement of rotosonic soil borings, microwells, and monitoring wells. All SCAPS penetrations were grouted to ground surface with a silica flour and cement mixture.

2.2.4 SCAPS Soil Sampling

The general objectives of the SCAPS soil sampling investigation are listed below:

- Obtain SCAPS LIF calibration and verification samples representative of different soil types, different emission spectra, and different emission intensities throughout the investigation locations within the SCAPS depth limitations (Phases I, II, and III [PCP Mixing Shed]).

- Obtain soil samples to verify anomalous LIF sensor responses (Phases I, II, and III [PCP Mixing Shed]).

- Confirm the true end depth of POL and PAHs/PCP, and PCP contamination (Phases I, II, and III [PCP Mixing Shed]).

- Determine SVOC and trace metals contamination in suspected dredge spoils located on The Dutra Group property.

- Determine the areal extent of the suspected LNAPL and PCP contamination within the A-zone areas that are not contaminated with creosote NAPL and along the southern McCormick and Baxter property boundary around A-3, A-4, A-5, and A-6 (Phase III, Event One).

- Identify PCP and LNAPL contamination in the subsurface soils around the PCP mixing shed (Phase III, Event Two).

- Determine if a subsurface confining structure is present and the extent of vadose zone PCP contamination in the Cellon process area (Phase III, Event Three).

Details regarding how each sampling location was selected can be found in Appendix B. SCAPS soil sampling locations were denoted with "SS" and a number (e.g., SS-100).

SCAPS soil sampling locations were generally offset 1 to 2 feet from the initial LIF/CPT push location. The SCAPS truck pushed a hollow core to the desired sample collection depths and pulled out an approximately 2-foot-long by 1.5-inch-diameter soil sample. The soil core was then placed on a table in the field, where the sampling crew examined the core, performed a visual soil classification, and collected the subsequent soil samples in sample jars with Teflon®-coated lids (samples for PCP/PAH and field PCP analyses) and in Encore® samplers (for VOC analyses). Soil sample depths are included in the soil sample identification number for easy tracking (e.g., SS0137-48-50 was collected from 48 to 50 feet bgs at SE-137). Phase III SCAPS soil sampling locations were denoted with "SV" and a number (e.g., SV-114). After sampling was complete, the SCAPS soil borings were grouted to the ground surface with a silica flour and cement mixture.

Soil samples were collected from the SCAPS push locations indicated in Table 2-3.

2.2.5 Rotosonic Drilling, Soil Sampling, and Monitoring Well Installation

The rotosonic drilling was conducted from July 24, 2000 until August 29, 2000. During the field season, six borings (i.e., SB-101, SB-112, SB-126, SB-154, SB-165, and SB-179) were logged, as well as sampled and analyzed for diesel range total petroleum hydrocarbons (TPH-Dx) and PAH/PCP. Two monitoring wells (i.e., MW-3E and MW-4E) were also installed. A total of 1,470 feet were drilled, with 1,030 feet logged and sampled. The objectives of the rotosonic soil borings are presented below:

- Determine the nature and extent of contamination and evaluate the geology at depths in the E-zone north of the Old Mormon Slough and at depths beyond SCAPS capabilities.

- Determine the nature and extent of contamination and evaluate the geology at depths in the E-zone southeast of the McCormick and Baxter property (i.e., on the UPRR property) and at depths beyond SCAPS capabilities.

Most of the drilling locations were placed near SCAPS boreholes. The rotosonic explorations were used to confirm SCAPS LIF data as well as to collect soil samples and provide stratigraphic data at intervals deeper than SCAPS was able to penetrate. Of the six borings completed, four were collocated with SCAPS borings. Boring SB-101, later to be made into a well was not collocated. SB-101 was placed as far south of SE-101 as could be safely drilled near the slough banks. SB-126 was placed nearer to the DSW-1 well cluster. Two monitoring wells were installed. MW-4E was installed in the E-zone on UPRR property near boring SB-126 in the DSW-1 well cluster. MW-3E was installed in the E-zone on Stockton Cold Storage property in boring SB-101 north of the Old Mormon Slough between SE-101 and SE-102. Rotosonic boring locations are shown in Plate 1. MW-3E was placed north of the Old Mormon Slough for long-term monitoring of potential NAPL migration in the E-zone aquifer. The fourth monitoring well, MW-4E, was relocated from north of the Old Mormon Slough, as planned in the FY00

Management Plan Addendum (USACE 2000b) to the DSW-1 well cluster for long-term monitoring of NAPL migration in the E-zone east of the Main Process Area.

MW-3E was screened from 238 to 248 feet bgs to allow for groundwater sample collection in the E-zone north of Old Mormon Slough. MW-4E was screened from 238 to 248 feet bgs to allow for groundwater sample collection in the E-zone on the UPRR property. Both monitoring wells were completed using stainless steel prepacked well screens and were installed using a dielectric coupling between the stainless steel and the mild steel casing.

2.2.6 SCAPS Microwell Installation

SCAPS microwells were installed in August 2000 on the UPRR property east and southeast of the suspected source areas, near the PCP Mixing Shed, south of the Central Processing Area, and south of the Oily Waste Ponds to provide an A-zone groundwater monitoring mechanism. Except for SW-61A, which was installed south of the central processing area, and SW-187A, which was installed south of the Oily Waste Ponds, all microwells were generally (i.e., within two feet) collocated with SCAPS CPT/LIF pushes. Microwell locations were identified as 'SW' and the SCAPS CPT/LIF push number.

Fifteen 1-inch-diameter SCAPS microwells with hydrophobic screens were installed during the FY00 field investigation Phase III using the methods contained in *Standard Operating Procedure for Microwell Installation and Environmental Sampling by Site Characterization and Analysis Penetrometer System (SCAPS)* (SOP M-0002-SWT-03, April 1999). The microwells were screened across the current water table (i.e., approximately 16 feet bgs). Groundwater samples were collected from these microwells in November 2000, and the analytical results will be presented in a separate report.

2.3 DEVIATIONS FROM THE MANAGEMENT PLAN

It is common for field conditions to cause investigators to make changes from their plans to ensure that they can meet their investigation objectives. A number of changes from the Management Plan Addendum (USACE 2000b) were made by investigation personnel. These changes are summarized below.

- Investigation Schedule. Because creosote NAPL was not detected in initial SCAPS LIF/CPT pushes or confirmed in the soil samples collected from SCAPS or the rotosonic borings on The Dutra Group and Stockton Cold Storage properties, the FY00 field investigation was completed approximately 30 days before the scheduled completion date. A maximum of 45 SCAPS LIF/CPT pushes and 18 SCAPS soil samples were planned on The Dutra Group and Stockton Cold Storage properties in the event NAPL was detected in the initial SCAPS and rotosonic locations. Fourteen SCAPS LIF/CPT pushes were completed and 13 SCAPS samples were collected.

- Survey. The survey team was not able to set the requested survey control monuments on The Dutra Group and Stockton Cold Storage properties before the investigation of the north side of the slough was complete. The survey control monuments were intended to enhance the accuracy of the portable GPS unit and hand level to be used north of slough for horizontal and vertical control and reduce costs associated with surveying a large number of exploration locations. Since far fewer exploration locations were required north of the slough than originally anticipated, the SPK survey team surveyed the explorations north of the slough rather than setting control monuments. The SPK survey team also surveyed the horizontal and vertical locations of all SCAPS explorations south of the slough while they were surveying the monitoring well and microwell locations.

- SCAPS LIF/CPT. Several SCAPS probes and umbilical cords were used because of equipment failures and availability of a longer probe. The maximum depth pushed using SCAPS was 144.7 feet bgs. The actual maximum depth possible was not deeper than 155.8 feet bgs due to several factors (e.g., length of the SCAPS umbilical, encountering refusal, cone and sleeve CPT readings indicating possible probe breakage).

- SCAPS LIF/CPT Investigation Scope. Phase I–North of the Slough: Fifteen initial SCAPS LIF/CPT locations were planned; however, only 14 were completed due to the proximity of the proposed locations to the Dutra sheetpile wall. Moving the SCAPS locations away from the sheetpile wall to prevent potential damage to the underlying construction would place the SCAPS too far from the Old Mormon Slough shoreline to obtain useful information and the western most location was abandoned. This location also was far from areas of suspected NAPL migration. Phase I–Old Mormon Slough: Eighteen initial SCAPS locations were planned in Old Mormon Slough in the event NAPL was not detected on The Dutra Group and Stockton Cold Storage properties. The spud barge was contracted for a 13-day period, and during that time period, 24 SCAPS LIF/CPT locations were investigated. Phase II: Twenty SCAPS LIF/CPT pushes were planned on UPRR property and 24 pushes were completed. The maximum depth of the SCAPS pushes in many locations was less than 50 feet, which required less time for grouting the push hole and moving to the next location. Phase III, Event Two: No LIF/CPT pushes were planned around the PCP Mixing

Shed, but after discussions with former McCormick and Baxter employees described the use of medium-weight petroleum hydrocarbons in this area, nine LIF pushes were completed to focus the SCAPS soil sampling locations and to determine if the PCP Mixing Shed was the source of the hydrocarbons with signature similar to the LIF signature at SE-43.

- SCAPS Operations in Old Mormon Slough. Initially, steel outer casing was pushed through the Slough sediments to provide stability to the LIF/CPT push rod. A single push was completed through the protective casing for pushes SE-127 through SE-141. The push procedure was modified to include an uncased pre-push to collect LIF/CPT information from the top of the mud line into the unconsolidated slough sediments. Following the pre-push, the steel outer casing was set and a second LIF/CPT push was made to the maximum depth achievable. These data were combined to provide a continuous sampling point at SE-142 through SE-150.

- SCAPS Soil Sampling and Analysis Scope. Phase I–North of the Slough: Eight soil samples were planned and five were collected to confirm no visible NAPL or detectable TPH or PAHs/PCP. Phase I–Old Mormon Slough: Eight soil samples collected from two locations were planned and 11 samples were collected from three locations to confirm the LIF wavelength and response indicating NAPL. Phase II: Twenty soil samples from five locations were planned and eight samples were collected from four locations to confirm no visible NAPL or detectable TPH or PAHs/PCP. Phase III, Event One: One hundred fifty four samples from 11 locations were planned and 49 samples were collected from four locations. The five additional locations were eliminated from the scope, because the suspected LNAPL and high concentrations of diisopropyl ether were not detected. Phase III, Event 2: Forty-two soil samples from two locations were planned and 18 soil samples were collected from three locations. Fewer locations and samples were required to determine the nature and extent of the PCP and VOC contamination resulting from the PCP Mixing Shed operations because the suspected LNAPL was not encountered. Phase III, Event Three: One hundred twenty soil samples from 10 locations were planned, and 43 samples were collected from five location. Fewer locations and samples were necessary to define the lateral and vertical extent of diisopropyl ether and PCP concentrations and to determine that the suspected confining structure did not exist. In addition, the FY00 Management Plan Addendum (USACE 2000b) specified soil samples to be collected for PCP and VOCs only. TPH and PAHs/PCP analyses were added, in addition to PCP and VOCs analyses, to the Phase III sampling and analysis scope to provide additional information about different NAPL types, to further compare the A-zone groundwater contamination to that in the subsurface soils, and to be consistent with the NAPL investigation. Ex situ LIF soil measurements were not made as specified in the FY00 Management Plan Addendum (USACE 2000b).

- SCAPS Microwell Installation. Eleven contingency microwells were planned. Four microwells were to be co-located with A-zone monitoring wells A-3, A-4, A-5, and A-6 and seven were to be installed along the southern property line. Sixteen microwells were installed. Ten were installed on UPRR property along the railroad tracks south of the McCormick and Baxter perimeter fence. Two were located on UPRR property east of the McCormick and Baxter site and adjacent to SE-171. Three were installed near the PCP Mixing Shed and one was installed south of the Oily Waste Ponds.

- Rotosonic Soil. The FY00 Management Plan Addendum (USACE 2000b) for the Phases I and II investigation specified PAH/PCP analysis on all samples with detectable TPH contamination or on ten percent of the total number of samples collected if TPH is not detected in any sample. Because contamination was not detected in the rotosonic borings and the investigation was collecting fewer soil samples than anticipated, PAHs/PCP and TPH analyses were requested on all soil samples collected.

- Laboratory Scope. The FY00 Management Plan Addendum (USACE 2000) described the analysis of soil and field QC blank samples for an abbreviated VOC analysis that included ethers and ketones only by the on-site EPA Field Analytical Support Program (FASP) laboratory. However, all samples were shipped to the EPA Region 9 laboratory, located in Richmond, California, for VOC analysis that included diisopropyl ether. The soil samples collected for VOC analysis were prepared (i.e., weighted and potentially high concentration samples extracted in methanol) in the FASP laboratory before shipment to the Region 9 laboratory.

- SCAPS Soil. Permeability and treatability testing were not conducted, because the NAPL encountered was not significantly different from that encountered during the FY99 field investigation and the soil materials where NAPL was encountered were similar to those already tested.

- Monitoring Well Installation. Two groundwater monitoring wells were planned north of Old Mormon Slough along The Dutra Group and Stockton Cold Storage properties. One monitoring well, MW-4E was re-sited on the UPRR property in the E-zone near the DSW-1 well cluster, because NAPL was determined not to be migrating north of the slough. The location of MW-4E was selected to provide a mechanism to monitor potential long-term NAPL migration in the E-zone near the DSW-1 well cluster, where the D-zone was highly contaminated.

- Performance Evaluation (PE) Sampling. Several PE samples were submitted to the EPA Region 9 and FASP laboratories for PAHs/PCP, PCP and TPH-Dx analyses in soil. PE samples for VOC analysis were not available and therefore were not included in the sample set shipped to the Region 9 laboratory. PE samples collected and analyzed are presented in Table 2-4.

- Groundwater Monitoring. Groundwater monitoring (i.e., first quarter) of the Remedial Design Groundwater Monitoring Program was completed in November, rather than during the summer. The groundwater monitoring results will be presented in a separate report.

2.4 DISPOSITION OF INVESTIGATION-DERIVED WASTE

Waste generated during the field investigation was collected and managed consistent with applicable regulations. Approximately 22 55-gallon drums of waste were generated during the field investigation, 18 drums of soil cuttings and excess samples, and 2 drums of water. All drums were labeled in accordance with the procedures described in the FY00 Management Plan Addendum (USACE 2000b). A summary of the investigation-derived waste (IDW) generated (and its current disposition) for each field activity is presented below.

- Survey. No waste was generated.

- Groundwater Sampling. All purge water was initially placed in two 55-gallon drums. No water was contaminated with NAPL, based on the analytical results and visual inspection of the groundwater during purging. All water was allowed to evaporate in the decontamination pad on site. Once empty, the drums were returned to the on-site drum storage area.

- EPA FASP Laboratory. Spent aqueous samples with hexane were containerized in amber glass jars and given to USACE for disposal in the hazardous waste laboratory pack (i.e., two 55-gallon drums). Waste organic solvents (primarily hexane and methanol) were containerized in amber glass jars and given to USACE for disposal in the hazardous waste laboratory pack. Any additional aqueous waste was containerized in amber glass jars and given to USACE for on-site storage in the hazardous waste laboratory pack and was stored for future disposal. Solid laboratory waste (soil samples and glassware) was containerized in a 55-gallon drum and stored in the on-site drum storage area.

- SCAPS LIF/CPT and Soil Sampling. Soil cores that were not collected as samples were placed in two 55-gallon drums and were stored in the on-site drum storage area for future disposal. One drum was used for excess soil volume and the other was used for glassware and Sudan IV dye. Equipment decontamination rinsewater (water and laboratory-grade detergent) was collected in 55-gallon drums and was allowed to evaporate on site.

- Rotosonic Drilling. Drill cuttings were collected in 17 55-gallon drums and were stored on site in the drum storage area for future disposal. Soil cores that were not collected as samples were placed in 55-gallon drums and stored on site for future disposal. Equipment decontamination rinsewater (i.e., water and laboratory-grade detergent) was collected in 55-gallon drums and was allowed to evaporate on site.

Table 2-1
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase I—Problem: Subsurface NAPL cannot be efficiently removed without thermally enhanced extraction methods. Sufficient data are not available to characterize contaminant extent and select a treatment technology, based on the FY99 field investigation data.			
SCAPS CPT and LIF			
Determine whether NAPL has migrated north of Old Mormon Slough from the McCormick and Baxter site.	Horizontal and vertical extent of POL and PAHs. Measure concentration of primarily 3 or more ring aromatic compounds (and some 2-ring compounds) using LIF.	LIF detection threshold: 100 to 500 mg/Kg TPH. 15 LIF pre-selected penetrations estimated. Initial locations selected consistent with the FY99 investigation results. Spacing of penetrations will be determined in the field and will be evaluated against estimated 100-foot treatment unit size (also used in the FY99 NAPL Investigation). Continuous readings to depth of 150 feet, if possible, final decisions regarding depth of penetration will be made in the field.	Threshold LIF value (reporting limit) determined in field. Approximately 100 to 500 mg/Kg TPH. Spatial resolution of 4 cm (0.13 foot) when driven at 1 m/min. LIF penetration locations will be finalized on a daily basis by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader). Initial SCAPS penetration locations were selected to detect NAPL contamination north of Old Mormon Slough, based on the FY99 NAPL investigation results.
Characterize NAPL extent (vertical and horizontal) in the subsurface soils north of Old Mormon Slough.	Horizontal and vertical extent of POL and PAHs. Measure concentration of primarily 3 or more ring aromatic compounds (and some 2-ring compounds) using LIF.	LIF detection threshold: 100 to 500 mg/Kg TPH. 45 LIF penetrations estimated. Spacing of penetrations will be determined in the field and will be evaluated against estimated 100-foot treatment unit size (also used in the FY99 NAPL Investigation). Continuous readings to depth of 150 feet, if possible, final decisions regarding depth of penetration will be made in the field.	Threshold TPH value (reporting limit) determined in field. Approximately 100 to 500 mg/Kg TPH. Spatial resolution of 4 cm (0.13 foot) when driven at 1 m/min. LIF penetration locations will be determined on a daily basis by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader). SCAPS penetration locations will be selected to maximize understanding of the site CSM and extent of NAPL contamination north of Old Mormon Slough.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase I (continued)			
Characterize NAPL extent (vertical and horizontal) beneath Old Mormon Slough.	Horizontal and vertical extent of POL and PAHs. Measure concentration of primarily 3 or more ring aromatic compounds (and some 2-ring compounds) using LIF.	LIF detection threshold: 100 to 500 mg/Kg TPH. 18 LIF penetrations estimated. Initial locations will be selected in areas suspected to have been impacted by site contamination. Spacing of penetrations will be determined in the field and will be evaluated against estimated 100-foot treatment unit size (also used in the FY99 NAPL Investigation). Continuous readings to depth of 170 feet, if possible, final decisions regarding location and depth of penetration will be made in the field.	Threshold LIF value (reporting limit) determined in field. Approximately 100 to 500 mg/Kg TPH. Spatial resolution of 4 cm (0.13 foot) when driven at 1 m/min. LIF penetration locations will be determined on a daily basis by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader). SCAPS penetration locations will be selected to maximize understanding of the site CSM and extent of NAPL contamination.
Identify if there is more than one unit (as defined by contaminant type) requiring treatment.	Spatial distribution of TPH and PAHs/PCP contamination based on soil fluorescence emission spectra. These intervals will be targeted for collection of soil samples with SCAPS and analysis of soil samples for TPH, PAHs, and PCP. Chemical data will assist with interpretation of LIF wavelength signature.	Nontarget fluorescence will be evaluated by SCAPS soil sampling and analysis. TPH-Dx and PAHs/PCP results will be used in the field to verify apparent anomalous LIF sensor responses and assist with interpretation of wavelength signature.	Identify LIF results representative of different soil types, different emission spectra, and different emission intensity. Identify apparent anomalous LIF responses.
Expand the hydrogeologic CSM to include the area north of Old Mormon Slough. Determine natural subsurface feature impacts to the movement of NAPL.	Geotechnical and stratigraphic data from cone pressure and sleeve friction sensors. Aquitard topography and continuity.	Soil classification using SCAPS sensors according to ASTM Method D3441.	SCAPS soil classification will be compared to existing soil boring logs. Spatial resolution of 4 cm for soil classification at a rate of 1 m/min.
Determine where soil samples will be collected.	Estimated contaminant concentrations in soil from LIF.	Select sampling locations where contamination is high and reflects a range of contaminant compositions as defined by wavelength signature. Soil samples also will be collected to verify suspected anomalous LIF sensor responses, and confirm non-detect LIF responses.	Locations for SCAPS soil samples will be determined in the field by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader). SCAPS soil sample locations will be selected by evaluating existing data and SCAPS LIF data.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase I (continued)			
SCAPS SOIL SAMPLING			
Determine accuracy of the SCAPS LIF data. Verify apparent anomalous LIF readings.	Co-located soil samples with SCAPS LIF penetrations.	Visual evaluation of soil cores for NAPL compared with LIF data. Conduct a maximum of 22 SCAPS penetrations. Approximately 4 horizons per penetration will be sampled. Depths decided in field.	Sensitivity for TPH must be at least as good as LIF threshold. LIF and confirmation TPH should be in agreement on detect versus nondetect for 80 percent of the samples; false negative less than five percent.
Determine variability of contamination composition. Determine if contaminant extent can be better estimated. Confirm the bottom of POL, PAH, and PCP contamination. Develop the conceptual design of an in situ thermal treatment system.	Soil data for TPH-Dx, PAH, and PCP. Compare soil chemical analysis with LIF results representative of different soil types, emission spectra and emission intensity. Chemical makeup, magnitude, and variability of contamination.	Soil samples analyzed by the following methods: TPH fingerprinting by GC/FID to be conducted by the FASP on-site laboratory, limited semivolatile organic compound (SVOC) TCL by GC/MS to be conducted by the Region 9 Laboratory.	Sensitivity for TPH and SVOC analyses must be at least as good as LIF threshold. Sensitivity for SVOCs and TPH determined based on limitations of analytical instrumentation.
Determine how much NAPL is present. Evaluation of NAPL percent saturation is required to assist with evaluation of areas of mobile NAPL.	Percent saturation of NAPL contamination in soil.	A maximum of 20 samples may be submitted to PTS Laboratory for NAPL saturation analysis using API RP40. A visual evaluation of NAPL saturation will be completed in the field.	NAPL occurrence in all soil samples will be described according to the criteria presented in the FY99 SAP. Heavily contaminated soil samples will be submitted for NAPL saturation analyses.
Identify optimum locations for collecting continuous rotosonic soil cores and installing four groundwater monitoring wells, if warranted.	Soil contaminant concentrations.	Select boring locations in areas of highest contamination based on SCAPS results. In addition borings will be located in areas with different contaminant signatures if possible.	Selection of locations for continuous borings will be made in the field by Mamie Brouwer, Kira Lynch, Richard Smith, and Fred Hart, Marie Lacey, and Eva Davis. Decisions regarding well construction and design will be made in the field by Richard Smith.
Determine if the movement of dissolved organic contaminants, if present, is affected by adsorption onto naturally occurring organic matter.	Soil TOC concentrations in unimpacted areas and representative of soil conditions across the site.	A maximum of 20 soil samples analyzed for TOC using the Walkley-Black method. Samples will be selected to obtain TOC information representative of different aquifer and aquitard zones.	Detection limit of 1,000 mg C/kg to allow for K_d calculation.
Determine downward migration potential for groundwater and NAPL, if present. Provide input for model, and assist with conceptual design of thermal treatment system.	Permeability (hydraulic conductivity) data on aquitard and aquifer materials. Need site-wide data to evaluate variability. Data on permeability of sand zones required to assist with design of thermal treatment system.	A maximum of 20 soil samples to be collected from aquitard and aquifer materials and analyzed for hydraulic conductivity measurements. Locations to be determined in the field.	Permeability measurements using EPA 9100/ASTM 5084 will be made on soil cores that may have to be repacked. The purpose of the permeability data is to estimate average permeability so this method should provide adequate permeability data quality.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase I (continued)			
	Geochemistry comparison between zones to provide information to design extraction and treatment system.	A maximum of 20 soil samples will be collected from different aquifer and aquitard zones and analyzed for CEC using EPA 9081 by PTS Laboratories.	Sensitivity based on limitations of analytical instrumentation. Samples selected from most sand-rich and clay-rich soils in clean zones.
	Physical characteristics of soil to determine downward migration potential for groundwater and NAPL. Provide input for model.	Soil classification during drilling. 20 soil samples analyzed for moisture content (ASTM D2216, grain size (ASTM D422), bulk density (ASTM D2937), and effective porosity.	Sensitivity based on limitations of analytical instrumentation. Samples collected for physical testing will be from soil zones that appear to have relatively low levels of contamination, using visual inspection, and be representative of different stratigraphic horizons.
Determine the rate of creosote (PAH) recovery as a function of pore volumes of (condensed) steam injected, and determine the amount of residual creosote remaining after approximately two to four pore volumes of steam have been injected.	For feasibility and determination of design parameters of thermal treatment of Old Mormon Slough sediments.	Samples for steam treatability tests, including steam column tests and leaching tests prior to and following steam treatment, may be collected from within Old Mormon Slough and analyzed by the EPA Kerr Laboratory.	Focus on creosote and PAHs/PCP only. Sediment samples for treatability testing will be selected in the field with input from EPA Kerr Laboratory. They will bracket the concentration range and be representative of varying contaminant signatures and geologic materials.
ROTOSONIC SOIL BORINGS/MONITORING WELLS			
Determine variability of contamination composition. Determine if contaminant extent can be better estimated. Confirm the bottom of POL, PAH, and PCP contamination. Develop the conceptual design of an in situ thermal treatment system.	Soil data for TPH-Dx, PAH, and PCP. Compare soil chemical analysis with LIF results representative of different soil types, emission spectra and emission intensity. Chemical makeup, magnitude, and variability of contamination.	Soil samples analyzed by the following methods: 1) FASP TPH fingerprinting by GC/FID conducted by the FASP on-site laboratory and limited SVOC TCL by GC/MS conducted by Region 9 Laboratory. 2) TPH-Dx by GC/FID by FASP on-site laboratory. All soil samples archived for additional chemical or physical testing. 3) SVOC limited TCL by GC/MS by Region 9 Laboratory only if concentration greater than the TPH detection limit or within the 10 percent non-detect confirmation subset, whichever is greater.	Sensitivity for TPH and SVOC analyses must be at least as good as LIF threshold. Sensitivity for SVOCs and TPH determined based on limitations of analytical instrumentation.
Determine how much NAPL is present. Evaluation of NAPL percent saturation is required to assist with evaluation of areas of mobile NAPL.	Percent saturation of NAPL contamination in soil.	A visual evaluation of NAPL saturation will be conducted in the field.	NAPL occurrence in the soil samples will be described according to the criteria presented in the FY99 Field Sampling Plan (FSP).

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase I (continued)			
Install monitoring points north of the slough to evaluate contaminant migration.	Groundwater monitoring well installation.	A maximum of four groundwater monitoring wells may be installed after soil borings completed.	Monitoring well requirements will be determined in the field dependant on the extent of contamination detected. If contamination is not detected north of the slough during the initial SCAPS LIF sampling, a minimum of two monitoring wells will be installed across from the Cellon process area and SB-099 to monitor contaminant transport.
CONTINGENCY ROTOSONIC SOIL BORINGS			
Determine the extent/composition of contamination at depths where SCAPS penetrations are not possible.	Soil characterization where SCAPS met refusal before contamination was fully characterized.	Continuous sampling with a 10 ft core barrel with 5 ft split spoon to below SCAPS refusal to a depth of 250 feet bgs at a maximum of five locations. A maximum of 250 soil samples (i.e., a maximum of 50 samples per borehole) will be collected. Selection of soil samples in field for analysis by: 1) TPH-Dx by GC/FID by FASP on-site laboratory. All soil samples archived for additional chemical or physical testing. 2) SVOC limited TCL by GC/MS by Region 9 Laboratory only if concentration greater than the TPH detection limit or within the 10 percent non-detect confirmation subset, whichever is greater.	Sensitivity for TPH and SVOC analyses must be at least as good as LIF threshold. Sensitivity for SVOCs and TPH based on limitations of analytical instrumentation. Selection of locations will be made in the field by Mamie Brouwer, Kira Lynch, Richard Smith and Fred Hart, Marie Lacey, and Eva Davis. Contingency boring locations may be approximate to SCAPS locations or in locations selected to maximize understanding of the site CSM and extent of NAPL contamination north of Old Mormon Slough. Soil samples will be collected for chemical analysis at changes in soil type, or in intervals where contamination is suspected, based on odor or visual evidence of contamination.
Determine if the movement of dissolved organic contaminants, if present, is affected by adsorption onto naturally occurring organic matter.	Soil TOC concentrations in unimpacted areas and representative of soil conditions across the site.	A maximum of 20 soil samples analyzed for TOC using the Walkley-Black method. Samples will be selected to obtain TOC information representative of different aquifer and aquitard zones.	Detection limit of 1,000 mg C/kg to allow for K_d calculation.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase I (continued)			
Determine downward migration potential for groundwater and NAPL, if present. Provide input for model and assist with conceptual design of thermal treatment system.	Permeability (hydraulic conductivity) data on aquitard and aquifer materials. Need site-wide data to evaluate variability. Data on permeability of sand zones required to assist with design of thermal treatment system.	A maximum of 20 soil samples to be collected from aquitard and aquifer materials and analyzed for hydraulic conductivity measurements. Locations to be determined in the field.	Permeability measurements using EPA 9100/ASTM 5084 will be made on soil cores that may have to be repacked. The purpose of the permeability data is to estimate average permeability so this method should provide adequate permeability data quality.
	Geochemistry comparison between zones to provide information to design extraction and treatment system.	A maximum of 20 soil samples will be collected from different aquifer and aquitard zones and analyzed for cation exchange capacity using EPA 9081 by PTS Laboratories.	Sensitivity of all methods based on limitations of analytical instrumentation. Samples selected from most sand-rich and clay-rich soils in clean zones.
	Physical characteristics of soil to determine downward migration potential for groundwater and NAPL. Provide input for model.	Soil classification during drilling. 20 soil samples analyzed for moisture content (ASTM D2216, grain size (ASTM D422), bulk density (ASTM D2937), and effective porosity and NAPL saturation (API RP40) by PTS Laboratories.	SCAPS soil classification compared to soil boring logs. Sensitivity based on limitations of analytical instrumentation. Samples collected for physical testing will be from soil zones that appear to have relatively low levels of contamination, using visual inspection, and be representative of different stratigraphic horizons.
Determine the nature and extent of contamination beneath Old Mormon Slough.	Horizontal and vertical extent of NAPL.	Contingency rotosonic soil borings will only be conducted in Old Mormon Slough if SCAPS is unable to complete the planned investigation. Continuous soil cores will be collected at a maximum of five locations to 170 linear feet. The cores will be visually evaluated to estimate NAPL saturation. Soil samples will be collected for analysis approximately every five feet for a maximum of 34 samples per borehole or a total of 170 samples. Soil samples will be analyzed by the following methods: TPH fingerprinting by GC/FID will be conducted by the FASP on-site laboratory.	Soil samples will be selected from the rotosonic soil borings in the field. Selection criteria will be based on identifying unique geologic intervals and visible contamination. Soil samples will be collected for chemical analyses at changes in soil type or in intervals where contamination is suspected based on odor or visual evidence of contamination.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase I (continued)			
		Region 9 Limited TCL SVOC GC/MS analysis to be conducted by the EPA Region 9 Laboratory only if TPH is detected or a maximum of ten percent of the total nondetect samples, whichever is greater. Collect soil samples for treatability study analyses, if warranted.	
Phase II—Problem Statement: Subsurface NAPL cannot be efficiently removed without thermally enhanced extraction methods. Sufficient data are not available to characterize contaminant extent and select a treatment technology, based on the FY99 NAPL investigation data			
SCAPS CPT and LIF			
Determine where NAPL exists and the approximate extent (vertical and horizontal) east of SE-79, southeast of the DSW-4 wells, and south of SE-97.	Horizontal and vertical extent of POL and PAHs. Measure concentration of primarily 3 or more ring aromatic compounds (and some 2-ring compounds) using LIF.	LIF detection threshold: 100 to 500 mg/Kg TPH. 20 LIF penetrations estimated. Initial locations will be selected based the FY99 NAPL investigations data at SE-79, DSW-4, and SE-97. Spacing of penetrations will be determined in the field and will be evaluated against estimated 100-foot treatment unit size (also used in the FY99 NAPL Investigation). Continuous readings to depth of 150 feet, if possible, final decisions regarding depth of penetration will be made in the field.	Threshold LIF value (reporting limit) determined in field. Approximately 100 to 500 mg/Kg TPH. Spatial resolution of 4 cm (0.13 foot) when driven at 1 m/min. LIF penetration locations will be determined on a daily basis by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader). SCAPS penetration locations will be selected to maximize understanding of the site CSM and extent of NAPL contamination.
Identify if there is more than one unit (as defined by contaminant type) requiring treatment.	Spatial distribution of TPH and PAHs/PCP contamination based on soil fluorescence emission spectra. These intervals will be targeted for collection of soil samples with SCAPS and analysis of soil samples for TPH, PAH, and PCP. Chemical data will assist with interpretation of LIF wavelength signature.	Nontarget fluorescence will be evaluated by SCAPS soil sampling and analysis for TPH. TPH-Dx and PAHs/PCP results will be used in the field to verify apparent anomalous LIF sensor responses and assist with interpretation of wavelength signature.	Identify LIF results representative of different soil types, different emission spectra, and different emission intensity. Identify apparent anomalous LIF responses.
Determine how the hydrogeologic CSM can be improved. Determine what natural subsurface features impact movement of NAPL.	Geotechnical and stratigraphic data from cone pressure and sleeve friction sensors.	Soil classification using SCAPS sensors according to ASTM Method D3441.	SCAPS soil classification compared to existing soil boring logs. Spatial resolution of 4 cm for soil classification at a rate of 1 m/min.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase II (continued)			
Determine soil sample collection locations.	Estimated contaminant concentrations in soil across site from LIF.	Select sampling locations where contamination is high and reflects a range of contaminant compositions as defined by wavelength signature. Soil samples also will be collected to verify apparent anomalous LIF sensor responses and confirm nondetect LIF responses.	Locations for SCAPS soil samples will be determined in the field by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader). SCAPS soil sample locations will be selected by evaluating existing data and SCAPS LIF data.
SCAPS SOIL SAMPLING			
Determine accuracy of the SCAPS LIF data. Verify apparent anomalous LIF readings.	Co-located soil samples with SCAPS LIF penetrations.	Visual evaluation of soil cores for NAPL compared with LIF data. Collect soil samples at 5 penetration locations for a maximum of 20 soil samples. Approximately 4 locations per penetration. Depths decided in field.	Sensitivity for TPH must be at least as good as LIF threshold. LIF and confirmation TPH should be in agreement on detect versus nondetect for 80 percent of the samples; false negative less than 5 percent. Soil samples will be collected to accomplish the following objectives: (1) Obtain LIF verification samples representative of different soil types, different emission spectra, and different emission intensity selected throughout the site within SCAPS depth limitations; (2) Obtain soil samples to verify apparent anomalous LIF sensor responses; (3) Identify locations for continuous rotosonic soil borings; (4) Confirm the maximum depth of petroleum, oils, and lubricants (POL) and PAHs/PCP contamination; (5) Assess the percent saturation of NAPL contamination; (6) Collect data on the chemical makeup and magnitude of NAPL to complete the conceptual design of an in situ thermal treatment system.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase II (continued)			
Determine variability of contamination composition. Determine if contaminant extent can be better estimated. Confirm the bottom of POL, PAH, and PCP contamination. Develop the conceptual design of an in situ thermal treatment system.	Soil data for TPH-Dx, PAH, and PCP. Compare soil chemical analysis with LIF results representative of different soil types, emission spectra and emission intensity. Chemical makeup, magnitude, and variability of contamination.	Soil samples analyzed by the following methods: TPH fingerprinting by GC/FID conducted by the FASP on-site laboratory and limited SVOC TCL by GC/MS to be conducted by Region 9 Laboratory.	Sensitivity for TPH and SVOC analyses must be at least as good as LIF threshold. Sensitivity for SVOCs and TPH determined based on limitations of analytical instrumentation.
Determine how much NAPL is present. Evaluation of NAPL percent saturation is required to assist with evaluation of areas of mobile NAPL.	Percent saturation of NAPL contamination in soil.	A visual evaluation of NAPL saturation will be conducted in the field.	NAPL occurrence in all soil samples will be described according to the criteria presented in the FY99 FSP.
CONTINGENCY SOIL BORINGS			
Determine how amenable the site and contamination is to treatment by thermal methods.	Soil samples collected for chemical characterization of areas of suspected NAPL contamination and potentially differing contaminant signatures.	A maximum of five soil borings to 250 feet bgs will be completed east of SE-79, southeast of the DSW-4 wells, and south of SE-97. Continuous soil cores will be obtained. The cores will be visually evaluated to estimate NAPL saturation. Soil samples for analysis collected approximately every five feet (50 samples per boring for a maximum of 250 samples).	Samples will be selected from borings in the field. Selection criteria will be based on identifying unique geologic intervals and visible contamination. Soil samples will be collected for chemical analysis at changes in soil type, or intervals where contamination is suspected, based on odor or visual evidence of contamination.
Determine the extent/composition of contamination at depths where SCAPS penetrations are not possible.	Soil characterization where SCAPS met refusal before contamination was fully characterized.	Continuous sampling with a 10 ft core barrel with 5 ft split spoon to below SCAPS refusal to a depth of 250 feet bgs at a maximum of 5 locations (i.e., 50 samples per borehole and a maximum of 250 samples). Selection of soil samples in field for analysis by: (1) TPH-Dx by GC/FID by FASP on-site laboratory. All soil samples archived for additional chemical or physical testing. (2) SVOC limited TCL by GC/MS by Region 9 Laboratory, if TPH is detected. Ten percent of all samples with no detectable concentrations of TPH will be analyzed.	Sensitivity for TPH and SVOC analyses must be at least as good as LIF threshold. Sensitivity for SVOCs and TPH based on limitations of analytical instrumentation.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase III—Problem Statement: Surface soil samples collected in the Cellon process area and historical data indicate the potential for a significant PCP source to be located in this area and to have contaminated the A-zone groundwater downgradient from the source area. Sufficient data are not available to determine the extent of the suspected contamination source, whether the source is contained in a subsurface feature, confirm groundwater contamination, or determine the extent of the suspected contamination in the A-zone groundwater.			
DIRECT PUSH OR SCAPS SOIL SAMPLE SAMPLING			
Investigate potential presence of a subsurface confining structure in the PCP disposal area (Event Three).	Horizontal and vertical extent of confining structure.	10 sample collection penetrations. Initial locations will be placed within the Cellon process area, referred to here as the PCP source area. Spacing and final depth of penetrations will be determined in the field. If the SCAPS rods encounter groundwater near 16 feet bgs, which is believed to be the current water table, then this information will be used to evaluate the presence of the confining structure and the remainder of the pushes will be used to determine the extent of PCP/LNAPL contamination.	Soil sample locations will be determined on a daily basis by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader). Soil sample collection locations will be selected to maximize understanding of the site CSM and extent of LNAPL/PCP contamination.
Determine extent of PCP and LNAPL contamination in the PCP disposal area (Event Three).	Soil data for VOCs and PCP	A maximum of 120 soil samples will be analyzed by the following methods: (1) PCP by immunoassay field test kits to be conducted by the FASP on-site laboratory (2) VOCs (i.e., ethers and ketones) by GC/MS to be conducted by FASP on-site laboratory. The Region 9 laboratory located in Richmond, California, will be used as a contingency backup facility. Region 9 laboratory will confirm all detected VOCs or if VOCs are not detected, the laboratory will analyze a maximum of ten percent of all samples where VOCs are not detected. Samples will be collected every two feet from 6.5 feet bgs through the saturated zone to approximately 30 feet bgs	Sensitivities for PCP will be equal to 1.0 ppm. Each sample will initially be screened with 100 and 50 ppm test kits. Sensitivities for VOCs (e.g., diisopropyl ether and MIBK) will be determined based on the method limitations. Soil samples will be selected to minimize interference from creosote NAPL.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase III (continued)			
Determine extent of PCP and LNAPL contamination around the PCP mixing shed (Event Two).	Soil data for VOCs, plus TICs and PCP	A maximum of 42 soil samples will be analyzed by the following methods: PCP by immunoassay field test kits to be conducted by the FASP on-site laboratory VOCs (i.e., ethers and ketones) by GC/MS to be conducted by FASP on-site laboratory. The Region 9 laboratory located in Richmond, California, will be used as a contingency backup facility. Region 9 laboratory will confirm all detected VOCs or if VOCs are not detected, the laboratory will analyze a maximum of ten percent of all samples where VOCs are not detected. Samples will be collected every two feet from ground surface through the saturated zone to approximately 40 feet bgs.	Sensitivities for PCP will be equal to 1.0 ppm. Each sample will initially be screened with 100 and 50 ppm test kits. Sensitivities for VOCs (e.g., diisopropyl ether and MIBK) will be determined based on the method limitations. Soil samples will be selected to minimize interference from creosote NAPL.
CONTINGENCY DIRECT PUSH OR SCAPS SOIL SAMPLING			
Determine the areal extent of LNAPL/PCP contamination outside areas where the A-zone groundwater is known to be contaminated with creosote NAPL and alongside the southern property boundary (Event One)	Soil data for VOCs plus TICs (with particular emphasis for diisopropyl either and MIBK) and PCP, based on historical evidence.	A maximum of 154 soil samples analyzed by the following methods: VOCs using a modified version of SW 8260 and PCP using immunoassay field test kits (SW Method 4010A) by the EPA Region 9 FASP laboratory. The Region 9 laboratory, located in Richmond, California, will be used to analyze VOCs depending on the sample collection rate and FASP capacity. Region 9 laboratory will confirm all detected VOCs or if VOCs are not detected, the laboratory will analyze a maximum of ten percent of all samples where VOCs are not detected. Samples will be collected every two feet from the top of the saturated zone to approximately 40 feet bgs.	Sensitivities for VOCs (e.g., diisopropyl ether and MIBK) will be determined based on the method limitations. Sensitivities for PCP will be equal to 1.0 ppm. Each sample will initially be screened with 100 and 50 ppm test kits first. Soil sampling locations will be determined in the field by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader).

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase III (continued)			
CONTINGENCY SCAPS MICROWELL INSTALLATION			
Identify PCP and LNAPL in the A-zone groundwater (Event One).	PCP and VOC plus TICs data with particular emphasis in diisopropyl ether and MIBK	Install a maximum of four stainless steel microwells screened across the water table the near four A-zone groundwater wells. Measure water level to 0.01 foot.	Microwell installation locations will be determined in the field by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart geologist), and Steve Brewer (SCAPS team leader).
Refine direction of groundwater flow in the A-zone (Event One).	Water level data to establish flow conditions downgradient of the PCP source area around the southern property boundary.	Install a maximum of seven stainless steel microwells screened across the water table at the southern property boundary of the site. Measure water level to 0.01 foot.	Microwell installation locations will be determined in the field by Mamie Brouwer and Kira Lynch (team leaders/chemists), Richard Smith (hydrogeologist), Marie Lacey (EPA RPM), Eva Davis (EPA Technical Support), Fred Hart (geologist), and Steve Brewer (SCAPS team leader).
CONTINGENCY GROUNDWATER SAMPLE COLLECTION			
Determine the extent of PCP and LNAPL contamination in the A-zone groundwater at and/or near A3, A4, A5, and A6 (Event One).	Determine LNAPL presence or collect groundwater data for VOCs plus TICs, SVOCs, PCP, and dioxins.	Test newly installed microwells for LNAPL presence using indicator paste, interface probe and/or bailer. Collect and analyze LNAPL if present. Alternatively, a maximum of four groundwater samples collected from the newly installed microwells will be analyzed by the following methods: VOCs using a modified version of SW 8260 and SVOCs using SW 8270 by the EPA Region 9 laboratory. PCP using SW 8151 and dioxins using EPA Method 1613 collected in the newly installed microwells only will be conducted by laboratories identified in the Final FY00 SAP	Method sensitivities for dioxins and SVOCs to be equal to those defined in the FY99 NAPL Investigation SAP. Sensitivities for VOCs (e.g., diisopropyl ether and MIBK) will be determined based on the method limitations.

Table 2-1 (Continued)
McCormick and Baxter Data Quality Objectives Process

Investigation Objectives	Data Requirements	Investigation Strategy	Field Decision Criteria/ Performance Specifications
Phase III (continued)			
CONTINGENCY GROUNDWATER SAMPLE COLLECTION			
Determine the extent of PCP and LNAPL contamination alongside the southern property boundary (Event One)	Determine LNAPL presence and/or collect groundwater data for VOCs plus TICs, SVOCs, PCP, and dioxins.	Test wells for LNAPL presence using indicator paste, interface probe, and/or bailer. Collect and analyze LNAPL if present. Alternatively, a maximum of five groundwater samples analyzed by the following methods: VOCs using a modified version of SW 8260 and SVOCs using SW 8270 by the EPA Region 9 laboratory. PCP using SW 8151 and dioxins using EPA Method 1613 will be conducted by laboratories to be determined using laboratories identified in the FY00 SAP.	PCP detection limit to be equal to the MCL (1.0 μg/L). Method sensitivities for dioxins and SVOCs to be equal to those defined in the FY99 NAPL Investigation SAP. Sensitivities for VOCs plus TICs (e.g., diisopropyl ether and MIBK) will be determined based on the method limitations.
Phase IV—Problem Statement: SCAPS soil sampling pushes near the southeast corner of the stormwater retention ponds met refusal at approximately 16 feet bgs. Sufficient data are not available to determine whether refusal was encountered due to a subsurface structure.			
TRENCH EXCAVATION			
Determine subsurface features responsible for SCAPS refusal at 16 feet bgs during the FY99 NAPL Investigation.	Identify responsible subsurface feature(s).	Soil samples visually inspected and described from composites taken from excavator bucket and trench sidewalls. Soil classification according to ASTM Method D2488-93.	If no significant subsurface structure or confining layer is encountered within 16 feet bgs, no further exploration will be conducted.

Table 2-2
Monitoring Well Groundwater Sampling and Analysis

Monitoring Well ID	Rationale	Analyses Conducted
A-3	PCP concentration	SVOCs and VOCs, plus diisopropyl ether
A-4	PCP Concentration	SVOCs and VOCs, plus diisopropyl ether
A-5	PCP and dioxin concentration	SVOCs and VOCs, plus diisopropyl ether
A-6	PCP concentration	SVOCs and VOCs, plus diisopropyl ether

Table 2-3
SCAPS Soil Sampling Locations

Sample Location	Intervals Collected (feet bgs)
SS0102	44 to 45.8
SS0105	2 to 3.8, 6 to 7.5, 10 to 11.8, 14 to 15.8
SS0108	54 to 55.8
SS0109	28 to 30, 52 to 53.8, 60 to 61.8
SS0113	2 to 3.8, 6 to 7.8, 10 to 11.8, 14 to 15.8
SS0127	43 to 45
SS0133	35.6 to 38, 38 to 40, 40 to 42
SS0137	20 to 22, 22.7 to 22.8, 22.8 to 24, 25.1 to 26, 26.5 to 28, 30 to 32, 48 to 50, 78 to 80
SS0153	51 to 53, 53 to 55
SS0156	63 to 65
SS0169	42 to 44
SS0173	36 to 38, 38 to 40, 40 to 42
SS0176	48 to 50, 66 to 68
SS0179	7 to 9, 65 to 67
SV0114	16 to 17.1, 18 to 20, 20 to 22, 22 to 24, 24 to 25.5, 26 to 28, 30 to 31.3, 32 to 33.7, 24 to 26, 36 to 38, 38 to 40
SV0115	9.5 to 11.5, 11.5 to 13.5, 13.5 to 15.5, 15.5 to 17.5, 17.5 to 19.5, 19.5 to 21.5, 21.5 to 23.5, 23.5 to 25.5, 25.5 to 27.5, 27.5 to 29.5, 29.5 to 30.3, 33.5 to 35.5, 35.5 to 37.5, 37.5 to 39.5
SV0116	8.5 to 10.5, 16 to 18, 18 to 20, 20 to 22, 22 to 23, 24 to 26, 28 to 30, 30 to 32, 32 to 34, 34 to 36, 36 to 38, 38 to 40
SV0117	6.5 to 8.5, 10.5 to 12.5, 12.5 to 14.5, 14.5 to 16.5, 16.5 to 18.5, 185 to 20.3, 20.5 to 22.3, 22.5 to 24.5
SV0118	3.5 to 4.3, 5.5 to 6.2, 7.5 to 8.9, 10.1 to 10.7, 11.5 to 13.3, 13.5 to 15.3, 15.5 to 17.3, 19.5 to 21.3, 23.5 to 25.3
SV0119	4 to 6, 6 to 8, 8 to 10, 10 to 12, 14 to 16, 18 to 20, 20 to 22, 24 to 26, 26 to 28
SV0120	8 to 10, 19 to 21
SV0121	9 to 11, 11 to 12.4, 13 to 14.4, 15 to 17, 17 to 19, 19 to 21, 21 to 23, 23 to 25, 25 to 27, 27 to 29, 29 to 31, 31 to 32.8, 35 to 37, 37 to 39
SV0122	1 to 3, 3 to 5, 5 to 7, 9 to 11, 11 to 13, 15 to 17, 17 to 19, 19 to 21, 23 to 25, 27 to 29, 29 to 31, 31 to 33, 38 to 40
SV0123	10 to 12, 18 to 20, 32 to 34
SV0151	9 to 11.0, 11 to 13, 13 to 15, 15 to 17, 17 to 19, 19 to 21, 21 to 23, 23 to 25, 25 to 27, 27 to 29
SV0152	10 to 12, 12 to 14, 24 to 25.4, 26 to 28

Table 2-4
Performance Evaluation Sample IDs

Sample Date	Field Sample ID	PCP	TPH-Dx	PAH/PCP
31 July 2000	SV9151-0.0-0.1	X	X	X
31 July 2000	SV9151-29.0-31.0	X		
01 August 2000	SV9152-0.0-0.1	X	X	X
01 August 2000	SV9152-0.1-0.2	X	X	X

3.0 DATA SUMMARY

3.1 EXPLORATION LOCATION SURVEY

SCAPS LIF/CPT and soil sampling locations were measured in the field using a Trimble Pro XR GPS receiver and Pathfinder Office (version 2.1) software. The horizontal accuracy of the unit was verified to be within two feet by obtaining readings with the unit at survey control points on the site.

The vertical accuracy of the GPS unit was not adequate for the data needs of this investigation. Therefore, elevation measurements for SCAPS sampling locations were measured using a hand level by measuring the relative elevation difference between each SCAPS location and a nearby location of known elevation. Locations of known elevation included monitoring wells and survey monuments for land based SCAPS locations. SCAPS elevations in the slough were measured relative to a surveyed position on the east end of the sheet pile wall. The elevation of the top of each slough SCAPS LIF/CPT push was measured as the top of the steel pipe used to stabilize the SCAPS push rods. Since the steel pipe was set firmly into the slough sediment and did not change with rising and falling tides, SCAPS depth information was corrected to the top of the steel pipe as each push progressed. The depth to the mudline at each SCAPS exploration location was measured from the top of the steel pipe. The elevation of the mudline was calculated by subtracting the depth to mud from the elevation of the steel pipe.

A SPK survey team surveyed the position and elevation of the new monitoring wells, microwells, sonic borings, and all SCAPS push locations except pushes conducted in Old Mormon Slough. Horizontal and vertical position data collected by SPK were used in place of the lower accuracy GPS unit data. Survey data for all new wells and exploration locations are shown in Table 3-1.

3.2 SCAPS GEOTECHNICAL AND STRATIGRAPHIC DATA

The SCAPS CPT unit consists of strain gauges that measure cone pressure and sleeve friction in accordance with ASTM Standard D3441. The electromechanical responses of the strain gauges are translated into a soil classification number. A complete description of the SCAPS CPT system and results are given in the SCAPS field investigation report (USACE 2000a). The soil classification numbers and associated material descriptions produced by the SCAPS CPT unit are as follows:

- 0: Peats
- 0-1: Clays

- 1-2: Silt mixtures
- 2-3: Sand mixtures
- 3-4: Sands
- 4-5: Sands and gravels

A soil classification number is assigned every 0.1 foot to the material penetrated.

3.2.1 SCAPS Soil Classification and Visual Observation Comparability

Confirmation soil samples were collected using the SCAPS rig adjacent to CPT/LIF push locations, typically within 2 feet of the original push location. Soil borings using the rotosonic rig were typically drilled within 10 feet of the associated SCAPS CPT/LIF push. The CPT soil classification and SCAPS confirmation soil sampling visual determination of grain size are compared in Table 3-2. The SCAPS soil classification agrees with each associated visual soil sample with only a few exceptions. Contradictory soil descriptions between the CPT results and visual descriptions are most likely due to the natural spatial variability of subsurface materials.

Soil descriptions for the portions of rotosonic borings that were coincident with SCAPS CPT data are not included in Table 3-2 because the length of SCAPS CPT push and rotosonic boring soil description overlap is too large to present in a table. The results of the two methods were compared when geologic cross sections were developed. Agreement between the two methods is excellent.

The SCAPS CPT and soil classification interpretation provides an accurate measurement of grain size distribution at the McCormick and Baxter site.

3.3 SCAPS LIF DATA

The in situ laser-induced fluorescence system collected peak intensity and peak wavelength for each LIF spectrum. The intensity of the return signal is related to the magnitude of the PAH compounds that are components of the petroleum hydrocarbon contamination. Data were collected continuously at each of the 75 push locations, with a total of 5473 feet of depth pushed. LIF data for all the SCAPS CPT pushes are presented in the SCAPS field investigation report (USACE 2000a).

The in situ LIF data were used to identify contaminated areas at the site and to refine the NAPL CSM. In situ LIF data were also compared with on-site laboratory TPH analyses of soil samples collected by the SCAPS from locations adjacent to the LIF push locations**.** This evaluation is presented in the SCAPS field investigation report (USACE 2000a).

Additional details on the SCAPS LIF effort, including groundwater monitoring system (GMS) figures that display the LIF data, can be found in the SCAPS field investigation report (USACE 2000a).

3.4 SCAPS SOIL SAMPLING DATA

3.4.1 FASP TPH Data

Soil samples collected during the FY00 field investigation were analyzed on site by the EPA Region 9 FASP laboratory using modified EPA SW-846 Method 8015. TPH was detected above the laboratory quantitation limit of 100 mg/kg (wet weight) in 44 of 87 SCAPS soil samples. All TPH data are summarized in Table A-1 of Appendix A. The TPH detections in the SCAPS soil samples are also presented in Table A-1 of Appendix A. The SCAPS soil sample results are discussed in more detail in Section 5.

3.4.2 FASP PCP Data

Soil samples collected during the FY00 field investigation were analyzed on site by the EPA Region 9 FASP laboratory using modified EPA SW-846 Method 8081. PCP was detected above the laboratory quantitation limit of 1 mg/kg (dry weight) in 57 of 134 SCAPS soil samples. All PCP data are summarized in Table A-1 of Appendix A. The PCP detections in the SCAPS soil samples are presented on Plate 2 and in Table A-1 of Appendix A. The SCAPS soil sample results are discussed in more detail in Section 5.

3.4.3 PAH/PCP Data

Soil samples collected during the FY00 field investigation were analyzed for PAH/PCP and SVOC using EPA SW-846 Method 8270C by the EPA Region 9 laboratory in Richmond, California. Naphthalene was detected above the laboratory quantitation limit of 20 mg/kg (dry weight) in 35 of 89 SCAPS soil samples. PCP was detected above the laboratory quantitation limit of 60 mg/kg (dry weight) in 8 of 158 SCAPS soil samples. All PAH/PCP data are summarized in Table A-1 of Appendix A. The SVOC detections in the SCAPS soil samples collected in the suspected dredge spoils on The Dutra Group property are presented in Table A-2 of Appendix A. The SCAPS soil sample results are discussed in more detail in Section 5.

3.4.4 VOC Data

Soil samples collected during the FY00 field investigation were prepared on site by the FASP laboratory (i.e., weighed only for low-concentration VOC analysis and weighed and extracted with methanol for high-concentration VOC analysis) and analyzed by the EPA Region 9 laboratory in Richmond, California. Diisopropyl ether was detected above the laboratory quantitation limit of 10 mg/kg (dry weight) in 40 of 160 SCAPS soil samples. All VOC data are summarized in Table A-3 of Appendix A. The VOC detections in the SCAPS soil samples are presented on Plate 2 and in Table A-3 of Appendix A. The SCAPS soil sample results are discussed in more detail in Section 5.

3.4.5 Trace Metals Data

Soil samples collected on The Dutra Group property during the FY00 field investigation were analyzed for trace metals by the EPA Region 9 laboratory in Richmond, California. Trace metals were detected above the laboratory quantitation limit in all 11 SCAPS soil samples. The trace metals detections in the SCAPS soil samples are presented in Table A-4 of Appendix A.

3.4.6 LIF Measurement and Soil Chemical Data Comparability

Soil fluorescence data was qualitatively and semi-quantitatively interpreted with respect to the screening results reported by the EPA FASP and Region 9 laboratory. Project personnel evaluated the SCAPS LIF/CPT panel plots on site and selected various depths to be sampled, based on wavelength signatures, emission intensity, and suspected location of NAPL. Soil samples were collected and analyzed by various chemical techniques to assist in characterizing the site. In general, the in situ LIF responses poorly correlated with selected analytical results presented by the on-site laboratory. Tabulated laboratory results and related LIF responses and wavelengths are presented in Appendix D of the FY00 SCAPS Investigation Report (USACE 2000). In the absence of ex situ LIF data, a complete understanding of the correlation between LIF responses and analytical results generated during the site investigation could not be developed. Due to the data limitations, a limited evaluation of the correlation between in situ LIF responses and related on-site TPH results was performed and is presented in the FY00 SCAPS Investigation Report (USACE 2000a).

3.4.7 Interpretation of LIF Data

The SCAPS LIF data were evaluated to identify zones of probable high concentrations of contaminants and likely pathways of NAPL transport. The following criteria were used as lines of evidence to identify intervals of probable NAPL contamination within each SCAPS push.

- LIF counts above 500 were considered an indication of NAPL presence. Intervals with LIF counts between 100 and 500 were considered questionable and may be considered, with other lines of evidence, as an indication of NAPL presence.

- An evaluation of stained soil samples (i.e., SE-120, SE-122, SE-137, and SE-179) and the corresponding in situ LIF responses revealed wavelengths ranging from approximately 450 to 520 nanometers. LIF spectral profiles for pushes located within and near the Main Processing Area, which were associated with confirmed creosote NAPL observations during soil sampling, were common at peak wavelengths between 450 and 520 nanometers. LIF spectral profiles for pushes located within the slough, which were associated with confirmed creosote NAPL observations during soil sampling, were common at peak wavelengths between 450 and 520 nanometers. This information was used to screen the LIF data set and identify intervals associated with creosote contamination.

- Collocated SCAPS soil sampling results were evaluated to determine whether contamination was reported in the interval of interest as odor, sheen, or visible NAPL.

- The location of each LIF push and its proximity to confirmed NAPL presence was considered.

Table 3-3 summarizes the SCAPS LIF data interpretation and identifies intervals of significant creosote contamination or other unique petroleum hydrocarbon contamination within each SCAPS push.

The "gray area" for determining a significant LIF response was lowered from 300 used for the FY99 data interpretation to 100 counts based on an evaluation of NAPL presence in soil samples collected during the FY00 field investigation. The LIF data collected during the FY99 field investigation was reevaluated to determine if potential LIF responses of significance had been overlooked because of low level response between 100 and 300 counts. There are two potential intervals of NAPL contamination in SE-43 at 69-70 feet and 77-81 feet bgs that had not been identified in the FY99 FIR because of low level response. The results for this push have been reinterpreted and are included on Table 3-3.

3.5 ROTOSONIC BORINGS SOIL SAMPLING DATA

All rotosonic soil boring soil data are identified on the report tables located in this section and in Appendix A using the "SB" prefix.

3.5.1 FASP TPH Data

Soil samples collected during the FY00 field investigation were analyzed on site by the EPA Region 9 FASP laboratory. A total of 55 soil samples were collected from six locations (Figure 3-1) using rotosonic drilling methods and analyzed for TPH by the EPA FASP laboratory in accordance with the EPA Region 9 FASP standard operating procedure (SOP) for modified SW-846 Method 8015. Rotosonic boreholes were drilled at locations where data regarding

NAPL presence was needed at depths unreachable by SCAPS. TPH was detected in one sample only (i.e., SB0179-72.0 to 72.3 at 650 mg/kg).

All TPH data are summarized in Table A-2 of Appendix A.

3.5.2 PAH/PCP Data

Soil samples collected during the FY00 field investigation were analyzed by the EPA Region 9 laboratory in Richmond, California. A total of 55 soil samples were collected from six locations using rotosonic drilling methods and analyzed by the EPA Region 9 laboratory in accordance with the EPA Region 9 SOP 315 for analysis of SVOCs by EPA SW-846 Method 8270. Rotosonic boreholes were drilled at locations where data regarding NAPL presence was needed at depths unreachable by SCAPS. The initial sample collection depths were located at or below the SCAPS refusal depth or at selected depth intervals to confirm the SCAPS LIF responses.

Naphthalene was detected in concentrations greater than the laboratory quantitation limit of 20 mg/kg (dry weight) in two samples, including SB0179-72.0-72.3 (400 mg/kg) and SB0112-82 to 82.5 (10J mg/kg). PCP was not detected. All PAH/PCP data are summarized in Table A-2 of Appendix A.

3.6 PRELIMINARY PCP AND VOC GROUNDWATER SAMPLING DATA

Groundwater was collected from four A-zone monitoring wells: A-3, A-4, A-5, and A-6. Sampling locations are shown in Figure 3-2.

3.6.1 Naphthalene

Five groundwater samples were collected March 28 (A-4, A-4 field duplicate, and A-5), April 13 (A-3), and May 10, 2000 (A-6) and analyzed for SVOCs by Columbia Analytical Services Laboratory using SW-846 Method 8270. Naphthalene was not detected in the A-zone groundwater monitoring wells. The analytical results for these groundwater samples are presented in Table 3-4.

3.6.2 Pentachlorophenol

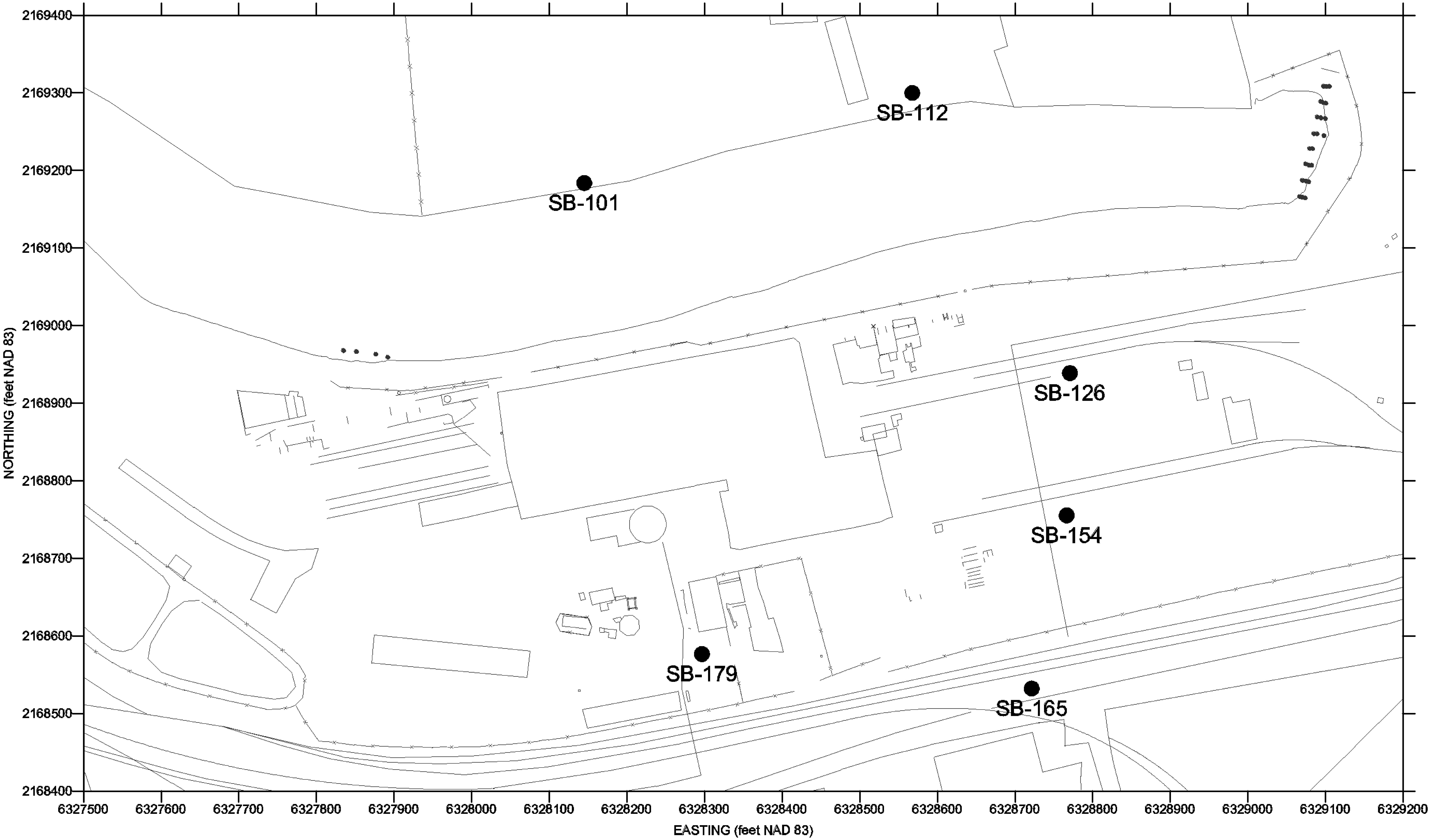
Five groundwater samples were collected March 28 (A-4, A-4 field duplicate, and A-5), April 13 (A-3), and May 10, 2000 (A-6), and analyzed for SVOCs by Columbia Analytical Services using SW-846 Method 8270. Pentachlorophenol was detected in five groundwater monitoring wells: A-3 (3.5J µg/L), A-4 (180 µg/L), A-4 field duplicate (230 µg/L), A-5 (10J µg/L), and A-6 (1,100 µg/L). Pentachlorophenol concentrations detected in these groundwater samples are presented in Table 3-4.

3.6.3 Carcinogenic PAHs

Five groundwater samples were collected March 28 (A-4, A-4 field duplicate, and A-5), April 13 (A-3), and May 10, 2000 (A-6). The carcinogenic PAHs (cPAHs) include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, chrysene, and indeno(1,2,3-c,d)pyrene). No cPAHs were detected in the A-zone groundwater samples. All detected PAH concentrations are presented in Table 3-4.

3.6.4 VOCs

Five groundwater samples were collected March 28 (A-4, A-4 field duplicate, and A-5), April 13 (A-3), and May 10, 2000 (A-6), and analyzed for SVOCs by Columbia Analytical Services using SW-846 Method 8260. Diisopropyl ether was detected in A-6 (14.8J µg/L) and A-4 (26 µg/L). All detected VOC concentrations are presented in Table 3-5.



LEGEND

Sonic boring location
SB-101

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS

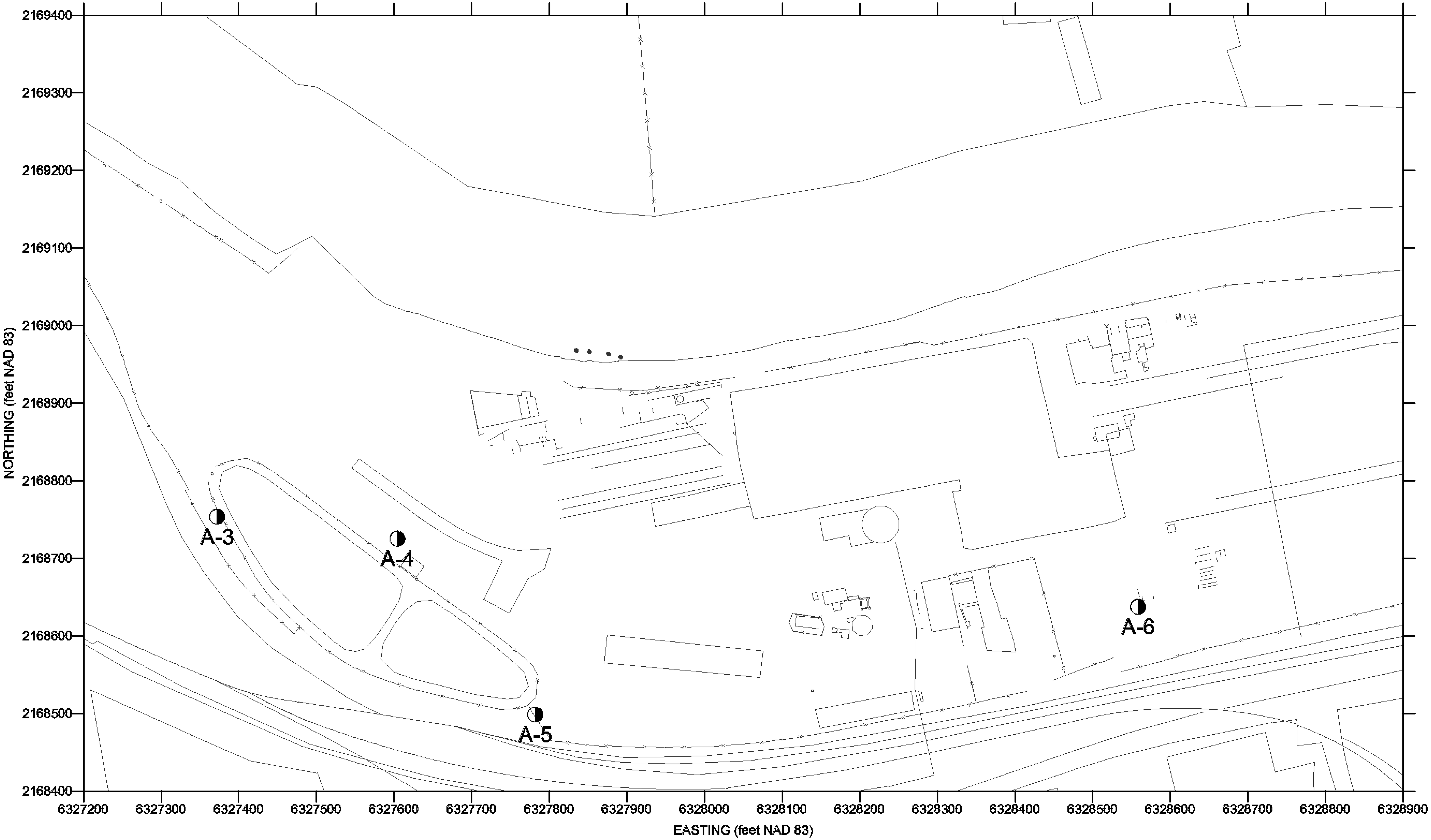
SEATTLE, WASHINGTON

MC CORMICK & BAXTER SUPERFUND SITE
SITE INVESTIGATION

Figure 3-1

FY00 ROTOSONIC BORINGS

STOCKTON CALIFORNIA



LEGEND

◑ A3 **Monitoring Well**

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS

SEATTLE, WASHINGTON

MC CORMICK & BAXTER SUPERFUND SITE
SITE INVESTIGATION

Figure 3-2
PRELIMINARY PCP AND VOC GROUNDWATER SAMPLING LOCATIONS

STOCKTON CALIFORNIA

Table 3-1
Summary of Survey Data

Location ID	Northing	Easting	Elevation (foot)					Surveyed Location?	Surveyed Elevation?
			Ground Surface/ Mudline	Barge Deck	Inner Casing	Outer Casing	Monument		
MW-3E	2169183.593	6328145.124	11.581		12.702	13.034		yes	yes
MW-4E	2168938.705	6328770.624	10.63		13.282	13.475		yes	yes
SB-101	2169183.694	6328144.998	11.581					yes	yes
SB-112	2169299.928	6328567.576	9.815					yes	yes
SB-126	2168938.718	6328770.654	10.63					yes	yes
SB-154	2168755.376	6328766.521	9.509					yes	yes
SB-165	2168532.14	6328721.438	7.117					yes	yes
SB-179	2168576.654	6328296.622	9.527					yes	yes
SE-100	2169158.19	6328007.529	11.044					yes	yes
SE-101	2169176.953	6328104.764	10.585					yes	yes
SE-102	2169147.605	6327911.274	15.076					yes	yes
SE-103	2169204.181	6327672.952	16.029					yes	yes
SE-104	2169295.188	6327553.655	13.044					yes	yes
SE-105	2169319.921	6327500.179	12.748					yes	yes
SE-106	2169155.175	6327838.643	15.522					yes	yes
SE-107	2169177.621	6327743.708	16.351					yes	yes
SE-108	2169190.789	6328194.493	11.588					yes	yes
SE-109	2169241.4	6328290.678	10.275					yes	yes
SE-110	2169269.026	6328385.95	8.748					yes	yes
SE-111	2169286.453	6328441.639	8.2					yes	yes
SE-112	2169291.872	6328567.738	9.754					yes	yes
SE-113	2169428.905	6327350.945	12.545					yes	yes
SE-120	2168582.899	6328221.144	9.722					yes	yes
SE-122	2168634.174	6328185.934	10.591					yes	yes
SE-124	2168806.551	6328755.69	9.649					yes	yes
SE-125	2168704.081	6328773.161	9.389					yes	yes

Table 3-1 (Continued)
Summary of Survey Data

Location ID	Northing	Easting	Elevation (foot)					Surveyed Location?	Surveyed Elevation?
			Ground Surface/ Mudline	Barge Deck	Inner Casing	Outer Casing	Monument		
SE-126	6328734.231	2168917.959	10.63					yes	yes
SE-127	6328639.109	2169193.578	-10	10.2				yes	yes
SE-128	2169155.527	6328413.164	-8.4	9.5				yes	yes
SE-129	2169100.916	6328231.018	-4.4	10.5				yes	yes
SE-130	2169055.727	6328041.506	-8.3	10.5				yes	yes
SE-131	2169035.143	6327879.755	-11	9.8				yes	yes
SE-132	2169062.361	6327712.684	-12.9	12.0				yes	yes
SE-133	2169133.046	6327554.473	-11.4	12.0				yes	yes
SE-134	2169243.411	6327362.643	-7	11.6				yes	yes
SE-135	2169079.146	6327565.469	-8.6	11.5				yes	yes
SE-136	2168998.943	6327791.205	-10.7	9.9				yes	yes
SE-137	2169043.587	6328149.854	-7.9	10.1				yes	yes
SE-137A	2169043.587	6328149.854	-7.9	10.6				yes	yes
SE-138	2169094.584	6328311.86	-9.1	10.4				yes	yes
SE-139	2169003.928	6327960.169	-8.5	10.3				yes	yes
SE-140	2169195.126	6328755.111	-8.5	9.0				yes	yes
SE-141	2169009.513	6328038.906	-8.1	10.2				yes	yes
SE-142	2169275.96	6327313.297	-7.2	9.1				yes	yes
SE-142A	2169275.96	6327313.297	-7.3	8.8				yes	yes
SE-143	2169193.914	6327467.554	-9.2	12.6				yes	yes
SE-143A	2169193.914	6327467.554	-8.9	11.8				yes	yes
SE-144	2169068.804	6328142.53	-8.2	9.5				yes	yes
SE-144A	2169068.804	6328142.53	-8.2	9.1				yes	yes
SE-145	2169047.63	6328195.381	-7.8	12.8				yes	yes
SE-145A	2169047.63	6328195.381	-7.8	12.0				yes	yes
SE-146	2169131.492	6328526.57	-7.8	10.7				yes	yes

Table 3-1 (Continued)
Summary of Survey Data

Location ID	Northing	Easting	Elevation (foot)					Surveyed Location?	Surveyed Elevation?
			Ground Surface/ Mudline	Barge Deck	Inner Casing	Outer Casing	Monument		
SE-146A	2169131.492	6328526.57	-7.7	9.8				yes	yes
SE-147	2169168.059	6328630.784	-8.1	12.6				yes	yes
SE-147A	2169168.059	6328630.784	-8.1	12.4				yes	yes
SE-148	2169108.651	6328427.15	-7.8	10.8				yes	yes
SE-148A	2169108.651	6328427.15	-7.8	9.9				yes	yes
SE-149	2168995.681	6327879.159	-10.2	8.9				yes	yes
SE-149A	2168995.681	6327879.159	-10.2	8.6				yes	yes
SE-150	2169045.019	6327655.234	-11.4	12.6				yes	yes
SE-150A	2169045.019	6327655.234	-11.4	12.5				yes	yes
SE-153	2168860.459	6328744.44	10.088					yes	yes
SE-154	2168751.022	6328766.529	9.63					yes	yes
SE-155	2168659.109	6328779.005	9.488					yes	yes
SE-156	2168598.797	6327332.942	8.988					yes	yes
SE-157	2168720.383	6327274.87	10.234					yes	yes
SE-158	2168688.087	6327286.503	9.928					yes	yes
SE-159	2168445.465	6327690.545	8.636					yes	yes
SE-160	2168428.902	6327798.436	8.907					yes	yes
SE-161	2168426.183	6327812.624	8.983					yes	yes
SE-162	2168410.619	6327898.371	8.904					yes	yes
SE-163	2168475.507	6328386.051	9.708					yes	yes
SE-164	2168502.536	6328517.51	9.093					yes	yes
SE-165	2168531.674	6328724.875	7.127					yes	yes
SE-166	2168565.797	6328256.067	10.008					yes	yes
SE-167	2168591.944	6328184.54	9.832					yes	yes
SE-168	2168648.921	6328222.352	10.612					yes	yes
SE-169	2168677.373	6328161.746	10.427					yes	yes

Table 3-1 (Continued)
Summary of Survey Data

Location ID	Northing	Easting	Elevation (foot)					Surveyed Location?	Surveyed Elevation?
			Ground Surface/ Mudline	Barge Deck	Inner Casing	Outer Casing	Monument		
SE-170	2168639.948	6328112.882	10.212					yes	yes
SE-171	2168935.467	6328820.467	10.485					yes	yes
SE-172	2168871.838	6328832.607	9.976					yes	yes
SE-173	2168765.057	6328866.869	9.254					yes	yes
SE-174	2168676.683	6328878.935	9.522					yes	yes
SE-174A	2168675.575	6328874.184	9.577					yes	yes
SE-175	2168678.755	6328851.347	9.163					yes	yes
SE-176	2168562.101	6328876.041	6.744					yes	yes
SE-177	2168664.67	6327301.677	9.665					yes	yes
SE-178	2168645.076	6327322.243	9.35					yes	yes
SE-179	2168582.386	6328294.417	9.477					yes	yes
SE-180	2168516.546	6328144.963	10.076					yes	yes
SE-181	2168719.469	6327274.656	10.23					yes	yes
SE-182	2168511.785	6327473.852	8.114					yes	yes
SE-183	2168440.487	6327640.533	8.108					yes	yes
SE-184	2168409.36	6328166.323	9.571					yes	yes
SE-185	2168541.057	6328765.492	7.12					yes	yes
SE-186	2168573.45	6328924.587	9.72					yes	yes
SE-187	2169001.274	6327302.094	12.435					yes	yes
SE-188	2168654.565	6328373.44	9.813					yes	yes
SE-189	2168562.749	6328388.591	9.696					yes	yes
SE-190	2168495.158	6328442.194	10.074					yes	yes
SE-191	2168432.546	6328263.774	9.884					yes	yes
SV-114	2168637.551	6328550.582	9.532					yes	yes
SV-115	2168508.666	6327797.753	10.887					yes	yes
SV-116	2168751.041	6327367.957	14.279					yes	yes

Table 3-1 (Continued)
Summary of Survey Data

Location ID	Northing	Easting	Elevation (foot)					Surveyed Location?	Surveyed Elevation?
			Ground Surface/ Mudline	Barge Deck	Inner Casing	Outer Casing	Monument		
SV-117	2168896.172	6327837.087	12.599					yes	yes
SV-118	2168890.783	6327829.593	12.386					yes	yes
SV-119	2168901.861	6327853.932	13.206					yes	yes
SV-121	2168734.743	6327606.727	12.507					yes	yes
SV-122	2168635.964	6328185.414	10.639					yes	yes
SV-123	2168618.096	6328168.045	10.364					yes	yes
SV-151	2168927.903	6327834.204	13.918					yes	yes
SV-152	2168926.888	6327866.313	13.922					yes	yes
SW-120A1	2168584.007	6328219.672	9.645		9.628	9.798		yes	yes
SW-120A2	2168581.663	6328220.968	9.645		9.671	9.857		yes	yes
SW-162A	2168408.516	6327898.195	8.911		8.881	9.09		yes	yes
SW-163A	2168476.341	6328387.941	9.54		9.656	9.808		yes	yes
SW-164A	2168502.086	6328515.887	9.29		9.397	9.538		yes	yes
SW-171A1	2168937.577	6328821.925	10.556		11.083	11.203		yes	yes
SW-171A2	2168936.161	6328823.104	10.556		11.065	11.214		yes	yes
SW-173A	2168766.998	6328865.813	9.342		9.934	10.049		yes	yes
SW-181A	2168719.469	6327274.656	9.934		10.194	10.316		yes	yes
SW-182A	2168511.785	6327473.852	8.114		8.26	8.443		yes	yes
SW-183A	2168440.487	6327640.533	8.108		8.111	8.274		yes	yes
SW-184A1	2168409.36	6328166.323	9.571		9.736	9.926		yes	yes
SW-184A2	2168409.076	6328164.901	9.571		9.835	10.011		yes	yes
SW-186A	2168573.45	6328924.587	6.948		6.885	7.045		yes	yes
SW-187A	2169001.274	6327302.094	12.435		12.908	12.925		yes	yes
SW-61A	2168677.205	6328068.576	10.678		10.659	10.813		yes	yes

Table 3-2
Comparison of SCAPS CPT Soil Classification to Visual Soil Descriptions

Location ID	Sample ID/Depth Interval[1]	Soil Description				
		SCAPS CPT				Visual
		Soil Classification Number			Equivalent Grain Size[2]	
		Average	Min	Max		
SE-102	SS0102-44-45.8	1.47	0.70	2.30	silt mixtures	clayey silt
SE-105	SS0105-2-3.8	1.87	0.78	3.79	silt mixtures	fill: clayey silt and sand
SE-105	SS0105-6-6.5	0.62	0.15	1.00	clays	sand
SE-105	SS0105-10-11.8	0.24	0.00	0.57	clays	sand and silt
SE-105	SS0105-14-15.8	ND	ND	ND	ND	clayey silt
SE-108	SS0108-54-55.8	1.00	0.25	1.68	silt mixtures	clayey silt
SE-109	SS0109-28-30	3.33	3.12	3.53	sands	sand with silt
SE-109	SS0109-52-53.8	0.89	0.38	2.90	clays	sand and silt
SE-109	SS0109-60-61.8	2.78	1.24	4.06	sand mixtures	sand with silt
SE-113	SS0113-2-3.8	0.66	0.24	1.37	clays	clayey silt
SE-113	SS0113-6-7.8	0.57	0.04	1.53	clays	clayey silt and sand
SE-113	SS0113-10-11.8	0.46	0.05	1.57	clays	clayey silt
SE-113	SS0113-14-15.8	ND	ND	ND	ND	clayey silt
SE-127	SS0127-43-45	1.09	0.27	2.79	silt mixtures	sand with silt
SE-133	SS0133-35.6-37	4.46	4.40	4.56	sands & gravels	sand
SE-133	SS0133-38-40	3.91	3.23	4.26	sands	sand
SE-133	SS0133-40-42	2.83	1.85	3.57	sand mixtures	sand
SE-137	SS0137-20-22	0.97	0.90	1.09	clays	clay
SE-137	22-24	1.47	0.85	2.55	silt mixtures	clay and silt
SE-137	SS0137-25.1-26	1.53	1.02	2.01	silt mixtures	clayey silt
SE-137	SS0137-26.5-28	2.03	1.41	2.36	sand mixtures	sand
SE-137	28-30	1.87	0.55	2.65	silt mixtures	sand and silt
SE-137	SS0137-30-32	2.11	1.84	2.54	sand mixtures	clayey silt
SE-137	SS0137-48-50	3.20	2.87	3.36	sands	sand
SE-137	SS0137-78-80	1.10	0.47	1.75	silt mixtures	clayey silt
SE-153	SS0153-51-53	1.44	0.67	1.94	silt mixtures	clayey silt
SE-153	SS0153-53-55	1.46	1.12	1.91	silt mixtures	clayey silt
SE-156	SS0156-63-65	0.79	0.55	1.12	clays	clayey silt
SE-169	SS0169-42-44	1.12	0.69	1.85	silt mixtures	clayey silt
SE-173	SS0173-36-38	0.66	0.49	0.98	clays	clayey silt
SE-173	SS0173-38-40	0.84	0.64	1.30	clays	clayey silt
SE-173	SS0173-40-42	1.03	0.44	1.64	silt mixtures	clayey silt
SE-176	SS0176-48-50	1.02	0.57	1.50	silt mixtures	clayey silt
SE-176	SS0176-66-68	0.92	0.43	1.44	clays	sand
SE-179	SS0179-7-9	1.38	1.18	1.54	silt mixtures	clayey silt
SE-179	SS0179-65-67	2.06	0.18	3.76	sand mixtures	sand

Table 3-2 (Continued)
Comparison of SCAPS CPT Soil Classification to
Visual Soil Descriptions

[1]Sample ID shows depth interval of soil sample. If no sample collected (or sample collected from small portion of interval) then the depth interval of visual description recorded.
[2]Based on the average soil classification number for the sampled interval.

Note: ND - Not detected—SCAPS CPT malfunction and no soil classification number available.

Table 3-3
Identification of Soil Intervals Containing NAPL

Push Location	Depth Interval (feet bgs or feet below deck)	In Situ Wavelength (nanometer)	Comments
SE-100			Clean Push to 83' bgs
SE-101			Clean Push to 94' bgs
SE-102			Clean push to 127' bgs. Low level response 44-46', however low wavelength for site target cont. Soil sample collected 44-45.8' bgs non-detect for TPH and PAH/PCP. Calcite found throughout interval.
SE-103			Clean push to 142' bgs
SE-104			Clean push to 60' bgs
SE-105			Clean push to 125' bgs. Soil samples collected 2-3.8' bgs, 6-7.5' bgs, 10-11.8' bgs, and 14-15.8' bgs non-detect for TPH and PAH/PCP confirmed interval as clean.
SE-106	36-37	429	Clean push to 129' bgs. Low level response 36-37' and 98-100' bgs low wavelength for site target contamination most likely calcite.
SE-107			Clean push to 58' bgs.
SE-108			Clean push to 95' bgs. Confirmed with soil sample collected 54-55.8' bgs non-detect for TPH and PAH/PCP.
SE-109			Clean push to 64' bgs. Low response (300 counts) at 60-63' low wavelength for site contamination. Soil sample collected 28-30', 52-53.8', and 60-61.8' confirmed no visible NAPL or detectable TPH or PAH/PCP contamination.
SE-110			Clean push to 78' bgs
SE-111			Clean push to 68' bgs
SE-112			Clean push to 62' bgs
SE-113			Clean push to 77' bgs. Soil sample collected confirmed no visible NAPL or detectable TPH or PAH/PCP at 2-3.8', 6-7.8', 10-11.8', or 14-15.8' bgs.
SV-114-SV-119			No SCAPS LIF collected at these locations.
SE-120	8-11 and 18-24	454 - 456	Soil samples collected 8-10' and 19'-21'bgs. No visible NAPL or stain, but Sudan dye reaction positive and fuel odor. TPH reported in both samples, however, PAHs & PCP were below detection level. Note lower wavelength response at this push location, and unique peak shape similar to SE-43. Most likely similar to unique petroleum hydrocarbon type identified in SE-43 not creosote.
SV-121			No SCAPS LIF collected at this location.
SE-122	3-10	423	Strong odor and positive Sudan 9' bgs.
	10-12		Strong odor and positive Sudan test 11' bgs.
	15-20		Stained with strong odor Sudan test negative.
	20-26	496	Visible sheen positive Sudan test.

Table 3-3 (Continued)
Identification of Soil Intervals Containing NAPL

Push Location	Depth Interval (feet bgs or feet below deck)	In Situ Wavelength (nanometer)	Comments
SE-122	30-36	447	NAPL confirmed based on soil sample. NAPL contaminated soil found to have PCP but all PAHs were non-detect.
SE-124			Clean push to 84' bgs
SE-125			Clean push to 63' bgs. Low level response 50-56' bgs, however low wavelength for site target contamination.
SE-126			Clean push to 49' bgs. Rotosonic completed collocated to SCAPS LIF push no contamination detected.
SE-127	29-30	468	NAPL suspected based on wavelength and response.
	44-47	488	Soil sample collected 43-45 - sheen and strong odor - NAPL visible. Low level response at 52' bgs believed to be calcite based on wavelength and response.
SE-128	26-28	472	NAPL suspected based on wavelength and response. Low level response 51-54' bgs is suspected to be calcite based on low wavelength.
SE-129	32-34	490	NAPL suspected base on wavelength and response. Low level response 55-57' bgs is suspected to be calcite based on low wavelength.
SE-130	30-32	490	NAPL suspected based on wavelength and response. Low level response 57-58' bgs is suspected to be calcite based on low wavelength.
	35-36	514	NAPL suspected based on wavelength and response.
SE-131	25-29	481-486	NAPL suspected based on wavelength and response.
SE-132			Clean push to 70' bgs. Casing pushed past unconsolidated slough sediments into recent flood basin sediments.
SE-133			Clean push to 53' bgs. Sample collected 35-37' and 38-40', 40-42' bgs. No odor, sheen or detectable contaminants in any sample. Casing pushed past unconsolidated slough sediments into recent flood basin sediments.
SE-134			Clean to 67' bgs. LIF response 25-27' bgs questionable may be carried with casing. Low level response at 40' bgs suspected to be calcite.
SE-135	32-34	488	NAPL suspected based on wavelength and response.
SE-136	63-65	491	NAPL suspected based on wavelength and response. Low level response and wavelength at 40-41' bgs indicative of calcite in silt.
SE-137	20-46	486-510	NAPL confirmed based on soil samples collected. Two hump peak similar to SE-05
	50-51	495	NAPL confirmed based on soil samples collected. Two hump peak similar to SE-05
	55-60		NAPL suspected based on wavelength and response.
	65-66		NAPL suspected based on wavelength and response.
	68-71	486	NAPL suspected based on wavelength and response.

Table 3-3 (Continued)
Identification of Soil Intervals Containing NAPL

Push Location	Depth Interval (feet bgs or feet below deck)	In Situ Wavelength (nanometer)	Comments
SE-137	77-81		NAPL confirmed based on soil samples collected. Two hump peak similar to SE-05
	20-22		NAPL visible
	22.7-22.8		NAPL with crystal material most likely Naphthalene based on SVOC results.
	22.8-24		NAPL with some crystals
	25.1-26		No NAPL or sheen.
	26.5-28		Odor but no visible NAPL.
	28-30		NAPL and sheen
	30-32		NAPL oozing from sample - NAPL distribution non-uniform occurs in pockets.
	48-50		No NAPL or sheen.
	78-80		Sheen and Naphthalene odor.
SE-138	30-33	494	NAPL suspected based on wavelength and response.
SE-139	28-31	489	NAPL suspected based on wavelength and response.
SE-140	28-30	490	NAPL suspected based on wavelength and response.
SE-141	28-30	487	NAPL suspected based on wavelength and response.
	30-36	490	NAPL suspected based on wavelength and response.
	39-42	489	NAPL suspected based on wavelength and response.
	68-70	514	NAPL suspected based on wavelength and response.
SE-142	18-20	468	NAPL suspected based on wavelength and response. Contamination in sediments only, remaining push clean to 61’ bgs.
SE-143	24-27	468-471	NAPL suspected based on wavelength and response. Contamination in sediments only, the remaining push clean to 69’ bgs.
SE-144	20-32	466-513	NAPL suspected based on wavelength and response.
	37-38	515	NAPL suspected based on wavelength and response.
	39-41	515	NAPL suspected based on wavelength and response.
	54-56	513	NAPL suspected based on wavelength and response.
SE-145	23-28	485-495	NAPL suspected based on wavelength and response.
SE-146	20-26	472-482	NAPL suspected based on wavelength and response. Low level response at 48-50’ bgs determined to be calcite based on wavelength of 412 µm.
SE-147	25-29	470-487	NAPL suspected based on wavelength and response. Low level response at 46-47’ bgs determined to be calcite based on wavelength of 413 µm.
	49-50	487	NAPL suspected based on wavelength and response.
	59-60	515	NAPL suspected based on wavelength and response.
SE-148	20-28	480-495	NAPL suspected based on wavelength and response.
	32-34	488-497	NAPL suspected based on wavelength and response.
	35-36		NAPL suspected based on wavelength and response.

Table 3-3 (Continued)
Identification of Soil Intervals Containing NAPL

Push Location	Depth Interval (feet bgs or feet below deck)	In Situ Wavelength (nanometer)	Comments
SE-148	42-44	510	NAPL suspected based on wavelength and response.
	47-48	489	NAPL suspected based on wavelength and response.
SE-149	20-26	467-484	NAPL suspected based on wavelength and response. No contamination below sediments to 56’ bgs.
SE-150	28-30	485	NAPL suspected based on wavelength and response. No contamination below sediments to 80’ bgs.
SV-151 and SV-152			No LIF collected
SE-153			Clean push to 75’ bgs. Low level response 50-54’ bgs 427-430 µm confirmed calcite by soil sampling.
SE-154			Clean push to 63’ bgs. Rotosonic soil samples collected to 233’ bgs, all results non detect.
SE-155			Clean push to 73’ bgs. Low level response 35-37’ bgs believed to be calcite because of wavelength 425 µm.
SE-156			Clean push to 105’ bgs. Low level response at 64-65’ bgs 470 µm could be site contamination but response only 57 counts. Soil sample collected 63-65’ bgs non-detect for all TPH and PAH/PCP.
SE-157			Clean push to 47’ bgs.
SE-158			Clean push to 50’ bgs.
SE-159			Clean push to 62’ bgs.
SE-160			Refusal at 16’ bgs.
SE-161			Refusal at 16’ bgs.
SE-162			Clean push to 60’ bgs. Low level response 33’ bgs suspected to be calcite based on wavelength of 436 µm.
SE-163			Clean push to 50’ bgs. Low level response 38’ bgs (450 µm) and 44’ bgs (420 µm) suspected to be calcite.
SE-164			Clean push to 54’ bgs.
SE-165			Clean push to 96’ bgs. Low level response at 86-88’ bgs suspected to be calcite because of wavelength of 427 µm. Rotosonic soil samples collected to 227’ bgs with no detectable contamination.
SE-166	11-13	447	Lower wavelength and unique shape similar to SE-120 and SE-43.
	14-17	449	Lower wavelength and unique shape similar to SE-120 and SE-43.
SE-167			Clean push to 52’ bgs. Potentially same surface soil contamination but difficult to interpret because dummy push completed to 3’ bgs.
SE-168			Clean push to 50’ bgs.
SE-169			Clean push to 86’ bgs. Low level response 42-43.5 (447 µm) due to calcite. Calcite confirmed in soil sample collected 42-44’ bgs.
SE-170			Clean push to 58’ bgs.
SE-171			Clean push to 37’ bgs.
SE-172			Clean push to 33’ bgs.

Table 3-3 (Continued)
Identification of Soil Intervals Containing NAPL

Push Location	Depth Interval (feet bgs or feet below deck)	In Situ Wavelength (nanometer)	Comments
SE-173			Clean push to 63’ bgs. Response at 36-42’ bgs (429-433 µm) due to calcite. Soil samples collected 36-38’, 38-40’, and 40-42’ bgs, no detectable contamination and calcite confirmed.
SE-174			Refusal hit 14’ bgs.
SE-174a			Refusal hit 14’ bgs.
SE-175			Refusal hit 13’ bgs.
SE-176			Clean push to 93’ bgs. Low level response at 48-50 (436 µm) and 66-68 (435 µm) due to calcite. Soil samples collected 48-50’ and 66-68’ bgs, no detectable contamination and calcite confirmed in soil sample.
SE-177			Clean push to 51’ bgs.
SE-178			Clean push to 47’ bgs.
SE-179	7-8	466	Soil sample collected 7-9’ bgs. Strong fuel odor.
	66-68	470	Soil sample collected 65-67’ bgs. NAPL oozing from sample. NAPL contains only very low level of PAH.
SE-180			Clean push to 51’ bgs.
SE-181–SE-187			No LIF collected CPT data only
SE-188	63-64	466	NAPL suspected based on wavelength and response.
SE-189			Clean push to 64’ bgs
SE-190			Clean push to 29’ bgs
SE-191			Clean push to 52’ bgs
SE-43	0-10	477	Note lower wavelength in this boring. Soil sampling results indicate that LIF response at this location is due to unique petroleum hydrocarbon type not creosote. All PAHs were below detection level. Soil sample had fuel odor but no visible NAPL. SE-43 has unique peak shape.
	10-20	455	Note lower wavelength in this boring. Soil sampling results indicate that LIF response at this location is due to unique petroleum hydrocarbon type not creosote. All PAHs were below detection level. Soil sample had fuel odor but no visible NAPL. SE-43 has unique peak shape.
	20-30	454	Note lower wavelength in this boring. Soil sampling results indicate that LIF response at this location is due to unique petroleum hydrocarbon type not creosote. All PAHs were below detection level. Soil sample had fuel odor but no visible NAPL. SE-43 has unique peak shape.
	69-70	469-471	NAPL suspected based on wavelength and response. Interval not identified as contaminated in FY99 FIR because of low level response.

Table 3-3 (Continued)
Identification of Soil Intervals Containing NAPL

Push Location	Depth Interval (feet bgs or feet below deck)	In Situ Wavelength (nanometer)	Comments
SE-43	77-81	448	NAPL suspected based on wavelength and response. Interval not identified as contaminated in FY99 FIR because of low level response.
SE-47	7-18	437-447	Note lower wavelength in this boring. Soil sampling results indicate that LIF response at this location is due to unique petroleum hydrocarbon type not creosote. PCP was detected at two depths: 12-14 and 14-15 ' bgs. The only PAH reported was phenanthrene at very low levels. Total TPH reported as diesel was very high, up to 9,200 ppm.
	90-91	437	Interval that may be of interest not identified in FY99 analysis.

Note: Slough stabilizing casing prevented LIF measurements in unconsolidated slough sediments SE-127 through SE-141.

Table 3-4
PAHs and PCP Detected in Groundwater

Location ID	**A-3**	**A-4**	**A-4**	**A-5**	**A-6**
Date Collected	**4/13/00**	**3/28/00**	**3/28/00**	**3/28/00**	**5/10/00**
Field QC			**Field Duplicate**		
PAHs and PCPs (in µg/L)					
2,4,5-Trichlorophenol	10U	10U	10U	10U	1J
2,4,6-Trichlorophenol	10U	10U	10U	10U	9J
Naphthalene	10U	10U	10U	10U	10U
Fluoranthene	10U	0.2J	0.4J	10U	10U
Pyrene	10U	0.5J	0.5J	10U	10U
Pentachlorophenol	3.5J	180	230	10J	1,100

Notes:
J - estimated
U - undetected

Table 3-5
VOCs Detected in Groundwater

Location ID	**A-3**	**A-4**		**A-5**	**A-6**
Date Collected	**4/13/00**	**3/28/00**	**3/28/00**	**3/28/00**	**5/10/00**
Field QC			**Field Duplicate**		
Diisopropyl ether (in µg/L)	10U	26	27	10U	14JN

Notes:
J - estimated
N - tentatively identified compound
U - undetected

4.0 DATA QUALITY ASSURANCE SUMMARY

After the laboratory data deliverables were reviewed, an evaluation was performed to determine how well the analytical portion of the project was executed and to what extent the chemical data achieved the project-specific data quality objectives. The precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) were evaluated and are summarized in this section. Overall data quality was high and the data are acceptable for all project-specific purposes. In addition, all on-site field screening and off-site confirmatory sample analyses (which were performed by Lockheed Martin, Environmental Services Assistance Team, Region 9, in Stockton, California, and Richmond, California, respectively) were compliant with the project-approved Sampling and Analysis Plan (SAP) (USACE 1999a) and Management Plan Addendum (MPA) for FY00 (USACE 2000b) for NAPL field exploration, except for the items discussed in the following sections. The data are not being used for health-risk purposes, but only to confirm the extent of contamination determined during previous investigations.

4.1 DATA QUALITY REVIEW METHODS

Data were reviewed in accordance with the project-specific criteria established in the SAP and MPA for NAPL field exploration for the PARCCS parameters, and validated following the intent of the EPA *Contract Laboratory Program (CLP) National Functional Guidelines for Organic Data Review* (USEPA 1999), and the EPA *CLP National Functional Guidelines for Inorganic Data Review* (USEPA 1994). Because the analytical methods performed by the laboratory (i.e., modified SW-846, which are based on the project-specific criteria established in the SAP and MPA) have different quality control (QC) requirements than those referenced in the CLP National Functional Guidelines, the project-specific criteria were used to qualify the data. Results for the following on-site screening and off-site laboratory confirmatory QC samples were reviewed:

- Field duplicates
- Matrix spike/matrix spike duplicates (MS/MSD)
- Postdigestion spikes (PDSs) (metals only)
- Laboratory control samples (LCSs) and blank spikes
- Performance evaluation (PE) samples (PAH/PCP, PCP and TPH-Dx only)
- Equipment rinsate, trip, and method blanks
- Surrogates (PAH/PCP, TPH-Dx and VOC only)
- Internal standards (PAH/PCP and VOC only)
- Instrument tuning standards (PAH/PCP and VOC only)
- Initial and continuing calibration (ICAL and CCAL) standards

Additionally, chain-of-custody (COC) and cooler receipt forms were reviewed, as part of sample representativeness, to evaluate sample integrity during shipping and handling procedures and to verify contractual and technical holding times. Laboratory quantitation limits were reviewed to determine whether project-specific reporting limits were met. Frequency of collection and analysis of field and laboratory QC samples were reviewed to evaluate completeness and adherence to the SAP and MPA.

The sample delivery groups (SDGs) that were reviewed (i.e., desktop and full data validation reports) are included in Appendix C. It should be noted that not all SDGs associated with this site investigation were subjected to the data review process.

4.2 SUMMARY OF PARCCS REVIEW FOR CHEMICAL ANALYSES

The desktop and full data validation reports (Appendix C) were reviewed to identify trends in QC parameters that may impact overall data usability. Infrequent and random exceedances of QC limits are expected and do not necessarily limit data usability. A general discussion of the QC exceedances and resulting data qualification is presented in the following sections. Appendix E, Tables E-1 and E-2, list the method references, laboratory reporting limits, and QC limits.

4.2.1 Precision

Precision examines the distribution of the reported values about their mean. The distribution of reported values refers to how different the individual reported values are from the average reported value. Precision may be affected by the natural variation of the matrix or by contamination within that matrix, as well as by errors made in the field and/or laboratory handling procedures. Precision is evaluated using analyses of primary and field duplicate samples and laboratory MS/MSDs, which not only exhibit sampling and analytical precision but also indicate analytical precision through the reproducibility of the analytical results. Relative percent difference (RPD) is used to evaluate precision. RPD QC limits for primary and field duplicate evaluation are ≤30 percent RPD for aqueous samples and ≤50 percent RPD for soil and NAPL samples. The RPD QC limits for MS/MSDs and matrix duplicates (MDs) are those established by the laboratories, as referenced in Appendix E, Tables E-1 and E-2. The data quality indicator *precision* was acceptable for this project.

The required frequency of field duplicate samples and laboratory MS/MSDs are 10 percent and 5 percent, respectively, and were met for all analytical methods.

RPDs were generally within project-specific QC limits. Specific exceedances are referenced in Appendix C. Exceedances were likely due to one or more of the following analytical variances:

- High levels of target analytes in samples, which require secondary dilutions to bring the concentrations within the linear range of calibration (e.g., PAH/PCP, PCP, TPH-Dx, and VOCs in soils). High dilution factors tend to cause RPD inaccuracies. Also, high levels of target analytes result in diluting out the matrix spike analytes.

- Sample heterogeneity for soil samples.

- Primary and field duplicate results at or near the limit of detection, which tend to have RPDs outside QC limits.

The organic analytical results did not require qualification based upon RPD exceedances, in accordance with the National Functional Guidelines (USEPA 1999).

4.2.2 Accuracy

Accuracy measures the analytical bias in a measurement system. Sources of error can be the sampling process, field contamination, preservation, sample handling, sample matrix, sample preparation, and analysis techniques. Sampling and laboratory accuracy may be assessed by evaluating the results from equipment rinsate blanks, trip blanks, and method blanks. These data help to assess the potential contamination contribution from various sources. The laboratory objective for accuracy is to equal or exceed the accuracy demonstrated for the applied analytical methods on samples of the same matrix. The percent recovery criterion is used to estimate accuracy based on recovery in MS/MSDs, blank spikes, PDSs, LCSs, PE samples, surrogates, internal standards, and calibration standards. The MS/MSDs, surrogates, and internal standards, which give an indication of matrix effects that may affect target analyte quantitation and identification, are also a good gauge of method efficiency. The data quality indicator *accuracy* was acceptable for this project.

The required frequency of these QC samples for collection and analysis were met except for the following:

- No equipment rinsate blank results were reported for the pentachlorophenol (PCP) field screening data.

The following target analytes were detected in the equipment rinsate blanks associated with the soil samples in SDG Nos. 00166B and 00166C: 4-chloro-3-methylphenol, copper, lead, thallium, and zinc, but the soil sample concentrations were either non-detect or their values were five times greater than the equipment rinsate blank concentrations. No qualifiers were recommended based on these variances, in accordance with the National Functional Guidelines (USEPA 1999 and 1994).

The volatile organic compound (VOC) case narratives indicated that the laboratory qualified all acetone results as estimated (J/UJ) due to potential field contamination. The soil sample containers (i.e., preserved with sodium bisulfate for low-level analysis and methanol for medium-level analysis) were prepared in the on-site FASP laboratory prior to sample collection. The laboratory believes that acetone and hexane present in the on-site FASP laboratory contaminated the sample containers, thus rendering the acetone results suspect. Acetone and hexane are solvents used during the field extraction/analysis of pentachlorophenol. Since the acetone results are considered suspect, all detected acetone results were qualified as non-detect (U) at the appropriate quantitation levels, in accordance with the National Functional Guidelines (USEPA 1999). Hexane was a tentatively identified compound (TIC) in a majority of the soil samples and should also be considered suspect.

In addition, the laboratory believes that the low levels of bromomethane and chloromethane detected in medium-level analyses of several samples are not related to the samples because they were not detected in the low-level analyses. Rather, their presence in the medium-level analyses may be due to contaminated methanol. The laboratory did not report any bromomethane and chloromethane detections from the medium-level VOC analyses.

Trip blanks TB-06-23-2000, TB-06-24-2000, TB-06-24-2000B, and TB-07-31-2000 exhibited VOC contamination for methylene chloride. No qualifiers were recommended based on this variance because methylene chloride was not detected in any of the associated soil samples.

TPH-Dx was detected in the equipment rinsate blanks associated with the soil samples in SDG No. SV0122. The TPH-Dx results for soil samples SV0122-15-17 and SV0122-27-29 were qualified as non-detect (U) at their respective quantitation levels, in accordance with the National Functional Guidelines (USEPA 1999), because they were less than five times the equipment rinsate blank concentrations.

The method blank associated with SDG No. 00210B exhibited naphthalene contamination. The only soil sample affected was SB101-131.8-132.3, which had the naphthalene result qualified as non-detect (U), and the value was raised to the reporting limit, in accordance with the National Functional Guidelines (USEPA 1999). The metals soil preparation blank associated with SDG No. 00166C exhibited calcium (Ca) contamination above the reporting limit. No qualifiers were recommended based on this variance, in accordance with the CLP National Functional Guidelines (USEPA 1994), because the associated sample concentrations for Ca was greater than ten times the preparation blank concentration.

MS/MSDs, blank spikes, PDSs, and LCSs were generally within project-specific QC limits. However, a few exceedances for metals resulted in data qualification:

- The MS/MSD for soil sample SS0105-6-7.5 (SDG No. 00166C) exhibited low recoveries (<75 percent) for antimony (Sb), manganese (Mn), selenium (Se), and thallium (Tl) and a high recovery (>125 percent) for lead (Pb) in the MSD only (which resulted in an elevated RPD). The Tl recoveries were <30 percent. The non-detect Sb and Se results and the detected Mn and Pb results for the associated samples (SDG No. 00166C) were qualified as estimated (UJ and J, respectively), whereas the non-detect Tl results were rejected (R), in accordance with the National Functional Guidelines (USEPA 1994).

The organic analytical results did not require further qualification based upon MS/MSD, blank spike, and LCS exceedances, in accordance with the National Functional Guidelines (USEPA 1999). Exceedances were likely due to one or more of the following analytical variances:

- Matrix spike analytes being diluted out due to the presence of high levels of target analytes in samples, which are the same analytes used for spiking the QC samples

- Sample heterogeneity for soil samples

- Presence of matrix interference

Four blind soil PE samples (one for PCP [field screening]; one for PCP [field screening], TPH-Dx, and polycyclic aromatic hydrocarbons/pentachlorophenol [PAH/PCP] analyses; and two for PAH/PCP analyses) were submitted to the EPA Region 9 Laboratory for this site investigation. One of the PCP PE samples (SV9152-0.1-0.2) was inadvertently submitted for PAH/PCP analysis. Consequently, the PE results for SV9152-0.1-0.2 are unusable. The remaining PE sample results were within QC limits, except for a slightly elevated recovery of fluorene (SDG No. 00215A for SV9152-0.0-0.1). The laboratory reported a PE result for anthracene above QC limits, but when the anthracene result was adjusted to the appropriate number of significant figures (three), the value is actually within QC limits. The PE results are presented in Table 4-1. The PE exceedance for fluorene indicates that the detected sample results may be biased slightly high. However, it is not expected that the detected sample results for fluorene would change by an order of magnitude. No qualifiers were recommended based on this PE exceedance.

Surrogate recoveries were within method QC limits, except for the following that resulted in data qualification:

- Rinse blank SV7137-20-22 (plus associated method blank) was not fortified with surrogates because it was inadvertently extracted as a TPH-Dx sample (SDG No. 00199C). Consequently, the PAH/PCP data for this rinse blank were rejected (R), in accordance with the National Functional Guidelines (USEPA 1999).

- TPH-Dx soil samples SV0117-6.5-8.5, SV0117-8.5-10.5, SV0122-1-3, SV0122-9-11, SV0122-19-21, and SV0122-29-31 (SDG Nos. SV0117 and SV0122) exhibited elevated surrogate recoveries for n-hexacosane (C26). The elevated surrogate recoveries are due to coeluting matrix interference and/or sample dilution. The positive sample results were qualified as estimated (J), in accordance with the National Functional Guidelines (USEPA 1999).

- The initial VOC analysis of soil sample SV0122-31-33 exhibited a low recovery for 4-bromofluorobenzene (BFB). The sample was reanalyzed at a secondary dilution, due to elevated levels of target compounds, with compliant surrogate recoveries. The results from the initial analysis were qualified as estimated (J/UJ), in accordance with the National Functional Guidelines (USEPA 1999). It should be noted that the laboratory reported non-detect results for all compounds associated with the same internal standard used for BFB quantitation from the secondary dilution; hence the elevated detection limits (i.e., 500 µg/kg). Since the National Functional Guidelines do not specify which compounds are associated with each surrogate, the detection limits for the affected compounds were revised to reflect the undiluted analysis.

- VOC surrogates were not calibrated at the appropriate levels (10 µg/kg, 20 µg/kg, 50 µg/kg, etc.) during the ICALs. Instead, they were calibrated at a constant level (50 µg/kg). Surrogates were added to the standards by the instrument auto-sampler, not manually.

The field laboratory did not add surrogates to the PCP field screening samples prior to extraction, contrary to laboratory standard operating procedures. Since PCP is a known site contaminant and the associated blank spikes, LCSs, and MS/MSD exhibited acceptable to slightly high recoveries (which indicates high extraction efficiency), no qualifiers were recommended based on this variance.

Internal standards (ISs) were within method QC limits for all PAH/PCP, SVOC, and VOC analyses, except for the following instances that resulted in data qualification:

- The initial analysis of soil sample SV0117-6.5-8.5 (SDG No. 00175E) exhibited a low recovery for phenanthrene-d_{10}. A high level of PCP in the sample caused the IS to be suppressed. The sample was reanalyzed at a secondary dilution for PCP only with compliant IS recoveries. The non-detect results associated with phenanthrene-d_{10} were qualified as estimated (UJ), in accordance with the National Functional Guidelines (USEPA 1999).

- The VOC analysis of soil samples SV5116-24-26 and SV0122-27-29 exhibited low recoveries for all ISs. The samples were not reanalyzed to confirm matrix interference. The results were qualified as estimated (J/UJ), in accordance with the National Functional Guidelines (USEPA 1999).

- The VOC analysis of soil samples SV0122-3-5, SV0122-5-7, and SV0122-9-11 exhibited a low recovery for chlorobenzene-d_5. Samples SV0122-3-5 and SV0122-9-11 were not reanalyzed to confirm matrix interference. Sample SV0122-5-7 was reanalyzed at a secondary dilution, with compliant IS recoveries, but the secondary dilution was not warranted (no target compounds above the linear range of calibration). The initial results were qualified as estimated (J/UJ), in accordance with the National Functional Guidelines (USEPA 1999).

There were a few instances where low IS recoveries were reported for initial sample analyses, which affect quantitation of naphthalene and 2-methylnaphthalene. Since the affected samples required secondary dilutions for these compounds and the IS recoveries were within QC limits, the data were not qualified.

All initial calibrations were within QC limits except for the following:

- The VOC ICAL associated with aqueous field QC samples TB (62000), TB-06-21-2000, TB-06-25-2000 TB-07-15-2000, TB-07-16-2000, TB-07-31-2000, and SV7151-3.0-5.0 exhibited average response factors (RFs) <0.05 for 2-hexanone and/or 1,2-dibromo-3-chloropropane (DBCP). The non-detect results were rejected (R), in accordance with the National Functional Guidelines (USEPA 1999).

- The VOC initial calibration associated with all aqueous field QC samples in SDG Nos. H00622AQ, H00623AQ, H00624AQ, H00627AQ, and H00628AQ was performed using a 25-mL purge volume for all target compounds except acetone, 2-butanone, carbon disulfide, diisopropyl ether, 2-hexanone, 4-methyl-3-pentanone, and methyl-t-butyl ether (MTBE). The results for these compounds were obtained from a 5-mL purge volume ICAL (except for samples TB (62000) and TB-06-21-2000 in SDG No. H00622AQ); hence the elevated detection limits (10 μg/L). The laboratory did not reanalyze samples TB (62000) and TB-06-21-2000 using a 5-mL purge volume. Hence, there are no results for these compounds for these two field QC samples.

- The VOC aqueous DBCP results reported by the laboratory (all non-detect) reflect the 25-mL purge analyses but were determined to be unusable due to a average response factor <0.05. Therefore, the non-detect DBCP results for all field QC samples in SDG Nos. H00623AQ, H00624AQ, H00627AQ, and H00628AQ were revised to reflect the 5-mL purge volume ICAL because the average RF was ≥0.05.

- The laboratory performed only a VOC four-point calibration for bromoform (25-mL purge). Therefore, the detection limits have been elevated to represent the lowest point of the ICAL (2 μg/L).

Continuing calibrations associated with the PCP field screening analyses (SDG No. SV0151), SVOC analyses (SDG Nos. 00166B and 00166C), PAH/PCP analyses (SDG Nos. 00175E, 00176A, 00199B, 00230C, and 00243A), and VOC analyses associated with all SDG numbers (except No. 00199C) exhibited elevated percent differences (%Ds). The SVOC and PAH/PCP continuing calibration exceedances were for one or more of the following target analytes: carbazole, pentachloro- phenol, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, 3,3'-dichlorobenzidine, hexachlorocyclopenta-diene, and 3-nitroaniline. The VOC continuing calibration exceedances were for one or more of the following target compounds: acetone, bromomethane, 2-butanone, carbon disulfide, chloromethane, dichlorodifluoromethane, trans-1,2-dichloroethene, 2-hexanone, MTBE, 4-methyl-2-pentanone, and vinyl chloride. The affected PCP, SVOC and PAH/PCP results (specifically referenced in Appendix C) were considered estimated (J/UJ), in accordance with the National Functional Guidelines (USEPA 1999). Instrument calibrations for all other fractions were within QC limits.

All affected sample results associated with the noncompliant standards were qualified as estimated (J/UJ), in accordance with the National Functional Guidelines (USEPA 1999).

4.2.3 Representativeness

Representativeness expresses the degree to which the sample data accurately and precisely represent the characteristics of a population of samples, parameter variations at a sampling point, or environmental conditions. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling program or subsampling of a given sample. Objectives for representativeness are defined for sampling and analysis tasks and are a function of the project-specific data quality objectives (DQOs). Field sampling procedures, as described in the SAP and MPA, have been selected with the goal of obtaining representative samples for the media of concern.

Representativeness is evaluated by examining sample tracking information and COC/cooler receipt documentation. This evaluation verifies adherence to contractual and technical holding times and maintenance of proper documentation to allow traceability of laboratory analytical results to specific field sample locations. Representativeness can also be assessed by the evaluation of field duplicate precision, as discussed in Section 4.2.1. The data quality indicator *representativeness* was acceptable for this project.

Sample integrity was generally maintained in accordance with SAP and MPA procedures, except for variances specifically referenced in Appendix C. Exceptions include the following:

- Cooler temperatures outside the QC limits of 4°C ±2°C or not recorded
- Sample IDs on the COCs not in agreement with sample containers (SDG Nos. 00166D [SV7122-33.0-35.0] and 00175E [SV0117-10.5-12.5])
- Incorrect analysis (PAH/PCP) requested on the COC for PE sample (SDG No. 215A)
- Sample not documented on COC, but the sample container received by the laboratory and the appropriate analysis performed (SDG No. SV0117 for PCP, SDG Nos. 00166D and 00210A for PAH/PCP)
- Parent sample associated with MS/MSD not identified on COC for PAH/PCP (SDG No. 00210A)
- Technical extraction holding time exceedances for SVOCs (SDG No. 00166C), PAH/PCP (SDG No. 00166D), and TPH-Dx (SDG Nos. SV0120 and SV0122)

Although all of the above referenced variances could potentially affect representativeness, the only variance that resulted in data qualification was the technical extraction holding time exceedances for SVOCs, PAH/PCP, and THP-Dx. The following sample results were estimated (J/UJ), in accordance with the National Functional Guidelines (USEPA 1999).

- SVOC soil samples SS0105-6-7.5, SS0105-14-15.8, and SS0113-14-15.8 (SDG No. 00166C)

- PAH/PCP rinsate blank SV7122-33.0-35.0 (SDG No. 00166D)

It is not expected that the cooler temperature exceedances (range from 1°C to 10°C) would adversely effect the sample results because of the chemical nature of the project-specific analytes; PAH/PCP, SVOC, TPH-Dx, and metals are relatively stable and would not be expected to degrade significantly during sample transport. Since the VOC soil samples were field-preserved with sodium bisulfate to a pH <2 for low-level analysis and with methanol for medium-level analysis, the elevated cooler temperatures are not expected to adversely affect the VOC results. The affected samples are presented in Table 4-2.

Since the sample ID discrepancies on the COCs were resolved between the laboratory and project personnel, these documentation discrepancies do not impact the reported analytical results.

4.2.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. This goal is achieved through the use of standard techniques to collect and analyze representative samples and by reporting analytical results in appropriate units. Complete field documentation using standardized data collection forms support the assessment of comparability. Comparability is limited by other PARCCS parameters because only when precision and accuracy are known can data set comparison be performed with confidence. For data sets to be comparable, it is imperative that the analytical methods and procedures be strictly followed.

Comparability is evaluated by examining the laboratory analytical data and comparing the reported results for compliance with the project-specific approved methods and standard operating procedures (SOPs). The data review determined that the analytical results are acceptable for use, despite minor deviations from the methods and SOPs. The data quality indicator *comparability* was met by the laboratories for this project.

Comparability is also evaluated by comparing interlaboratory split sample results. However, split samples were not a project-specific requirement.

4.2.5 Completeness

Completeness is defined as a measure of the amount of valid data (usable for project-specific purposes) obtainable from a measurement system compared to the total amount of measurements expected to be obtained under normal conditions. It is important that appropriate quality assurance (QA) procedures be maintained to ensure that valid data are obtained and the desired level of completeness meets the project-specific DQOs. For the data generated, the overall project-specific goal of 98 percent is required for completeness (or usability) of the analytical data. The overall completeness for this project is above 98 percent.

4.2.6 Sensitivity

The sensitivity (i.e., reporting limits) of the analytical methods is driven by the project-specific DQOs. All reporting limits met the project-specific requirements, except for the following minor variances:

- The PAH/PCP results for soil sample SS137-22.7-22.8 (SDG No. 00199B) were reported on a wet-weight basis due to the nature of the sample (i.e., contains 400,000 mg/kg [or 40%] naphthalene), as identified in Appendix C. The high organic content in this sample prevented the laboratory from determining the percent moisture. No qualifiers were recommended based on this variance.

- The VOC results for soil samples SV0152-26-28 and SV5152-26-28 are elevated to reflect decreased sample size, as identified in Appendix C. No qualifiers were recommended based on this variance.

- The low-level VOC soil analysis of sample SV0118-5.5-6.2 was determined to be unusable by the laboratory due to instrument malfunction. Therefore, the laboratory only reported the medium-level soil analysis, as identified in Appendix C.

It should be noted that several VOC and PAH/PCP soil samples required secondary dilutions due to the presence of high levels of target analytes, which resulted in elevated reporting limits for non-detect analytes.

4.3 OVERALL DATA USABILITY

After information in the laboratory data deliverables was reviewed, an evaluation was performed to determine how well the analytical portion of the project was executed and to what extent the chemical data achieved the project-specific DQOs identified in the MPA.

The overall DQOs for this project were to generate data to support the following uses:

Phase I

- Collect data north of Old Mormon Slough (The Dutra Group and Stockton Cold Storage properties) or beneath Old Mormon Slough for use in refining the existing conceptual site model (CSM) of light nonaqueous-phase liquid (LNAPL) contamination related to the McCormick and Baxter site.

- Confirm the maximum depth of petroleum, oil, and lubricant (POL) and PAH/PCP contamination above site-specific threshold concentrations in the vadose zone, capillary fringe, and saturated zone.

- Substantially reduce the uncertainty in the CSM and obtain sufficient information to develop a conceptual design for in situ thermal technology evaluation.

Phase II

- Determine whether LNAPL has migrated beyond the current McCormick and Baxter property line, and, if so, the lateral and vertical extent of that migration.

- Assess the percent saturation of NAPL at the site.

Phase III

- Characterize the surficial and subsurface PCP and VOC contamination in the Cellon process area near SE-08, and investigate LNAPL and PCP in the A-zone groundwater downgradient from the Cellon process area.

- Determine whether natural attenuation may be limiting the mobility of contamination in the groundwater.

Phase IV

- Determine the nature of the subsurface feature that caused site characterization and analysis penetrometer system (SCAPS) refusal at SE-3, SB-52, and SE-95 during the FY99 investigation.

- Characterize subsurface soil for geochemical and physical characteristics.

Data are not intended to be legally defensible, used to prepare a risk assessment, or used to evaluate compliance with regulatory screening levels; therefore, less rigorous documentation and a higher level of uncertainty in quantitation do not impact the project-specific DQOs. Despite the minor data QC issues identified in this section and in Appendix C, the analytical data reported for this project are usable.

Table 4-1
Performance Evaluation Sample Results

Sample ID	Compound	Laboratory Results (mg/kg)	Acceptance Criteria[a] (mg/kg)
SV9151-0.0-0.1	PCP (field screening)	4.3	1.16–5.41
	TPH-Dx	1,700	970–2,540
	Naphthalene	20	14.8–105
	Acenaphthene	70	30.7–114
	Fluorene	80	31.8–103
	Pentachlorophenol	50	22.7–106
	Anthracene	30	6.77–39.4
	Pyrene	80	32.3–111
	Benzo(a)pyrene	10	3.80–20.2
SV9151-29.0-31.0	PCP (field screening)	4.3	1.16–5.41
SV9152-0.0-0.1	Naphthalene	60	14.8–105
	Acenaphthene	110	30.7–114
	Fluorene	**110**	31.8–103
	Pentachlorophenol	50	22.7–106
	Anthracene	40*	6.77–39.4
	Pyrene	80	32.3–111
	Benzo(a)pyrene	10	3.80v20.2
SV9152-0.1-0.2**	**Naphthalene**	**ND**	14.8–105
	Acenaphthene	**ND**	30.7–114
	Fluorene	**ND**	31.8–103
	Pentachlorophenol	**ND**	22.7–106
	Anthracene	**ND**	6.77–39.4
	Pyrene	**ND**	32.3–111
	Benzo(a)pyrene	**ND**	**3.80–20.2**

[a]Acceptance criteria established by Environmental Resource Associates, Inc.

Notes:
ND - nondetect
Performance evaluation sample results outside QC limits are indicated in **bold**.
*The reported laboratory result is outside QC limits, but if appropriate significant figures were used (i.e., same as used for the QC limits), then the result (i.e., 35.0 mg/kg) would be within the QC limits.
**It was determined during the data review that the incorrect analysis (i.e., PAH/PCP by Method 8270C) was requested on the COC. The PE sample should have been analyzed for PCP (only) by a more sensitive analytical technique (e.g., gas chromatography/electron capture detector [GC/ECD], the same as the PCP field screening technique), rather than for PAH/PCP by gas chromatography/mass spectrometry (GC/MS). This, coupled with the project-specific modifications for the extraction of PAH/PCP soil samples (i.e., 10 grams extracted, final extract volume of 20 mL), attributed to the non-detect results for PAH/PCP. The minimum GC/MS quantitation limits for PAH and PCP are 20 mg/kg and 50 mg/kg, respectively.

Table 4-2
Cooler Temperature Exceedances

SDG No.	Sample ID	Cooler Temperature (°C)
00166C	SV7117-14.5-16.5	9
00175E	SV0117-16.5-18.5	1
	SV0117-18.5-20.3	
	SV0117-20.5-22.3	
	SV0117-22.5-24.3	
	SV0117-6.5-8.5	
	SV0117-10.5-12.5	
	SV5117-10.5-12.5	
	SV0117-12.5-14.5	
00199C	SB7101-190	6.5
	SV7151-3.0-5.0	
	SB7154-151.0-152.0	
00210B	All samples	8
00215A	SB0112-151-151.5	10
	SB0112-169-169.5	
	SB5112-151-151.5	
	SB0112-189.0-189.5	
	SB0112-198.0-198.5	
00224A	All samples	8
H00621	All samples	9.6
H00622	All samples	1.8
H00623, H00623A	All samples	1

5.0 DATA INTERPRETATION/CONCEPTUAL SITE MODEL

5.1 PHYSICAL SYSTEM

5.1.1 Geology

5.1.1.1 Regional Geology

The City of Stockton is located on the margin of the Sacramento-San Joaquin delta near the axis of the Great Valley geomorphic province. The Great Valley is a sedimentary basin consisting of a series of homoclinal beds of clay, silt, sand, and gravel with a gently dipping east flank and more steeply dipping west flank (ICF Kaiser 1998). Stockton is located within the Sacramento sedimentary basin, which is separated from the San Joaquin sedimentary basin by the Stockton fault and the poorly defined Stockton Arch to the south of the project site. Approximately 6,000 feet of Quaternary and Tertiary alluvial deposits and sedimentary rocks overlie approximately 4,000 feet of Tertiary and Jurassic Melanges, which overlie crystalline basement rocks of the southwestward tilted Sierran block.

The California Department of Water Resources (DWR) mapped the surface geology of the McCormick and Baxter site as undifferentiated recent alluvium and Victor Formation. Quaternary flood basin deposits were mapped approximately 1 mile to the east of the site. The mid-Pleistocene to recent alluvium and Victor Formation overlie the Plio-Pleistocene Laguna Formation, which overlies the Mio-Pliocene Mehrten Formation. The flood basin deposits contain delta equivalents of the Victor and Laguna Formations (i.e., the Victor and Laguna Formations interfinger with flood basin deposits).

Flood basin deposits were described as consisting of silty clay, clayey silt, and micaceous silt that represent deposits on the time-transgressive flood plain of the San Joaquin River (Atwater 1982). The flood plain deposits were noted to have common calcium carbonate nodules and locally common black spherules of manganese and/or iron oxides.

The Quaternary Victor Formation is a heterogeneous assemblage of low-sloping alluvial fan and fluvial floodplain deposits derived from the Sierra Nevada (DWR 1967). The deposits consist of a heterogeneous sequence of gravel, sand, and clay. In the vicinity of the site, the thickness of this unit was shown to be approximately 170 feet (DWR 1967). The coarse-grained fluvial deposits of the Victor Formation reportedly grade laterally and vertically into the clays and silts of the flood basin deposits in a manner that “provides little correlation of material between wells” (DWR 1978).

Surface materials have more recently been mapped as Modesto Formation (CDMG 1990) and as fan deposits of the Calaveras River (Atwater 1982). The Modesto Formation represents Pleistocene glacial outwash fans that are approximately 10 to 15 feet thick. The Calaveras fan deposits are described as Quaternary fan deposits consisting of clayey silt, silt, sandy silt, and subordinate sand and gravel. Draining an unglaciated basin, the Calaveras River fan deposits are composed predominantly of lithic rock fragments and contain little mica. Because the Modesto Formation is derived from the Sierra Nevada, it is considered analogous to the Victor Formation for the purposes of this report.

The Plio-Pleistocene Laguna Formation underlies the Victor Formation. The Laguna Formation is interpreted to have been deposited as coalescing alluvial fans from the Sierra Nevada. The Laguna Formation consists of abundant beds of clayey silt and silty sand with some poorly graded sand in relatively thin zones and scarce well-graded gravel beds. It is lithologically similar to the Victor Formation, which makes the contact between the two formations difficult to discern visually. In the vicinity of the site, the Laguna Formation occurs between depths of approximately 170 to 1,000 feet bgs (DWR 1967). The Laguna Formation dips to the southwest and is derived from material eroded from the Sierra Nevada.

The Mehrten Formation lies beneath the Laguna Formation and is composed of moderately indurated andesitic sand and sandstone interbedded with tuffaceous silt and claystones. In the vicinity of Stockton, the Mehrten Formation is approximately 600 feet thick.

5.1.1.2 Site Geology

Lithological data are available on average 75 to 100 feet apart to approximately 110 feet bgs (approx. –100 feet NVD88). Deeper than 110 feet bgs (approx. –100 feet NVD88), additional lithologic data are available but are relatively sparse compared to shallow data. The geologic interpretations presented in this report are based upon all lithologic data collected to date, including the following: Old Mormon Slough sediment cores (SC-OMS series), RI borings (IB series), pre-RI geophysical and boring logs (A, DSW, EB, ONS, OFS, and OS series), SCAPS CPT data (SE series), grain size analysis data, SCAPS soil samples (SE series), and rotosonic soil borings (SB series).

Subsurface materials at the McCormick and Baxter site above 200 feet bgs (approx. –190 feet NVD88) were interpreted in the RI report (ICF Kaiser 1998) to be the flood basin deposits described by Atwater (1982). Sand and gravel deposits deeper than 200 feet bgs (approx. –190 feet NVD88) were interpreted in the RI report to be part of the Laguna Formation. Subsurface materials shallower than approximately 240 feet bgs (approx. 230 feet NVD88) consist primarily of two types. A uniform stiff to very stiff gray-green micaceous clayey silt with common calcite nodules and/or veins comprises approximately 60 percent of the subsurface volume to 240 feet bgs (approx. –230 feet NVD88). A gray to gray-green fine- to mediumgrained sand and silty sand comprise the remaining 40 percent (Plates 3 through 12). Sedimentary structures such as laminations and cross-bedding were not observed in the soil samples of site sands and silts. Contacts between the two materials are usually abrupt but occasionally are gradational. No significant lithological differences were observed between these two material types above and below 200 feet bgs (approx. –190 feet NVD88).

The silt material has been classified visually as clay in the majority of past soil borings based primarily on its plastic nature. However, this material was determined to be primarily silt with a large clay component based upon grain size analyses.

Sand zones exist as laterally continuous horizontal layers and as discontinuous layers and pods within and between the clayey silt material. These sand zones range in thickness from a few feet up to 30 feet thick. Most laterally continuous sand units are approximately 10 feet thick.

The density of CPT data collected at the site during 1999 and 2000 are sufficient to allow analysis of the relative horizontal and vertical continuity of the sand units above an elevation of −100 feet. The distribution of sand and silt within 5-foot-thick horizontal slices for the elevation interval –0 to –200 feet is illustrated in Figures 5-1 to 5-40. Figures 5-1 to 5-20 were prepared by examining the CPT data from each SCAPS push and determining the top and bottom of vertically continuous sand intervals at each CPT push location. For a given 5-foot elevation interval, a value of 1 was assigned to a CPT push location if a sand greater than 1 foot thick was present at that location within that 5-foot interval. Otherwise, a value of zero was assigned to that location. The resulting two-dimensional scatter point set was interpolated and the 0.5-foot contour was used as the boundary between sand and silt. The procedure for generating Figures 5-21 through 5-40 was identical as that for Figures 5-1 through 5-20 except that data from exploratory borings and monitoring well installations were used to supplement the relatively sparse CPT data available below –100 feet elevation.

The upper 10 feet of upland site sediments is almost entirely clayey silt. Therefore, laterally continuous sand units are nonexistent above –0 feet elevation.

Above an elevation of –15 feet, sand units are small and isolated resulting in limited horizontal continuity of sand at these elevations (Figures 5-1 to 5-3). However, much of the sand above –15 feet elevation is vertically connected to more continuous sands at lower elevations. From –15 to –25 feet elevation, sands are more laterally connected (Figures 5-4 to 5-5). The elevation interval from approximately –10 to –25 feet has been termed the A1-zone of the aquifer. The A1-zone sand is laterally continuous across the western half of the site extending from north of the slough under the Oily Waste Ponds and Cellon Process Area, to the southern boundary of the site, and under the office building and parking area. The A1-zone in the eastern half of the site (UPRR property) is separated from the western A1-zone by silt that extends from the slough, under the asphalt cap, and along the UPRR property boundary to Washington Street.

Between elevation –25 and –35 feet, sand comprises a smaller percentage of the subsurface materials. Along the southern and eastern portions of the site, the sands are not laterally extensive and are generally isolated resulting in relatively low horizontal continuity (Figures 5-6 to 5-7). However, there are locations on site (e.g., Cellon Process area) where these sand zones have vertical continuity with sand zones above (A1-zone) and below (A2-zone).

The sand units between elevations –35 and –45 feet (Figures 5-8 and 5-9) laterally continuous across the site. This elevation interval has been termed the A2-zone. The A2 sand zone ends just east of the north-south trending UPRR boundary east of the asphalt cap.

Between –45 and –75 feet elevation the sand units are generally continuous in a north-south orientation (Figures 5-10 through 5-15). The B-zone of the aquifer typically has been designated as the interval between –50 and –90 feet elevation. Between –75 and –100 feet elevation, sand units are very sparse and isolated with little or no lateral or vertical continuity (Figures 5-16 through 5-20).

Between –100 and –115 feet elevation (Figures 5-21 through 5-23), sand layers have some lateral continuity, but are not laterally continuous across the entire site. The sand units in the elevation interval –115 to –135 feet elevation (Figures 5-24 through 5-27) are both vertically and horizontally continuous across most of the site. This elevation interval represents the C-zone of the aquifer.

Between –135 to –145 feet elevation (Figures 5-28 through 5-29) the sand units are not laterally continuous across the site. The sand units present between –145 and –160 feet elevation (Figures 5-30 through 5-32) are vertically and horizontally continuous across most of the site. This elevation interval represents a portion of the D-zone of the aquifer. Between –160 and –200 feet elevation (Figures 5-33 through 5-40), the sand units are not horizontally continuous, and most of the sand units present are located toward the margins of the site property boundary or east of the Main Process Area. The D-zone designation has been extended to as deep as –190 feet elevation, but the sand units in this deeper portion of the D-zone do not appear to be continuous with the –145 to –160 feet elevation sand units.

In addition to the detailed analysis of sand continuity presented above, some general trends regarding the occurrence of silts and sands in the deeper subsurface are apparent. The sand units are vertically well connected to –100 feet elevation beneath the former Cellon Process Area. Thus, many laterally extensive sand units at various depths are vertically connected beneath the Cellon Process Area. The proportion of silt to sand appears to be greater below an elevation of approximately –200 feet and above the gravelly sand/sandy gravel unit at –240 feet elevation.

The observed vertical and lateral relations of the sand and silt materials at the site are consistent with features attributed to bedload channel (sand) deposits and flood basin overbank (silt and clay) deposits of a fluvial system, suggesting that the subsurface materials are the flood basin deposits described by Atwater. Bedload channel fluvial deposits typically display the following features, which are well represented in the geologic cross sections and horizontal sections (Plates 3 through 12 and Figures 5-1 to 5-40): channel fill is dominantly sand, channels have a high width-to-depth ratio, channels are slightly sinuous, individual channels are of uniform thickness across their width, bed accretion dominates over sediment infill, sands show irregular and poorly developed fining upward sequences, and multilateral sand channel fills commonly volumetrically exceed overbank deposits (Davis 1983). Since sand channel deposits represent a large percentage of the subsurface materials (approximately 40 percent), channels tend to overlap each other, allowing a locally high degree of horizontal and vertical connectivity of the sand deposits.

A sandy gravel/gravelly sand unit was encountered at approximately –240 feet elevation in 13 rotosonic borings and 8 borings completed under previous investigations. This unit is laterally continuous and varies in thickness from 5 to more than 20 feet thick. The gravel and sand consists primarily of quartz/quartzite, volcanic, and metamorphic lithic fragments. These lithologies are similar to those discussed in the RI report (ICF Kaiser 1998). The sandy gravel/gravelly sand was interpreted by the authors of the RI report to be part of the Laguna Formation because the observed gravel lithologies are consistent with deposits from the Calaveras River whose drainage is composed almost entirely from metamorphic and volcanic rocks.

The bottom of the sandy gravel/gravelly sand unit was penetrated at two locations (SB-004 and SB-052). The gravelly unit was thinnest (approximately 5 feet) at SB052. Sand and silts encountered below the gravelly unit were similar in grain size, color and consistency to those encountered above the gravelly unit.

Old Mormon Slough sediments and floodplain deposits below the slough were investigated as part of the FY00 field work using the SCAPS LIF/CPT sensors. However, the CPT response in the soft clays of the slough were typically zero, and at many of the slough push locations a steel stabilizer pipe was set through the slough sediments preventing an accurate CPT or LIF reading of the soft slough sediments. Soil samples of slough sediments and the underlying recent flood basin deposits were collected at one SCAPS push location. Shallow slough sediment data from the RI of the surface water operable unit (Battelle 1996) were incorporated into the geologic cross sections developed for this report. Sediments in the slough adjacent to the McCormick and Baxter site contain stratified clay, silt, and sand. The uppermost sediments consist of 1.4 to 3.8 feet of very soft, very dark gray to black, homogeneous clayey silt with common gas holes. Battelle interpreted these sediments to have been deposited in a quiescent, stagnant water environment (i.e., the current depositional conditions) after the channel was cut off from its upstream source in 1970 when Mormon Slough was partially filled and Interstate 5 was constructed. From the western edge of the sheet pile wall along the shoreline in front of the former Oily Waste Ponds to the eastern end of the slough, the uppermost sediments in the channel are underlain by a distinctive sticky, very soft, dark-gray clay layer approximately 1.5 to 2 feet thick. This material may have come from a manmade source (e.g., related to the infilling of portions of the slough in 1970 during the construction of Interstate 5) based upon the unusual texture and color of this material. The uppermost clayey silt layer and the gray clay are underlain by a thin, soft, very dark or dark olive-gray silt with plant remains and occasional discontinuous, thin sand layers. The contact between the recent unconsolidated slough deposits and the older pre-Old Mormon Slough recent flood basin deposits occurred between 3 and 5 feet below the mudline (–11 to –13 feet NVD88) at push location SE-137. Silt identical in color and consistency to that observed at upland locations was present at 5 feet below the mudline (–13 feet NVD88) at SE-137. Between 3 and 5 feet (–11 to –13 feet NVD88) below the mudline, interbedded silt and sand was encountered, but the presence of NAPL made comparison with upland sediments difficult. The slough sediment descriptions in the Battelle report were re-interpreted based upon observations at SE-137. The change in consistency from soft to firm within the silts noted in the Battelle sediment core descriptions was interpreted to be the contact between the older pre-Old Mormon Slough recent flood basin deposits and the recent Old Mormon slough unconsolidated deposits.

5.1.2 Hydrogeology

The upper 200 feet of sediments are collectively referred to as the shallow aquifer. Groundwater in this zone occurs primarily in laterally continuous sand layers and lenses of fine- to coarse-grained greenish-gray sand. The sediments from 200 feet bgs (approx. –190 feet NVD88) to a depth of at least 1,000 feet bgs in the vicinity of Newark-Sierra Paper Corporation (NSPC), located approximately 1,500 feet southeast of the site, have been termed the deep aquifer. The deep aquifer supplies industrial water to NSPC. Before 1993, three NSPC wells pumped 2 to 3 million gallons of water per day. Only two of the wells are still operational and currently pump 400,000 to 500,00 gallons per day. The results of a survey of local supply wells conducted by the USACE Sacramento District in 1999 are provided in Table 5-1.

The horizontal and vertical overlapping distribution of relatively permeable versus impermeable materials in the subsurface above an elevation of –100 feet prohibits the presence of well-defined aquifers and aquitards. At this site, it is likely that the permeable sands and gravel units above –60 feet elevation are interconnected vertically and horizontally by some pathway. Between –60 feet elevation and –100 feet elevation, sand units are not vertically connected. The density of lithologic data below –100 feet elevation is sparse and interpretation of the horizontal and vertical continuity of water bearing sand zones is not possible. Additional lithologic information at depth may show continuity of the sands similar to that observed above –100 feet elevation.

Previous site investigations have divided the subsurface into five hydrogeological sand zones designated A, B, C, D, and E (Table 5-2). At well clusters where nearby wells are screened at different depths, thick clay sequences often separate the screened "aquifer" zones. However, the elevations of well screens within a particular designated aquifer zone are not always consistent across the site. Different wells screened within a given aquifer zone may or may not be connected by horizontally or vertically continuous sand channel deposits within that aquifer zone. Sand units at a given elevation may have some lateral continuity across the site, but silt deposits can separate sands at equal elevation (e.g., the A1-zone aquifer is discontinuous between the UPRR property and the western portion of the site.) The sandy zones beneath the former Cellon Process Area (SE-08) are well connected vertically, effectively connecting the A- and B-zones in this area (Plates 4 and 10 and Figures 5-4 through 5-15). Therefore, the aquifer zone designation applies only locally to areas of the site where the silts are laterally continuous and not vertically bisected by sand channels.

5.1.2.1 Permeability

FY99 field investigation laboratory permeability results for sand material samples ranged from 6 millidarcies (0.017 ft/day) to 3,000 millidarcies (8.7 ft/day). Sand aquifer hydraulic conductivity values derived from pumping test data (ICF Kaiser 1998) yielded values ranging on average from 16 to 110 feet/day. The laboratory analysis measured vertical conductivity for the samples collected by the SCAPS rig (SS samples) and composite vertical and horizontal conductivity for the rotosonic samples (SB samples). Horizontal hydraulic conductivity were generated from pumping test data. SCAPS sand samples were collected directly into a plastic sleeve that was sent to the laboratory intact. Rotosonic sand samples were disturbed and repacked at the laboratory. Vertical conductivity for geologic materials are often one or more orders of magnitude lower than horizontal conductivity because sediments are typically deposited in horizontal layers. Thus, the laboratory permeability data are likely biased low. All permeability results reported by the laboratory and calculated for the pumping tests fall within published ranges (Domenico and Schwartz 1990) for materials with similar grain size.

FY99 field investigation laboratory permeability results for the silt/clay materials ranged from 0.05 millidarcy (0.0001 ft/day) to 4.9 millidarcies (0.014 ft/day) discounting samples with sand stringers. Clay/silt aquitard hydraulic conductivity derived from pumping test data on average ranged from 0.0053 to 0.060 ft/day.

All laboratory permeability results for clay/silt material were measured on intact, vertical samples. Pumping test hydraulic conductivity values were slightly higher than laboratory values. Pumping test vertical hydraulic conductivity calculations incorporate the sandy layers present between main aquifer zones and are thus biased high. All laboratory and pumping test values for hydraulic conductivity were within published ranges for clay and silt.

The E-zone gravel laboratory permeability measurements were 29 millidarcies (0.08 ft/day) and 240 millidarcies (0.70 ft/day). The E-zone hydraulic conductivity derived from pumping test data averaged 130 ft/day. The laboratory samples were disturbed and repacked, which may account for part of the significant difference in results between the two methods. Laboratory results for site materials are low when compared to published values for gravel.

5.1.2.2 Water Quality

Groundwater beneath the site is generally of poor quality due primarily to high dissolved chloride concentrations (greater than 300 mg/L). From 1953 to 1963, the eastward edge of the 300-mg/L chloride contour migrated from approximately 0.5 mile east of the site to 1.0 mile east of the site (DWR 1967). Measured chloride concentrations in groundwater used by DWR to produce the 300-mg/L contour were mostly from wells deeper than 150 feet bgs (approx. –140 feet NVD88). DWR noted that the delta within San Joaquin County generally contains groundwater of undesirable mineral quality throughout its entire surface area from just below ground surface to the base of unconsolidated sediments. The few exceptions were local lenses of fresh water supplied from seepage from the delta channels and areas in the northwest portion of the county where surplus surface water and groundwater from the Mokelumne River system flushed out poor quality groundwater. The origin of the inferior quality groundwater was unknown but two possible sources were considered to be the most likely. Poor quality water may have accumulated in the trough of the valley and subsequently moved northward or was squeezed out of the trough by higher water levels or pressure from the south. Alternatively, poor quality water could be derived from rising saline connate water deposited with the deltaic sediments when the sea covered much of what is now the inland valley.

Chloride concentrations measured in monitoring wells sampled in July 1999 averaged 230, 180, 280, 310, and 550 mg/L in the A-, B-, C-, D-, and E-zone wells, respectively. Based on these limited data, chloride concentrations appear to increase with depth at the site. A rapid increase in chloride occurs between the D- and E-zones. The abrupt increase in chloride (based on one data point in the E-zone) provides evidence that groundwater in the E-zone is derived from a source that is different from that above the E-zone. Hence, the concept of an upper aquifer above –190 feet elevation and a lower aquifer below –190 feet elevation appears to be justified. A periodic groundwater monitoring program, scheduled to begin in October/November 2000 includes chloride analysis from a larger sampling of E-zone wells. These new data will provide a more definitive description of E-zone chloride concentrations.

5.1.2.3 Tidal Influences

To evaluate the extent to which tidal fluctuations in Old Mormon Slough affect groundwater levels at the site, a tidal influence study was conducted for the A-zone aquifer in 1995. The results of the study concluded that there was insufficient response in water levels to show the effects of tidal ranges, and tidal effects were likely masked by daily changes in barometric pressure. However, tidal responses of up to 4 feet were reported for deeper wells monitored during the RI pumping tests. These tidal responses in deeper sand units are likely due to tidal loading of the deeper confined sands.

5.1.2.4 Groundwater Flow

The horizontal component of groundwater flow at the site is southeastward in the A-zone (combined A1- and A2-zones), turning gradually to the east-northeast in successively deeper aquifer zones. An east-northeast E-zone flow direction is consistent with historical regional groundwater data (DWR 1967; ICF Kaiser 1998) that show a large groundwater cone of depression due to groundwater pumping centered over the central portion of the City of Stockton. The calculated average horizontal velocities of groundwater in the A-, B-, C-, D-, and E-zone sand units are 0.2, 0.2, 0.2, 0.05, and 0.3 ft/day, respectively. The observed vertical gradient of flow has been downward between all aquifer zones. The calculated vertical groundwater flow velocities between aquifer zones A and B, B and C, C and D, and D and E are 0.0001, 0.00003, 0.00002, and 0.00006 ft/day, respectively. Calculated vertical groundwater flow velocities are three to four orders of magnitude less than horizontal groundwater velocities. Therefore, the predominant direction of groundwater flow and dissolved-phase contaminant transport is horizontal within sand zones. Vertical flow velocities were calculated assuming average thicknesses of silt and sand materials observed between clustered well screens. Vertical velocities are likely higher in areas where sand units have a strong vertical connection.

The southeasterly flow of groundwater within the A- through D-zones suggests that groundwater recharge of the upper aquifer is from the northwest and/or local pumping of the upper aquifer is to the southeast. The Stockton deepwater channel is north of the site, and the main channel of the San Joaquin River is west of the site. These are likely groundwater recharge sources for the upper aquifer.

Four lines of evidence suggest that Old Mormon Slough has a poor hydrogeologic connection to the upper aquifer. Groundwater elevations in A-zone wells have varied seasonally and on long term cycles by more than 10 feet with little difference in the magnitude of groundwater elevation variations between wells near the slough and wells distant from the slough. The A-zone groundwater gradient does not appear to deflect or alter near the slough. Tidal fluctuations of up to 4 feet induced minimal response in A-zone wells (ICF Kaiser 1998). The bottom of the slough is blanketed with fine sediments that are likely to have low permeability, and unconsolidated slough sediments are generally in contact with clayey silt rather than sand units that are hydraulically connected to A-zone sands beneath the uplands. Therefore, Old Mormon Slough does not appear to have a strong hydraulic connection to the A-zone aquifer and is likely to contribute little if any water to the upper aquifer. Old Mormon Slough may contribute some water to the upper aquifer at the extreme northwest corner of the site in the vicinity of wells A-1 and A-10. The A-zone gradient near wells A-1 and A-10 is deflected from its average southeast trend and is roughly parallel to the slough, indicating that flow is from the north. Dredging of the slough in this area in 1987 may have opened a connection between the slough and the A-zone sands along the bank side wall where shallow sands appear to intersect the slough near or below the water surface.

5.1.3 Physical Properties of NAPL

Physical properties of NAPL collected from monitoring wells have been measured during the RI and the FY99 field investigation. A treatability study examining thermal effects on NAPL contaminated soil from the site is currently in progress. The treatability study includes measurements of NAPL density as a function of temperature, NAPL viscosity as a function of temperature, NAPL boiling point distribution/distillation, NAPL saturation, NAPL wettability, NAPL solubility and NAPL oil-water interfacial tension. Data available at the writing of this report are summarized below. The complete results of the treatability study will be presented in a separate report.

Density has been measured for NAPL collected from wells A-8, A-10, ONS-1B and DSW-6B. All NAPL densities at ambient temperatures were very close to that of water, with a measured range of 0.96 to 1.05 g/mL. Density as a function of temperature was measured for NAPL from wells A-10, ONS-1B and DSW-6B. The data show that the product from well DSW-6B may become an LNAPL at temperatures as low as 20^{o}C, whereas the product from well A-10 will become an LNAPL at temperatures around 30^{o}C. However, the product from well ONS-1B will not become lighter than water even at temperatures as high as 90^{o}C.

The dynamic viscosity has been measured for NAPL collected from wells A-8, A-10, ONS-1B and DSW-6B. At ambient temperatures, the NAPL has a measured range of 6.7 to 11.5 cp. For this range of viscosity, NAPL is expected to flow at rates 10 to 35 times less than the flow of water under the same gradient. The viscosity decreases exponentially as the temperature increases, and at temperatures approaching steam temperatures, the mobility of the NAPL is increased by approximately a factor of 10.

NAPL boiling point distillation data were measured for NAPL from wells A-10, ONS-1B and DSW-6B. Approximately 50 percent of the NAPL was distilled within a temperature range of 500 to 560ºF for the three NAPL samples. All of the sample volume was distilled within a final temperature range of 1020 to 1060ºF for the three NAPL samples. The NAPL recovered from well A-10 consists of a mixture of hydrocarbons heavier than those from ONS-1B or DSW-6B. Well A-10 NAPL fractions separated at consistently higher temperatures than either ONS-1B or DSW-6B fractions. ONS-1B and DSW-6B distilled at the same temperatures between the zero to 30 percent volume fractions. Between 30 and 95 percent volumes, DSW-6B fractioned at lower temperatures, but was similar to ONS-1B between 95 and 100 percent distillation. The data also suggest that the DSW-6B NAPL contains the lightest molecular weight hydrocarbon mixture.

NAPL soil saturation was measured for ten soil samples. Of the 10 samples, 8 were sand and 2 were clay. Hydrocarbon saturation ranged from less than 0.1 to 77 percent. The average saturation was 12.5 percent and the median was 4 percent. Clay/silt samples had the lowest measured NAPL saturation (less than 0.1 to 1.9 percent) and sand samples had the highest (2.1 to 77 percent).

5.2 CONTAMINATION CHEMISTRY

5.2.1 Petroleum Hydrocarbon Product Type Identification and Location

The type of petroleum hydrocarbon contamination found in various areas of the site was identified as a factor that would have to be considered during conceptual design of an in situ thermal treatment system. To determine what different petroleum product types are present at the site, EPA Region 9 FASP laboratory TPH-Dx analysis chromatograms were reviewed. The TPH-Dx method is applicable for the identification of semivolatile petroleum products by pattern matching (or "fingerprinting"). Specific petroleum products (e.g., diesel fuel, creosote, hydraulic oil, lube oil) can be identified by comparing chromatograms from site samples to those of "pure" product standards. Often a laboratory will run a series of different "pure" products for this purpose. For this project, the FASP laboratory analyzed two standards:

- Florida TRPH standard (a mixture of even-numbered alkanes from C_6 to C_{40})
- XHc diesel fuel No. 2 composite standard

If specific product types cannot be identified from comparisons to available standard chromatograms, patterns may still be observed that represent other unidentified product types or even naturally occurring organic materials. Unidentified patterns can be compared to each other and grouped to help characterize the site.

Five distinct patterns were identified (A through E) during review of FY99 soil data. Results are provided in the 1999 NAPL Field Investigation Report (USACE 2000). Laboratory TPH-Dx chromatograms for the FY00 soil data were reviewed against the initial five product types identified in 1999. A subset of SCAPS soil samples (67 samples) were reviewed. The TPH-Dx chromatograms for the soil boring samples, and the SCAPS soil samples with non-detected results, were not generated and were therefore not available for review (90 samples). Four of the initial five product types were observed. Additionally, a new product type (identified as F) was observed at location SV-117. Representative chromatograms and locations where these patterns were observed in samples collected from the site are shown in Plate 13. To confirm the results of the chromatogram review, laboratory results for SVOC, VOC, and TPH-Dx were also reviewed. Laboratory results are listed in Table 5-3 for six representative samples (FY99 and FY00). Results of this evaluation on FY00 samples are summarized below.