RECEIVED

10:00 am, May 15, 2009

Alameda County
Environmental Health

Ian Robb
Project Manager
Marketing Business Unit

Chevron Environmental Management Company
6111 Bollinger Canyon Road
San Ramon, CA 94583
Tel (925) 543-2375
Fax (925) 543-2324
irobb@chevron.com

Alameda County Health Care Services
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

Re: Former Signal Service Station No. 20-6145
800 Center Street
Oakland, CA

I have reviewed the attached report dated May 14, 2009.

I agree with the conclusions and recommendations presented in the referenced report. This information in this report is accurate to the best of my knowledge and all local Agency/Regional Board guidelines have been followed. This report was prepared by ARCADIS U.S., Inc., upon who assistance and advice I have relied.

This letter is submitted pursuant to the requirements of California Water Code Section 13267(b)(1) and the regulating implementation entitled Appendix A pertaining thereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Sincerely,

Ian Robb
Project Manager

Attachment: Report

ARCADIS
Infrastructure, environment, buildings

ARCADIS
2033 North Main Street
Suite 340
Walnut Creek
California 94596
Tel 925.274.1100
Fax 925.274.1103
www.arcadis-us.com

ENVIRONMENT

Mr. Steven Plunkett
Hazardous Materials Specialist
Alameda County Environmental Health Services
1131 Harbor Bay Parkway, Suite 250
Alameda, CA 94502-6577

Subject:
Revised Draft Corrective Action Plan
Former Signal Oil Station
Site # 206145
800 Center Street
Oakland, California

Date:
May 14, 2009

Contact:
Michael P. Fleischner

Phone:
925.296.7813

Email:
Michael.Fleischner@arcadis-us.com

Our ref:
B0046478

Dear Mr. Plunkett:

ARCADIS U.S., Inc. (ARCADIS) is submitting this letter as the Revised Draft Corrective Action Plan (RDCAP) for the above referenced site on behalf of Chevron Environmental Management Company (CEMC).

This RDCAP responds to Alameda County Health Services' (ACEH) letter of March 16, 2009 requesting additional evaluation of the effectiveness of the proposed remedial option of low flow air sparging (LFAS) in addressing human health risks, and response to technical comments. It supplements Conestoga Rovers and Associates'' (CRA) November 2007 Feasibility Study/Corrective Action Plan (FS/CAP).

A: Human Health Risk Assessment

ARCADIS completed a HHRA (attached) for the site after CRA's submittal of the FS/CAP in 2007. As will be discussed in further detail below in Responses to Technical Comments, the HHRA provides additional support for the adequacy of the proposed LFAS.

As requested, the HHRA evaluates the risks posed by residual contamination in all sampled media assuming the proposed residential development of the property. A brief summary of the HHRA and the results of the evaluation are presented below:

- The HHRA was performed for the proposed multi-unit residential property.

- Evaluation of exposure pathways indicated that potentially complete exposure pathways may exist for a construction worker or future resident. This includes a construction worker potentially ingesting soil or inhaling vapors during construction activities and future adult and child residents inhaling soil vapors that may enter the buildings.

- Based on evaluation of these pathways, three calculations were performed depending on the chemical of interest. These calculations provide estimates of excess lifetime cancer risk, noncancer hazards, and blood lead concentration. Results of these calculations are compared to published guidelines.

- Potential future estimated cancer risks and noncancer hazards did not exceed acceptable levels as defined by standard state and federal regulatory guidance. Risks and hazards are summarized below.

Receptor	**Total Excess Lifetime Cancer Risk**	**Noncancer Hazard Index**	**Blood-Lead Estimates**
Acceptable Range	<1E-06	<1.0	10 µg/dL
Construction Worker	5E-09	0.09	2.0 µg/dL; 5.8 µg/dL (fetus)
Resident Child	Not applicable; Carcinogens not detected in soil vapor	0.008	Not applicable; insignificant exposure to subsurface soil
Resident Adult	Not applicable; Carcinogens not detected in soil vapor	0.003	Not applicable; insignificant exposure to subsurface soil

B: Responses to Technical Comments:

1: The first ACEH comment regards the concern that, while LFAS may be effective in enhancing biodegradation in groundwater, it does not adequately address soil and vapor risks for future residents. ACEH requests that EMC evaluate other remedial methods and evaluate risks posed to future residents.

The HHRA demonstrates that even without LFAS or any other remedial methods residual contaminants beneath the site pose no unacceptable risk to future residents. Accordingly, we propose the use of LFAS solely to address groundwater issues. Neither LFAS nor any other remedial methods are required to address risks to residents and, as such, no other remedial methods are presented in this RDCAP.

2: The second ACEH comment acknowledges that groundwater concentrations at depth have decreased significantly over time and that reduced monitoring may be considered.

Based on this comment groundwater wells screened in the deeper interval will be reduced to semi-annual monitoring frequency.

3: The third ACEH comment requests that additional soil vapor samples be considered.

Chevron employed a conservative approach to implementing the soil vapor sampling. Six vapor probe sampling points were installed on the approximately 0.15 acre site. By comparison, DTSC guidance suggests a minimum of one vapor sampling point per quarter acre or one sampling point per planned residential building (DTSC, 2005). The soil vapor probe density at the site is six times the minimum density specified in the guidance based on the acreage of the site. In addition, one soil vapor sampling point was installed within the footprint of two of the three planned buildings. A soil vapor point is not warranted for the third planned building (on the northeast side of the site) because petroleum hydrocarbons and associated constituents were not detected in samples from vapor probes VP-2 and VP-6 which are nearer to the maximum residual soil and groundwater concentrations (ARCADIS, 2008 and CRA, 2007). Thus the sampling density is sufficient to assess risk to future residents.

If you have any questions or comments, please contact me at your earliest convenience.

Sincerely,

ARCADIS

Michael P. Fleischner, P.E.
Vice President

REGISTERED PROFESSIONAL ENGINEER
MICHAEL P. FLEISCHNER
C 65705
EXP. 9/30/09
CIVIL
STATE OF CALIFORNIA

Copies:

Ian Robb, Chevron
Todd Littleworth, Chevron
Rene Boisvert, Boulevard Equity Group
Terrilla Sadler

References:

ARCADIS, 2008. Human Health Risk Assessment for Former Signal Oil Service Station Site #206145

Conestoga Rovers and Associates (CRA), 2007. Feasibility Study and Corrective Action Plan (FSCAP). Former Signal Oil Station #20-6145. Conestoga-Rovers & Associates. November 1.

Department of Toxic Substances Control (DTSC), 2005. Interim Final Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air. February 7, 2005.

ARCADIS
Infrastructure, environment, buildings

Imagine the result

Chevron Environmental Management Company

Human Health Risk Assessment for Former Signal Oil Service Station

Site #206145

800 Center Street
Oakland, California

March 2009

ARCADIS

Human Health Risk Assessment for Former Signal Oil Service Station Site #206145

800 Center Street
Oakland, California

Kim Walsh, MPH
Principal Risk Assessor

Judy Nedoff

Judy Nedoff
Principal Risk Assessor

Michael Fleischner, P.E.
Vice President

REGISTERED PROFESSIONAL ENGINEER
MICHAEL P. FLEISCHNER
C 65705
EXP. 9/30/2009
CIVIL
STATE OF CALIFORNIA

Prepared for:
Chevron Environmental Management Company

Prepared by:
ARCADIS
2033 North Main Street
Suite 340
Walnut Creek
California 94596
Tel 925.274.1100
Fax 925.274.1103

Our Ref.:
B0046478.0000.00004

Date:
March 2009

Executive Summary **1**

1. Introduction **1-1**

2. Site Description and Investigation History **2-1**

2.1 Site Setting and Land Use 2-1

2.2 Site History 2-1

2.3 Summary of Site Geology and Hydrogeology 2-2

2.4 Summary of Site Investigations and Remedial Actions 2-3

2.5 Summary of Previous Focused Risk Evaluation 2-8

3. Exposure Assessment **3-1**

3.1 Conceptual Site Model 3-1

3.1.1 Chemical Sources 3-1

3.1.2 Transport Pathways 3-2

3.1.3 Receptors and Exposure Assessment 3-2

3.1.3.1 Construction Worker 3-2

3.1.3.2 Resident 3-3

3.2 Dose Equations for Exposure Estimates 3-3

3.3 Data Evaluation 3-6

3.3.1 Soil 3-6

3.3.2 Soil Vapor 3-7

3.3.3 Constituents of Potential Concern 3-7

3.4 Exposure Point Concentrations 3-7

3.4.1 Soil Exposure Point Concentrations 3-8

3.4.2 Soil Vapor Exposure Point Concentrations 3-8

3.4.3 Ambient Air Exposure Point Concentrations 3-8

3.4.4 Indoor Air Exposure Point Concentrations 3-9

4. Toxicity Assessment **4-1**

4.1 Toxicity Values for Carcinogenic Health Effects 4-1

4.2 Toxicity Values for Noncarcinogenic Health Effects 4-2

4.3 TPH Assessment 4-2

4.3.1 Petroleum Hydrocarbons in Soil 4-3

4.3.2 Petroleum Hydrocarbons in Soil Vapor 4-3

4.4 Toxicity Assessment for Lead 4-4

5. Risk Characterization 5-1

6. Uncertainties Associated with Human Health Risk Assessment 6-1

6.1 Uncertainties Related to Dataset 6-1

6.2 Exposure Assessment Uncertainty 6-2

6.3 Toxicity Data Uncertainty 6-3

6.4 Uncertainties Summary 6-3

7. Conclusions 7-1

8. References 8-1

Tables

2-1 Soil Data

2-2 Groundwater Data

2-3 Soil Vapor Data

3-1 Exposure Parameters

3-2 Statistics Summary Table for Constituents of Potential Concern

3-3 Exposure Point Concentrations

4-1 Toxicity Values for Carcinogens

4-2 Toxicity Values for Noncarcinogens

5-1 Summary of Risk Characterization Results for Hypothetical Future Construction Worker

5-2 Summary of Risk Characterization Results for Hypothetical Future Adult Resident

5-3 Summary of Risk Characterization Results for Hypothetical Future Child Resident

Figures

1-1 Site Location Map
1-2 Residential Site Plan
2-1 Former Site Features
2-2 Extent of Excavations and Representative Sample Locations
2-3 Historical Soil, Groundwater, and Soil Vapor Sample Locations
3-1 Human Health Conceptual Site Model

Appendices

A ProUCL Outputs
B Lead Model Calculations
C Vapor Intrusion Technical Memorandum

Acronyms and Abbreviations

ADD	Average Daily Dose
ALM	Adult Lead Methodology
ARCADIS	ARCADIS U.S., Inc.
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and total xylenes
CalEPA	California Environmental Protection Agency
CDC	Center for Disease Control
CET	Cambria Environmental Technology, Inc.
CHHSL	California Human Health Screening Level
COPC	constituent of potential concern
CPT	cone-penetrometer
CRA	Conestoga-Rover and Associates

CSF	cancer slope factor
CSM	conceptual site model
Delta	Delta Environmental Consultants, Inc.
dL	deciliter
DTSC	Department of Toxic Substances Control
ELCR	excess lifetime cancer risk
EPC	exposure point concentration
Freon 11	trichlorofluoromethane
ft	feet
HEAST	Health Effects Assessment Summary Table
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
kg	kilogram
L	liter
LADD	lifetime average daily dose
mg	milligram(s)
m^3	cubic meters
MTBE	methyl tert butyl ether
OEHHA	Office of Environmental Health Hazard Assessment
PAH	polynuclear aromatic hydrocarbon
PEG	Pacific Environmental Group
PPRTV	Provisional Peer Reviewed Toxicity Values
REL	reference exposure levels
RfC	reference concentration
RfD	reference dose

SCI	Subsurface Consultants, Inc.
TICs	Tentatively identified compounds
TPH	total petroleum hydrocarbons
TPHd	total petroleum hydrocarbons in the diesel range
TPHg	total petroleum hydrocarbon in the gasoline range
UCL	upper confidence limit
µg	microgram
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound

Executive Summary

On behalf of Chevron Environmental Management Company, ARCADIS U.S., Inc. (ARCADIS) conducted a human health risk assessment (HHRA) for the former Signal Oil service station facility located at 800 Center Street, Oakland, California. The purpose of the HHRA is to assess risk to potential receptors under a future site development plan.

The site is a well-characterized former service station site that closed in 1973. A total of 55 soil borings were advanced in a series of investigations beginning in 1989. Soil and groundwater samples indicated residual concentrations of total petroleum hydrocarbons (TPH) as diesel and gasoline, and benzene, toluene, ethyl benzene, and total xylenes (BTEX). Soil vapor samples also indicated the presence of residual hydrocarbon concentrations, principally TPH as gasoline and diesel.

Potential future cancer risks and noncancer hazards did not exceed acceptable levels as defined by standard state and federal regulatory guidance. ARCADIS evaluated risks and hazards for future construction workers and future residents under the current development plan using current and historical site data and conservative assumptions that generally lead to the overestimation of risks. ARCADIS estimated the potential risks and hazards assuming no future remediation. Risks will only decrease over time as a result of natural attenuation. If remediation is implemented, as a result of other considerations, potential risks and hazards would be expected to decrease further.
The key elements of the future development plan underpinning the risk assessment are (1) site use as high-density urban housing, (2) the minimal area of unpaved soil accessible to residents, and (3) the plan to construct slab-on-grade foundations with shallow (above the saturated zone) utility placement. In the event that these plans change, the HHRA should be reviewed for applicability.

1. Introduction

ARCADIS U.S., Inc. (ARCADIS) conducted a human health risk assessment (HHRA) for the Former Signal Oil service station facility (Site #206145) located at 800 Center Street, Oakland, California (Figure 1-1). The purpose of the HHRA is to assess risk to potential future receptors based on the site reuse plan (Figure 1-2) or a redevelopment scenario with similar characteristics (i.e., multi-unit residential, slab-on-grade construction, minimal unpaved soil area, shallow underground utilities). The methods used to estimate excess lifetime cancer risk (ELCR) and noncancer hazard index (HI) are consistent with standard risk assessment practices primarily following state (California Environmental Protection Agency [CalEPA] Department of Toxic Substances Control [DTSC]) guidance, and adding components of federal (U.S. Environmental Protection Agency [USEPA]) guidance where state guidance is lacking.

The owner of the site intends to develop the land for residential housing. The development site plan (Figure 1-2) details five, densely grouped, urban residential buildings with mostly paved spaces between the structures. Potential future receptors and exposure pathways were identified based on the urban residential future land use and the site characteristics. Data from soil, groundwater, and soil vapor samples collected from the site were considered for the HHRA. Risk is quantified for potentially complete and significant exposure pathways. The remainder of this report is organized as follows:

Section 2, Site Description and Investigation History, details the site history, physical characteristics of the site, as well as the investigations completed at the site.

Section 3, Exposure Assessment, details the potential source of contaminants, their movement in the environment, and the resulting exposure to potential future receptors.

Section 4, Toxicity Assessment, details the toxicological data used to quantify risk to the potential receptors at the site.

Section 5, Risk Characterization, presents the findings of the risk assessment.

Section 6, Uncertainties Associated with Human Health Risk Assessment, analyzes the results in light of site characteristics and provides a discussion of the potential biases, both under- and over-estimating risk.

Section 7, Conclusions, provides a summary of the conclusions of the risk assessment.

Section 8, References, lists the sources of information cited.

Appendix A, ProUCL Outputs, contains the ProUCL 4 outputs for the 95% upper confidence limit (UCL) calculations used in this HHRA.

Appendix B, Lead Model Calculations, provides the model input parameters and estimated lead risk estimates for construction workers.

Appendix C, Vapor Intrusion Technical Memorandum, evaluates the vapor intrusion pathway for future residents based on soil vapor data.

2. Site Description and Investigation History

This section presents the site history and physical characteristics of the site and describes the investigations conducted at the site from which data were used in this HHRA. The purpose of this section is to provide background information in support of the development of a conceptual site model presented in the following section.

2.1 Site Setting and Land Use

The site is a former Signal Oil gasoline service station located on the northeastern corner of the intersection of 8th Street and Center Street in Oakland, California (Figure 2-1). The site is currently undeveloped and fenced. Both commercial and residential properties are located in the vicinity of the site. The areas immediately adjacent to the site are single and multi-unit residences.

Consistent with the surrounding area, the site is planned to be developed as multi-story residences with slab-on-grade building foundations (Figure 1-2). As indicated on this figure, most of the property area not included as part of building complexes will be paved and likely used for parking.

Local topography is relatively flat and the site is about 15 feet above mean sea level. The nearest surface water body is Oakland Inner Harbor, located approximately 1 mile south of the site (CRA, 2007a).

2.2 Site History

The site history is an important foundation for developing a conceptual site model for potential human exposure to residual chemical concentrations. The conceptual site model, discussed in Section 3.0, includes a description of primary sources of chemicals identified based on site history and chemical data collected at the site.

The site was first developed as a service station in 1932. Several USTs and associated piping were formerly present on the site. Four 1,000-gallon USTs were used to store gasoline when the service station operated from 1932 to 1973. A 550-gallon waste oil UST and a buried 55-gallon drum were also used at the site. All of these containers stored petroleum mixtures that may have been released into subsurface soil either directly from tanks or through leaks from associated pipelines. All fuel and used-oil USTs and associated pipelines were removed by 2001 (see Section 2.4). Current and former site features are shown on Figure 2-1.

Soil and groundwater characterization was first undertaken by Chevron in 1989 and site features were completely demolished by 2001. In 2002, soil at the former UST locations and dispenser islands was excavated down to about 12 feet below ground surface (ft bgs). Approximately 1,584 tons of petroleum-impacted soil were disposed offsite. Class II aggregate base rock was used as backfill. The locations and extent of site excavations are shown on Figure 2-2. Post-excavation soil, groundwater, and soil vapor investigations have occurred since 2002 to further delineate petroleum hydrocarbons impacts (CRA, 2007a,b).

2.3 Summary of Site Geology and Hydrogeology

The site geology and hydrogeology influence the transport of chemicals released to the subsurface. As discussed above, the site was operated as a service station and included USTs. The rate and extent of transport of petroleum products released from USTs to the subsurface is a function of the site geology and hydrogeology. Chemical transport affects potential human exposure. The conceptual site model, discussed in Section 3.0, explains the relationship between primary sources of chemicals and potential human receptors given the potential release mechanisms affecting the site. A summary of the site geology and hydrogeology is provided below.

The site is underlain by Holocene and Pleistocene Merritt sands. Unconsolidated sediments beneath the site and site vicinity consist primarily of silty sands with intermittent silts, sands, and clayey silts to approximately 75 ft bgs. The silty sands and sands are found primarily from the surface, or beneath the fill, to approximately 55 ft bgs, and the silts are commonly found beneath the sands (CRA, 2007a).

Historically, groundwater flow direction beneath the site has been variable, but most recent sampling events indicate a dominant flow to the south-southwest at a relatively flat gradient (between 0.003 to 0.01 ft/ft). Measured depth to groundwater varies seasonally at the site, and ranges from 5 to 11 ft bgs (Table 2-2). Depths to groundwater measured over four quarters in 2008 indicate a declining water table, but groundwater was measured as shallow as 6.23 ft bgs at well MW-4, at the edge of the sidewalk next to 8th Street. Based on the topography and natural drainage patterns in the area, the regional groundwater flow direction appears to be towards Oakland Inner Harbor (CRA, 2007a).

2.4 Summary of Site Investigations and Remedial Actions

The site is well characterized with a high density of sampling locations. Figure 2-3 shows the locations of soil samples, monitoring wells, and vapor probes. A total of 55 borings have been advanced both onsite and offsite and 11 soil vapor probes were advanced onsite (five locations were from 1997 and the remainder from permanent locations sampled in 2007 and 2008). A total of 17 monitoring wells were installed both onsite and offsite. One onsite monitoring well (MW-1) was destroyed and replaced (MW-1A). Well MW-7 is offsite and upgradient, and wells MW-4, MW-5, MW-6, and MW-8 are offsite and downgradient. Following soil excavation in 2002, 34 confirmation soil samples were collected from sidewalls at 5 and 10 ft bgs plus samples collected from the bottom of the excavations. Past investigations that provide data considered in the HHRA are the following:

- *1989 Subsurface Investigation:* Soil borings B-1 through B-5 were advanced to depths ranging from 4.5 to 27 ft bgs (all but B-5 were installed in the vicinity of former USTs, dispenser island, and sumps along the eastern fence line). Temporary wells were installed in borings B-1 and B-3. Elevated concentrations of petroleum hydrocarbons and benzene, toluene, ethylbenzene, and total xylenes (BTEX) were detected in soil and groundwater. TPH in the diesel range (TPHd) (14,000 milligrams per kilogram [mg/kg]), TPHg (31,000 mg/kg), and benzene (500 mg/kg) were detected in soil. Benzene was detected in groundwater at concentrations up to 340 micrograms per liter [µg/L]) (Subsurface Consultants, Inc. [SCI], 1989).

- *1995 Subsurface Investigation*: Soil and groundwater sampling was conducted to evaluate the lateral and vertical extent of petroleum hydrocarbons in soil and groundwater in the vicinity of the site. Borings SB-1 through SB-3 were advanced to 12 ft bgs, and borings MW-1 through MW-4 were advanced to 15 ft bgs and completed as monitoring wells. The maximum TPHg concentration detected in soil was 14,000 mg/kg, and the maximum benzene concentration in soil was 120 mg/kg. Both of these concentrations were detected at 5 ft bgs at MW-1 (located near the former UST location). Soil from MW-2 and MW-4 did not contain detectable concentrations of BTEX or TPHg. Groundwater from MW-2 did not contain concentrations of BTEX or TPHg above the detection limits, but remaining groundwater samples (MW-1, MW-3, and MW-4) contained benzene (up to 19,000 µg/L) and TPHg (up to 170,000 µg/L) (Groundwater Technology, Inc., 1995).

- *1996 Subsurface Investigation*: Nine additional soil borings (P-1 through P-9) were advanced in March 1996, and soil and groundwater grab samples were collected. In soil, only borings P-2 and P-3 contained detectable concentrations of TPHg or benzene. TPHg was detected in every groundwater grab sample except P-9.

  Offsite borings MW-5 through MW-8 were advanced in December 1996. All borings were converted into groundwater monitoring wells, except boring MW-8, because no evidence of TPH was observed in the boring. TPHg and benzene were not detected in any offsite soil sample (Pacific Environmental Group [PEG], 1997a).

- *1997 Soil Vapor Sampling*: Soil and soil vapor samples were collected to evaluate remaining concentrations of TPH in soil and groundwater at the site and to evaluate whether these would pose a risk to human health. Soil vapor points SV-1 through SV-5 were advanced to depths up to 12 ft bgs by PEG. TPHg was detected in all borings at a maximum of 8,000 mg/kg, and benzene was detected at a maximum of 52 mg/kg in soil. TPHg was detected in soil vapor at a maximum of 50,000 µg/L and benzene was detected in soil vapor at a maximum of 65 µg/L. Based on these soil vapor data, PEG concluded that the site did not pose risk to adults or children from indoor air inhalation, and based on soil analytical data from this investigation, the site did not pose a risk to construction workers (PEG, 1997b).

- *1999/2001 Site Demolition:* Dispenser island, sumps, hydraulic hoist, building foundations, garbage enclosure, yard lights, and asphalt were removed in 1999. During these activities, a 1,000-gallon UST, a 550-gallon used oil UST, and a buried 55-gallon drum were encountered. These were removed in April 2001 (Delta Environmental Consultants, Inc. [Delta], 2001).

- *2002 Monitoring Well Installation*: Groundwater monitoring well MW-8 was installed offsite and downgradient to further delineate the extent of TPH in groundwater southwest of the site. TPH were not detected in any of the soil samples collected from MW-8. TPHd was the only compound detected in the groundwater (130 µg/L) (Delta, 2002).

- *2002 Subsurface Investigation:* Soil borings G-1 through G-23 were advanced to approximately 12 ft bgs, with samples collected at 5 and 10 ft bgs in each boring to collect analytical data to profile soil for possible landfill disposal and to further define the degree and extent of TPH impact to soil. The maximum detected concentrations of TPHg, benzene, and methyl tert butyl ether (MTBE) were 19,000 mg/kg, 83 mg/kg, and 170 mg/kg, respectively. These analytical results indicated the proposed extent of soil excavation would be adequate except for an area of approximately 80 cubic yards that was added near the former dispenser island (Delta, 2003a).

Lead was detected below the residential California Human Health Screening Level (CHHSL) of 150 mg/kg except one sample that contained 368 mg/kg lead at 5 ft bgs.

- *2002 Remedial Action:* Soil was removed to approximately 12 ft bgs (to 14 ft bgs in one location) at the locations of the former USTs, dispenser island, hydraulic lift, and sumps. Well MW-1 was destroyed because it was located within the excavation area. Approximately 1,584 tons of TPH-impacted soil were removed from the site, and approximately 900 pounds of an oxygen releasing compound were placed in the bottom of the excavation to promote degradation of TPH present in groundwater. Class II aggregate base was used for backfill. Thirty-four confirmation samples were collected during excavation activities. Confirmation samples collected at the former sump and hydraulic cylinder lift area indicated TPH-impacted soil was removed, and confirmation samples collected near the former dispenser island and fuel USTs showed residual petroleum hydrocarbons and BTEX concentrations remaining at 10 to 12 ft bgs. Groundwater at 12 ft bgs limited the excavation near these areas (Delta, 2003a).

- *2003 Soil Borings and Well Installation:* Monitoring well MW-1A was installed near the former location of monitoring well MW-1, which was destroyed during excavation activities in 2002. Soil borings GP-24 through GP-30 were installed to further delineate TPH concentrations to the east of the former dispenser island and UST over-excavation and were advanced to approximately 16 ft bgs. Soil samples were collected at 5, 10, and 15 ft bgs. The maximum detected concentrations of TPHd, TPHg, benzene, and MTBE were 1,600 mg/kg, 16,000 mg/kg, 92 mg/kg, 150 mg/kg, respectively (Delta, 2003b).

- *2004 Geoprobe® and Cone-Penetrometer (CPT) Investigation:* Cambria Environmental Technology, Inc. (CET) advanced five CPT borings and nine Geoprobe borings, and collected soil and groundwater grab samples to further define the lateral and vertical extent of TPH impacts beneath the site (CET, 2005).

- *2007 Monitoring Well Installation:* Monitoring wells MW-9 through MW-17 were installed in a cluster and screened at various depths to further define the vertical profile of TPH concentrations in the groundwater (CRA, 2007b). Maximum detected soil concentrations were 7,300 mg/kg for TPHg, 710 mg/kg for TPHd, and 7.2 mg/kg for benzene. In groundwater, the maximum concentration of TPHg was 16,000 µg/L and of benzene was 550 µg/L. The first groundwater sampling event was on April 20, 2007, and the second and third monitoring events were performed at 2-month intervals (CRA, 2007c).

- *Groundwater Monitoring:* Quarterly groundwater monitoring has been conducted since February 1997 and is ongoing. The highest TPH concentrations have been detected in wells MW-1A and MW-3, and the horizontal extent is limited and defined by clean wells MW-5 through MW-8. Wells MW-9 through MW-17 were installed to investigate TPH impacts at depth, and concentrations have been consistently decreasing since monitoring began in April 2007 (CRA, 2007a).

- *2007/2008 Soil Vapor Sampling:* Vapor points VP-1 through VP-6 were installed in November 2007 to depths of 5 to 5.5 feet bgs. Soil vapor samples were collected from VP-1 through VP-6 in November 2007 (CRA, 2007b) and in VP-1 and VP-3 to VP-6 in October 2008 (CRA, 2008). In 2007, the detected chemicals were TPHg and toluene. In 2008, the detected chemicals were trichlorofluoromethane (Freon-11), TPHg, carbon disulfide, and 2,2,4-trimethylpentane (CRA, 2008). Soil vapor results are discussed in detail below.

The constituents of interest at the site are various petroleum hydrocarbon mixtures (gasoline, diesel, motor oil, and hydraulic fluid), including individual components such as BTEX, and metals that may be present in waste oil (particularly lead). Although MTBE has been detected in soil and groundwater samples, MTBE was not used in gasoline during the period this station operated (closed in 1973). Accordingly any MTBE detections are unrelated to the operation of the former Signal Oil Service Station. Nonetheless, MTBE is included in the risk assessment.

TPHd and TPHg are present in soil at locations and depths of relevance to human health (see section 3.3 for additional detail). Soil data (Table 2-1) show that the highest TPH and BTEX concentrations in soil are at approximately 10 ft bgs, which is within the saturated zone. TPH and BTEX concentrations above the water table (at approximately 5 ft bgs) are significantly lower (typically by one to three orders of magnitude). At approximately 5 ft bgs, TPHg and TPHd were detected at a maximum concentration of 81 mg/kg (average of 5 mg/kg) and 560 mg/kg (average of 73 mg/kg), respectively. At approximately 5 ft bgs, benzene was detected in 7 out of 40 samples with a maximum concentration of 0.11 mg/kg. Lead is present in soil ranging from 2.4 to 22.5 mg/kg at 5 ft bgs, as well as one sample at a concentration of 368 mg/kg. At 10 ft bgs, lead concentrations range from 5 to 44 mg/kg.

The depth to groundwater has been variable both seasonally and annually with a current average depth of 8 ft bgs, but historically as shallow as 5 ft bgs and as deep as 12 ft bgs, depending on location. Although groundwater data were not used in the quantitative risk evaluation, the groundwater data from the monitoring wells were reviewed to support the development of a conceptual site model discussed in Section 3.1. Quarterly monitoring is ongoing, and the monitoring well data for quarterly sampling in 2008 (four most recent quarters available) are provided in Table 2-2. Data were seasonally collected annually since 1995 with additional wells added in subsequent years; specifically for 2008, the months were February, May, August, and December.

Chemicals detected in groundwater are TPHd, TPHg, BTEX, and MTBE (Table 2-2). Recent groundwater data show elevated concentrations of petroleum hydrocarbons and aromatic hydrocarbons centered around MW-3 and MW-4. Petroleum hydrocarbons in the nearest deep wells (MW-13 and MW-14) were often detected, but at low concentrations (approximately an order of magnitude lower than concentrations in MW-3 and MW-4). The horizontal extent of hydrocarbons in groundwater is bounded by samples from clean downgradient wells (MW-5, MW-6, and MW-8).

Historically, elevated concentrations of petroleum hydrocarbons were detected in MW-1 just north of the former dispenser island. MW-1 was destroyed during the excavation of soil contamination in 2002. MW-1 was replaced by MW-1A and steadily decreasing concentrations of TPHg and benzene have been observed since 1995 at this location based on results from both MW-1 and MW-1A (CRA, 2007a).

Soil vapor data were collected in November 2007 and October 2008 from permanent soil vapor sampling points VP-1 to VP-6 at a depth of 5 to 5.5 ft bgs (CRA, 2007a,b) and are summarized in Table 2-3. Samples were analyzed for BTEX, MTBE, and naphthalene using EPA Method TO-15, and TPHg using EPA Method TO-3 in 2007. In 2007, TPHg was detected in soil vapor at VP-1 (1,400 $\mu g/m^3$), VP-4 (280 $\mu g/m^3$), and VP-5 (2,100,000 $\mu g/m^3$). Toluene was detected at 16 $\mu g/m^3$ (14 $\mu g/m^3$ in the laboratory duplicate) at VP-1. BTEX reporting limits were elevated in sample VP-5 due to sample dilution related to the high TPHg concentration. The high level of dilution of this sample leads to significant uncertainty regarding the accuracy of the reported TPHg concentration; thus, this data point was not included in the soil vapor dataset. The TPHg concentration at VP-5 in 2008 was orders of magnitude lower as presented below.

In October 2008, soil vapor samples were collected from five of the six permanent probes; VP-2 was not sampled due to water in the tubing. A field duplicate was collected from VP-4 and a lab duplicate of sample VP-5 was analyzed. All soil vapor samples were analyzed using modified EPA Method TO-15. TPHg was detected at two sample locations, VP-4 and VP-5. It was detected in VP-4 (390 $\mu g/m^3$), VP-4 duplicate (240 $\mu g/m^3$), VP-5 (57,000 $\mu g/m^3$), and VP-5 duplicate (65,000 $\mu g/m^3$). Additional constituents detected in soil vapor include: Freon-11 in VP-1 at 6.7 $\mu g/m^3$; 2,2,4-trimethylpentane in VP-5 at 28,000 $\mu g/m^3$ and VP-5 (duplicate) at 25,000 $\mu g/m^3$; and carbon disulfide in VP-5 (duplicate) at 20 $\mu g/m^3$ and VP-6 at 12 $\mu g/m^3$. Neither naphthalene nor benzene was detected in any soil vapor sample collected at the site. The individual constituents of the TPHg detected in the samples collected from VP-4 and VP-5 were further analyzed and characterized as tentatively identified compounds (TICs). A more detailed discussion of the soil vapor sampling and results is provided in Appendix C.

2.5 Summary of Previous Focused Risk Evaluation

In 2008, Chevron conducted an initial *Evaluation of Vapor Intrusion to Indoor Air from Soil Vapor, Former Signal Oil Service Station, Site Number 20-6145.* This technical memorandum was updated and is attached as Appendix C to this report. Potential health risks were estimated for indoor air exposures to chemicals of potential concern (COPCs) identified in soil vapor. Chevron evaluated this pathway consistent with the DTSC *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (CalEPA, 2005) using soil vapor data collected in 2008 and concluded that risks were acceptable based on standard regulatory guidance. Toxicity values and the attenuation factor presented in the evaluation were also used in this HHRA to evaluate potential exposure to soil vapors migrating to indoor air.

3. Exposure Assessment

This section provides the current understanding of site conditions as illustrated by a Conceptual Site Model (CSM), the methods used to estimate exposure doses, an evaluation of chemical data used in the dose estimates, and exposure point concentrations (EPCs) used in the dose estimates. The CSM illustrates the potentially complete and significant exposure pathways for the site. Dose equations were identified for estimating potential chemical exposure associated with these exposure pathways. Chemical data from investigations described in Section 2 were used to develop EPCs used in the dose equations for each receptor. The chemical data were evaluated prior to calculating EPCs and a description of the data evaluation is presented in this section. The data evaluation describes the selection of data used in the HHRA, as well as a summary of methods used to calculate EPCs.

3.1 Conceptual Site Model

The CSM, illustrated on Figure 3-1, provides a summary of and illustrates the relationships between the chemical sources, potentially complete transport pathways (shown by solid lines), exposure media, potential future receptors, and potentially complete and significant exposure pathways (shown by solid lines and filled circles) under future conditions at the site. Details are provided in the following sections.

3.1.1 Chemical Sources

As described in Section 2, several USTs and associated piping were formerly present on the site. Four 1,000-gallon USTs were used to store gasoline when the service station operated from 1932 to 1973. A 550-gallon waste oil UST and a buried 55-gallon drum were also used at the site. All of these containers stored petroleum mixtures that may have been released into subsurface soil either directly from tanks or through leaks from associated pipelines.

Based on the discussion in Section 2, the chemicals present in site media are TPHd, TPHg, BTEX, MTBE, carbon disulfide, Freon 11, and lead. Lead concentrations throughout the site appear to be naturally-occurring with concentrations typically less than 10 mg/kg. Two subsurface soil samples contained elevated lead concentrations (368 mg/kg and 44 mg/kg; Table 2-1).

3.1.2 Transport Pathways

This section describes the mechanisms whereby chemicals may have migrated from their point of release in the primary medium into other environmental media. Because the known releases occurred from underground tanks, primary releases were to subsurface soil. As a result, potentially complete and significant exposure pathways include direct and indirect exposure to constituents in subsurface soil and impacted groundwater. Groundwater at the site has historically been recorded as shallow as 5 ft bgs and petroleum constituents present in subsurface soil may have been in direct contact with groundwater prior to excavation activities. In addition, volatile petroleum hydrocarbon constituents may have infiltrated to groundwater. Volatile petroleum hydrocarbon constituents present in soil and groundwater may migrate into the soil vapor, which can then migrate into ambient air and trench air. These volatile constituents may migrate into indoor air with soil vapor if buildings are present above or near impacted soil or groundwater.

3.1.3 Receptors and Exposure Assessment

The potential future receptors at the site were selected based on review of the site development plan (Figure 1-2), which indicates that low-rise, multi-family residences will be constructed on the property. Therefore, hypothetical future receptors include adult and child residents. In addition, future construction workers may be exposed to chemicals present onsite.

3.1.3.1 Construction Worker

The construction worker receptor was evaluated through the following pathways using soil data to 10 ft bgs and soil vapor data, as applicable:

- Incidental ingestion of soil
- Inhalation of vapors in ambient air during soil moving and grading activities
- Inhalation of soil vapor during trench work.

Construction activities involving soil moving, trenching, and grading are assumed to occur over a period of three months. Workers are assumed to be onsite nine hours a day and five days a week during this three-month period. Incidental ingestion of soil may occur due to hand to mouth contact. Although dermal contact will likely occur, all constituents of potential concern (COPCs) in soil, except for lead, are volatile compounds and are, therefore, appropriately evaluated through ingestion and inhalation pathways. Dermal exposure to lead in soil is evaluated using the USEPA's Adult Lead Methodology (ALM; USEPA, 2003a,b; 2007e) for estimating blood-lead concentrations. The ALM is further discussed in Section 4.4, and additional details and the model worksheet are provided in Appendix B. Inhalation of volatiles may occur through volatilization of VOCs from soil to ambient air at the construction site. For trenching or utility work where the work space may be more confined and exposure to contaminants potentially higher than at surface level, this HHRA conservatively assumes the same worker will be in the trench a maximum of one hour per work day for three months. Inhalation of volatiles from soil vapor migrating to trench air may occur when a construction worker is performing work inside a trench. Risk calculations assume that the construction worker works in the trench for one hour per day and works outside the trench for 8 hours per day. Table 3-1 presents the exposure parameters used in the HHRA to evaluate risk to future construction workers.

3.1.3.2 Resident

Based on the site development plan, there will be minimal exposed soil areas after development, minimizing direct exposure of site soil to residents. Adding to this, the shallow water table and conventional construction practices would limit excavation and re-grading of soil from deeper than the top few feet. As discussed in Section 2, chemical sources at the site were leaking USTs and associated piping resulting in residual chemical concentrations several feet below ground surface (e.g., in soil the highest concentrations occur at approximately 10 ft bgs). Potentially complete and significant exposure pathways for the future resident are, therefore, limited to inhalation of vapors migrating into indoor air. Future indoor air concentrations were derived using measured soil vapor data and assuming site concentrations remain at current levels. There is no direct exposure to groundwater for future residents because the City of Oakland requires new developments to be connected to the municipal water supply, which precludes use of site groundwater for domestic supply. Table 3-1 presents the exposure parameter values used in the HHRA to evaluate risk to future residents.

3.2 Dose Equations for Exposure Estimates

The following equations were used in this HHRA to quantify receptor doses of COPCs.

The doses of COPCs associated with incidental ingestion of soil were calculated as follows:

General Equation 3-1:

$$Dose = \frac{C_S * IR_S * CF * FI * EF * ED}{BW * AT}$$

Where:

Dose = Average daily dose (ADD) or lifetime average daily dose (LADD) (mg/kg per day [mg/kg/day])

C_S = COPC concentration in soil (mg/kg)

IR_S = Soil ingestion rate (mg/day)

CF = Conversion factor (1×10^{-6} mg/kg)

FI = Fraction ingested from impacted source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (days)

The doses of COPCs associated with inhalation were calculated as follows:

General Equation 3-2:

$$Dose = \frac{C_a * BR * ET * EF * ED}{BW * AT}$$

And:

$C_a = C_S$ / VF for ambient (outdoor) air

$C_a = C_{SV}$ / AF for indoor air

Note: C_a for indoor air exposure is the modeled air concentration using soil vapor data.

Where:

Dose = ADD or LADD (mg/kg/day)

C_a = COPC concentration in air (mg per cubic meter [m^3])

BR = Inhalation rate or breathing rate (m^3/day or m^3/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (days)

C_s = COPC concentration in soil (mg/kg)

VF = Volatilization factor (m^3/kg)

C_{sv} = COPC concentration in soil vapor (mg/ m^3)

AF = Attenuation factor (unitless)

The breathing rate units may vary between exposures as either daily or hourly. Only the hourly rate requires an averaging time value. The residential breathing rate for indoor air and construction worker breathing rate for ambient air uses a daily rate in m^3/day. The limited time expected for trenching activities required an hourly breathing rate in conjunction with an averaging time for the trench work exposure scenario.

3.3 Data Evaluation

Data used to assess potential human health risks are representative of the environmental media to which a receptor is likely to be exposed under anticipated future site conditions. As discussed in Section 2.4, chemical data from soil, soil vapor, and groundwater were collected at the site during a series of investigations. These chemical data, along with potential exposure pathways and human receptors, were considered when developing the CSM and preparing the datasets to support both qualitative and quantitative risk assessment. As noted previously, groundwater will not be encountered by future site receptors. Therefore, groundwater data were not considered further. Soil and soil vapor data were evaluated for representativeness for use in risk calculations as described in the following sections. ARCADIS made no independent determination of the validity of the data.

3.3.1 Soil

Available data from all 55 soil borings were evaluated for the dataset (soil data collected from 1989 through 2007). Based on an evaluation of sample locations, the following were removed from the risk assessment dataset:

- Samples collected deeper than 10 ft bgs (CalEPA, 1992). Although USEPA guidance recommends 10 ft bgs as the depth cut-off for risk assessment, the guidance allows that site-specific characteristics may limit the actual depth chosen. Because groundwater is encountered at less than 10 ft bgs at the site, construction activities will likely avoid intrusion to this depth. Nonetheless, soil data collected to 10 ft bgs were included as a protective and conservative measure.

- Soil samples collected in locations and depths that were later excavated during remedial activities.

- Offsite locations. Only those results from inside the fence line were included.

Chemicals detected in soil at the site include TPHd, TPHg, BTEX, MTBE, and lead. Polynuclear aromatic hydrocarbons (PAHs) were not analyzed. MTBE has primarily been detected at 10 ft bgs and appears to be associated with groundwater at that depth. The fuel USTs at the site were removed in 1973 (prior to the introduction of MTBE) and the site was closed (CRA, 2007a). Therefore, the site-related chemicals are TPHd, TPHg, BTEX, and lead. Consistent with state and federal regulatory guidance, potential risks associated with all detected chemicals at the site (regardless of relationship to site operations), including MTBE, were estimated.

3.3.2 Soil Vapor

Soil vapor samples were collected from permanent sampling probes, which were placed in locations based on the planned building footprints and also in proximity to groundwater monitoring wells that demonstrated elevated concentrations of petroleum hydrocarbons and BTEX. Data collected in November 2007 and October 2008 were used for the final dataset, as described below. Results are provided in Table 2-3 and a statistical summary is provided in Table 3-2.

As noted in Section 2, soil vapor data collected in November 2007 and October 2008 were compiled for use in risk estimates. One TPHg measurement from VP-5 was excluded from the dataset due to data quality concerns: the 2007 TPHg concentration may not be accurate due to a high level of dilution. Following CalEPA guidance (CalEPA, 2005), the maximum detected soil vapor concentrations of VOCs (toluene, carbon disulfide, and Freon 11) from the 2007 and 2008 soil vapor data and the maximum TPHg value reported for the analyses in 2008 were used in the risk calculations.

3.3.3 Constituents of Potential Concern

Only chemicals that are site-related were included in the datasets, with the addition of MTBE. Chemicals identified as lab artifacts or in the case of soil vapor, associated with sampling procedures, were omitted. All other chemicals detected at least once in the final dataset are listed in Table 3-2 for consideration for COPC selection. Chemicals selected as COPCs in soil include TPHd, TPHg, BTEX, MTBE, and lead. Soil vapor COPCs are TPHg, toluene, Freon-11, 2,2,4-trimethylpentane, and carbon disulfide. Table 3-2 also summarizes statistics for each COPC in soil and soil vapor (number of samples analyzed, frequency of detection, and range of concentrations).

3.4 Exposure Point Concentrations

The exposure point concentration (EPC) is the representative concentration of a COPC in an environmental medium that is potentially contacted by a receptor. EPCs used in this HHRA are presented in Table 3-3. EPC calculation methods for each exposure media (soil, soil vapor, ambient air, and indoor air) are presented below.

3.4.1 Soil Exposure Point Concentrations

The EPC is defined as “the arithmetic average of the concentration that is contacted over the exposure period” (USEPA, 1989). To obtain an estimate of the arithmetic average that is conservative and is not underestimated, a statistically based 95% UCL on the mean concentration was used as the EPC (USEPA, 1989; CalEPA, 1992). The 95% UCL was calculated for each COPC in soil.

The 95% UCLs were calculated using USEPA’s ProUCL 4 software (http://www.epa.gov/nerlesd1/tsc/software.htm). The ProUCL 4 outputs for the 95% UCL calculations used in this HHRA are presented in Appendix A. The ProUCL 4 software provides a variety of UCLs based on the characteristics of the dataset. The selection criteria used in this HHRA are from USEPA’s recommendations for the optimal 95% UCL methods for various types of datasets and are summarized in Tables 15 and 16 of the ProUCL 4 User’s Guide (USEPA, 2007c) and Tables 2-3, 2-4, and 2-5 of the ProUCL 4 Technical Guide (USEPA, 2007d). In accordance with state and federal guidance, lead is not evaluated based on standard dose equations; rather, the EPC for lead in soil is used in the lead model that estimates blood-lead concentrations (See Section 4.4). The EPC for lead is calculated using the arithmetic mean of lead concentrations in soil throughout the site (USEPA, 2003a).

3.4.2 Soil Vapor Exposure Point Concentrations

The dataset for soil vapor was not sufficient to calculate 95% UCLs for the COPCs in soil vapor. The maximum detected soil vapor concentrations were used to represent EPCs for construction worker exposure to trench air. This approach is conservative because it assumes that workers are directly exposed to soil vapor without dilution by air in the trench. Further, selecting the maximum as the EPC is the most conservative approach given a small dataset.

3.4.3 Ambient Air Exposure Point Concentrations

The inhalation of chemicals adsorbed to airborne soil dust particles and volatilized from surface soil is considered a potentially complete exposure pathway for future construction workers. Lead is the only nonvolatile COPC in soil and may be adsorbed to dust particles then inhaled. The EPC for lead was calculated using the arithmetic mean of lead concentrations in soil throughout the site (USEPA, 2003a). For vapors in ambient air, the 95% UCL of the concentration of volatile COPCs in the soil was converted to an air concentration using chemical-specific volatilization factors, which are shown in Table 3-3.

3.4.4 Indoor Air Exposure Point Concentrations

As noted above, due to the limited soil vapor dataset, the maximum detected soil vapor concentration for each COPC was used to calculate indoor air concentrations with the application of the default attenuation factor of 0.001 (CalEPA, 2005). CalEPA DTSC (2005) guidance states: "*DTSC recommends that modeling approaches for future buildings be sufficiently conservative to protect public health…To make a site-specific evaluation for future buildings, maximum soil gas and groundwater concentrations should be used."* Although conservative, using the maximum detected concentration instead of an average is protective of receptors spending significant time in one specific location on the site.

4. Toxicity Assessment

This section describes how toxicity criteria were selected for the COPCs at this site. Cancer and noncancer risks are quantified and evaluated separately.

4.1 Toxicity Values for Carcinogenic Health Effects

The current approach to carcinogenic risk assessment used by USEPA (1999, 2003c) and CalEPA (2009) assumes, without confirmatory studies, that exposure to any carcinogen poses a finite probability, however small, of producing a carcinogenic response. That is, the agencies assume that the carcinogenic response does not have a threshold dose below which no carcinogenic effect is seen. If the response does not have a threshold, then this type of assessment is referred to as a linear dose-response assessment. In the case of carcinogens, linear extrapolation is typically used as the default approach for dose-response assessment. Uncertainty factors are not used in the extrapolation; rather, a straight line is drawn from the point of departure for the observed data to the origin (where there is zero dose and zero response). The slope of this straight line, called the slope factor or cancer slope factor, is used to estimate risk at exposure levels that fall along the line. When linear dose-response is used to assess cancer risk, EPA calculates ELCR resulting from exposure to a chemical by considering the degree to which individuals are exposed, as compared to the slope factor. Thus,

Cancer Risk = Exposure x Slope Factor

For more information, please see http://www.epa.gov/risk/dose-response.htm.

Cancer slope factors (CSFs) were used in the risk characterization to estimate potential cancer risk and represent the upper bound probability of carcinogenic response per unit daily intake of a substance over a lifetime. CSFs were used to assess ELCR for all receptors. CSFs were selected from the CalEPA's Office of Environmental Health Hazard Assessment (OEHHA) Cancer Potency List and OEHHA Online Toxicity Criteria Database (CalEPA, 2009). Carcinogenic COPCs at the site are benzene, ethyl benzene, and MTBE, and CSFs are presented in Table 4-1.

4.2 Toxicity Values for Noncarcinogenic Health Effects

Noncarcinogenic toxicity values are applied in the risk characterization to estimate the potential noncancer hazards associated with chemical exposure. In contrast to the default non-threshold assumption used for assessing carcinogenic risk, noncarcinogenic effects are assumed by most regulatory agencies, including CalEPA and the USEPA, to exhibit a biological or toxicological threshold below which adverse effects are not expected.

Following USEPA (1989) guidance, chronic reference doses (RfDs) were used in the risk characterization to assess potential noncarcinogenic hazard to adult residents. Subchronic RfDs were used in the risk characterization to assess potential noncarcinogenic hazard to construction workers and child residents with exposure durations less than seven years. Whenever a subchronic RfD was unavailable, the chronic RfD was used. This was the case for benzene for the oral pathway, and MTBE and xylenes for the inhalation pathway. Chronic and subchronic noncarcinogenic RfDs (Table 4-2) were obtained from the following sources in order of priority:

- CalEPA's Chronic Reference Exposure Levels (RELs) (CalEPA, 2008) and the OEHHA Online Toxicity Criteria Database (CalEPA, 2009).
- USEPA's Integrated Risk Information System (IRIS) online database (USEPA, 2009).
- USEPA's HEAST (USEPA, 1997) was primarily used as a source of subchronic RfDs. The HEAST value was also used for the Freon 11 chronic RfD because a value was not available from either CalEPA or IRIS.

RELs were converted to chronic RfDs using standard default exposure assumptions for adult body weight (70 kg) and adult inhalation rate (20 m^3/day, which assumes 24 hours per day exposure).

4.3 TPH Assessment

TPH mixtures present in the environment can consist of a broad range of chemicals that are highly dependent upon the source and age of the release. To support characterization of petroleum present at this site, TPH is subdivided into gasoline range and middle distillates (diesel range). The gasoline range is predominantly branched alkanes and aromatic hydrocarbons (BTEX) with carbon ranges of C6 to

C12. The diesel range is characterized by a wider variety of alkanes, naphthalenes and other PAHs, and heterocyclic compounds with carbon ranges of C9 to C25. If available, data for individual chemical constituents that have available toxicity data are used to evaluate risk from the various petroleum hydrocarbons ranges. If data for individual chemical constituents are not available, petroleum hydrocarbons may be evaluated as a mixture using conservative assumptions about its composition to develop toxicity values.

4.3.1 Petroleum Hydrocarbons in Soil

In this HHRA, risk from TPHg in soil was estimated using data for BTEX. Because PAH data in soil were not available, TPHd was evaluated based on the methods developed by the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG; 1997). Consistent with the TPHCWG (1997) guidelines, an oral RfD for TPHd of 0.04 mg/kg/day for aromatics was selected for this risk assessment as a conservative measure to account for the lack of PAH data. An inhalation RfC for either aliphatics or aromatics in TPHd was not selected, as this exposure pathway for a weathered diesel mixture is considered insignificant as compared to the exposure to the construction worker from soil ingestion. Note that naphthalene, the most volatile of the PAHs present in diesel, was not detected in soil vapor samples, providing support for this conclusion.

4.3.2 Petroleum Hydrocarbons in Soil Vapor

Individual components typically used to evaluate risk from TPHg (BTEX) were not detected in soil vapor, except for toluene at one location in 2007. (Other aromatic components of TPHg (e.g., naphthalene) were also not detected.) Toluene is not carcinogenic; therefore, only noncancer effects of TPHg and toluene required evaluation. Appendix C details the methods used to 1) characterize the constituents of TPHg; 2) select applicable toxicity criteria; 3) model the subsurface to indoor air concentrations; and 4) estimate noncancer hazard to potential residents. As discussed in Appendix C, the reference concentration (RfC) of 18,400 $\mu g/m^3$ (18.4 mg/m^3) for the C5 to C8 aliphatic compounds defined by the TPH Criteria Working Group was selected for the inhalation toxicity value for TPHg. This value is based on several lifetime exposure studies using a mixture of aliphatics composed of 53% n-hexane, 16% 3-methylpentane, 14% methylcyclopentane, 12% 2-methylpentane, 3% cyclohexane, 1% 2,3-dimethylbutane and <1% several minor compounds. This RfC value should still be considered conservative for the TPHg mixture measured in soil vapor samples from this site because n-hexane and n-heptane were tested for but not detected in soil vapor.

4.4 Toxicity Assessment for Lead

The potential hazard associated with lead exposure was evaluated by comparing the predicted blood-lead concentrations to the Centers for Disease Control (CDC) blood-lead threshold concentration. The threshold lead concentration is 10 micrograms per deciliter (µg/dL) of whole blood based on potentially adverse neurological effects in children (CDC, 1991). A blood-lead concentration less than 10 µg/dL is deemed acceptable. For the construction worker evaluation, USEPA's Adult Lead Methodology (ALM; USEPA, 2003a,c; 2007e), which estimates the blood-lead levels of workers and the fetus of a pregnant worker, was used to evaluate the potential exposure to lead in soil for construction workers.

5. Risk Characterization

Risk characterization integrates the exposure assessment and the toxicity information to quantify the potential human health risks specific to the site. The cancer risk and/or noncancer hazard was calculated for each COPC and for each medium and potentially complete exposure pathway. An ELCR is calculated for compounds identified by CalEPA or USEPA as probable human carcinogens. The cancer risk is defined by CalEPA (1994) as “the risk, or theoretical probability of developing cancer from that chemical upon exposure to that medium.” The ELCR is estimated by multiplying the LADD by the chemical-specific CSF as shown in the following equation:

Equation 5-1:

$$\text{CSF x LADD = ELCR}$$

The total ELCR at the site is calculated by summing the risk for each carcinogen over all exposure media for all complete exposure pathways.

A hazard quotient (HQ) is calculated for all noncarcinogenic COPCs with available toxicity values. As discussed in Section 4 and consistent with standard risk assessment practice, the potential hazard associated with lead exposure was evaluated separately from other noncarcinogens by comparing the predicted blood-lead concentrations to the CDC blood-lead threshold concentration (10 µg/dL). For the remaining noncarcinogenic COPCs, the HQ is defined as the ratio of the estimated dose from exposure to a compound in a particular medium to the dose that is not expected to result in adverse health effects, other than cancer.

Equation 5-2:

$$HQ = \frac{ADD}{RfD}$$

An HQ value greater than 1 suggests a possible noncarcinogenic hazard. The HQ is not a mathematical prediction of the severity or incidence of the effects, but rather is an indication that a hazard may exist. CalEPA (1992) and USEPA (1989) recommend that the total HI (i.e., the sum of the HQs for all chemicals) not exceed a value of 1.

Consistent with CalEPA (1994) and USEPA (2003d) recommendations, it is assumed that ELCRs exceeding the 1×10^{-4} to 1×10^{-6} range (one in ten thousand to one in one million) or a noncancer HI of greater than 1 suggest that exposure to chemicals may pose a threat to human health. Lead exposures estimated to result in blood-lead concentrations less than 10 µg/dL are considered acceptable (USEPA, 1994). Cancer and noncancer risk estimates (including blood-lead estimates) are summarized below.

Receptor	Total Excess Lifetime Cancer Risk	Noncancer Hazard Index	Blood-Lead Estimates
Construction Worker	5E-09	0.09	2.0 µg/dL; 5.8 µg/dL (fetus)
Resident Child	Not applicable; Carcinogens not detected in soil vapor	0.008	Not applicable; insignificant exposure to subsurface soil
Resident Adult	Not applicable; Carcinogens not detected in soil vapor	0.003	Not applicable; insignificant exposure to subsurface soil

Notes:

Construction Worker calculations are presented in Table 5-1.

Adult and child resident calculations are presented in Table 5-2 and 5-3, respectively.

ARCADIS estimated the ELCR for the construction worker from exposure to soil, ambient air, and soil vapor, including during trenching activities, to be 5×10^{-9}, which is well below the risk threshold of 1×10^{-6}. The noncancer HI was estimated to be 0.09, which is well below the threshold of 1 (shown in the table above).

Future onsite residents may be exposed to soil vapor migrating into residential structures. However, no carcinogenic chemicals were detected in soil vapor and therefore excess cancer risk cannot be estimated for the future residential receptors. Assuming a maximum indoor air concentration of TPHg estimated to be 65 µg/m^3, and a reference concentration of 18,400 µg/m^3 (Appendix C), the noncancer HI for the future resident child and adult would be 0.008 and 0.003, respectively, which are well below the HI threshold of 1. Note that the hazard index calculated here is representative of the cumulative risk from all chemicals present in the TPHg mixture except lead which is evaluated separately.

Use of the average concentration of lead in the soil and the USEPA ALM model (USEPA, 2003a) results in calculated blood-lead levels of 2.0 µg/dL for the adult construction worker and 5.8 µg/dL for a fetus carried by a pregnant worker. These levels are below the threshold blood-lead level of 10 µg/dL established by USEPA (1994).

To summarize, ELCR and noncancer hazards for the site are acceptable for hypothetical future receptors. Therefore, the residual chemical concentrations do not pose unacceptable health risks to future construction workers or future residents should the site be developed according to the site development plan.

6. Uncertainties Associated with Human Health Risk Assessment

In the site characterization and the human health risk assessment, assumptions are made regarding some of the gaps in our understanding of the physical aspects of a site, and to predict future exposures and consequent risks from those exposures. These assumptions must be reasonably conservative in order to be protective of human health but not so conservative as to be outside of the range of probability (CalEPA, 2005).

This section discusses site-specific topics where a potential lack of information resulted in an action or assumption that may have contributed to an under- or overestimate of the risks.

6.1 Uncertainties Related to Dataset

Surface soil data are lacking for the site; only data for samples collected from approximately 5 ft bgs and 10 ft bgs are available. This issue is only relevant for the construction worker because the site development plan leaves few areas of unpaved soil accessible to future residents. Although constituents of interest were not characterized in surface soil, petroleum hydrocarbons, BTEX, and lead are the only COPCs from the former USTs, which were subsurface sources as illustrated on the CSM (Figure 3-1). Even if releases occurred near the surface, VOCs are not persistent in surface soil, and closure of the site in 1973, with subsequent excavation of the tanks and later removal of excavated soil, makes it highly improbable that any significant concentrations remain in the surface soil. Therefore, ARCADIS assumed that use of the existing soil data (5 to 10 ft bgs) for the risk assessment was protective. There is no evidence that surface soil was impacted.

All available soil data collected historically at the site were initially considered for this HHRA. Only results of unknown quality, outside the depth range of interest (maximum depth of 10 ft bgs), or representing excavated and removed locations, were omitted from the soil dataset. This approach is conservative because it does not take into account the natural attenuation that has occurred since the samples were collected (some as early as 1995). Using older data likely overestimates risk.

Analytical results for confirmation samples taken from excavations of the service station hoist and sump areas were not available (SWH 1-4 and SWW 1-4). Some samples from the former sumps excavation were analyzed only for total recoverable petroleum hydrocarbons (a non-specific gravimetric method), which does not provide usable data for a risk assessment. Appropriate data for risk assessment were collected from adjacent locations and included in this HHRA. Therefore, the data limitations associated with the two sampling locations (SWH 1-4 and SWW 1-4) do not appear to contribute significantly to the uncertainty in the HHRA.

6.2 Exposure Assessment Uncertainty

The direct contact exposure pathways (incidental ingestion, dermal contact, and inhalation of ambient air) for potential future residents were assumed to be insignificant due to the site development plan, which limits accessible unpaved soil. Consistent with the high-density housing plan, most of the area outside the building footprint will be paved and likely used for parking. Typically, incidental ingestion is a route of exposure quantitatively evaluated for residential receptors, but at this site it is implausible that a significant area of exposed soil will be accessible for future residents to directly contact. Additionally, VOCs are not persistent in surface soil, and following construction and landscaping activities VOC concentrations will likely be negligible. The qualitative, rather than quantitative, evaluation of this pathway potentially underestimates risk. This potential underestimate is not judged to be significant. However, significant changes in the future development plan (i.e., change from high-density urban housing with associated limited access to unpaved soil) could result in greater uncertainty in the applicability of the HHRA.

Data to 10 ft bgs were included in the dataset, even though the construction worker is unlikely to contact soil at this depth because groundwater is encountered at less than 10 ft bgs at the site, and construction activities will likely avoid intrusion to this depth. Constituent concentrations at 10 ft bgs are one to three orders of magnitude greater than concentrations at 5 ft bgs. Including the 10 ft bgs data likely overestimates risk.

As a conservative measure, the maximum detected soil vapor concentrations were used to represent vapor concentrations in trench air. This approach assumes that the trench worker obtains all air while working in the trench from soil vapor without dilution by ambient air. Not accounting for any dilution of soil vapor prior to inhalation overestimates risk.

Actual soil vapor conditions under future onsite buildings are unknown. Soil vapor concentrations may vary seasonally due to variations in groundwater levels, flow rate, and gradient. Use of the maximum concentrations of detected constituents in soil vapor is consistent with guidance and deemed conservative. Although there is uncertainty regarding future soil vapor concentrations, petroleum constituents in the environment typically degrade over time, leading to lower concentrations than were used in this risk assessment.

6.3 Toxicity Data Uncertainty

There is uncertainty associated with the toxicity of complex mixtures such as TPHd and TPHg. A discussion of these uncertainties is presented in Appendix C.

6.4 Uncertainties Summary

Most of the uncertainties described above result in the overestimation of risk. The direct exposure pathways for future residents were considered potentially incomplete and insignificant. Not including them in the risk estimate potentially underestimates risks to future residents. However, given the site development plan, little exposed soil will be available for direct exposure. Further, VOCs in the soil would likely occur at trace concentrations (if any) because VOCs are not persistent in surface soil, and, therefore, exposure would result in insignificant risk.

7. Conclusions

In summary, potential future estimated cancer risks and noncancer hazards did not exceed acceptable levels as defined by standard state and federal regulatory guidance. ARCADIS identified the risks and hazards for future construction workers and residents under the current development plan using current and historical site data and conservative assumptions that generally lead to the overestimation of risks. The results indicate that exposure to petroleum hydrocarbons and lead present in site soil and soil vapor by future residents or redevelopment construction workers should not result in excess health risks greater than those generally acceptable by regulatory agencies. ARCADIS estimated the potential risks and hazards assuming no future remediation. If further remediation is performed, potential risks and hazards would be expected to decrease further.

8. References

CalEPA. 1992. Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities. California Environmental Protection Agency, Office of Scientific Affairs. July.

CalEPA. 1994. *Preliminary Endangerment Assessment Guidance Manual.* California Environmental Protection Agency, Department of Toxic Substances Control. January.

CalEPA. 2005. *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air*. Interim Final. California Environmental Protection Agency, Department of Toxic Substances Control. Revised February 7.

CalEPA. 2008. *Chronic Reference Exposure Levels*. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. Available at: http://www.oehha.ca.gov/air/chronic_rels/pdf/allchrels.pdf.

CalEPA. 2009. OEHHA Toxicity Criteria Database. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. Available at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp.

CDC. 1991. *Preventing Lead Poisoning in Young Children*. Centers for Disease Control. Available at: http://www.cdc.gov/nceh/lead/publications/books/plpyc/contents.htm.

CET. 2005. *Subsurface Investigation Report*. Cambria Environmental Technology, Inc. January 14.

CRA. 2007a. *Feasibility Study and Corrective Action Plan (FSCAP). Former Signal Oil Station #20-6145.* Conestoga-Rovers & Associates. November 1.

CRA. 2007b. *Feasibility Study/Corrective Action Plan Addendum. Former Signal Oil Service Station (Chevron Site No. 206145). 800 Center Street, Oakland, California.* Conestoga-Rovers & Associates. January 23.

CRA. 2007c. *Well Installation Report.* Conestoga-Rovers & Associates. May 14.

CRA. 2008. *Soil Vapor Analytical Data for Samples Collected on October 3, 2008 at Signal Oil Service Station, Chevron Site Number 20-6145, 800 Center Street, Oakland, California*. Conestoga-Rovers & Associates.

Delta. 2001. *Report of Soil Sampling during UST Removal*. Delta Environmental Consultants, Inc. April 23.

Delta. 2002. *Well Installation Report*. Delta Environmental Consultants, Inc. April.

Delta. 2003a. *Well Destruction, Over-Excavation and Soil Sampling Report*. Delta Environmental Consultants, Inc. January 23.

Delta. 2003b. *Soil Boring and Well Installation Report*. Delta Environmental Consultants, Inc. May 15.

Groundwater Technology, Inc. 1995. *Additional Site Assessment Report- Former Signal Service Station No. S0800. 800 Center Street, Oakland, California*. November.

PEG. 1997a. *Soil and Groundwater Investigation- Former Signal Service Station S0800. 800 Center Street at 8th Street, Oakland, California.* Pacific Environmental Group. January 24.

PEG. 1997b. *Results of the Soil Vapor Investigation. Former Signal Service Station 0800. 800 Center Street at Eighth Street, Oakland, California*. Pacific Environmental Group. July 28.

SCI. 1989. *Preliminary Hydrocarbon Contamination Assessment, 800 Center Street, Oakland, California*. Subsurface Consultants, Inc. October 13.

TPHCWG.1997. TPH Criteria Working Group Series, Volumes 1 through 5, Amherst Scientific Publishers, Amherst, Mass. 1997.

USEPA. 1989. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A).* EPA/540/1-89-002. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. December.

USEPA. 1994. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities.* OSWER Directive No. 9355.4-12. Office of

Emergency and Remedial Response, Washington, D.C. EPA/540/F-94/043, PB94-963282.

USEPA. 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. U.S. Environmental Protection Agency, Technical Review Workgroup from Lead.

USEPA. 1997. *Health Effects Assessment Summary Tables*. EPA-540-R-97-036. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. July.

USEPA. 1999. *Guidelines for Carcinogen Risk Assessment*. NCEA-F-0644. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. July.

USEPA. 2003a. *Adult Lead Methodology (ALM) Spreadsheet*. U.S. Environmental Protection Agency, Technical Review Workgroup for Lead, Adult Lead Committee. January. Available at: http://www.epa.gov/superfund/programs/lead/products.htm.

USEPA. 2003b. *Recommendation of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*. EPA-540-R-03-001. U.S. Environmental Protection Agency, Technical Review Workgroup for Lead. December.

USEPA. 2003c. *OSWER Directive 9285.7-53, Human Health Toxicity Values in Superfund Risk Assessments*. Memo from Michael B. Cook. U.S. Environmental Protection Agency, Office of Superfund Remediation and Technology Innovation. December. Available at: http://www.epa.gov/oswer/riskassessment/pdf/hhmemo.pdf.

USEPA. 2003d. National Oil and Hazardous Substances Contingency Plan (NCP). 40 Code of Federal Regulations, Part 300, Subpart E, *300*.430 Remedial investigation/feasibility study and selection of remedy. July 1, 2003 edition.

USEPA. 2007c. *ProUCL Version 4.0. User Guide*. EPA/600/R-07/038. U.S. Environmental Protection Agency, Office of Research and Development. April. Available at: http://www.epa.gov/nerlesd1/tsc/software.htm.

USEPA. 2007d. *ProUCL Version 4.0. Technical Guide*. EPA/600/R-07/041. U.S. Environmental Protection Agency, Office of Research and Development. April. Available at: http://www.epa.gov/nerlesd1/tsc/software.htm.

USEPA. 2007e. *Addressing Lead at Superfund Sites, Frequently Asked Questions from Risk Assessors on the Adult Lead Methodology (ALM), What is an appropriate soil ingestion rate (IR) for a construction scenario (i.e., soil contact-intensive scenario)?* Webpage last updated on August 18th,2008 at: http://www.epa.gov/superfund/health/contaminants/lead/almfaq.htm.

USEPA. 2009. *Integrated Risk Information System (IRIS).* U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. Available at: http://www.epa.gov/iris/index.html.

Tables

Table 2-1
Soil Data

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Sample ID/ Date	Depth (ft bgs)	TPHd[a] (mg/kg)	TPHg[b] (mg/kg)	Benzene[c] (mg/kg)	Toluene[c] (mg/kg)	Ethyl-benzene[c] (mg/kg)	Total Xylenes[c] (mg/kg)	MTBE[c] (mg/kg)	Lead (mg/kg)
MW-2									
10/17/95	5	---	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	--	--
10/17/95	10	---	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	--	--
MW-3									
10/17/95	5	---	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	--	--
10/17/95	10	---	<1.0	**0.24**	**0.01**	**0.016**	**0.019**	--	--
G-15									
6/21/02	5	---	<1.0	<0.0050	**0.020**	<0.0050	**0.017**	<0.050	**22.5**
6/21/02	10	---	**5,800**	**12**	**320**	**110**	**450**	**31**	**6.5**
G-16									
6/21/02	5	---	<1.0	<0.0050	**0.015**	<0.0050	<0.015	<0.050	**2.4**
6/21/02	10	---	**2,100**	**5.1**	**110**	**52**	**230**	**11**	**6.5**
G-17									
6/21/02	5	---	**35**	**0.082**	**0.78**	**0.54**	**1.2**	**0.22**	**368**
6/21/02	10	---	**420**	**0.62**	**9.2**	**9.9**	**41**	<5.0	**5.7**
G-18									
6/21/02	5	---	**81**	**0.11**	**1.1**	**0.76**	**2.6**	<0.20	**3.7**
6/21/02	10	---	**1,700**	**4.9**	**68**	**51**	**220**	<5.0	**5**
G-19									
6/21/02	5	---	<1.0	<0.0050	<0.0050	<0.0050	<0.015	<0.050	**2.6**
6/21/02	10	---	**4,500**	**20**	**230**	**110**	**450**	<5.0	**5.8**
G-21									
6/21/02	5	---	<1.0	<0.0050	**0.016**	<0.0050	**0.016**	<0.050	**4.2**
6/21/02	10	---	**1.0**	**0.0091**	**0.18**	**0.055**	**0.23**	<0.050	**44**
SW-1									
11/15/02	5	<10	<1.0	<0.0050	**0.0073**	<0.0050	**0.017**	<0.050	--
11/15/02	10	<10	<1.0	<0.0050	<0.0050	<0.0050	<0.015	<0.050	--
SW-2									
11/18/02	5	<10	<1.0	<0.0050	**0.0088**	<0.0050	<0.015	<0.050	--
11/18/02	10	**1,600**	**2,800**	**2.5**	**75**	**52**	**250**	<10	--
SW-3									
11/18/02	5	<10	<1.0	<0.0050	**0.0089**	<0.0050	**0.021**	<0.050	--
11/18/03	10	**1,200**	**7,300**	**19**	**330**	**170**	**650**	**26**	--
SW-4									
11/18/02	5	<10	<1.0	<0.0050	**0.0081**	<0.0050	<0.015	<0.050	--
11/18/02	10	**3,400**	**18,000**	**91**	**1,200**	**440**	**1,900**	**150**	--
SW-5									
11/16/02	5	<10	<1.0	**0.0072**	**0.039**	**0.0057**	**0.022**	<0.050	--
11/16/02	10	<10	<1.0	<0.0050	<0.0050	<0.0050	<0.015	<0.050	--

Table 2-1
Soil Data

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Sample ID/ Date	Depth (ft bgs)	TPHd[a] (mg/kg)	TPHg[b] (mg/kg)	Benzene[c] (mg/kg)	Toluene[c] (mg/kg)	Ethyl-benzene[c] (mg/kg)	Total Xylenes[c] (mg/kg)	MTBE[c] (mg/kg)	Lead (mg/kg)
SW-6									
11/16/02	5	**110**	**4.1**	**0.0084**	**0.15**	**0.079**	**0.41**	<0.050	--
11/16/02	10	**920**	**3,900**	**7.3**	**140**	**110**	**450**	**10**	--
SW-7									
11/15/02	5	<10	<1.0	<0.0050	**0.011**	<0.0050	<0.015	<0.050	--
11/15/02	10	**700**	**4,800**	**11**	**250**	**130**	**540**	**13**	--
SW-8									
11/15/02	5	<10	<1.0	<0.0050	**0.016**	<0.0050	<0.015	<0.050	--
11/15/02	10	<10	<1.0	<0.0050	<0.0050	<0.0050	<0.015	<0.050	--
SW-9									
11/15/02	5	<10	<1.0	<0.0050	<0.0050	<0.0050	<0.015	<0.050	--
11/15/02	10	<10	<1.0	<0.0050	<0.0050	<0.0050	<0.015	<0.050	--
SW-10									
11/15/02	5	<10	<1.0	<0.0050	<0.0050	<0.0050	<0.015	<0.050	--
11/15/02	10	**240**	**570**	<0.10	**0.66**	**3.7**	**21**	<1.0	--
SWW-1-S-7.5-021118									
11/18/02	7.5	--	--	--	--	--	--	--	--
SWW-2-S-8.0-021118									
11/18/02	8	--	--	--	--	--	--	--	--
SWW-3-S-7.5-021118									
11/18/02	7.5	--	--	--	--	--	--	--	--
SWW-4-S-7.5-021118									
11/18/02	7.5	--	--	--	--	--	--	--	--
SWH-1(7.5)									
11/16/02	7.5	--	--	--	--	--	--	--	--
SWH-2(7.5)									
11/16/02	7.5	--	--	--	--	--	--	--	--
SWH-3(8)									
11/16/02	8	--	--	--	--	--	--	--	--
SWH-4(7.5)									
11/16/02	7.5	--	--	--	--	--	--	--	--
G-24									
1/29/03	5	**52**	<1.0	<0.0050	**0.012**	<0.0050	<0.015	<0.050	--
1/29/03	10	<10	<1.0	**0.0074**	**0.014**	<0.0050	<0.015	<0.050	--
G-25									
1/29/03	5	**53**	<1.0	<0.0050	**0.0095**	<0.0050	<0.015	<0.050	--
1/29/03	10	**1,400**	**8,800**	**27**	**560**	**290**	**1,200**	<53	--
G-26									
1/29/03	5	<10	**2.2**	<0.0050	**0.020**	**0.0076**	**0.036**	<0.050	--
1/29/03	10	<10	<1.0	<0.0050	**0.0092**	<0.0050	<0.015	<0.050	--

Table 2-1
Soil Data

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Sample ID/ Date	Depth (ft bgs)	TPHd[a] (mg/kg)	TPHg[b] (mg/kg)	Benzene[c] (mg/kg)	Toluene[c] (mg/kg)	Ethyl- benzene[c] (mg/kg)	Total Xylenes[c] (mg/kg)	MTBE[c] (mg/kg)	Lead (mg/kg)
G-27									
1/29/03	5	<10	<1.0	<0.0050	**0.020**	<0.0050	**0.018**	<0.050	--
1/29/03	10	**1,600**	**5,500**	**13**	**250**	**180**	**700**	**20**	--
G-28									
1/29/03	5	<10	<1.0	**0.0054**	**0.030**	**0.0063**	**0.026**	<0.050	--
1/29/03	10	<10	**16**	**0.027**	**0.096**	**0.056**	**0.28**	<0.050	--
G-29									
1/29/03	5	<10	<1.0	<0.0050	**0.021**	**0.0057**	**0.021**	<0.050	--
1/29/03	10	**410**	**5,200**	**39**	**380**	**160**	**640**	**95**	--
G-30									
1/29/03	5	<10	**7.1**	**0.014**	**0.25**	**0.14**	**0.70**	<0.050	--
1/29/03	10	**1,600**	**16,000**	**92**	**1,000**	**480**	**1,900**	**150**	--
CPT-2									
10/6/04	5	**560**	<4.0	<0.0005	<0.001	<0.001	<0.001	--	--
CPT-4									
10/6/04	5	**46**	<1.0	<0.0005	<0.001	<0.001	<0.001	--	--
C-1									
11/1/04	5	<10	**2.8**	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
11/1/04	10	<10	<1.0	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
C-2									
11/1/04	5	**450**	<1.0	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
11/1/04	10	**67**	<1.0	<0.0005	**0.002**	<0.001	<0.001	<0.0005	--
C-3									
11/1/04	10	**640**	**4,800**	**0.75**	**94**	**66**	**310**	<0.063	--
C-4									
11/1/04	5	**160**	**9.2**	**0.001**	**0.008**	<0.001	**0.003**	<0.0005	--
11/2/04	10	**1,000**	**6,300**	**11**	**410**	**200**	**780**	<0.63	--
C-5									
11/1/04	5	**160**	**1.0**	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
11/2/04	10	**330**	**2.3**	<0.0005	**0.002**	<0.001	**0.002**	<0.0005	--
C-6									
11/2/04	10	**94**	**880**	<0.063	**3.8**	**6.9**	**36**	<0.063	--
C-7									
11/1/04	10	**520**	<10	<0.0005	**0.003**	<0.001	**0.002**	<0.0005	--
C-8									
11/1/04	5	**38**	<1.0	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
11/2/04	10	<10	**2.7**	<0.0005	<0.001	<0.001	**0.001**	<0.0005	--
C-9									
11/1/04	5	**47**	<4.0	<0.0005	**0.003**	<0.001	<0.001	<0.0005	--
11/2/04	10	<10	<1.0	<0.0005	<0.001	<0.001	<0.001	<0.0005	--

Table 2-1
Soil Data

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Sample ID/ Date	Depth (ft bgs)	TPHd[a] (mg/kg)	TPHg[b] (mg/kg)	Benzene[c] (mg/kg)	Toluene[c] (mg/kg)	Ethyl-benzene[c] (mg/kg)	Total Xylenes[c] (mg/kg)	MTBE[c] (mg/kg)	Lead (mg/kg)
P-7									
3/22/06	6	--	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.025	--
3/22/06	10	--	**1.0**	<0.0050	<0.0050	<0.0050	<0.0050	<0.025	--
B-1									
6/12/06	9.5	<10	<1.0	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
B-2									
6/12/06	9.5	<10	<1.0	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
B-3									
6/12/06	10	<10	<1.0	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
B-5									
6/12/06	9.5	<10	<1.0	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
B-6									
6/12/06	9.5	**26**	**47**	<0.002	<0.005	<0.005	<0.002	<0.002	--
MW-11									
4/9/07	9.5	<4.0	<1.0	<0.0005	<0.001	<0.001	<0.001	--	--
MW-14									
4/11/07	9.0	**33**	**3,400**	**0.23**	**35**	**34**	**180**	--	--
MW-17									
4/13/07	9.5	**710**	**7,300**	**7.2**	**330**	**150**	**650**	--	--
VP-1									
10/25/07	6	**4.9**	--	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
VP-2									
10/25/07	6	**300**	--	<0.0005	<0.001	<0.001	**0.001**	<0.0005	--
VP-3									
10/25/07	6	**6.4**	--	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
VP-4									
10/25/07	6	**44**	--	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
VP-5									
10/25/07	6	<4.0	--	<0.0005	<0.001	<0.001	<0.001	<0.0005	--
VP-6									
10/25/07	6	<4.0	--	<0.0005	<0.001	<0.001	<0.001	<0.0005	--

Table 2-2
Groundwater Data

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Well ID/ Date	DTW (ft)	TPHd[a] (µg/L)	TPHg (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	MTBE (µg/L)
MW-1A								
02/05/08	6.48	**2,100**	**63**	**4.8**	<0.5	<0.5	<1.5	<2.5
05/20/08	8.93	**940**	**50**	**1.5**	<0.5	<0.5	<1.5	<2.5
08/06/08	9.86	**1,900**	**98**	**0.7**	<0.5	<0.5	<1.5	<2.5
12/05/08	10.43	**940**	**96**	**0.6**	<0.5	**0.5**	<1.5	<2.5
MW-2								
02/05/08	7.43	**1,100**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
05/20/08	9.31	**650**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
08/06/08	10.15	**200**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
12/05/08	11.28	**680**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
MW-3								
02/05/08	7.10	**2,400**	**18,000**	**210**	**950**	**1,800**	**1,700**	<500
05/20/08	9.08	**6,900**	**45,000**	**190**	**4,900**	**2,800**	**6,200**	<500[d]
08/06/08	9.81	**5,000**	**40,000**	**220**	**1,500**	**3,200**	**6,500**	<500[d]
12/05/08	10.51	**4,000**	**15,000**	**26**	**590**	**1,800**	**1,800**	**230**
MW-4								
02/05/08	6.23	**250**	**1,100**	**270**	**2.2**	**63**	**7.6**	<50
05/20/08	8.07	**1,100**	**3,300**	**720**	**4.1**	**13**	**15**	<50[d]
08/06/08	8.89	**2,200**	**11,000**	**2,700**	**33**	**460**	**87**	<100[d]
12/05/08	9.52	**540**	**2,500**	**380**	**1.4**	**22**	<5.0[e]	**11**
MW-5								
02/05/08	INACCESSIBLE AT TIME OF SAMPLING			**--**	**--**	**--**	**--**	**--**
02/29/08	6.80	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
05/20/08	8.47	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
08/06/08	9.39	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
12/05/08	10.05	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5

Table 2-2
Groundwater Data

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Well ID/ Date	DTW (ft)	TPHd[a] (µg/L)	TPHg (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	MTBE (µg/L)
MW-6								
02/05/08	6.78	**120**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
05/20/08	8.41	**70**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
08/06/08	9.27	<160	<50	<0.5	<0.5	<0.5	<1.5	<2.5
12/05/08	9.89	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
MW-7								
02/05/08	7.83	**100**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
05/20/08	9.94	**52**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
08/06/08	10.85	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
12/05/08	11.55	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
MW-8								
02/05/08	7.35	**120**	<50	<0.5	<0.5	<0.5	<1.5	<2.5
05/20/08	9.10	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
08/06/08	9.90	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
12/05/08	10.49	<50	<50	<0.5	<0.5	<0.5	<1.5	<2.5
MW-9								
02/05/08	7.34	**390**	<50	<0.5	<0.5	<0.5	<1.5	--
05/20/08	9.26	<50	<50	<0.5	<0.5	<0.5	<1.5	--
08/06/08	10.11	<50	<50	<0.5	<0.5	<0.5	<1.5	--
12/05/08	10.78	<50	<50	<0.5	<0.5	<0.5	<1.5	--
MW-10								
02/05/08	8.34	**330**	<50	<0.5	<0.5	<0.5	<1.5	--
05/20/08	9.71	**120**	<50	<0.5	<0.5	<0.5	<1.5	--
08/06/08	10.49	<50	<50	<0.5	<0.5	<0.5	<1.5	--
12/05/08	11.32	<50	<50	<0.5	<0.5	<0.5	<1.5	--
MW-11								
02/05/08	7.58	**84**	<50	<0.5	<0.5	<0.5	<1.5	--
05/20/08	9.48	<50	<50	<0.5	<0.5	<0.5	<1.5	--
08/06/08	10.31	<50	<50	<0.5	<0.5	<0.5	<1.5	--
12/05/08	11.05	<50	<50	<0.5	<0.5	<0.5	<1.5	--

Table 2-2
Groundwater Data

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Well ID/ Date	DTW (ft)	TPHd[a] (µg/L)	TPHg (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	MTBE (µg/L)
MW-12								
02/05/08	9.84	**200**	**51**	**0.9**	<0.5	<0.5	<1.5	--
02/05/08	9.66	**66**	<50	<0.5	<0.5	<0.5	<1.5	--
08/06/08	12.06	<50	<50	<0.5	<0.5	<0.5	<1.5	--
12/05/08	12.26	<50	<50	<0.5	<0.5	<0.5	<1.5	--
MW-13								
02/05/08	7.58	**57**	<50	<0.5	<0.5	<0.5	<1.5	--
05/20/08	9.44	**100**	<50	<0.5	<0.5	<0.5	<1.5	--
08/06/08	10.25	**78**	<50	<0.5	<0.5	<0.5	<1.5	--
12/05/08	10.90	<50	<50	<0.5	<0.5	<0.5	<1.5	--
MW-14								
02/05/08	9.60	**160**	**450**	**16**	**2.7**	**7.6**	**3.0**	--
05/20/08	10.90	**120**	<50	**0.7**	<0.5	<0.5	<1.5	--
08/06/08	11.24	**88**	<50	**0.9**	<0.5	<0.5	<1.5	--
12/05/08	11.76	<50	**100**	**1.7**	**0.5**	<0.5	<1.5	--
MW-15								
02/05/08	7.41	**52**	<50	<0.5	<0.5	<0.5	<1.5	--
05/20/08	9.26	<50	<50	<0.5	<0.5	<0.5	<1.5	--
08/06/08	10.08	**190**	<50	<0.5	<0.5	<0.5	<1.5	--
12/05/08	10.80	<50	<50	<0.5	<0.5	<0.5	<1.5	--
MW-16								
02/05/08	8.83	**350**	**930**	**2.6**	**15**	**9.3**	**18**	--
05/20/08	10.31	**79**	<50	<0.5	<0.5	<0.5	<1.5	--
08/06/08	11.08	**74**	<50	<0.5	<0.5	**0.6**	<1.5	--
12/05/08	11.77	**89**	<50	<0.5	<0.5	<0.5	<1.5	--
MW-17								
02/05/08	13.61	**460**	**1,000**	**16**	**26**	**49**	**60**	--
05/20/08	10.26	**89**	<50	<0.5	<0.5	<0.5	<1.5	--
08/06/08	12.73	**150**	**180**	**2.5**	**2.0**	**2.8**	**1.5**	--
12/05/08	11.93	**120**	**360**	**3.4**	<2.0[f]	**0.7**	<1.5	--

Table 2-3
Soil Vapor Data

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Well ID/ Date	Probe Depth Interval (ft bgs)	TPHg[g] (µg/m^3)	Benzene[h] (µg/m^3)	Toluene[h] (µg/m^3)	Ethylbenzene[h] (µg/m^3)	Total Xylenes[h] (µg/m^3)	MTBE[h] (µg/m^3)	Freon 11 (µg/m^3)	Carbon Disulfide (µg/m^3)	2,2,4-Trimethylpentane (µg/m^3)
VP-1										
11/06/07	5.0-5.5	**1,400**	<3.8	**16**	<5.2	<5.2	<17	**--**	**--**	**--**
LAB DUPLICATE (11/06/07)		**--**	<3.8	**14**	<5.2	<5.2	<17	**--**	**--**	**--**
10/3/2008	5.0-5.5	<97	<3.8	<4.5	<5.2	<5.2	<4.3	**6.7**	<3.7	<5.6
VP-2										
11/06/07	5.0-5.5	<250	<3.9	<4.6	<5.2	<5.2	<17	**--**	**--**	**--**
10/3/2008	5.0-5.5	Not able to sample due to water in tubing.								
VP-3										
11/06/07	5.0-5.5	<240	<3.7	<4.4	<5.0	<5.0	<17	**--**	**--**	**--**
10/03/08	5.0-5.5	<92	<3.6	<4.2	<4.9	<4.9	<4.0	<6.3	<3.5	<5.2
VP-4										
11/06/07	5.0-5.5	**280**	<3.9	<4.6	<5.2	<5.2	<17	**--**	**--**	**--**
10/03/08	5.0-5.5	**390**	<4.1	<4.9	<5.6	<5.6	<4.6	<7.4	<4.0	<6.0
VP-4 Duplicate										
10/03/08	5.0-5.5	**240**	<4.2	<5.0	<5.7	<5.7	<4.8	<7.4	<4.1	<6.2
VP-5										
11/06/07	5.0-5.5	**2,100,000**	<760	<900	<1000	<1000	<3400			
10/03/08	5.0-5.5	**57,000**	<86	<100	<120	<120	<97	<150	<84	**28000**
LAB DUPLICATE (10/03/08)		**65,000**	<15	<18	<21	<21	<17	<27	**20**	**25000 E**
VP-6										
11/06/07	5.0-5.5	<260	<4.0	<4.8	<5.5	<5.5	<18	**--**	**--**	**--**
10/03/08	5.0-5.5	<97	<3.8	<4.5	<5.2	<5.2	<4.3	<6.7	**12**	<5.6
VP-6 Duplicate										
11/06/07	5.0-5.5	<250	<3.9	<4.6	<5.4	<5.4	<18	**--**	**--**	**--**

Notes for All Section 2 Tables

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Notes:

Concentrations in bold font indicate detections.
Soil dataset contains locations inside the fence line boundary only and represent current site conditions.
Historic soil samples collected prior to and within the areas excavated were not included in the data tables.

[a] TPHd with silica gel clean-up.
[b] TPHg by USEPA Method 8015M.
[c] BTEX and MTBE by USEPA Method 8260B.
[d] Laboratory report indicates that due to the presence of an interferent near its retention time, the normal reporting limit was not attained for MTBE.
[e] Laboratory report indicates that due to the presence of an interferent near its retention time, the normal reporting limit was not attained for total xylenes. The presence or concentration of this compound cannot be determined due to the presence of this interferent.
[f] Laboratory report indicates that due to the presence of an interferent near the retention time, the normal reporting limit was not attained for toluene. The presence or concentration of this compound cannot be determined due to the presence of this interferent.
[g] TPHg by USEPA Method TO-3 for samples collected 11/06/07; TPHg USEPA Method TO-15 for samples collected 10/03/08.
[h] BTEX, MTBE, Freon 11, carbon disulfide, and 2,2,4-trimethylpentane by USEPA method TO-15.

--- or -- = not analyzed
< - concentration below laboratory method detection limits
ASTM = American Society for Testing and Materials (International)
bgs = below ground surface
BTEX = benzene, toluene, ethylbenzene, and xylenes
DTW = depth to water
E = exceeds instrument calibration range.
ft = feet
mg/kg = milligram(s) per kilogram
MTBE = methyl tert butyl ether
TPHd = total petroleum hydrocarbons as diesel
TPHg = total petroleum hydrocarbons as gasoline
µg/L = microgram(s) per liter
µg/m^3 = microgram(s) per cubic meter
USEPA = U.S. Environmental Protection Agency

Table 3-1
Exposure Parameters

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Parameter	Symbol	Units	Future Site Conditions					
			Residents[a]				Construction Worker	
			Child		Adult			
General Factors								
Averaging Time (cancer)	ATc	days	25,550	a	25,550	a	25,550	a
Averaging Time (noncancer)	ATnc	days	2,190	a	8,760	a	91	a
Body Weight	BW	kg	15	b	70	b	70	b
Exposure Frequency	EF	days/yr	350	b	350	b	63	c
Exposure Duration	ED	yr	6	b	24	b	0.25	c
In-Trench - Inhalation of Volatiles From Soil and Groundwater								
Breathing Rate (daily)	BRd	m³/day	--		--		20	b
Breathing Rate (hourly)	BRhr	m³/hr	--		--		2.5	b
Exposure Time (in trench)	ETtrench	hours/day	--		--		1	c
Soil - Ingestion (Oral)								
Incidental Soil Ingestion Rate	IRs	mg/day	--		--		330	b
Fraction Ingested from Source	FI	unitless	--		--		1	
Soil - Inhalation of Vapor								
Breathing Rate	BRs	m³/day	--		--		20	b
Indoor Air - Inhalation								
Breathing Rate	BRair	m³/day	10	b	20	b	--	
Conversion Factors								
milligrams to kilograms	CF1	mg : kg	1000 milligrams to 1 kilogram					
micrograms to milligram	CF2	µg : mg	1000 micrograms to 1 milligram					

Notes:

[a] The averaging time for cancer risk is the expected lifespan of 70 years expressed in days (70 yr x 365 day/yr).
The averaging time for non-cancer hazard is the total exposure duration (ED) expressed in days (ED x 365 day/yr).

[b] CalEPA. 2005. *Recommended DTSC Default Exposure Factors for Use in Risk Assessment at California Military Facilities.* California Environmental Protection Agency, Department of Toxic Substances Control (DTSC), Human and Ecological Risk Division (HERD). Human Health Risk Assessment (HHRA) Note 1. October.

[c] Professional judgment; assuming three months (13 weeks) of construction activities with exposed site soil.

-- = not applicable
kg = kilogram(s)
m^3 = cubic meter(s)
mg = milligram(s)
yr = year(s)

Table 3-2
Statistics Summary Table for Constituents of Potential Concern

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Constituent[a]	Frequency of Detection (FOD)[b] Number of Detects / Number of Samples	FOD %	Detects Min - Max	Detection Limits Min - Max	Mean[c]	Maximum Location	COPC (Yes/No)	COPC Basis
Soil (mg/kg)								
Lead	12 - 12	100	2.4 - 368	– - –	39.7	G-17	Yes	Detected
Benzene	29 - 83	35	0.001 - 92	0.0005 - 0.1	4.39	G-30	Yes	Detected
Ethylbenzene	31 - 83	37	0.0057 - 480	0.001 - 0.005	33.8	G-30	Yes	Detected
MTBE	10 - 74	14	0.22 - 150	0.0005 - 53	7.94	G-30,SW-4	Yes	Detected
Toluene	51 - 83	61	0.001 - 1200	0.001 - 0.005	69.9	SW-4	Yes	Detected
Total Xylenes	40 - 83	48	0.001 - 1900	0.001 - 0.015	140	G-30,SW-4	Yes	Detected
TPHg	34 - 77	44	1 - 18000	1 - 10	1430	SW-4	Yes	Detected, Evaluated using individual constituents
TPHd	33 - 65	51	4.9 - 3400	4 - 10	290	SW-4	Yes	Detected
Soil Vapor[d] (μg/m^3)				-				
TPHg	5 - 11	45%	ND - 2100000	92 - 260	197000	VP-5	Yes	Detected
Toluene	1 - 11	9%	ND - 16	4.2 - 900	95.7	VP-1	Yes	Detected
Carbon Disulfide	2 - 5	40%	ND - 20	3.5 - 4.1	8.66	VP-5	Yes	Detected
Freon 11	1 - 5	20%	ND - 6.7	6.3 - 450	35.4	VP-1	Yes	Detected
2,2,4-Trimethylpentane	1 - 5	20%	ND - 28000	5.2 - 6.2	5600	VP-5	Yes	Detected
Benzene	0 - 11	0%	– - –	3.6 - 760	80.1	NA	No	Not Detected
Ethylbenzene	0 - 11	0%	– - –	4.9 - 1000	106	NA	No	Not Detected
Total Xylenes	0 - 11	0%	– - –	4.9 - 1000	106	NA	No	Not Detected
MTBE	0 - 11	0%	– - –	4 - 3400	327	NA	No	Not Detected

Notes:

[a] Only chemicals detected at least once are presented.

[b] Frequency of detection (FOD) = number of detects / total number of samples analyzed.

[c] Arithmetic mean for detect and non-detect values is presented.

[d] Duplicate samples were reviewed and the maximum of the duplicate and sample result was selected prior to calculating descriptive statistics for soil vapor.

-- = not detected/ not analyzed/ not applicable
mg/kg = milligrams per kilogram
NA = not applicable
µg/m3= micrograms per cubic meter
ND= not detected

COPC = Constituent of potential concern
MTBE = Methyl tert butyl ether
TPHg = Total petroleum hydrocarbons as gasoline
TPHd = Total petroleum hydrocarbons as diesel

Table 3-3
Exposure Point Concentrations

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Constituent of Potential Concern (COPC)	Exposure Point Concentrations				
	Soil Concentration[a] 95% UCL (mg/kg)	Volatilization Factor[b] (m^3/kg)	Ambient Air[c] µg/m^3	Soil Vapor[d] µg/m^3	Indoor Air[e] µg/m^3
Lead[f]	39.7	--	--	NA	--
Benzene	7.19	2.7E+03	2.6E-03	ND	ND
Ethylbenzene	94.5	5.4E+03	1.8E-02	ND	ND
MTBE	12.51	5.4E+03	2.3E-03	ND	ND
Toluene	206	4.0E+03	5.2E-02	16	0.016
Total Xylenes	387.7	6.1E+03	6.4E-02	ND	ND
Carbon Disulfide	--	--	--	20	0.02
Freon 11	--	--	--	6.7	0.0067
2,2,4 Trimethylpentane	--	--	--	28,000	28
TPHg	2071	--	--	65,000	65
TPHd	416.3	--	--	ND	ND

Notes:

[a] The concentration measured in soil samples used for direct contact to soil pathways.

[b] Volatilization factors were obtained from: USEPA. 2004. Preliminary Remediation Goals (PRGs). Physical Chemical Data for Volatile Organic Compounds. Region 9: Superfund. U.S. Environmental Protection Agency. Available at: <http://www.epa.gov/region09/superfund/prg/index.html>

[c] Outdoor ambient air concentration derived by dividing the soil concentration by the volatilization factor.

[d] The maximum detected concentration measured in soil vapor is used directly as the trench scenario exposure point concentration.

[e] Calculated concentration using the maximum detected soil vapor concentration multiplied by the default attenuation factor of 0.001 from CalEPA (2005) guidance. CalEPA. 2005. Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air. Interim Final. California Environmental Protection Agency, Department of Toxic Substances Control. Revised February 7.

[f] Consistent with USEPA guidelines, construction worker lead exposures were evaluated using the Adult Lead Model (USEPA, 2001, 2003) and the arithmetic mean concentration, which is listed above (39.7 mg/kg). Calculation details are provided in Appendix B.

-- = not applicable
kg = kilogram
m^3 = cubic meter
mg = milligram

NA = not analyzed
ND = not detected
µg = microgram

Table 4-1
Toxicity Values for Carcinogens

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Constituent of Potential Concern (COPC)	Oral CSF	
	$(mg/kg/day)^{-1}$	***[ref]***
Benzene	1.0E-01	*CA*
Ethylbenzene	1.1E-02	*CA*
MTBE	1.8E-03	*CA*
Toluene	NC	--
Total Xylenes	NC	--
TPHg and TPHd	NC	--

Constituent of Potential Concern (COPC)	Inhalation CSF	
	$(mg/kg/day)^{-1}$	***[ref]***
Benzene	1.0E-01	*CA*
Ethylbenzene	8.7E-03	*CA*
MTBE	9.1E-04	*CA*
Toluene	NC	--
Total Xylenes	NC	--
Freon 11	NC	--
Carbon Disulfide	NC	--
2,2,4-Trimethylpentane	NC	--
TPHg and TPHd	NC	--

References [ref]:

CA CalEPA Toxicity Criteria Database (CalEPA, 2008).

Notes:

Dermal exposure was assessed for volatile compounds as they are best assessed via the oral/inhalation routes.

-- = not applicable
$(mg/kg/day)^{-1}$ = inverse milligrams per kilogram per day (risk per unit dose)
MTBE = Methyl tert butyl ether
NC = not evaluated as a carcinogen

Table 4-2
Toxicity Values for Noncarcinogens

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

	Oral RfD (mg/kg/day)[a]				Target Site/Critical Effect	
Constituent of Potential Concern (COPC)	**Subchronic**	***[ref]***	**Chronic**	***[ref]***	**Subchronic**	**Chronic**
Benzene	1.2E-02	*c*	4.0E-03	*I*	blood	blood
Ethylbenzene	1.0E-01	*N*	1.0E-01	*I*	liver, kidney	liver, kidney
MTBE	NA		NA		NA	NA
Toluene	2.0E+00	*H*	8.0E-02	*I*	kidney	kidney
TPHd[e]	4.0E-02	*T c*	4.0E-02	*T*	decreased body weight	decreased body weight
Total Xylenes	3.6E-01	*H*	2.0E-01	*I*	WB	WB

	Inhalation RfD (mg/kg/day)[a,b]				Target Site/Critical Effect		Reference Concentration (µg/m^3)	Derived RfD[b] (mg/kg-day)
Constituent of Potential Concern (COPC)	**Subchronic**	***[ref]***	**Chronic**	***[ref]***	**Subchronic**	**Chronic**	***(RfC)***	***(RfD)***
Benzene	1.7E-02	*c*	1.7E-02	*CA(REL)*	blood	blood	--	--
Ethylbenzene	5.7E-01	*c*	5.7E-01	*CA(REL)*	developmental	developmental	--	--
MTBE	2.3E+00	*c*	2.3E+00	*CA(REL)*	liver/kidney	liver/kidney	--	--
Toluene	2.6E-01	*H*	8.6E-02	*CA(REL)*	CNS	CNS	--	--
Total Xylenes	2.0E-01	*c*	2.0E-01	*CA(REL)*	CNS	CNS	--	--
Freon 11[c]	2.0E-01	*H*	2.0E-01	*H*	kidney	kidney	--	--
Carbon Disulfide	2.0E-01	*H*	2.0E-01	*I*	CNS	CNS	--	--
2,2,4-Trimethylpentane	NA		NA		NA	NA	--	--
TPHg[d]	5.26E+00	*T*	5.26E+00	*T*	CNS	CNS	*1.8E+04*	*5.3E+03*

References [ref]:

c chronic value used as a surrogate
CA CalEPA. 2008. OEHHA Toxicity Criteria Database. Available at: http://www.cdc.gov/nceh/lead/publications/books/plpyc/contents.htm
H USEPA. 1997. Health Effects Assessment Summary Tables (HEAST). EPA 540-R-97-036. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment.
I USEPA. 2007. Integrated Risk Information System (IRIS). U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. Available at: http://www.epa.gov/iris/index.html.
N USEPA, National Center for Environmental Assessment (NCEA) Provisional Criteria as referenced in RAIS (ORNL, 2008).
T TPHCWG. 1997. Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), “TPHCWG Series”, Volumes 1 through 5, Amherst Scientific Publishers, Amherst, Mass. 1997.

Notes:

Dermal exposure was assessed for volatile compounds as they are best assessed via the oral/inhalation routes.

[a] Toxicity values were obtained from sources referenced above in the following order of priority: California State Toxicity Values, USEPA IRIS, NCEA, HEAST.

[b] Inhalation reference concentrations were converted to mg/kg/day by the following equation: Inhalation RfD= RfC*(20 m^3/day/70 kg)

[c] These subchronic and chronic non-cancer toxicity values are found in Agency documents, but were calculated by alternative methods that are not currently practiced by the RfD/RfC Work Group. These values are considered to be adequate provisional values for risk assessment purposes at Superfund and RCRA sites, but are subject to be reviewed by the RfD/RfC Work Group and revised when necessary to reflect current work group practices.

[d] A reference concentration was determined for TPHg. A discussion is presented in Attachment C.

[e] Chronic RfD used in the absence of subchronic value.

CalEPA = California Environmental Protection Agency
CNS = Central nervous system
kg = kilograms
m^3 = cubic meters
mg/kg/day = milligrams per kilogram per day
MTBE = Methyl tert butyl ether
NA = not available
NR = none reported
RAIS = Risk Assessment Information System

RCRA = Resource Conservation and Recovery Act
REL = Reference Exposure Levels
RfC = reference concentration
RfD = reference dose
TPHg = total petroleum hydrocarbons as gasoline
µg/m^3 = micrograms per cubic meter
USEPA = U.S. Environmental Protection Agency
WB = whole body (includes increased mortality and changes to body weight)

Table 5-1
Summary of Risk Characterization Results for Hypothetical Future Construction Worker

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

				EXCESS LIFETIME CANCER RISK					NONCANCER HAZARD INDEX				
				Route-Specific Risk					Route-Specific Hazard				
Source Medium	Chemicals of Potential Concern[a]	Source EPC (mg/kg)	Air EPC (µg/m³)	Oral	Dermal[b]	Inhalation	Chemical Specific Risk	Percent of Total ELCR	Oral	Dermal[b]	Inhalation	Chemical Specific	Percent of Total Noncancer Hazard Index
SOIL	Benzene	7.19	0.00263	2.089E-09	--	4.63E-11	2.14E-09	40.7%	0.0005	--	7.59E-06	0.0005	0.6%
	Toluene	206	0.05177	NC	--	NC	0.00E+00	0.0%	0.0001	--	9.71E-06	0.0001	0.1%
	Ethylbenzene	94.5	0.01751	3.021E-09	--	2.68E-11	3.05E-09	58.1%	0.0008	--	1.52E-06	0.0008	0.9%
	Total Xylenes	387.7	0.06355	NC	--	NC	0.00E+00	0.0%	0.0009	--	1.57E-05	0.0009	1.0%
	MTBE	12.51	0.00232	6.544E-11	--	3.72E-13	6.58E-11	1.3%	NE	--	5.02E-08	0.0000001	0.0%
	TPHd	416.3	--	NC	--	NC	0.00E+00	0.0%	0.0085	--	NE	0.0085	9.6%
SOIL VAPOR	Toluene	--	16	--	--	NC	0.00E+00	0.0%	--	--	0.0004	0.00	0.4%
	TPHg	--	65000	--	--	NC	0.00E+00	0.0%	--	--	0.0764	0.08	86.5%
	Freon 11	--	6.7	--	--	NC	0.00E+00	0.0%	--	--	0.0002	0.00	0.2%
	Carbon Disulfide	--	20	--	--	NC	0.00E+00	0.0%	--	--	0.0006	0.00	0.7%
	2,2,4-Trimethylpentane	--	28000	--	--	NE	0.00E+00	0.0%	--	--	NE	0.00	0.0%
Exposure Pathway Specific Cancer Risk:				5.176E-09	--	7.35E-11			0.01072	--	0.077661		

ELCR from Soil:	5.25E-09	Noncancer Hazard Index from Soil:	0.0108
ELCR From Trench Air:	0.00E+00	Noncancer Hazard Index from Trench Air:	0.08
ELCR from Indoor Vapors:	--	Noncancer Hazard Index from Indoor Vapors:	--
Total ELCR:	**5.E-09**	**Total Hazard Index:**	**0.09**

Table 5-2

Summary of Risk Characterization Results for Hypothetical Future Adult Resident

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

				EXCESS LIFETIME CANCER RISK				NONCANCER HAZARD INDEX				
				Route-Specific Risk				Route-Specific Hazard				
Source Medium	**Chemicals of Potential Concern[a]**	**Source EPC (mg/kg)**	**Air EPC (µg/m³)**	**Oral**	**Dermal[b]**	**Inhalation**	**Chemical Specific Risk**	**Oral**	**Dermal[b]**	**Inhalation**	**Chemical Specific**	**Percent of Total Noncancer Hazard Index**
INDOOR AIR	TPHg	--	65	--	--	NC	0.00E+00	--	--	0.003387	0.0033874	97.5%
	Toluene	--	0.016	--	--	NC	0.00E+00	--	--	5.11E-05	5.114E-05	1.5%
	Freon 11	--	0.0067	--	--	NC	0.00E+00	--	--	9.18E-06	9.178E-06	0.3%
	Carbon Disulfide	--	0.02	--	--	NC	0.00E+00	--	--	2.74E-05	2.74E-05	0.8%
	2,2,4 Trimethylpentane	--	28	--	--	NC	0.00E+00	--	--	NE	0	0.0%
Exposure Pathway Specific Cancer Risk:				--	--	0		--	--	0.003475		

ELCR from Soil: --
ELCR From Trench Air: --
ELCR from Indoor Vapors: 0.0E+00
Total ELCR: 0.E+00

Noncancer Hazard Index from Soil: --
Noncancer Hazard Index from Trench Air: --
Noncancer Hazard Index from Indoor Vapors: 0.003
Total Hazard Index: 0.003

Table 5-3
Summary of Risk Characterization Results for Hypothetical Future Child Resident

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

				EXCESS LIFETIME CANCER RISK				NONCANCER HAZARD INDEX				
				Route-Specific Risk				Route-Specific Hazard				
Source Medium	**Chemicals of Potential Concern[a]**	**Source EPC (mg/kg)**	**Air EPC (µg/m^3)**	**Oral**	**Dermal[b]**	**Inhalation**	**Chemical Specific Risk**	**Oral**	**Dermal[b]**	**Inhalation**	**Chemical Specific**	**Percent of Total Noncancer Hazard Index**
INDOOR AIR	TPHg	--	65	--	--	NC	0.00E+00	--	--	0.0079	0.0079	98.5%
	Toluene	--	0.016	--	--	NC	0.00E+00	--	--	0.00004	3.879E-05	0.5%
	Freon 11	--	0.0067	--	--	NC	0.00E+00	--	--	0.00002	2.142E-05	0.3%
	Carbon Disulfide	--	0.02	--	--	NC	0.00E+00	--	--	0.0001	6.393E-05	0.8%
	2,2,4 Trimethylpentane	--	28	--	--	NC	0.00E+00	--	--	NE	0	0.0%
Exposure Pathway Specific Cancer Risk:				--	--	0		--	--	0.0080281		

ELCR from Soil:	--	Noncancer Hazard Index from Soil:	--
ELCR From Trench Air:	--	Noncancer Hazard Index from Trench Air:	--
ELCR from Indoor Vapors:	0.00E+00	Noncancer Hazard Index from Indoor Vapors:	0.008
Total ELCR:	**0.E+00**	**Total Hazard Index:**	**0.008**

Notes for Section 5 Tables

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Notes:

[a] COPC list does not include lead which is evaluated separately.

[b] The dermal exposure pathway is considered insignificant given all COPCs are volatile compounds. Volatile compounds are best assessed via the oral/inhalation routes.

-- = Not Applicable. This pathway deemed incomplete or an insignificant pathway.
ELCR = excess lifetime cancer risk
EPC = exposure point concentration
mg/kg = milligram(s) per kilogram
MTBE = methyl tert butyl ether
NC = Constituent evaluated as a noncarcinogen
NE = not evaluated because toxicity value not available for this exposure pathway
TPHg = total petroleum hydrocarbons as gasoline
µg/m^3 = microgram(s) per cubic meter

General Intake Equations (See Table 3-1 for Defined Parameters)

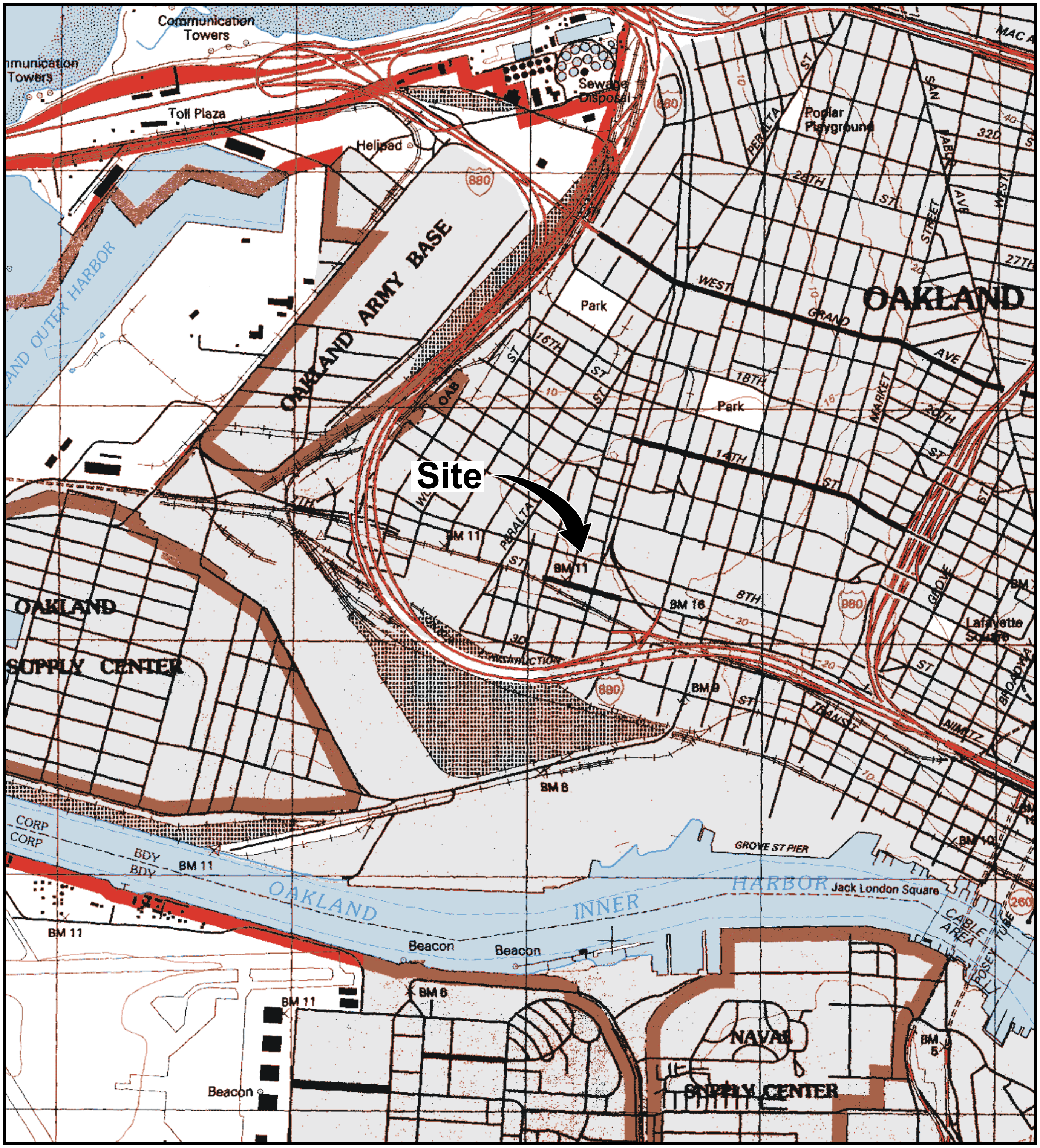
Ingestion (Oral) Route:

$$\frac{CS \times IR \times EF \times ED \times CF1 \times FI}{BW \times AT}$$

Inhalation Route:

$$\frac{CS \times ET \times EF \times ED \times CF2}{BW \times AT}$$

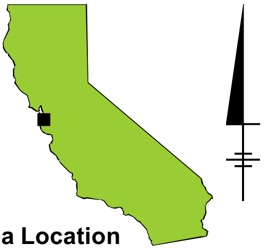
Figures



REFERENCE: BASE MAP USGS 7.5 MIN. QUAD. OAKLAND WEST, CA 1993.

2000' 0 2000'

Approximate Scale: 1" = 2000'



Area Location

FORMER SIGNAL OIL SERVICE STATION, SITE #20-6145
HUMAN HEALTH RISK ASSESSMENT

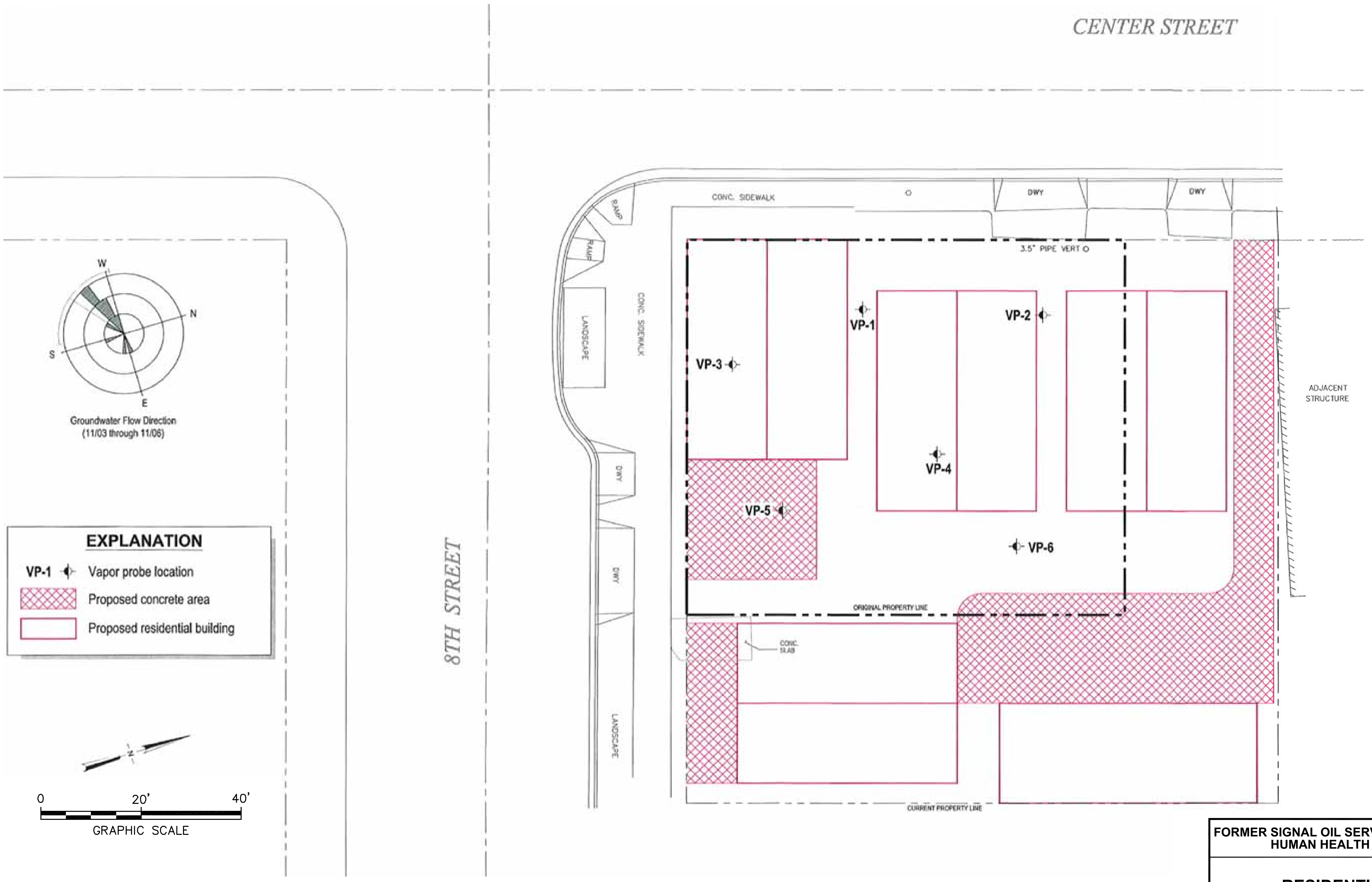
SITE LOCATION MAP

ARCADIS

FIGURE
1-1

01/26/09 SYRACUSE, NY-ENV/141-DJH
B0046478/0000/00001/CDR/46478N01.CDR

CITY:SYR DIV/GROUP:141 DB:WLJ LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0046478\0000\00001\DWG\46478B06.dwg LAYOUT: 1-2 SAVED: 3/27/2009 1:15 PM ACADVER: 17.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 3/27/2009 1:15 PM BY: JONES, WENDY
XREFS: IMAGES: fig6.jpg PROJECTNAME: ----



DRAWING SOURCE: DRAWING PROVIDED BY CONESTOGA–ROVERS & ASSOCIATES

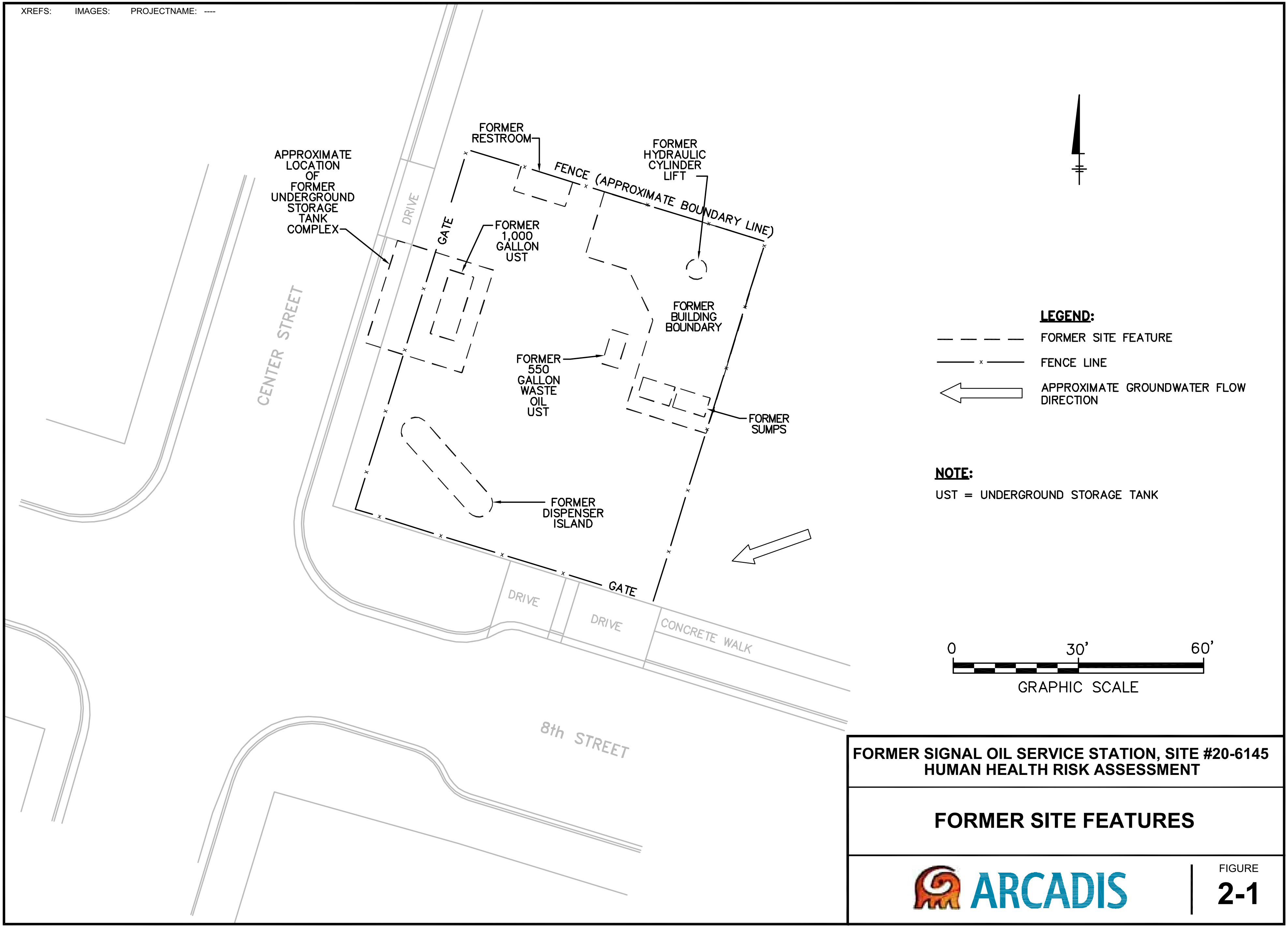
FORMER SIGNAL OIL SERVICE STATION, SITE #20-6145
HUMAN HEALTH RISK ASSESSMENT

RESIDENTIAL SITE PLAN

ARCADIS

FIGURE
1-2

CITY: SYR DIV/GROUP: 141 DB: WLJ LD: WLJ PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0046478\0000\00001\DWG\46478B02.dwg LAYOUT: 2-1SAVED: 2/25/2009 11:42 AM ACADVER: 17.0S (LMS TECH) PAGESETUP: ----PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 3/27/2009 1:14 PM BY: JONES, WENDY
XREFS: IMAGES: PROJECTNAME: ----



LEGEND:

— — — — FORMER SITE FEATURE

——x—— FENCE LINE

⇦ APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTE:

UST = UNDERGROUND STORAGE TANK

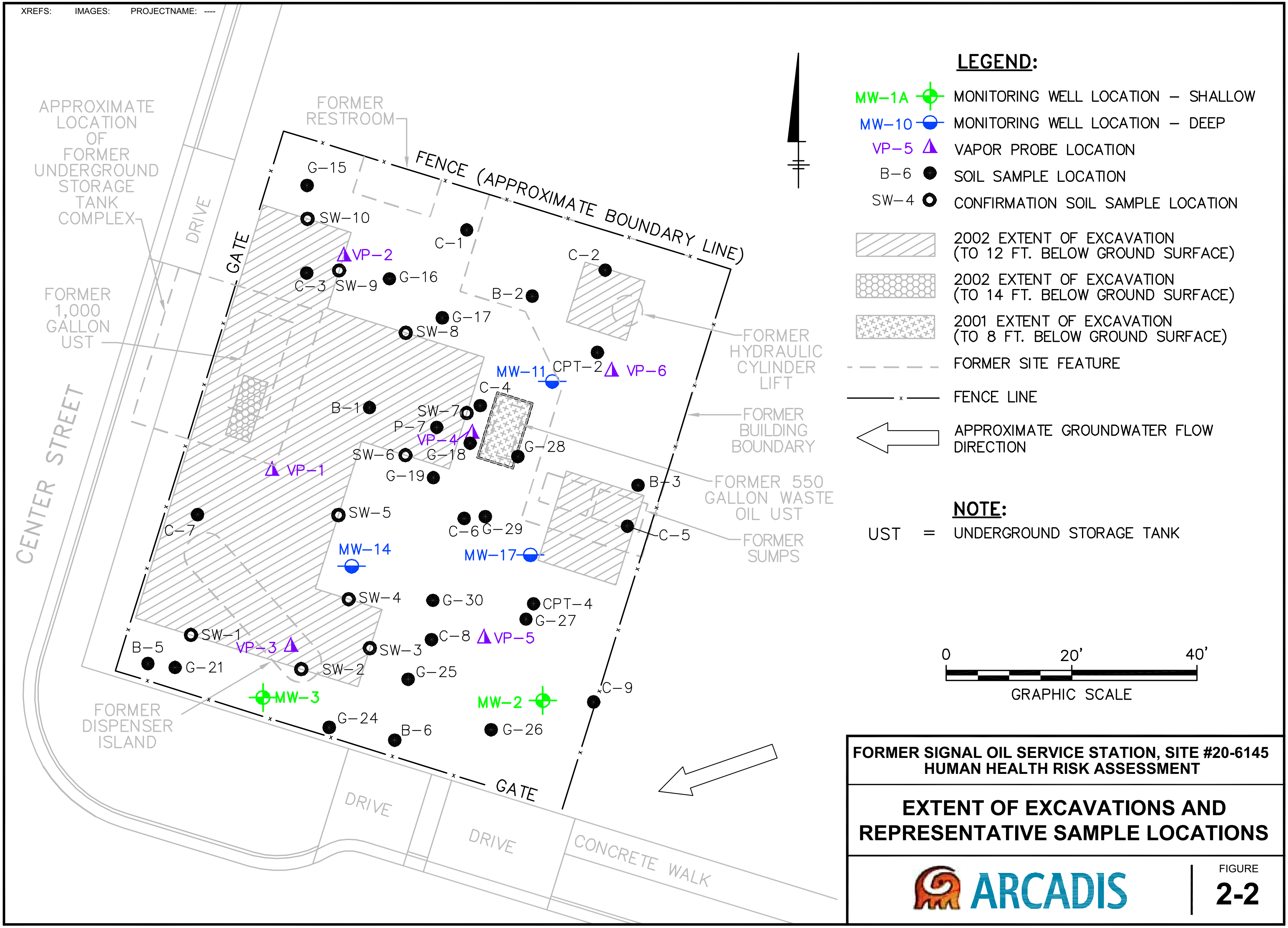
FORMER SIGNAL OIL SERVICE STATION, SITE #20-6145
HUMAN HEALTH RISK ASSESSMENT

FORMER SITE FEATURES

ARCADIS

FIGURE
2-1

CITY: SYR DIV/GROUP: 141 DB: WLJ LD: WLJ PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0046478\0000\00001\DWG\46478B04.dwg LAYOUT: 2-2SAVED: 3/27/2009 2:25 PM ACADVER: 17.0S (LMS TECH) PAGESETUP: ----PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 3/27/2009 2:25 PM BY: JONES, WENDY
XREFS: IMAGES: PROJECTNAME: ----

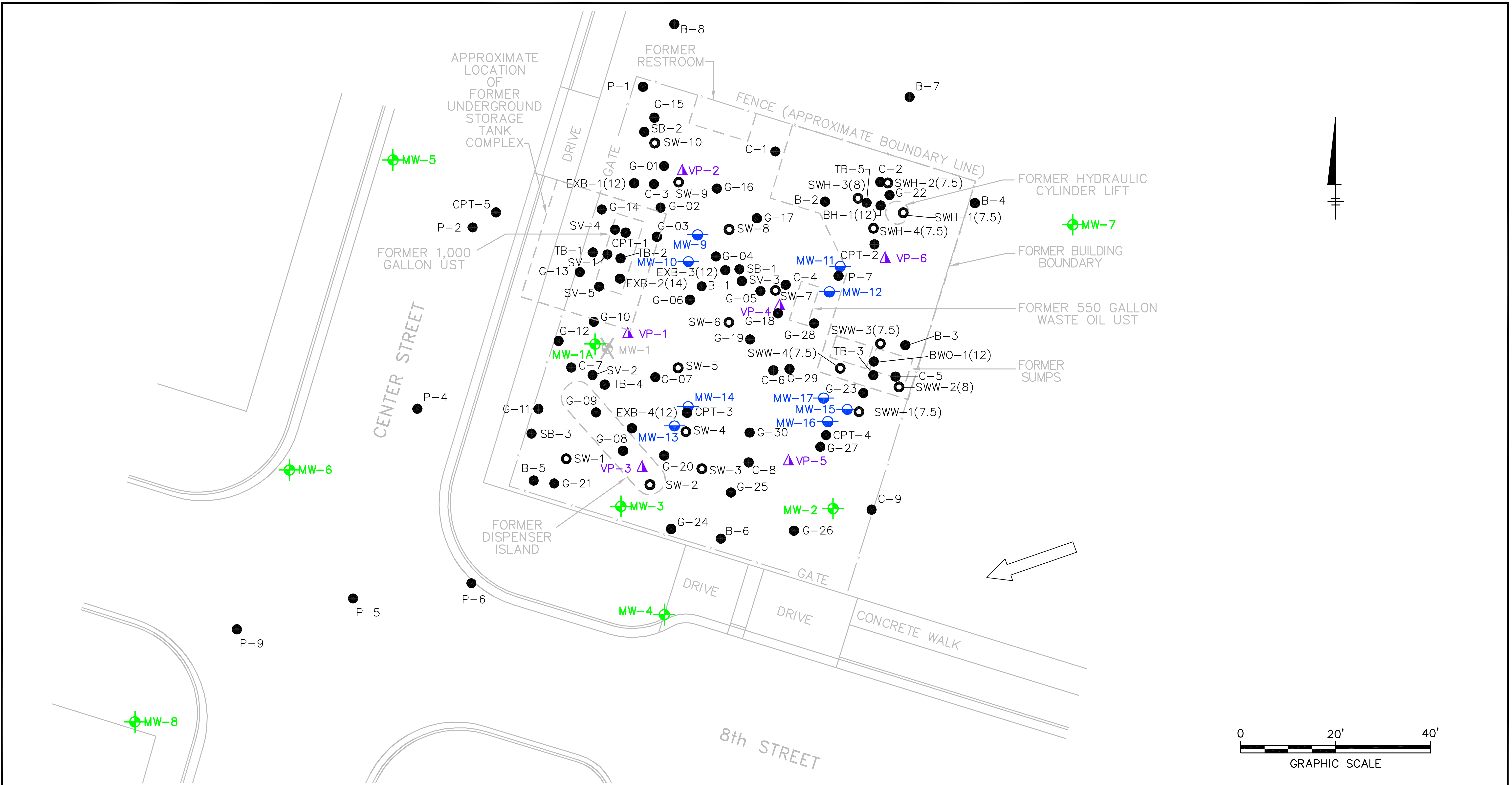


FORMER SIGNAL OIL SERVICE STATION, SITE #20-6145
HUMAN HEALTH RISK ASSESSMENT

EXTENT OF EXCAVATIONS AND REPRESENTATIVE SAMPLE LOCATIONS

ARCADIS

FIGURE
2-2



LEGEND:

- MW-1A ⊕ MONITORING WELL LOCATION – SHALLOW
- MW-10 ⊖ MONITORING WELL LOCATION – DEEP
- MW-1 ⊗ MONITORING WELL LOCATION – ABANDONED
- VP-5 ▲ VAPOR PROBE LOCATION
- SW-4 ○ CONFIRMATION SOIL SAMPLE LOCATION
- TB-1 ● BORING LOCATION

– – – – – – FORMER SITE FEATURE

–·–·–·– FENCE LINE

⇦ APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTE:

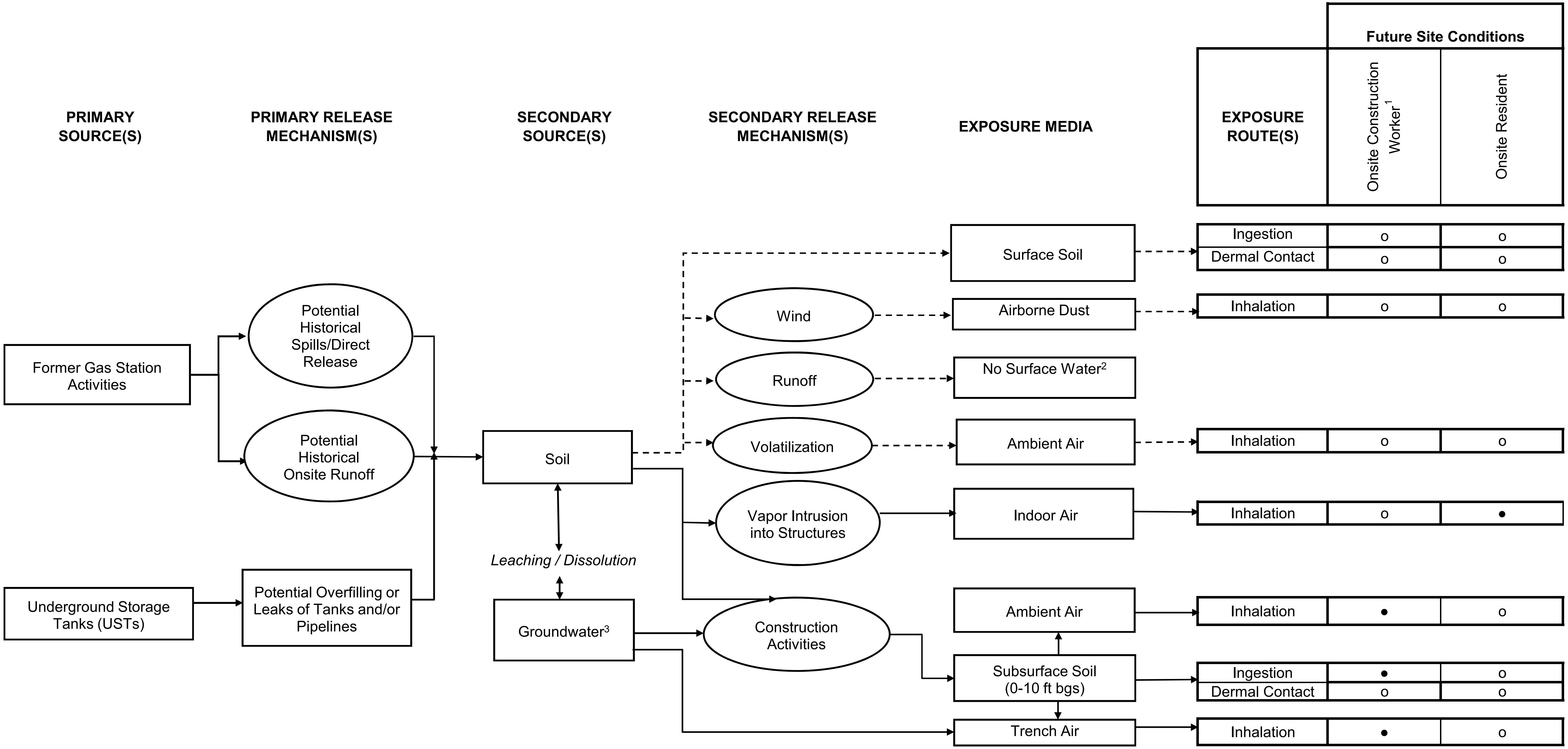
UST = UNDERGROUND STORAGE TANK

FORMER SIGNAL OIL SERVICE STATION, SITE #20-6145
HUMAN HEALTH RISK ASSESSMENT

HISTORICAL SOIL, GROUNDWATER, AND SOIL VAPOR SAMPLE LOCATIONS

ARCADIS

FIGURE
2-3



EXPOSURE MEDIA	EXPOSURE ROUTE(S)	Future Site Conditions: Onsite Construction Worker[1]	Future Site Conditions: Onsite Resident
Surface Soil	Ingestion	o	o
	Dermal Contact	o	o
Airborne Dust	Inhalation	o	o
No Surface Water[2]			
Ambient Air	Inhalation	o	o
Indoor Air	Inhalation	o	●
Ambient Air	Inhalation	●	o
Subsurface Soil (0-10 ft bgs)	Ingestion	●	o
	Dermal Contact	o	o
Trench Air	Inhalation	●	o

NOTES:

→ = Potentially complete exposure pathway.

- - → = Potentially incomplete or insignificant exposure pathway/release mechanism.

● = Complete and potentially significant exposure pathway.

o = Incomplete exposure pathway.

bgs = below ground surface

ft = feet

1. Construction worker exposure is assumed to be to a depth of 10 ft bgs during redevelopment construction activities.
2. Nearest surface water body is Oakland Inner Harbor, approximately 1 mile away. There are no known/observed complete transport pathways.
3. Depth to groundwater is approximately 5 to 10 feet bgs. Per California Regional Water Quality Control Board San Francisco Bay Region Groundwater Committee's June 1999 East Bay Plan Groundwater Basin Beneficial Use Evaluation Report, Alameda and Contra Costa Counties, Oakland has no plans to develop local groundwater resources for use as drinking water due to existing or potential salt water intrusion, contamination, or poor/limited quantity (CRA, 2007). As a result, domestic/industrial use of groundwater is an incomplete exposure pathway.

FORMER SIGNAL OIL SERVICE STATION, SITE #206145

HUMAN HEALTH CONCEPTUAL SITE MODEL

ARCADIS

FIGURE

3-1

Appendix **A**

ProUCL Outputs

Appendix A
ProUCL Output for Soil (0-10 Feet Interval)

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

	A	B	C	D	E	F	G	H	I	J	K	L
9	**Result (benzene)**											
10												
11	**General Statistics**											
12					Number of Valid Data	83					Number of Detected Data	29
13					Number of Distinct Detected Data	28					Number of Non-Detect Data	54
14											Percent Non-Detects	65.06%
15												
16	**Raw Statistics**						**Log-transformed Statistics**					
17					Minimum Detected	0.001					Minimum Detected	-6.908
18					Maximum Detected	92					Maximum Detected	4.522
19					Mean of Detected	12.56					Mean of Detected	-0.27
20					SD of Detected	23.83					SD of Detected	3.454
21					Minimum Non-Detect	0.0005					Minimum Non-Detect	-7.601
22					Maximum Non-Detect	0.1					Maximum Non-Detect	-2.303
23												
24	Note: Data have multiple DLs - Use of KM Method is recommended										Number treated as Non-Detect	63
25	For all methods (except KM, DL/2, and ROS Methods),										Number treated as Detected	20
26	Observations < Largest ND are treated as NDs										Single DL Non-Detect Percentage	75.90%
27												
28	**UCL Statistics**											
29	**Normal Distribution Test with Detected Values Only**						**Lognormal Distribution Test with Detected Values Only**					
30					Lilliefors Test Statistic	0.568					Lilliefors Test Statistic	0.909
31					5% Lilliefors Critical Value	0.926					5% Lilliefors Critical Value	0.926
32	**Data not Normal at 5% Significance Level**						**Data not Lognormal at 5% Significance Level**					
33												
34	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
35					DL/2 Substitution Method						DL/2 Substitution Method	
36					Mean	4.389					Mean	-4.603
37					SD	15.17					SD	3.93
38					95% DL/2 (t) UCL	7.159					95% H-Stat (DL/2) UCL	80.07
39												
40					Maximum Likelihood Estimate(MLE) Method	N/A					Log ROS Method	
41	**MLE yields a negative mean**										Mean in Log Scale	-6.829
42											SD in Log Scale	6.07
43											Mean in Original Scale	4.387
44											SD in Original Scale	15.17
45											95% Percentile Bootstrap UCL	7.313
46											95% BCA Bootstrap UCL	8.128
47												
48	**Gamma Distribution Test with Detected Values Only**						**Data Distribution Test with Detected Values Only**					
49					k star (bias corrected)	0.25	**Data appear Gamma Distributed at 5% Significance Level**					
50					Theta Star	50.23						
51					nu star	14.5						
52												
53					A-D Test Statistic	0.611	**Nonparametric Statistics**					
54					5% A-D Critical Value	0.876					Kaplan-Meier (KM) Method	
55					K-S Test Statistic	0.876					Mean	4.388
56					5% K-S Critical Value	0.178					SD	15.08
57	**Data appear Gamma Distributed at 5% Significance Level**										SE of Mean	1.685
58											95% KM (t) UCL	7.19
59	**Assuming Gamma Distribution**										95% KM (z) UCL	7.158
60					Gamma ROS Statistics using Extrapolated Data						95% KM (jackknife) UCL	7.155
61					Minimum	0.001					95% KM (bootstrap t) UCL	11.05
62					Maximum	92					95% KM (BCA) UCL	7.293
63					Mean	12.56					95% KM (Percentile Bootstrap) UCL	7.381
64					Median	12.42					95% KM (Chebyshev) UCL	11.73
65					SD	13.93					97.5% KM (Chebyshev) UCL	14.91
66					k star	0.613					99% KM (Chebyshev) UCL	21.15
67					Theta star	20.49						
68					Nu star	101.7	**Potential UCLs to Use**					
69					AppChi2	79.45					95% KM (t) UCL	7.19
70					95% Gamma Approximate UCL	16.08						
71					95% Adjusted Gamma UCL	16.15						
72	**Note: DL/2 is not a recommended method.**											

Appendix A
ProUCL Output for Soil (0-10 Feet Interval)

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

	A	B	C	D	E	F	G	H	I	J	K	L
73												
74												
75	**Result (ethyl-benzene)**											
76												
77	**General Statistics**											
78					Number of Valid Data	83					Number of Detected Data	31
79					Number of Distinct Detected Data	27					Number of Non-Detect Data	52
80											Percent Non-Detects	62.65%
81												
82	**Raw Statistics**						**Log-transformed Statistics**					
83					Minimum Detected	0.0057					Minimum Detected	-5.167
84					Maximum Detected	480					Maximum Detected	6.174
85					Mean of Detected	90.55					Mean of Detected	1.681
86					SD of Detected	125.2					SD of Detected	3.987
87					Minimum Non-Detect	0.001					Minimum Non-Detect	-6.908
88					Maximum Non-Detect	0.005					Maximum Non-Detect	-5.298
89												
90	Note: Data have multiple DLs - Use of KM Method is recommended										Number treated as Non-Detect	52
91	For all methods (except KM, DL/2, and ROS Methods),										Number treated as Detected	31
92	Observations < Largest ND are treated as NDs										Single DL Non-Detect Percentage	62.65%
93												
94	**UCL Statistics**											
95	**Normal Distribution Test with Detected Values Only**						**Lognormal Distribution Test with Detected Values Only**					
96					Lilliefors Test Statistic	0.743					Lilliefors Test Statistic	0.838
97					5% Lilliefors Critical Value	0.929					5% Lilliefors Critical Value	0.929
98	**Data not Normal at 5% Significance Level**						**Data not Lognormal at 5% Significance Level**					
99												
100	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
101					DL/2 Substitution Method						DL/2 Substitution Method	
102					Mean	33.82					Mean	-3.611
103					SD	87.61					SD	4.808
104					95% DL/2 (t) UCL	49.82					95% H-Stat (DL/2) UCL	21303
105												
106					Maximum Likelihood Estimate(MLE) Method	N/A					Log ROS Method	
107	**MLE yields a negative mean**										Mean in Log Scale	-5.031
108											SD in Log Scale	6.591
109											Mean in Original Scale	33.82
110											SD in Original Scale	87.61
111											95% Percentile Bootstrap UCL	49.98
112											95% BCA Bootstrap UCL	53.78
113												
114	**Gamma Distribution Test with Detected Values Only**						**Data Distribution Test with Detected Values Only**					
115					k star (bias corrected)	0.248	**Data do not follow a Discernable Distribution (0.05)**					
116					Theta Star	364.5						
117					nu star	15.4						
118												
119					A-D Test Statistic	1.147	**Nonparametric Statistics**					
120					5% A-D Critical Value	0.876					Kaplan-Meier (KM) Method	
121					K-S Test Statistic	0.876					Mean	33.82
122					5% K-S Critical Value	0.173					SD	87.08
123	**Data not Gamma Distributed at 5% Significance Level**										SE of Mean	9.717
124											95% KM (t) UCL	49.99
125	**Assuming Gamma Distribution**										95% KM (z) UCL	49.81
126					Gamma ROS Statistics using Extrapolated Data						95% KM (jackknife) UCL	49.82
127					Minimum	0.0057					95% KM (bootstrap t) UCL	57.36
128					Maximum	480					95% KM (BCA) UCL	51.62
129					Mean	91.84					95% KM (Percentile Bootstrap) UCL	50.24
130					Median	83.92					95% KM (Chebyshev) UCL	76.18
131					SD	76.53					97.5% KM (Chebyshev) UCL	94.5
132					k star	0.571					99% KM (Chebyshev) UCL	130.5
133					Theta star	160.8						
134					Nu star	94.82	**Potential UCLs to Use**					
135					AppChi2	73.36					97.5% KM (Chebyshev) UCL	94.5
136					95% Gamma Approximate UCL	118.7						
137					95% Adjusted Gamma UCL	119.2						
138	**Note: DL/2 is not a recommended method.**											

Appendix A
ProUCL Output for Soil (0-10 Feet Interval)

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

139				
140				
141	Result (lead)			
142				
143	**General Statistics**			
144	Number of Valid Observations	12	Number of Distinct Observations	11
145				
146	**Raw Statistics**		**Log-transformed Statistics**	
147	Minimum	2.4	Minimum of Log Data	0.875
148	Maximum	368	Maximum of Log Data	5.908
149	Mean	39.74	Mean of log Data	2.186
150	Median	5.75	SD of log Data	1.438
151	SD	104.1		
152	Coefficient of Variation	2.619		
153	Skewness	3.385		
154				
155	**Relevant UCL Statistics**			
156	**Normal Distribution Test**		**Lognormal Distribution Test**	
157	Shapiro Wilk Test Statistic	0.402	Shapiro Wilk Test Statistic	0.781
158	Shapiro Wilk Critical Value	0.859	Shapiro Wilk Critical Value	0.859
159	**Data not Normal at 5% Significance Level**		**Data not Lognormal at 5% Significance Level**	
160				
161	**Assuming Normal Distribution**		**Assuming Lognormal Distribution**	
162	95% Student's-t UCL	93.69	95% H-UCL	128.1
163	**95% UCLs (Adjusted for Skewness)**		95% Chebyshev (MVUE) UCL	64.46
164	95% Adjusted-CLT UCL	120.5	97.5% Chebyshev (MVUE) UCL	82.99
165	95% Modified-t UCL	98.59	99% Chebyshev (MVUE) UCL	119.4
166				
167	**Gamma Distribution Test**		**Data Distribution**	
168	k star (bias corrected)	0.381	**Data do not follow a Discernable Distribution (0.05)**	
169	Theta Star	104.3		
170	nu star	9.146		
171	Approximate Chi Square Value (.05)	3.415	**Nonparametric Statistics**	
172	Adjusted Level of Significance	0.029	95% CLT UCL	89.16
173	Adjusted Chi Square Value	2.902	95% Jackknife UCL	93.69
174			95% Standard Bootstrap UCL	86.57
175	Anderson-Darling Test Statistic	2.047	95% Bootstrap-t UCL	691.8
176	Anderson-Darling 5% Critical Value	0.798	95% Hall's Bootstrap UCL	635.1
177	Kolmogorov-Smirnov Test Statistic	0.399	95% Percentile Bootstrap UCL	97.17
178	Kolmogorov-Smirnov 5% Critical Value	0.261	95% BCA Bootstrap UCL	130.4
179	**Data not Gamma Distributed at 5% Significance Level**		95% Chebyshev(Mean, Sd) UCL	170.7
180			97.5% Chebyshev(Mean, Sd) UCL	227.4
181	**Assuming Gamma Distribution**		99% Chebyshev(Mean, Sd) UCL	338.7
182	95% Approximate Gamma UCL	106.4		
183	95% Adjusted Gamma UCL	125.2		
184				
185	**Potential UCL to Use**		Use 99% Chebyshev (Mean, Sd) UCL	338.7

Appendix A
ProUCL Output for Soil (0-10 Feet Interval)

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

	A	B	C	D	E	F	G	H	I	J	K	L
186												
187												
188	**Result (mtbe)**											
189												
190	**General Statistics**											
191					Number of Valid Data	74					Number of Detected Data	10
192					Number of Distinct Detected Data	9					Number of Non-Detect Data	64
193											Percent Non-Detects	86.49%
194												
195	**Raw Statistics**						**Log-transformed Statistics**					
196					Minimum Detected	0.22					Minimum Detected	-1.514
197					Maximum Detected	150					Maximum Detected	5.011
198					Mean of Detected	50.62					Mean of Detected	3.001
199					SD of Detected	58.52					SD of Detected	1.891
200					Minimum Non-Detect	0.0005					Minimum Non-Detect	-7.601
201					Maximum Non-Detect	53					Maximum Non-Detect	3.97
202												
203	Note: Data have multiple DLs - Use of KM Method is recommended										Number treated as Non-Detect	71
204	For all methods (except KM, DL/2, and ROS Methods),										Number treated as Detected	3
205	Observations < Largest ND are treated as NDs										Single DL Non-Detect Percentage	95.95%
206												
207	**UCL Statistics**											
208	**Normal Distribution Test with Detected Values Only**						**Lognormal Distribution Test with Detected Values Only**					
209					Lilliefors Test Statistic	0.754					Lilliefors Test Statistic	0.845
210					5% Lilliefors Critical Value	0.842					5% Lilliefors Critical Value	0.842
211	**Data not Normal at 5% Significance Level**						**Data appear Lognormal at 5% Significance Level**					
212												
213	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
214					DL/2 Substitution Method						DL/2 Substitution Method	
215					Mean	7.391					Mean	-3.764
216					SD	26.98					SD	3.908
217					95% DL/2 (t) UCL	12.62					95% H-Stat (DL/2) UCL	370.6
218												
219					Maximum Likelihood Estimate(MLE) Method	N/A					Log ROS Method	
220	**MLE yields a negative mean**										Mean in Log Scale	-3.297
221											SD in Log Scale	3.635
222											Mean in Original Scale	6.97
223											SD in Original Scale	26.91
224											95% Percentile Bootstrap UCL	12.76
225											95% BCA Bootstrap UCL	13.98
226												
227	**Gamma Distribution Test with Detected Values Only**						**Data Distribution Test with Detected Values Only**					
228					k star (bias corrected)	0.529	**Data appear Gamma Distributed at 5% Significance Level**					
229					Theta Star	95.73						
230					nu star	10.58						
231												
232					A-D Test Statistic	0.415	**Nonparametric Statistics**					
233					5% A-D Critical Value	0.764					Kaplan-Meier (KM) Method	
234					K-S Test Statistic	0.764					Mean	7.052
235					5% K-S Critical Value	0.278					SD	26.71
236	**Data appear Gamma Distributed at 5% Significance Level**										SE of Mean	3.274
237											95% KM (t) UCL	12.51
238	**Assuming Gamma Distribution**										95% KM (z) UCL	12.44
239					Gamma ROS Statistics using Extrapolated Data						95% KM (jackknife) UCL	13.76
240					Minimum	1E-09					95% KM (bootstrap t) UCL	15.51
241					Maximum	720.5					95% KM (BCA) UCL	23
242					Mean	219.6					95% KM (Percentile Bootstrap) UCL	20.19
243					Median	175.9					95% KM (Chebyshev) UCL	21.33
244					SD	205.8					97.5% KM (Chebyshev) UCL	27.5
245					k star	0.296					99% KM (Chebyshev) UCL	39.63
246					Theta star	743.1						
247					Nu star	43.74	**Potential UCLs to Use**					
248					AppChi2	29.57					95% KM (t) UCL	12.51
249					95% Gamma Approximate UCL	324.8						
250					95% Adjusted Gamma UCL	327.4						
251	**Note: DL/2 is not a recommended method.**											

Appendix A
ProUCL Output for Soil (0-10 Feet Interval)

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

252				
253				
254	**Result (toluene)**			
255				
256	**General Statistics**			
257	Number of Valid Data	83	Number of Detected Data	51
258	Number of Distinct Detected Data	44	Number of Non-Detect Data	32
259			Percent Non-Detects	38.55%
260				
261	**Raw Statistics**		**Log-transformed Statistics**	
262	Minimum Detected	0.001	Minimum Detected	-6.908
263	Maximum Detected	1200	Maximum Detected	7.09
264	Mean of Detected	113.7	Mean of Detected	-0.567
265	SD of Detected	243.2	SD of Detected	4.664
266	Minimum Non-Detect	0.001	Minimum Non-Detect	-6.908
267	Maximum Non-Detect	0.005	Maximum Non-Detect	-5.298
268				
269	Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	37
270	For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	46
271	Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	44.58%
272				
273	**UCL Statistics**			
274	**Normal Distribution Test with Detected Values Only**		**Lognormal Distribution Test with Detected Values Only**	
275	Lilliefors Test Statistic	0.333	Lilliefors Test Statistic	0.211
276	5% Lilliefors Critical Value	0.124	5% Lilliefors Critical Value	0.124
277	**Data not Normal at 5% Significance Level**		**Data not Lognormal at 5% Significance Level**	
278				
279	**Assuming Normal Distribution**		**Assuming Lognormal Distribution**	
280	DL/2 Substitution Method		DL/2 Substitution Method	
281	Mean	69.86	Mean	-3.027
282	SD	197.9	SD	4.824
283	95% DL/2 (t) UCL	106	95% H-Stat (DL/2) UCL	61258
284				
285	Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
286	**MLE yields a negative mean**		Mean in Log Scale	-4.788
287			SD in Log Scale	6.811
288			Mean in Original Scale	69.86
289			SD in Original Scale	197.9
290			95% Percentile Bootstrap UCL	109.8
291			95% BCA Bootstrap UCL	115.6
292				
293	**Gamma Distribution Test with Detected Values Only**		**Data Distribution Test with Detected Values Only**	
294	k star (bias corrected)	0.15	**Data do not follow a Discernable Distribution (0.05)**	
295	Theta Star	757.3		
296	nu star	15.31		
297				
298	A-D Test Statistic	3.92	**Nonparametric Statistics**	
299	5% A-D Critical Value	0.944	Kaplan-Meier (KM) Method	
300	K-S Test Statistic	0.944	Mean	69.86
301	5% K-S Critical Value	0.14	SD	196.7
302	**Data not Gamma Distributed at 5% Significance Level**		SE of Mean	21.81
303			95% KM (t) UCL	106.1
304	**Assuming Gamma Distribution**		95% KM (z) UCL	105.7
305	Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	106
306	Minimum	1E-09	95% KM (bootstrap t) UCL	125.4
307	Maximum	1200	95% KM (BCA) UCL	105
308	Mean	70.87	95% KM (Percentile Bootstrap) UCL	107.6
309	Median	0.011	95% KM (Chebyshev) UCL	164.9
310	SD	197.6	97.5% KM (Chebyshev) UCL	206
311	k star	0.0786	99% KM (Chebyshev) UCL	286.8
312	Theta star	901.4		
313	Nu star	13.05	**Potential UCLs to Use**	
314	AppChi2	5.928	97.5% KM (Chebyshev) UCL	206
315	95% Gamma Approximate UCL	156.1		
316	95% Adjusted Gamma UCL	158.3		
317	**Note: DL/2 is not a recommended method.**			

Appendix A
ProUCL Output for Soil (0-10 Feet Interval)

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

	A	B	C	D	E	F	G	H	I	J	K	L
318												
319												
320	**Result (total xylenes)**											
321												
322	**General Statistics**											
323	Number of Valid Data					83	Number of Detected Data					40
324	Number of Distinct Detected Data					33	Number of Non-Detect Data					43
325							Percent Non-Detects					51.81%
326												
327	**Raw Statistics**						**Log-transformed Statistics**					
328	Minimum Detected					0.001	Minimum Detected					-6.908
329	Maximum Detected					1900	Maximum Detected					7.55
330	Mean of Detected					290.1	Mean of Detected					1.257
331	SD of Detected					476.1	SD of Detected					4.976
332	Minimum Non-Detect					0.001	Minimum Non-Detect					-6.908
333	Maximum Non-Detect					0.015	Maximum Non-Detect					-4.2
334												
335	Note: Data have multiple DLs - Use of KM Method is recommended						Number treated as Non-Detect					47
336	For all methods (except KM, DL/2, and ROS Methods),						Number treated as Detected					36
337	Observations < Largest ND are treated as NDs						Single DL Non-Detect Percentage					56.63%
338												
339	**UCL Statistics**											
340	**Normal Distribution Test with Detected Values Only**						**Lognormal Distribution Test with Detected Values Only**					
341	Lilliefors Test Statistic					0.662	Lilliefors Test Statistic					0.85
342	5% Lilliefors Critical Value					0.94	5% Lilliefors Critical Value					0.94
343	**Data not Normal at 5% Significance Level**						**Data not Lognormal at 5% Significance Level**					
344												
345	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
346	DL/2 Substitution Method						DL/2 Substitution Method					
347	Mean					139.8	Mean					-2.705
348	SD					359.3	SD					5.233
349	95% DL/2 (t) UCL					205.4	95% H-Stat (DL/2) UCL					779612
350												
351	Maximum Likelihood Estimate(MLE) Method					N/A	Log ROS Method					
352	**MLE yields a negative mean**						Mean in Log Scale					-5.128
353							SD in Log Scale					7.697
354							Mean in Original Scale					139.8
355							SD in Original Scale					359.3
356							95% Percentile Bootstrap UCL					209.5
357							95% BCA Bootstrap UCL					217.1
358												
359	**Gamma Distribution Test with Detected Values Only**						**Data Distribution Test with Detected Values Only**					
360	k star (bias corrected)					0.175	**Data do not follow a Discernable Distribution (0.05)**					
361	Theta Star					1661						
362	nu star					13.97						
363												
364	A-D Test Statistic					1.97	**Nonparametric Statistics**					
365	5% A-D Critical Value					0.92	Kaplan-Meier (KM) Method					
366	K-S Test Statistic					0.92	Mean					139.8
367	5% K-S Critical Value					0.155	SD					357.1
368	**Data not Gamma Distributed at 5% Significance Level**						SE of Mean					39.7
369							95% KM (t) UCL					205.8
370	**Assuming Gamma Distribution**						95% KM (z) UCL					205.1
371	Gamma ROS Statistics using Extrapolated Data						95% KM (jackknife) UCL					205.4
372	Minimum					0.001	95% KM (bootstrap t) UCL					240.1
373	Maximum					1900	95% KM (BCA) UCL					212.1
374	Mean					292.9	95% KM (Percentile Bootstrap) UCL					211.1
375	Median					304.9	95% KM (Chebyshev) UCL					312.8
376	SD					329.6	97.5% KM (Chebyshev) UCL					387.7
377	k star					0.316	99% KM (Chebyshev) UCL					534.8
378	Theta star					925.8						
379	Nu star					52.52	**Potential UCLs to Use**					
380	AppChi2					36.87	97.5% KM (Chebyshev) UCL					387.7
381	95% Gamma Approximate UCL					417.2						
382	95% Adjusted Gamma UCL					419.8						
383	**Note: DL/2 is not a recommended method.**											

	A	F	G	L
384				
385				
386	**Result (tphd)**			
387				
388	**General Statistics**			
389	Number of Valid Data	65	Number of Detected Data	33
390	Number of Distinct Detected Data	30	Number of Non-Detect Data	32
391			Percent Non-Detects	49.23%
392				
393	**Raw Statistics**		**Log-transformed Statistics**	
394	Minimum Detected	4.9	Minimum Detected	1.589
395	Maximum Detected	3400	Maximum Detected	8.132
396	Mean of Detected	561.3	Mean of Detected	5.346
397	SD of Detected	724.5	SD of Detected	1.669
398	Minimum Non-Detect	4	Minimum Non-Detect	1.386
399	Maximum Non-Detect	10	Maximum Non-Detect	2.303
400				
401	Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	34
402	For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	31
403	Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	52.31%
404				
405	**UCL Statistics**			
406	**Normal Distribution Test with Detected Values Only**		**Lognormal Distribution Test with Detected Values Only**	
407	Lilliefors Test Statistic	0.748	Lilliefors Test Statistic	0.95
408	5% Lilliefors Critical Value	0.931	5% Lilliefors Critical Value	0.931
409	**Data not Normal at 5% Significance Level**		**Data appear Lognormal at 5% Significance Level**	
410				
411	**Assuming Normal Distribution**		**Assuming Lognormal Distribution**	
412	DL/2 Substitution Method		DL/2 Substitution Method	
413	Mean	287.3	Mean	3.464
414	SD	584	SD	2.266
415	95% DL/2 (t) UCL	408.2	95% H-Stat (DL/2) UCL	516.2
416				
417	Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
418	**MLE yields a negative mean**		Mean in Log Scale	3.305
419			SD in Log Scale	2.616
420			Mean in Original Scale	288.5
421			SD in Original Scale	583.4
422			95% Percentile Bootstrap UCL	415.6
423			95% BCA Bootstrap UCL	444.2
424				
425	**Gamma Distribution Test with Detected Values Only**		**Data Distribution Test with Detected Values Only**	
426	k star (bias corrected)	0.588	**Data appear Gamma Distributed at 5% Significance Level**	
427	Theta Star	955		
428	nu star	38.79		
429				
430	A-D Test Statistic	0.447	**Nonparametric Statistics**	
431	5% A-D Critical Value	0.799	Kaplan-Meier (KM) Method	
432	K-S Test Statistic	0.799	Mean	287.5
433	5% K-S Critical Value	0.161	SD	579.4
434	**Data appear Gamma Distributed at 5% Significance Level**		SE of Mean	72.98
435			95% KM (t) UCL	409.3
436	**Assuming Gamma Distribution**		95% KM (z) UCL	407.5
437	Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	407.9
438	Minimum	1E-09	95% KM (bootstrap t) UCL	448.2
439	Maximum	3400	95% KM (BCA) UCL	416.3
440	Mean	567.5	95% KM (Percentile Bootstrap) UCL	415.7
441	Median	344.9	95% KM (Chebyshev) UCL	605.6
442	SD	647.6	97.5% KM (Chebyshev) UCL	743.3
443	k star	0.21	99% KM (Chebyshev) UCL	1014
444	Theta star	2696		
445	Nu star	27.36	**Potential UCLs to Use**	
446	AppChi2	16.43	95% KM (BCA) UCL	416.3
447	95% Gamma Approximate UCL	944.9		
448	95% Adjusted Gamma UCL	956.1		
449	**Note: DL/2 is not a recommended method.**			

Appendix A
ProUCL Output for Soil (0-10 Feet Interval)

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

	A	B	C	D	E	F	G	H	I	J	K	L
450												
451												
452	**Result (tphg)**											
453												
454	**General Statistics**											
455					Number of Valid Data	77					Number of Detected Data	34
456					Number of Distinct Detected Data	30					Number of Non-Detect Data	43
457											Percent Non-Detects	55.84%
458												
459	**Raw Statistics**						**Log-transformed Statistics**					
460					Minimum Detected	1					Minimum Detected	0
461					Maximum Detected	18000					Maximum Detected	9.798
462					Mean of Detected	3244					Mean of Detected	5.55
463					SD of Detected	4426					SD of Detected	3.479
464					Minimum Non-Detect	1					Minimum Non-Detect	0
465					Maximum Non-Detect	10					Maximum Non-Detect	2.303
466												
467	Note: Data have multiple DLs - Use of KM Method is recommended										Number treated as Non-Detect	53
468	For all methods (except KM, DL/2, and ROS Methods),										Number treated as Detected	24
469	Observations < Largest ND are treated as NDs										Single DL Non-Detect Percentage	68.83%
470												
471	**UCL Statistics**											
472	**Normal Distribution Test with Detected Values Only**						**Lognormal Distribution Test with Detected Values Only**					
473					Lilliefors Test Statistic	0.745					Lilliefors Test Statistic	0.841
474					5% Lilliefors Critical Value	0.933					5% Lilliefors Critical Value	0.933
475	**Data not Normal at 5% Significance Level**						**Data not Lognormal at 5% Significance Level**					
476												
477	**Assuming Normal Distribution**						**Assuming Lognormal Distribution**					
478					DL/2 Substitution Method						DL/2 Substitution Method	
479					Mean	1433					Mean	2.129
480					SD	3337					SD	3.839
481					95% DL/2 (t) UCL	2066					95% H-Stat (DL/2) UCL	41631
482												
483					Maximum Likelihood Estimate(MLE) Method	N/A					Log ROS Method	
484	**MLE yields a negative mean**										Mean in Log Scale	0.59
485											SD in Log Scale	5.555
486											Mean in Original Scale	1432
487											SD in Original Scale	3337
488											95% Percentile Bootstrap UCL	2118
489											95% BCA Bootstrap UCL	2309
490												
491	**Gamma Distribution Test with Detected Values Only**						**Data Distribution Test with Detected Values Only**					
492					k star (bias corrected)	0.271	**Data Follow Appr. Gamma Distribution at 5% Significance Level**					
493					Theta Star	11965						
494					nu star	18.43						
495												
496					A-D Test Statistic	1.452	**Nonparametric Statistics**					
497					5% A-D Critical Value	0.866					Kaplan-Meier (KM) Method	
498					K-S Test Statistic	0.866					Mean	1433
499					5% K-S Critical Value	0.165					SD	3315
500	**Data follow Appr. Gamma Distribution at 5% Significance Level**										SE of Mean	383.4
501											95% KM (t) UCL	2071
502	**Assuming Gamma Distribution**										95% KM (z) UCL	2064
503					Gamma ROS Statistics using Extrapolated Data						95% KM (jackknife) UCL	2066
504					Minimum	1E-09					95% KM (bootstrap t) UCL	2287
505					Maximum	26433					95% KM (BCA) UCL	2165
506					Mean	4737					95% KM (Percentile Bootstrap) UCL	2090
507					Median	1977					95% KM (Chebyshev) UCL	3104
508					SD	6407					97.5% KM (Chebyshev) UCL	3827
509					k star	0.169					99% KM (Chebyshev) UCL	5248
510					Theta star	28057						
511					Nu star	26	**Potential UCLs to Use**					
512					AppChi2	15.38					95% KM (t) UCL	2071
513					95% Gamma Approximate UCL	8009						
514					95% Adjusted Gamma UCL	8091						
515	**Note: DL/2 is not a recommended method.**											

Appendix **B**

Lead Model Calculations

Table B-1
Summary of Parameter Values Used in the Adult Lead Model (ALM) for a Construction Worker Receptor[a]

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Exposure Variable	Description	Units	Receptor Scenario
			Construction Worker
			Table 5-3c
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	NA	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB[e]	NA	2.04
PbB_0	Baseline PbB	µg/dL	1.87
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.10 [b]
$AF_{S, D}$	Absorption fraction, Pb in soil and dust	NA	0.12
AF_f	Absorption fraction, Pb in food	NA	NA
$EF_{S, D}$	Exposure frequency, Soil Pb pathway	days/yr	65 [c]
$AT_{S, D}$	Averaging time, Soil Pb pathway	days/yr	91 [d]

Notes:

[a] Adopted from USEPA (2003) MS Excel™ Spreadsheet version 5/19/03 based on Equation 1 below (USEPA, 1996).

[b] Recommended central tendancy estimate for construction workers (soil contact-intensive activities; USEPA, 2009).

[c] Assumes 5 days a week for 13 weeks (From Exposure Parameters Table 3-1).

[d] Averaging time (From Exposure Parameters Table 3-1).

[e] Values represent a non-Hispanic black worker population (from Table 3a; USEPA 2003).

dL = deciliter
g = gram(s)
kg = kilogram
mg = milligram(s)
NA = not applicable
µg = microgram(s)
yr = year

References:

USEPA. 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. U.S. Environmental Protection Agency, Technical Review Workgroup from Lead.

USEPA. 2003. Adult Lead Methodology (ALM) Spreadsheet. U.S. Environmental Protection Agency, Technical Review Workgroup for Lead, Adult Lead Committee. Available at: http://www.epa.gov/superfund/health/contaminants/lead/products.htm.

USEPA. 2009. Frequent Questions from Risk Assessors on the ALM. Accessed on-line 2/25/09 at http://www.epa.gov/superfund/programs/lead/almfaq.htm#shortest.

Equation 1, based on USEPA (1996).

$$\mathbf{PbB_{adult}} = (PbS \times BKSF \times IR_{S+D} \times AF_{S,D} \times EF_S/AT_{S,D}) + PbB_0$$

$$\mathbf{PbB_{fetal,\ 0.95}} = PbB_{adult} \times (GSD_i^{1.645} \times R)$$

Table B-2
Results of the Adult Lead Model for Construction Worker[a]

Human Health Risk Assessment
Former Signal Oil Service Station, Site #206145
800 Center Street, Oakland, California

Exposure Variable	Description of Exposure Variable	Units	Site
PbS	Soil lead concentration (weighted arithmetic mean) (0 to 10 ft bgs)	µg/g or ppm	40
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	NA	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4
GSD_i	Geometric standard deviation PbB	NA	2.0
PbB_0	Baseline PbB	µg/dL	1.87
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.10
$AF_{S, D}$	Absorption fraction (same for soil and dust)	NA	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	65
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	91
PbB_{adult}	**PbB of adult worker, geometric mean**	**µg/dL**	**2.0**
$PbB_{fetal, 0.95}$	**95th percentile PbB among fetuses of adult workers**	**µg/dL**	**5.8**
PbB_t	**Target PbB level of concern (e.g., 10 ug/dL)**	**µg/dL**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB > PbBt assuming lognormal distribution**	**%**	**0.8%**

Notes:

Adopted from USEPA (2003) MS Excel^{TM} Spreadsheet version 5/19/03 based on Equation 1 below (USEPA, 1996).

bgs = below ground surface
dL = deciliter
ft = foot/feet
g = gram(s)
µg = microgram(s)
NA = not applicable
yr = year

References:

USEPA. 1996. Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. U.S. Environmental Protection Agency, Technical Review Workgroup from Lead.

USEPA. 2003. Adult Lead Methodology (ALM) Spreadsheet. U.S. Environmental Protection Agency, Technical Review Workgroup for Lead, Adult Lead Committee. Available at: http://www.epa.gov/superfund/health/contaminants/lead/products.htm.

USEPA. 2009. Frequent Questions from Risk Assessors on the ALM. Accessed on-line 2/25/09 at http://www.epa.gov/superfund/programs/lead/almfaq.htm#shortest.

Equation 1, based on USEPA (1996).

$$PbB_{adult} = (PbS \times BKSF \times IR_{S+D} \times AF_{S,D} \times EF_S / AT_{S.D}) + PbB_0$$

$$PbB_{fetal, 0.95} = PbB_{adult} \times (GSD_i^{1.645} \times R)$$

Appendix **C**

Vapor Intrusion Technical Memorandum

ARCADIS
2033 North Main Street
Suite 340
Walnut Creek
California 94596
Tel 925.274.1100
Fax 925.274.1103

MEMO

To:
Ian Robb,
Chevron Environmental Management Company

Copies:
Todd Littleworth, Chevron Corp.
Kim Walsh, ARCADIS
Michael Fleischner, ARCADIS

From:
Michele Amaral, ARCADIS
Lynn Spence, Spence Environmental Engineering

Date:
March 26, 2009

ARCADIS Project No.:
B0046478.0000

Subject:
Evaluation of Vapor Intrusion to Indoor Air From Soil Vapor
Former Signal Oil Service Station, Chevron Site Number 20-6145

Introduction

In this analysis, potential health risks were estimated for indoor air exposures to chemicals of potential concern (COPCs) identified in soil vapor at the former Signal Oil service station, Chevron Site Number 20-6145 (the site) located at 800 Center Street, Oakland, California. In 2007, soil vapor samples were collected at the site. Typical petroleum hydrocarbon volatile organic chemicals (VOCs), such as benzene, toluene, ethylbenzene, xylenes (BTEX) and naphthalene were not detected in soil vapor. However, TPH as gasoline (TPHg) measured in one soil vapor probe was detected at a concentration above the Regional Water Quality Control Board, San Francisco Bay Region's (SFR-RWQCB) Environmental Screening Level (ESL). To gain a better understanding of the composition of TPHg in soil vapor and to determine whether there is a health risk, additional soil vapor samples were collected at the site in 2008. The soil vapor data collected in 2008 from 6 soil vapor wells completed in the unsaturated soil directly above the groundwater table were used to evaluate potential human health risk from vapor intrusion at the site.

This evaluation describes the methods and assumptions used to evaluate potential vapor intrusion exposures to future onsite residents. Based on the results of this evaluation, the potential noncancer hazard for onsite child residents exposed to vapors that could migrate from COPCs identified in soil vapor onsite was estimated to be 0.004, well below the acceptable hazard index of 1.0 typically used by USEPA, Cal-EPA and other regulatory agencies. There were no carcinogens detected in soil vapor. This indicates that, given this particular exposure scenario, potential vapor intrusion does not present a health threat to individuals residing in future onsite buildings. The following sections describe the methods and information that were used to arrive at this conclusion.

Site Description

The site is a former Signal Oil service station located at 800 Center Street, Oakland, California. Currently, the site is vacant and is surrounded by a chain-link fence. The areas immediately adjacent to the site are multi-unit residences. The site is expected to be developed as multi-story residences with slab-on-grade building foundations. The entire property area not included as part of building complexes will be paved and used for parking. It is assumed that each ground-floor unit may have a relatively small portion of soil exposed for planting gardens. The depth to groundwater at the site is approximately 8 to 12 feet below ground surface (bgs).

The site has been evaluated in a series of environmental investigations beginning in 1989 and continuing today with quarterly groundwater monitoring. The site history is described in detail in Section 2.0 of the *Human Health Risk Assessment for Former Signal Oil Service Station, Site #206145, 800 Center Street Oakland, California* prepared by ARCADIS (2009).

Summary of Site Soil Vapor Investigations

In November 2007, Conestoga-Rovers & Associates (CRA, 2008a) conducted soil vapor sampling at the site (see *Feasibility Study/Corrective Action Plan Addendum* submitted to Alameda County Environmental Health Services (ACEHS) on January 23, 2008). Vapor points VP-1 to VP-6 were installed in associated soil borings at a depth of 5 to 5.5 feet bgs. The soil vapor samples were analyzed by Air Toxics LTD laboratory using Environmental Protection Agency (EPA) Method TO-15 for BTEX, methyl tert-butyl ether (MTBE) and naphthalene; and TO-3 for TPHg. TPHg was detected in soil vapor above the reporting limit in VP-1, VP-4 and VP-5 at concentrations of 1,400, 280, and 2,100,000 $\mu g/m^3$, respectively. A negligible amount of toluene was reported above the reporting limit in VP-1. No other constituents were detected in any sample. It was noted that the reporting limit for benzene was elevated in VP-5 due to sample dilution. A negligible amount of the tracer check compound, isobutene, was detected above the reporting limit in VP-1 and an elevated amount reported in VP-5 was attributed to interference from the relatively high TPHg detection in the same soil vapor sample.

In October 2008, soil vapor samples were collected by CRA (2008b) from five wells, VP-1, and VP-3 to VP-6, using permanent probes in Summa Canisters from 5 to 5.5 feet bgs (*Response to Technical Comments* submitted to ACEHS on October 30, 2008). VP-2 was not sampled due to water in the tubing. A field duplicate was collected from VP-4 and a lab duplicate was made of the sample from VP-5. All soil vapor samples were analyzed by Air Toxics LTD laboratory using modified EPA Method TO-15. For comparative purposes, the soil vapor sample collected from VP-5 was also analyzed by TO-3.

The analytical results for chemicals detected in soil vapor are presented in Table 1. TPHg was detected in soil vapor above the reporting limit at two sample locations, VP-4 and VP-5. It was detected in VP-4, VP-4 (duplicate), VP-5 and VP-5 (duplicate) at concentrations of 390, 240, 57,000 and 65,000 µg/m^3, respectively. Additional constituents detected in soil vapor include: trichlorofluoromethane (Freon-11) in VP-1 at 6.7 µg/m^3; 2,2,4-trimethylpentane in VP-5 at 28,000 µg/m^3 and VP-5 (duplicate) at 25,000 µg/m^3; and carbon disulfide in VP-5 (duplicate) at 20 µg/m^3 and VP-6 at 12 µg/m^3. The individual constituents of the TPHg detected in the samples collected from VP-4 and VP-5 were further analyzed and characterized as Tentatively Identified Compounds (TICs). The tracer check compound, helium, was not detected in soil vapor above the reporting limit in any sample, indicating that ambient air (from above the ground surface) was not entering soil vapor samples.

Chemicals of Potential Concern

The compounds detected at this site include 2,2,4-trimentylpentane, Freon-11, carbon disulfide and TPHg. These compounds will be considered chemicals of potential concern (COPCs). TPH is not specifically a measure of petroleum hydrocarbons, but is rather a measurement of the compounds that are soluble in certain solvents and detected by the gas chromatograph/mass spectrometer (GC/MS). The compounds present in TPH will differ greatly depending on the age of the release, the media the TPH is measured in and the underlying soil conditions. In order to perform a quantitative risk assessment, it is important to understand what the TPH is composed of.

The concentration of TPH in soil, water, or soil vapor, measured by an analytical laboratory is highly dependent on the solvent used in the extraction process and the analytical method (infrared, gravimetric, or gas chromatography). There are several lab methods available to measure TPH in soil vapor, including USEPA Method TO-3 and TO-15Modified. The same soil vapor sample, analyzed by different TPH methods, will produce different TPH concentrations due to differences in solvent type, extraction method, detection method and quantification standards.

When TPH is measured in soil or water, another complicating factor is that the concentration reported can include many compounds other than petroleum hydrocarbons including plant waxes, soil humic material, animal fats, etc. In the laboratory, alumina or silica gel clean-up are sometimes used to separate the petroleum hydrocarbons from other compounds that may be measured as part of TPH (e.g. naturally derived organic content in soil). In soil vapor, it is similarly likely that part of the TPHg measured is composed of naturally occurring compounds, such as degradation products from decomposition of plants and animals. One approach used to quantify the components of the TPH in soil or water samples is through the use of fractionation techniques to divide the mixture into groups of organic chemicals based on the chemical’s carbon number and whether the chemical is an aliphatic compound or aromatic compound. These analytical methods are not available yet for soil vapor. Therefore a new approach was used to identify specific chemicals that formed the TPHg measured in the TO-15Modified analytical results.

For the samples that had detectable levels of TPHg, the largest peaks from the GC/MS chromatogram of the four soil vapor samples from VP-4 and VP-5 were identified by the lab to determine the compounds present in the TPHg. These results are reported as TICs. The results of the soil vapor sampling, including the TICs, are shown in Table 1. The TICs will be used to evaluate the potential risks associated with the TPHg mixture measured at the site.

Exposure Assessment

As stated above, currently there are no structures on the site and it is planned for redevelopment. The site is expected to be developed as multi-story residences with asphalt pavement for parking. Slab-on-grade building foundations are planned. It is assumed that each ground-floor unit may have a relatively small portion of soil exposed for planting gardens. Given the high-density nature of the future residences planned for this site, the size of growing plots is likely to be small. Groundwater beneath the site is not used as a drinking water source and it is not expected to be used as a potable source in the future.

Due to the potential for petroleum hydrocarbons to migrate in soil, groundwater, and soil vapor beneath the future structures, an evaluation was conducted to assess potential exposures to residents living on the site. Given the potential for the COPCs to volatilize, the most likely exposure pathway for future residents is inhalation of vapors which have migrated from soil vapor through soil into buildings.

Soil and/or groundwater might be the source of the vapors.

In evaluating the potential risks associated with vapors migrating from soil or water into buildings, the preferred media to evaluate is generally soil gas (Cal-EPA 2005a, USEPA 2002). For this exposure assessment, the concentrations of COPCs to which people might be exposed were based on the soil vapor analytical data collected by CRA on October 3, 2008 (Table 1). Following Cal-EPA Department of Toxic Substances Control (DTSC) (Cal-EPA, 2005a) guidance, the maximum detected soil vapor concentrations of TPHg at 65,000 $\mu g/m^3$, Freon-11 at 6.7 $\mu g/m^3$, and carbon disulfide at 20 $\mu g/m^3$ were used to assess hazards.

Inhalation Toxicity Criteria

No carcinogens were found in soil vapor. Toxicity criteria are available for Freon-11 and carbon disulfide, but not for 2,2,4-trimethylpentane or the other aliphatic chemicals detected as TICs. However, there are some well-documented toxicity criteria that can be used for TPH hydrocarbon mixtures. The basis of these toxicity data will be discussed in this section.

The reference concentration (RfC) is “an estimate (with uncertainty spanning perhaps an order of magnitude) of continuous inhalation exposure to the human population, including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects during a lifetime” (USEPA, 1994). The

RfC is used to evaluate potential noncarcinogenic effects of exposure to a given compound. It is not used to evaluate carcinogenic endpoints.

Since there is limited toxicity information available for most of the constituents of gasoline (estimated to contain more than 200 individual chemicals), a surrogate toxicity is usually used to evaluate risk. In this approach, the TPH is divided into smaller fractions based on the carbon length of the chemicals and sometimes based on whether the chemical is aliphatic or aromatic. The first agency to develop the use of fractions was the Massachusetts Department of Environmental Protection (MADEP) in their Volatile Petroleum Hydrocarbons (VPH) and Extractable Petroleum Hydrocarbons (EPH) program (MADEP, 1997 and 2002). The Total Petroleum Hydrocarbons Working Group (TPHCWG) developed the concept further and proposed dividing the TPH into 13 fractions. In both the VPH/EPH program and the TPHCWG approach, risk is evaluated on an individual chemical basis, such as benzene, toluene, ethylbenzene and xylenes, and the remaining TPH mixture is divided into six fractions for risk evaluation. Each one of the fractions is assigned separate physical/chemical properties and toxicity values.

The SF-RWQCB (2008), has ESLs for soil gas based on residential land use and has a value for TPHg (carbon range 5 to 12). The SF-RWQCB ESL for TPHg in soil vapor is based on a RfC of 49 µg/m^3. This value came from MADEP's VPH/EPH program and represents the RfC assigned to the TPH aromatic C9-C10 and aromatic C11 to C22 fractions. This value was adopted by the SF-RWQCB because it was the most conservative (most toxic) value assigned to any of the TPH fractions. In this evaluation, there were no aromatic compounds detected in any soil vapor sample. In fact, all of the individual chemicals identified in the soil vapor samples from VP-4 and VP-5 are aliphatics, therefore the RfC of 49 µg/m^3 is not an appropriate estimate of the toxicity for the TPH present in soil vapor at this site.

In general, the toxicity of aromatic fractions is considered to be at least an order of magnitude higher than the toxicity of aliphatic fractions (TPHCWG 1997). As a result, toxicity criteria for aromatic fractions are actually lower than criteria for aliphatic fractions. This is well supported by the scientific literature which contains more toxicity information for TPH aliphatics than for the aromatic fractions. This is especially true for TPH mixtures.

MADEP assigned an RfC of 200 µg/m^3 to the C5-C8 and C9-C12 aliphatic fractions. This toxicity was based solely on the toxicity of n-hexane which is considered to be a neurotoxin. The only C5 to C8 hydrocarbons that exhibit neurotoxicity are n-hexane and n-heptane. It was noted that the toxicity of the other aliphatics (e.g., the butanes and pentanes) were expected to be much less than the toxicity of n-hexane because they do not exhibit neurotoxic effects in humans. At this site, n-hexane and n-heptane were included as target compounds in the TO-15 analysis and were not detected in any sample. The TPHCWG has assigned an RfC of 18,400 µg/m^3 (18.4 mg/m^3) for the C5 to C8 aliphatic compounds. This is based on several lifetime exposure studies using a mixture of aliphatics composed of 53% n-hexane, 16% 3-methylpentane, 14% methylcyclopentane, 12% 2-methylpentane, 3% cyclohexane, 1% 2,3-dimethylbutane and <1% several minor compounds. This RfC value should still be considered conservative for the mixture measured in soil vapor samples from this site because n-hexane and n-heptane were not measured in soil vapor.

Comparison of Detected Concentrations to Screening Criteria

Screening levels in soil vapor have been calculated by the SF-RWQCB, Cal-EPA DTSC (2005a) and the USEPA (2002). These screening levels represent concentrations in soil vapor that are protective of human health for the occupants of buildings overlying the soil vapor. They are calculated using a conservative attenuation factor that relates the concentrations in soil vapor with the maximum potential concentrations of the chemical in indoor air.

The SF-RWQCB and Cal-EPA do not include ESLs in soil vapor for Freon-11 and carbon disulfide. Therefore, the maximum concentrations of those chemicals in soil vapor were compared with USEPA (2002) soil vapor screening levels. A soil vapor screening level for both Freon-11 and carbon disulfide of 350,000 µg/m^3 is based on an Attenuation Factor of 0.002, as reported in USEPA (2002) guidance. The detected soil vapor concentrations of Freon-11 at VP-1 of 6.7 µg/m^3 and of carbon disulfide at VP-5 (duplicate) of 20 µg/m^3 are both well below the health-based screening levels.

The USEPA and Cal-EPA (2005b) do not have screening levels for TPH mixtures. The SF-RWQCB does have an ESL for TPHg (10,000 µg/m^3), however as discussed previously this ESL is based on an assumed aromatic content of the TPH mixture that does not exist at this site. Therefore the ESL is not applicable to this analysis and the noncarcinogenic risk presented by the TPHg mixture has been evaluated and quantified as described below. Lastly, none of the regulatory agencies have screening levels specifically for 2,2,4-trimethylpentane and the potential risks of this chemical are included in the overall analysis for the TPHg mixture.

Estimated Noncarcinogenic Risk for TPHg

Exposure Assessment and Use of Attenuation Factors

Attenuation factors are used to correlate VOC concentrations in soil vapor with concentrations in indoor air. An attenuation factor approach will be used to convert the soil gas data collected at this site to potential indoor air concentrations to which residents of buildings constructed at the site might be exposed.

Cal-EPA DTSC (2005a, 2005b) vapor intrusion guidance provides a default attenuation factor of 0.001 for residential slab-on-grade buildings. The same value is used by the SF-RWQCB in developing soil vapor ESLs for residential situations. This factor was derived using the USEPA spreadsheet version of the Johnson & Ettinger model to estimate a concentration in indoor air in residential slab-on-grade buildings that would result in 1.0 x 10^{-6} risk for carcinogens or a hazard quotient of 1.0 for noncarcinogens. Parameters assumed in developing this attenuation factor include: single-story construction, typical California slab-on-grade construction including assumptions regarding engineered fill beneath the structures, sand soil type, a USEPA default vapor flow rate into the building (Q_{soil}) of 5 liters/minute, and an indoor air exchange rate of 0.5 per hour for residential buildings. It was also assumed that subsurface impacts are located directly beneath the foundation.

The maximum TPHg concentration detected in soil vapor is 65,000 µg/m^3. Application of an attenuation factor of 0.001 results in a maximum indoor air concentration of TPHg of 65 µg/m^3.

Toxicity Criterion for TPHg

Based on analytical data collected at sample location VP-5 (Table 2 and Attachment A), approximately 98% (by volume) of the total organic chemicals in soil vapor (i.e., TPHg) have been quantified as follows:

- 47% was the target compound 2,2,4-trimethylpentane;
- 44% were TICs, mostly other trimethylpentanes; and
- 6.5% was the internal standard.

It is important to note that n-hexane was a target compound in the analytical method TO-15Modified; however, it was not detected above the reporting limits in any soil vapor sample collected at the site. The trimethylpentanes detected in the sample from VP-5 have equivalent carbon ranges from 6.9 to 7.6. The remainder of the compounds have equivalent carbon ranges from 5 to 10 and over 98% of the TPHg is composed of aliphatic compounds. Therefore, the TPHCWG reference concentration of 18,400 µg/m^3 described previously for the C5 to C8 aliphatic fractions is appropriate to use to evaluate TPHg in soil vapor at the site.

Estimated Noncarcinogenic Risk for TPHg

Assuming a maximum indoor air concentration of TPHg estimated to be 65 µg/m^3, and a reference concentration of 18,400 µg/m^3, the noncarcinogenic hazard index presented by TPHg in soil gas is 0.004. This is below the acceptable hazard index of 1.0. Note, the hazard index calculated here is representative of the cumulative risk from all chemicals present in the TPHg mixture.

Uncertainties

Uncertainty, which includes natural variability and incertitude originating from a lack of understanding (i.e., relevant data) are inherent in the risk assessment process. Many of the variables used to estimate risks and hazards are standard default values and may not accurately describe future conditions or characteristics of the site. As default values tend to overestimate exposure, the impact of this uncertainty is to typically overestimate risks.

Analytical data from soil vapor samples collected on the current vacant lot are being used to predict vapor intrusion hazards to occupants of a future building structure. It is uncertain what the soil vapor conditions will be under buildings or asphalt pavement once the site is developed. The degree to which this may impact the estimated risks and hazards was not quantified.

The actual dimensions and structural integrity of the proposed future onsite building foundations is not known. However, default model values tend to overestimate exposure and the impact of this uncertainty is typically to overestimate risks. For example, prediction of indoor air vapor concentrations for buildings is an area of uncertainty. However, the air exposure models typically are based on equations recommended by Cal-EPA DTSC and USEPA which provide a very conservative overestimate of actual risk for most cases. The degree to which this may impact the estimated risks and hazards was not quantified.

Soil vapor samples were collected at approximately 5.0 to 5.5 feet bgs. The SF-RWQCB (2008) recommends that if buildings are not present, soil vapor samples should be collected at a depth of approximately 10 feet bgs (3 meters). At this site the depth to groundwater ranges from 8 to 12 feet bgs. For this reason, soil vapor samples were collected from 5.0 to 5.5 feet bgs. The degree to which ambient air may impact results was not quantified.

It was conservatively assumed that maximum concentrations of chemicals in soil vapor collected at VP-5 are the same as those beneath future onsite resident buildings. Concentrations of VOCs in soil vapor collected at VP-5 are likely to exceed those collected from distances farther away due to biodegradation. However, the degree to which this may impact the results was not quantified and it is assumed that this evaluation is conservative.

This evaluation was based on use of the maximum detected soil vapor constituent concentrations as a source beneath a future onsite building. For most sites, typically the 95 percent upper confidence limit (UCL) of the mean soil vapor concentrations of the constituents are also evaluated because they are likely to be more representative estimates of the potential vapor source strength. As such, this evaluation will tend to over predict hazards.

The degradability of volatile petroleum hydrocarbons was not evaluated quantitatively in these calculations. Use of petroleum hydrocarbon soil vapor data to evaluate potential onsite indoor air exposures, without considering natural attenuation mechanisms known to affect petroleum hydrocarbons (such as degradability under natural conditions), likely results in an overestimate of hazards for future onsite residents.

Conclusions

Using the approach described in this evaluation, the estimated hazard index for future onsite residents at the former Signal Oil service station, Chevron Site Number 20-6145, is below an acceptable level of 1.0 for noncancer effects. This result indicates that potential health risks for future occupants of an onsite residential or commercial building, based on the above parameters, exposed to potential vapors migrating from chemicals in soil vapor collected onsite is below a level of concern.

References

ARCADIS. 2009. Human Health Risk Assessment for Former Signal Oil Service Station, Site #206145, 800 Center Street, Oakland, California. March.

Cal-EPA (California Environmental Protection Agency). 2005a. Department of Toxic Substances Control (DTSC). Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air. Interim Final. Revised February 7, 2005.

Cal-EPA (California Environmental Protection Agency). 2005b. *Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil*. Integrated Risk Assessment Section, Office of Environmental Health Hazard Assessment, November 2004, Revised January 2005.

CRA (Conestoga-Rovers & Associates). 2007. Feasibility Study and Corrective Action Plan. Former Signal Oil Service Station (Chevron Site No. 206145). November 1.

CRA (Conestoga-Rovers & Associates). 2008a. Feasibility Study/Corrective Action Plan Addendum. Former Signal Oil Service Station (Chevron Site No. 206145). January 23.

CRA (Conestoga-Rovers & Associates). 2008b. Soil Vapor Analytical Data for Samples Collected on October 3, 2008 at Signal Oil service station, Chevron Site Number 20-6145, 800 Center Street, Oakland, California.

MADEP (Massachusetts Department of Environmental Protection). 2002. Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of the MADEP VPH/EPH Approach, Final Policy, October 31, 2002.

SF-RWQCB (California Regional Water Quality Control Board, San Francisco Bay Region). 2008. Screening for Environmental Concerns at Sites with Contaminated Soils and Groundwater. Interim Final. May.

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), “TPHCWG Series”, Volumes 1 through 5, Amherst Scientific Publishers, Amherst, Mass., 1997 – 1998.

USEPA (United States Environmental Protection Agency). 1994. Review Draft Guidelines for Reproductive Toxicity Risk Assessment, EPA600.AP.94.001.

USEPA (United States Environmental Protection Agency). 2002. OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). EPA530-D-02-004. November.

Table 1. Summary of Detected Compounds (both target chemicals and TICs) in Soil Vapor Samples.

		CAS Number	*Match Quality*	*Reporting Limit (ppbv)*	*Amount (ppbv)*	*Reporting Limit (µg/m^3)*	*Amount (µg/m^3)*
SAMPLE: VP-1	**TO-15 Target Compounds Detected:**						
	Freon 11			*1.2*	***1.2***	*6.7*	*6.7*
	Tentatively Identified Compounds						
	Not performed			-	-	-	-
SAMPLE: VP-3	**TO-15 Target Compounds Detected:**						
	No chemicals were dectected			-	-	-	-
	Tentatively Identified Compounds						
	Not performed			-	-	-	-
SAMPLE: VP-4	**TO-15 Target Compounds Detected:**						
	TPH ref. to Gasoline (MW=100)	*NA*		*26*	***95***	*100*	*390*
	Tentatively Identified Compounds						
	2-ethyl-1-hexanol	*104-76-7*	*78%*	*na*	***6.5 N J***	*na*	
	Nonanal	*124-19-6*	*64%*	*na*	***8.0 N J***	*na*	
	ethyl-1,2,4-trimethylbenzene	*54120-62-6*	*81%*	*na*	***12 N J***	*na*	
	1-penylcyclopentanol-1	*10487-96-4*	*43%*	*na*	***11 N J***	*na*	
	2,3-dihydro-5,6-dimethyl-1H-indene	*1075-22-5*	*96%*	*na*	***6.9 N J***	*na*	
SAMPLE: VP-4 DUPLICATE	**TO-15 Target Compounds Detected:**						
	TPH ref. to Gasoline (MW=100)	*NA*		*26*	***58***	*110*	*240*
	Tentatively Identified Compounds						
	1-ethyl-2,4-dimethylbenzene	*874-41-9*	*50%*	*na*	***7.9 N J***	*na*	
	pentamethylbenzene	*700-12-9*	*81%*	*na*	***18 N J***	*na*	
	ethyl-1,2,4-trimethylbenzene	*54120-62-6*	*83%*	*na*	***14 N J***	*na*	
	2,3-dihydro-5,6-dimethyl-1H-indene	*1075-22-5*	*96%*	*na*	***11 N J***	*na*	
	2,3-dihydro-1,2-dimethyl-1H-indene	*17057-82-8*	*94%*	*na*	***10 N J***	*na*	
	1,3-dimethyl-5-(1-methylethyl)-benzene	*4706-90-5*	*87%*	*na*	***6.6 N J***	*na*	
SAMPLE: VP-5	**TO-15 Target Compounds Detected:**						
	2,2,4-Trimethylpentane		*na*	27	**6100**	120	28000
	TPH ref. to Gasoline (MW=100)		*na*	540	**14000**	2200	57000
	Tentatively Identified Compounds						
	2,2-dimethylpropane	*463-82-1*	*56%*	na	**440 N J**	na	
	2,2-dimethylbutane	*75-83-2*	*83%*	na	**570 N J**	na	
	2,2,3-trimethylbutane	*464-06-2*	*64%*	na	**550 N J**	na	
	2,2,3-trimethylpentane	*564-02-3*	*83%*	na	**470 N J**	na	
	2,3,4-trimethylpentane	*565-75-3*	*91%*	na	**1200 N J**	na	
	2,3,3-trimethylpentane	*560-21-4*	*90%*	na	**5600 N J**	na	
	2,2-dimethylheptane	*1071-26-7*	*47%*	na	**360 N J**	na	
	6-methyl-1-heptene	*5026-76-6*	*43%*	na	**160 N J**	na	
SAMPLE: VP-5 DUPLICATE	**TO-15 Target Compounds Detected:**						
	Carbon Disulfide		*na*	4.8	**6.5**	15	20
	2,2,4-Trimethylpentane		*na*	4.8	**5300 E**	23	25000 E
	TPH ref. to Gasoline (MW=100)		*na*	97	**16000**	400	65000
	Tentatively Identified Compounds						
	2,2-dimethylpropane	*463-82-1*	*72%*	na	**250 N J**	na	
	2,2-dimethylbutane	*75-83-2*	*83%*	na	**360 N J**	na	
	2,2,3-trimethylbutane	*464-06-2*	*64%*	na	**370 N J**	na	
	2,2,3-trimethylpentane	*564-02-3*	*83%*	na	**560 N J**	na	
	2,3,4-trimethylpentane	*565-75-3*	*91%*	na	**1400 N J**	na	
	2,3,3-trimethylpentane	*560-21-4*	*90%*	na	**5800 N J**	na	
	1,1,2-trimethylcyclopentane	*4259-00-1*	*81%*	na	**220 N J**	na	
	2,2-dimethylheptane	*1071-26-7*	*40%*	na	**430 N J**	na	
	2,5,6-trimethyldecane	*62108-23-0*	*64%*	na	**110 N J**	na	
	3,7-dimethylnonane	*17302-32-8*	*64%*	na	**100 N J**	na	
SAMPLE: VP-6	**TO-15 Target Compounds Detected:**						
	Carbon Disulfide		*na*	*1.2*	***4***	*3.7*	*12*
	Tentatively Identified Compounds						
	Not performed			-	-	-	-

na - not applicable, concentration was not presented by the laboratory in these units.

E - Exceeds instrument calibration range.

J - Non-detected compound associated with low bias in the CCV

N - The identification is based on presumptive evidence.

Table 2. Percentage of Each Compound in TPHg for the Samples from VP-5.

		Amount (ppbv)	*% of Total TPHg*
SAMPLE: VP-5	***TPH ref. to Gasoline (MW=100)***	**14000**	**100.0%**
	2,2,4-Trimethylpentane	6100	43.6%
	2,2-dimethylpropane	440	3.1%
	2,2-dimethylbutane	570	4.1%
	2,2,3-trimethylbutane	550	3.9%
	2,2,3-trimethylpentane	470	3.4%
	2,3,4-trimethylpentane	1200	8.6%
	2,3,3-trimethylpentane	5600	40.0%
	2,2-dimethylheptane	360	2.6%
	6-methyl-1-heptene	160	1.1%
	Unidentified compounds	-1450	-10.4%
SAMPLE: VP-5 DUPLICATE	***TPH ref. to Gasoline (MW=100)***	**16000**	**100.0%**
	2,2,4-Trimethylpentane	5300	33.1%
	2,2-dimethylpropane	250	1.6%
	2,2-dimethylbutane	360	2.3%
	2,2,3-trimethylbutane	370	2.3%
	2,2,3-trimethylpentane	560	3.5%
	2,3,4-trimethylpentane	1400	8.8%
	2,3,3-trimethylpentane	5800	36.3%
	1,1,2-trimethylcyclopentane	220	1.4%
	2,2-dimethylheptane	430	2.7%
	2,5,6-trimethyldecane	110	0.7%
	3,7-dimethylnonane	100	0.6%
	Unidentified compounds	**1100**	**6.9%**