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TRANSMITTAL

DATE: February 13, 2015 REFERENCE NO.: 240524
 PROJECT NAME: 4255 MacArthur Boulevard, Oakland
 TO: Jerry Wickham
Alameda County Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

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 By Alameda County Environmental Health at 11:10 am, Feb 17, 2015

Please find enclosed: Draft Final
 Originals Other
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Sent via: Mail Same Day Courier
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QUANTITY	DESCRIPTION
1	Corrective Action Plan

As Requested For Review and Comment
 For Your Use

COMMENTS:

If you have any questions regarding the contents of this document, please call the CRA project manager Peter Schaefer at (510) 420-3319 or the Shell program manager Perry Pineda at (425) 413-1164.

Copy to: Perry Pineda, Shell Oil Products US (electronic copy)
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 Ed C. Ralston, ConocoPhillips Risk Management & Remediation (electronic copy)

Completed by: Peter Schaefer Signed: 

Filing: Correspondence File



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Re: 4255 MacArthur Boulevard
Oakland, California
SAP Code 135701
Incident No. 98995758
ACEH Case No. RO0000486

Dear Mr. Wickham:

The attached document is provided for your review and comment. Upon information and belief, I declare, under penalty of perjury, that the information contained in the attached document is true and correct.

As always, please feel free to contact me directly at (425) 413-1164 with any questions or concerns.

Sincerely,
Shell Oil Products US

A handwritten signature in black ink, appearing to read 'Perry Pineda', is located below the typed name.

Perry Pineda
Senior Environmental Program Manager



CORRECTIVE ACTION PLAN

**FORMER SHELL SERVICE STATION
4255 MACARTHUR BOULEVARD
OAKLAND, CALIFORNIA**

**SAP CODE 135701
INCIDENT NO. 98995758
AGENCY NO. RO0000486**

**FEBRUARY 13, 2015
REF. NO. 240524 (31)**

This report is printed on recycled paper.

**Prepared by:
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TABLE OF CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	I
1.0 INTRODUCTION	1
2.0 EVALUATION OF REMEDIAL ALTERNATIVES.....	1
2.1 OBJECTIVES	1
2.2 EXCAVATION.....	2
2.2.1 FEASIBILITY AND COST EFFECTIVENESS.....	2
2.2.2 RECOMMENDATION	4
2.3 ISCO	4
2.3.1 FEASIBILITY AND COST EFFECTIVENESS.....	5
2.4 DPE.....	6
2.4.1 FEASIBILITY AND COST EFFECTIVENESS.....	7
2.5 SURFACTANT FLUSHING.....	8
2.5.1 FEASIBILITY AND COST EFFECTIVENESS.....	9
2.6 ISEB.....	9
2.6.1 FEASIBILITY AND COST EFFECTIVENESS.....	10
2.7 MNA.....	11
2.7.1 FEASIBILITY AND COST EFFECTIVENESS.....	11
2.7.2 RECOMMENDATION	12
2.8 REMEDIAL ALTERNATIVE COST COMPARISON.....	12
3.0 RECOMMENDATIONS.....	13

LIST OF FIGURES
(Following Text)

- FIGURE 1 VICINITY MAP
- FIGURE 2 SITE PLAN
- FIGURE 3 GEOLOGIC CROSS SECTION A-A'
- FIGURE 4 GEOLOGIC CROSS SECTION B-B'

LIST OF TABLES
(Following Text)

- TABLE 1 HISTORICAL SOIL ANALYTICAL DATA

LIST OF APPENDICES

- APPENDIX A SITE HISTORY

EXECUTIVE SUMMARY

- Excavation, mobile GWE and DPE, and SPH removal have been implemented at this site. The mobile GWE and DPE were discontinued due to decreased mass removal.
- The extent of COC impacts in soil is defined. COC detections in soil at depths below groundwater in wells and borings are likely attributable to SPHs and impacted groundwater.
- The extent of COC impacts in groundwater is adequately defined and there are no potential-impacted groundwater receptors.
- CRA's soil vapor investigation concluded that no unacceptable risk or hazard to on- or off-site receptors exists with current land use.
- CRA evaluated five remedial alternatives:
 - Excavation,
 - ISCO,
 - DPE,
 - Surfactant flushing,
 - ISEB, and
 - MNA.
- Because there is no unacceptable risk to receptors, MNA is the most appropriate remedial alternative with current land use and CRA recommends continued SPH removal and semiannual groundwater monitoring to further establish groundwater concentration trends.
- Excavation appears to be the most effective remediation option for addressing potential future land use; however, excavation will not be cost effective on site unless it is conducted concurrently with site redevelopment and is not possible off site with current site uses. Excavation would be evaluated if specific risks which cannot be mitigated in a more cost-effective manner are identified based on approved redevelopment plans.
- Depending on land use, mitigation may be a more appropriate option than active remediation. CRA recommends evaluating this option, along with possible remedial options, once development plans are approved.

1.0 INTRODUCTION

Conestoga-Rovers & Associates (CRA) prepared this *Corrective Action Plan* (CAP) on behalf of Equilon Enterprises LLC dba Shell Oil Products US (Shell), as requested in Alameda County Environmental Health's (ACEH's) November 24, 2014 letter. ACEH's January 29, 2015 electronic correspondence extended the due date for the CAP to February 13, 2015.

The site is a former Shell Service Station located on the western corner of MacArthur Boulevard and High Street in Oakland, California (Figure 1). Currently the site is a vacant lot. The former site layout consisted of a kiosk, three underground storage tanks, and three dispenser islands (Figure 2). The area surrounding the site is of mixed commercial and residential use. Shell has been informed that there may be plans for redevelopment.

A summary of previous work performed at the site and additional background information is contained in Appendix A.

2.0 EVALUATION OF REMEDIAL ALTERNATIVES

2.1 OBJECTIVES

Typical remedial action objectives are to implement the most prudent, cost-effective, and environmentally sustainable remediation approach to protect human health, groundwater quality, and other sensitive receptors. CRA's December 12, 2013 *Subsurface Investigation Report* summarized soil vapor investigation data and concluded that there was no human health risk on or off site with current site use. Historical groundwater monitoring has established that the separate-phase hydrocarbon (SPH) and dissolved-phase plumes are stable to declining and delineated to the extent practical.

The remedial alternatives CRA considered are:

- Excavation,
- In-situ chemical oxidation (ISCO),
- Dual phase extraction (DPE),
- Surfactant flushing,
- In-situ enhanced biodegradation (ISEB), and
- Monitored natural attenuation (MNA).

CRA evaluates each remedial alternative based on technical feasibility. The alternatives that are retained for consideration are then compared on the basis of cost effectiveness and environmental sustainability. Each alternative evaluated assumes standard permitting conditions and local ordinances that are not overly restrictive such that cost-effective of each applicable remedial alternative is compromised. CRA has made inquiries with permitting agencies regarding general requirements to include in this evaluation of alternatives and evaluated potential constructability issues at the site.

2.2 EXCAVATION

Excavation is a proven remedial technique to remove residual petroleum hydrocarbon mass to afford soil and groundwater clean up. Excavation would be the fastest method for removing hydrocarbon mass in soil. Dissolved-phased hydrocarbons should attenuate rapidly once the bulk of the source material is removed. The addition of an amendment to the backfill material may also enhance the natural biodegradation process.

Excavation is typically a high safety risk activity that requires engineered shoring and bracing systems or side sloping of the excavation to assure protection of health, life, and property.

2.2.1 FEASIBILITY AND COST EFFECTIVENESS

Excavation is a technically feasible active remedial option for reducing the mass of hydrocarbons. Constituent of concern (COC) detections that exceeded the following criteria are summarized in the table below.

- San Francisco Bay Regional Water Quality Control Board (RWQCB) environmental screening level (ESL)¹ for soils at sites with commercial land use, where groundwater is not a current or potential source of drinking water,
- California State Water Resources Control Board (SWRCB) *Low-Threat Underground Storage Tank Closure Policy* (Policy) media-specific soil vapor criteria for demonstrating a bioattenuation zone, or
- SWRCB Policy media-specific criteria for direct contact and outdoor air exposure with commercial land use.

¹ *User's Guide: Derivation and Application of Environmental Screening Levels*, RWQCB, Interim Final 2013

TABLE A			
Location ID (depth)	Concentrations exceeding RWQCB ESLs for soils with commercial land use (mg/kg)	Exceeds SWRCB's Policy media-specific soil vapor criteria for demonstrating a bioattenuation zone (mg/kg)	Exceeds SWRCB Policy media-specific criteria for direct contact and outdoor air exposure with commercial land use (mg/kg)
MW-3 (11.3 fbg)	1,700 TPHg, 33 E, 44 X.		
MW-3 (16 fbg)	610 TPHg, 3.3 B, 6.9 E, 33 X.		
BH-E (5 fbg)	5,900 TPHg, 23 B, 160 T, 120 E, 430 X.	5,900 TPHg	23 B, 120 E
TP-5 (10 fbg)	1.7 B		
P-3 (8 fbg)	5.2 E, 13 X.		
SB-7 (5 fbg)		220 TPHg	
SB-7 (10 fbg)	2,600 TPHg, 13 B, 17 T, 45 E, 270 X.		13 B
SB-7 (15 fbg)	1.4 B, 13 X.		
MW-6 (10 fbg)	17 B		17 B
MW-7 (15 fbg)	1.4 B, 16 E, 43 X.		
MW-9 (10 fbg)	552 TPHg, 4.7 E, 20 X.		
SB-11 (5 fbg)		210 TPHg	
SB-11 (16 fbg)	1,700 TPHg		
SB-12 (10 fbg)	6.3 E, 15.1 X.		

mg/kg = Milligrams per kilogram

fbg = Feet below grade

TPHg = Total petroleum hydrocarbons as gasoline

B = Benzene

T = Toluene

E = Ethylbenzene

X = Total xylenes

Soils with COCs exceeding both ESLs and Policy criteria are primarily located around the former dispenser islands and USTs adjacent to the area that was excavated to between 10 and 14 fbg when the station was decommissioned in 2003. Other soil

detections exceeding only ESLs are likely associated with groundwater impacts or the capillary fringe or “smear zone” in the area of the SPH plume, which extends from well MW-3 to MW-4 primarily at depths of 3 to 14 fbg. Significant soil impacts are in the fine-grained soils from 5 to 16 fbg. Figure 2 shows the soil sample locations and Table 1 presents the historical soil analytical data. Geologic cross sections are presented on Figures 3 and 4.

Excavation of off-site soils would disrupt and require closure of the adjacent mobile home park. In addition, excavation of on-site and/or off-site soils would be disruptive to nearby residences due to nuisance noise, increased traffic in an already busy area, and potentially unsafe odors.

Excavation would be costly and consume a significant amount of raw materials (fuel and grease for equipment and transport trucks); generate a significant amount of noise, thermal pollution, and greenhouse gas emissions from excavation activities; and generate water that would require disposal and/or treatment processes from the excavation. These considerations make excavation unfavorable for environmental sustainability.

2.2.2 RECOMMENDATION

Excavation has been conducted at the site previously and is a feasible approach for removing residual hydrocarbon mass. Excavation is typically the fastest method for removing hydrocarbon mass in soil and smear zone, but is very expensive. Excavation is not typically considered an environmentally sustainable approach given that it displaces the impact (to a landfill) and the process consumes natural resources, generates greenhouse gases, and generates other environmental nuisances (noise, dust, traffic, etc.). As noted, currently no receptors are at risk. Excavation appears to be the most effective remediation option; however, excavation will not be cost effective on site unless it is conducted concurrently with site redevelopment and is not possible off site with current site uses. Therefore, excavation is not warranted at this time.

2.3 ISCO

ISCO involves applying agents to facilitate in-situ chemical oxidation of the dissolved-phase COCs within the soil matrix. Typical oxidizing agents include permanganate (MnO_4^-), Fenton's reagent (hydrogen peroxide [H_2O_2] and ferrous iron [Fe^{+2}]), ozone (O_3), and sodium persulfate ($S_2O_8^{2-}$). Persulfate, a strong oxidizer, is

commonly applied in the form of sodium persulfate to effectively buffer the pH.² Since persulfate is also more persistent than H₂O₂ or ozone, the radius of influence would be greater. These oxidants react with a wide range of organic compounds. Successful treatment is dependent on delivery of sufficient amounts of oxidant to the impacted soil and groundwater and making "contact" with contaminant mass. The treatment success is also dependent on the soil chemistry. A critical factor in the evaluation of ISCO treatment is determining the dosages of oxidant that are required to effectively oxidize the hydrocarbon compounds present (referred to as stoichiometric demand) as well as the competing reactions. The competing reactions are typically caused by the presence of natural organic materials such as humates and fulvates, as well as reduced metal species. The consumption of oxidants by these non-target compounds is defined as natural oxidant demand. In order to determine the optimum dosage, bench scale and in-situ pilot test treatability studies are required. Large quantities of oxidizing chemicals require regulated handling and pose health and safety concerns. Chemical oxidation may cause mobilization of metals, possible formation of toxic by-products, heat, gas, and biological perturbation.

MnO₄⁻ does not exhibit a high solubility and requires a large delivery volume. Fenton's reagent is common for the treatment of volatile organic compounds (VOCs). However, the Fenton's reagent reaction is exothermic, and the heat generated can cause volatilization of the VOCs. It also requires a pH of 5 and ferrous sulfate catalyst. Base catalyzed sodium persulfate can be injected at concentrations up to 30 percent. It can oxidize a wide range of organic compounds including VOCs and will continue to oxidize organic material for up to a month.

2.3.1 FEASIBILITY AND COST EFFECTIVENESS

ISCO effectiveness is dependent on making sufficient reagent contact with residual source mass, which requires distribution/dispersion of the reagent in the soil formation where the mass resides. The soil analytical data indicates the residual source mass resides in and at the bottom of the silt/clay layer. The low permeability silt/clay layer is not conducive for distributing a reagent. Residual mass at the bottom of the silt/clay layer may be accessible, but there is no assurance for controlling the contact between the reagent and the mass. Although bench-scale testing can help estimate the amount of reagent needed to oxidize the target mass, the actual amount (and overall implementation cost) tends to be unpredictable due to actual amount source mass, subsurface distribution limitations, and competing organics. It is CRA's experience that

² Interstate Technology & Regulatory Council In Situ Chemical Oxidation Team, 2005

ISCO is an approach best suited for spot polish remediation in homogenous soil formations, which is not the case for this site.

In regards to environmental sustainability, ISCO would require travel and transport (and therefore fossil fuel consumption and greenhouse gas emissions), electricity for injection equipment, and potentially generate excessive unwarranted waste requiring disposal. These elements result in excessive and unwarranted utilization of natural resources and greenhouse gas emissions when historical groundwater monitoring has already established that the dissolved-phase plume is stable to shrinking in extent. It has also been demonstrated that there is no identified receptor at risk from the residual dissolved-phase plume associated with the site; thus the plume does not pose a risk to human health, nearby receptors, or the environment.

ISCO is not considered feasible and is removed from further consideration.

2.4 **DPE**

DPE consists of the vacuum-enhanced groundwater extraction (GWE) performed simultaneously with soil vapor extraction (SVE). GWE recovers the dissolved-phase COCs and draws down groundwater. SVE removes COCs adsorbed in the vadose zone and in deeper, previously saturated soils exposed by the groundwater drawdown in the vapor phase. The extended dewatering of the saturated zone attained through GWE also allows VOCs adsorbed to previously saturated soil to be removed in the vapor phase. The applied vacuum and soil vapor flow typically increases the groundwater yield compared to standard GWE in low to moderate permeability formations. In addition, GWE may provide hydraulic control of the dissolved-phase COC plume and remove dissolved-phase mass.

DPE system components include in-well pumps, an equipment compound for a skid- or trailer-mounted SVE unit (with vapor treatment capability), extracted groundwater temporary storage, and treatment facilities with treated water discharge into the site's combined storm drain and sanitary sewer lateral (under a permit obtained from San Francisco Public Utilities Commission). To minimize interference with the existing mobile home park, underground extracted groundwater and vapor conveyance piping and associated conduits would be installed to existing wells or new DPE extraction wells.

Typical SVE unit equipment includes a vapor/liquid separator, a vacuum blower (typically a liquid-ring pump or rotary claw/lobe blower), and a vapor treatment device. The vapor extraction device (blower) would be sized based on the radius of

influence (ROI), recovered vapor flow rate, and applied vacuum of the DPE wells observed during pilot testing. Extracted VOCs are typically treated by a thermal or catalytic oxidizer, or an internal combustion engine, and occasionally (as a “polish”) by granulated activated carbon. The extracted-VOC treatment device is selected based on the influent flow rate, VOC concentrations, air quality agency requirements, and expected DPE system operational duration. The treated soil vapor would be discharged to the atmosphere under the authorization of a permit to operate issued by the Bay Area Air Quality Management District.

DPE typically requires a separate electrical power service. For oxidizer supplemental fuel needs, electrical power, natural gas, or propane is typically utilized.

2.4.1 FEASIBILITY AND COST EFFECTIVENESS

A short-term SVE test on MW-1 and MW-2 was conducted on September 25, 1997 using an internal combustion engine and mobile DPE events were conducted from November 2000 to June 2001, from April 2002 to September 2003, from July 2003 to September 2003, and during September 2009 using a vacuum truck. The vapor flow rate during these events ranged from 0.8 to 14 cubic feet per minute (cfm; at 100 inches of water column) and 0.5 to 27.3 cfm (at unknown vacuum), respectively. The groundwater yield from the wells was also low. The equipment/methodology used for these events is not considered ideal for data collection and feasibility assessment.

The silt/clay layer where residual mass resides is not ideal for DPE, but some residual mass may be recoverable at a higher vacuum. Recovery of residual mass at the bottom of the silt/clay layer or trapped SPHs in the water-bearing zone may be feasible by DPE. A pilot test using more conventional DPE equipment and methods would be necessary to confirm feasibility. A pilot test would target MW-2, MW-3, and MW-6. The site is currently an empty lot, so there are no space restrictions. Hose and temporary speed bump-type hose covers would be used for wells MW-2 and MW-6. If DPE proved feasible and mass recovery effective, then the test could be extended or a temporary system could be fashioned at the site for extended operation. A one-week DPE pilot test is estimated to cost \$65,000. Extended testing is estimated to cost \$15,000 per week.

The feasibility of DPE to remove the residual mass from the silt/clay layer is considered marginal. Currently, receptors are not at risk. The future use/development plan for the site is unknown at this time. Therefore, the future-use risk scenario cannot be assessed. It is also unknown, but likely doubtful, whether DPE would adequately mitigate those future risks given the marginal performance of previously conducted DPE at the site.

In regards to environmental sustainability, a DPE system would not meet typical environmental sustainability criteria based on the substantial electricity use; excessive travel and transport to implement, operate, maintain, and decommission the DPE/SVE system; generate unwarranted waste requiring disposal (treated water and carbon consumption); limited sanitary sewer/wastewater treatment plant capacity; increased noise pollution; and substantial resource (raw materials, electricity, etc.) consumption. A significant amount of greenhouse gas emissions would result from electricity usage, recovered vapor destruction, and vehicle use for the implementation and operation of the DPE system.

DPE is not recommended and is removed from further consideration.

2.5 SURFACTANT FLUSHING

Surfactants are chemical agents that greatly enhance the solubility of organic contaminants in the saturated zone. They are also able to reduce the interfacial tension (IFT) between the aqueous and organic contaminants in order to mobilize the organic contaminants. IFT is the force existing where two fluids meet that keeps them as separate fluids. The primary objective of surfactant flushing is to remove the maximum amount of contaminant with a minimum amount of chemicals and in a minimal time while maintaining hydraulic control over the injected surfactant and contaminant. The use of surfactants in a flooding configuration enhances the solubility and mobility of SPH trapped in pore spaces and greatly increases the hydrocarbon removal rate achievable with DPE application.

A pre-determined volume of food-grade, biodegradable surfactant would be injected directly into a well that either contains measurable SPH or is located in an area in which dissolved contaminant concentrations are indicative of residual SPH sorbed to soil. The mixture of groundwater, mobilized SPH, and surfactant would then be extracted from the well after a short period of equilibration, typically at least 24 hours, but not greater than 48 hours. Fluid removal would continue until SPH and surfactant can no longer be observed or measured in the fluid extracted from the well.

A typical surfactant solution consists of approximately 2 percent surfactant in water. Surfactants such as Ivey-sol® are non-toxic, biodegradable, and engineered specifically based upon analysis of SPH samples.

2.5.1 **FEASIBILITY AND COST EFFECTIVENESS**

This approach would consist of injecting a biodegradable, food grade, surfactant into wells MW-2, MW-3, and MW-4, followed by a flush of potable water. After a 24-hour “rest”, CRA would extract groundwater and surfactant from the wells using a vacuum truck or other means until a requisite volume has been recovered or field observations (no or minimal bubbling) indicates the surfactant has been recovered.

This approach may remove residual, trapped SPHs (if any) around the wells. However, it would not address residual mass in the silt/clay layer. The residual mass would continue feeding the dissolved-phase plumes. Furthermore, mobile GWE and DPE data have shown groundwater yield to be minimal and recovery is very slow, which would reduce the likelihood of clearing the surfactant.

Surfactant injection would require travel and transport (and therefore fossil fuel consumption and greenhouse gas emissions) to perform each event, electricity for oxygen or air injection equipment, and generate excessive unwarranted waste. These elements would also result in excessive and unwarranted utilization of natural resources and greenhouse gas emissions.

Surfactant injection is not considered feasible and is removed from further consideration.

2.6 **ISEB**

ISEB (aerobic or anaerobic) is a treatment process that metabolizes COCs into less toxic or non-toxic compounds utilizing naturally occurring or injecting supplemental microorganisms. The microorganisms utilize the hydrocarbons as a source of carbon and energy. In order to stimulate biological activity, biodegradation processes can be enhanced by the injection of oxygen (air or oxygen releasing compound [ORC]), nutrients, microbial cultures, suitable electron acceptors, and carbon/energy sources. Site conditions can be manipulated to enhance in-situ biodegradation processes and speed up degradation rates of site COCs. In this process, several techniques can be applied to enhance biodegradation of the COCs, such as:

- Injection of air, oxygen, or ORC; or magnesium, calcium, or hydrogen peroxide to enhance biodegradation of the COCs under aerobic conditions.
- Injection of an organic substrate such as soy-lactate or hydrogen-releasing compound (HRC) to enhance biodegradation.

- Nutrient supplementation with suitable nitrogen and phosphorus sources to enhance biodegradation of contaminants by indigenous microbial populations.
- Injection of nitrate and/or sulfate to enhance the biodegradation of hydrocarbons under anaerobic conditions by denitrification/sulfate reduction.
- Bioaugmentation by injection of microbial cultures to improve the extent of the microbial populations in degrading the COCs.

One or a combination of these techniques can be applied. Technologies available for enhancing aerobic biodegradation processes within the shallow soil horizon are ORC treatment, biosparging, and denitrification. Biosparging and ORC are both technologies that supplement oxygen to enhance aerobic biodegradation. The injected oxygen would enhance the growth and metabolic activity of COC-degrading microorganisms, resulting in the oxidation of COCs to primarily carbon dioxide and water.

Typically, the affected media becomes nutrient deficient during enhanced biodegradation. Therefore, nutrient supplementation is typically warranted. Microbial augmentation is used when the natural microbial population has demonstrated to be in a stable or declining condition and need to be enhanced to facilitate continued biodegradation processes.

2.6.1 FEASIBILITY AND COST EFFECTIVENESS

ISEB is typically implemented at sites where residual mass has been addressed (to the extent practicable) and a polish of dissolved-phase impacts is required. Distribution and dispersion feasibility issues are the same as with ISCO. For this site, injection of an amendment into the lower sandy water-bearing zone appears feasible. However, ISEB would not address the residual mass in the silt/clay layer. The residual mass would continue feeding the dissolved-phase plumes.

ISEB would require travel and transport (and therefore fossil fuel consumption and greenhouse gas emissions) to perform each event, electricity for oxygen or air injection equipment, and generate excessive unwarranted waste. These elements would also result in excessive and unwarranted use of natural resources and greenhouse gas emissions.

ISEB is not considered feasible and is removed from further consideration.

2.7 MNA

MNA consists of allowing hydrocarbons and oxygenates to biodegrade naturally due to physical, chemical, and biological processes, while implementing long-term groundwater monitoring to establish trends of degradation. The processes involved in natural attenuation of petroleum hydrocarbons include aerobic and anaerobic biodegradation, dispersion, volatilization, and adsorption.³ The primary line of evidence to demonstrate the occurrence of natural attenuation in groundwater is the plume structure. A stable and/or shrinking plume is the primary indicator that natural attenuation of hydrocarbons and oxygenates is occurring at the site. To evaluate the applicability of using remediation by natural attenuation, the site must be adequately assessed and groundwater monitoring locations must include an up-gradient monitoring point, monitoring points within the COC plume, and a down-gradient monitoring point.

2.7.1 FEASIBILITY AND COST EFFECTIVENESS

MNA allows hydrocarbons to degrade naturally and does not require active remediation. MNA is appropriate when site data indicates that no receptors are at risk. The site is in a portion of the East Bay Plain not designated for municipal use. CRA's 2013 soil vapor investigation demonstrated the site has been adequately assessed and that is unlikely that residual petroleum hydrocarbon concentrations pose an unacceptable risk to on- or off-site receptors with current site use. In addition, periodic monitoring demonstrates that the SPH and groundwater plumes are stable or shrinking.

This technology does not require the removal or treatment of vapor-phase or aqueous-phase hydrocarbons, and has limited capital installation costs. Natural attenuation of hydrocarbons may take a significantly longer time than other remedial alternatives, but additional investigations to assess soil vapor risk, down-gradient groundwater delineation, and the decreasing concentration trends support MNA as an appropriate remedial alternative.

Groundwater monitoring to assess the MNA effectiveness is estimated to cost approximately \$12,000 per year. Assuming ten additional years of semiannual MNA groundwater monitoring, the total cost for would be \$120,000. Well destructions are estimated at \$47,000. The total estimated cost for this alternative is \$167,000.

³ Wiedemeier, T.H., Rifai, H.S., Newell, C.J., Wilson, J.T., 1999, *Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface*, John Wiley and Sons.

2.7.2 RECOMMENDATION

MNA is the most feasible and cost-effective remedial alternative with current land use. From a life-cycle perspective, MNA is a cost effective and environmentally sustainable alternative.

2.8 REMEDIAL ALTERNATIVE COST COMPARISON

The table below compares the approximate cost to perform the remedial alternatives retained for consideration in the evaluation above.

<i>TABLE B</i>		
	<i>Excavation</i>	<i>MNA</i>
Feasibility	Good	Good
Effectiveness	Poor - Cost	Good
Well Reinstallation Cost	\$40,000	N/A
Soil Vapor Probe Reinstallation Cost	\$30,000	N/A
Excavation Cost	\$1,200,000	N/A
Annual Groundwater Monitoring Cost	\$24,000 (1st year total for quarterly monitoring) \$12,000 (2nd year total for semiannual monitoring)	\$12,000 (per year for semiannual monitoring)
Post-Remediation Groundwater Monitoring Duration	2 years	N/A
Total Groundwater Monitoring Duration	2 years	10 years
Total Groundwater Monitoring Cost	\$36,000	\$120,000
Soil Vapor Sampling	\$20,000	N/A
Well Abandonment	\$70,000	\$47,000
Total Cost	\$1,396,000	\$167,000
Recommended Alternative		X

N/A = Not applicable

3.0 RECOMMENDATIONS

As noted above, because there is no unacceptable risk or hazard to on- or off-site receptors, MNA is the most appropriate remedial alternative with current site use. CRA recommends continuing SPH removal and monitoring groundwater concentration trends.

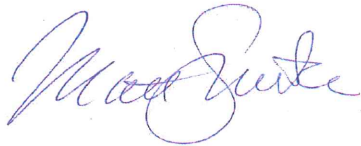
Additional remediation may be warranted as the most effective remediation option, depending on planned development and future land use; however, excavation will not be cost effective or environmentally sustainable unless it is conducted concurrently with site redevelopment. Excavation or mitigation measures, such as vapor barriers, may be implemented to address potential risks identified based on approved redevelopment plans.

CRA recommends implementing MNA at this time and reviewing any development plans when they become available to determine the appropriate course should land use change.

All of Which is Respectfully Submitted,
CONESTOGA-ROVERS & ASSOCIATES



Peter Schaefer, CEG, CHG

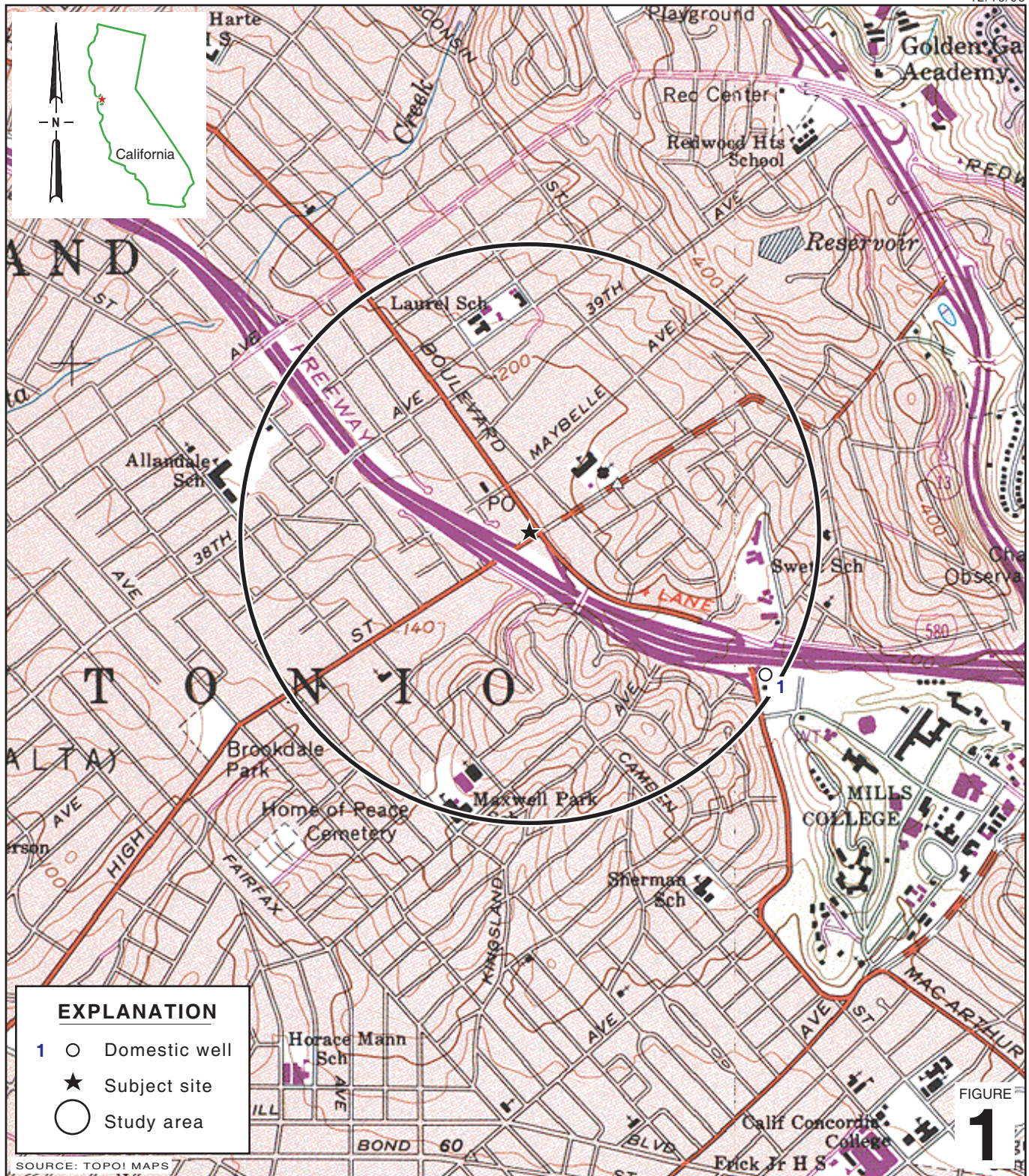


Matthew B. Smith, PE



DATED: 2/13/15

FIGURES



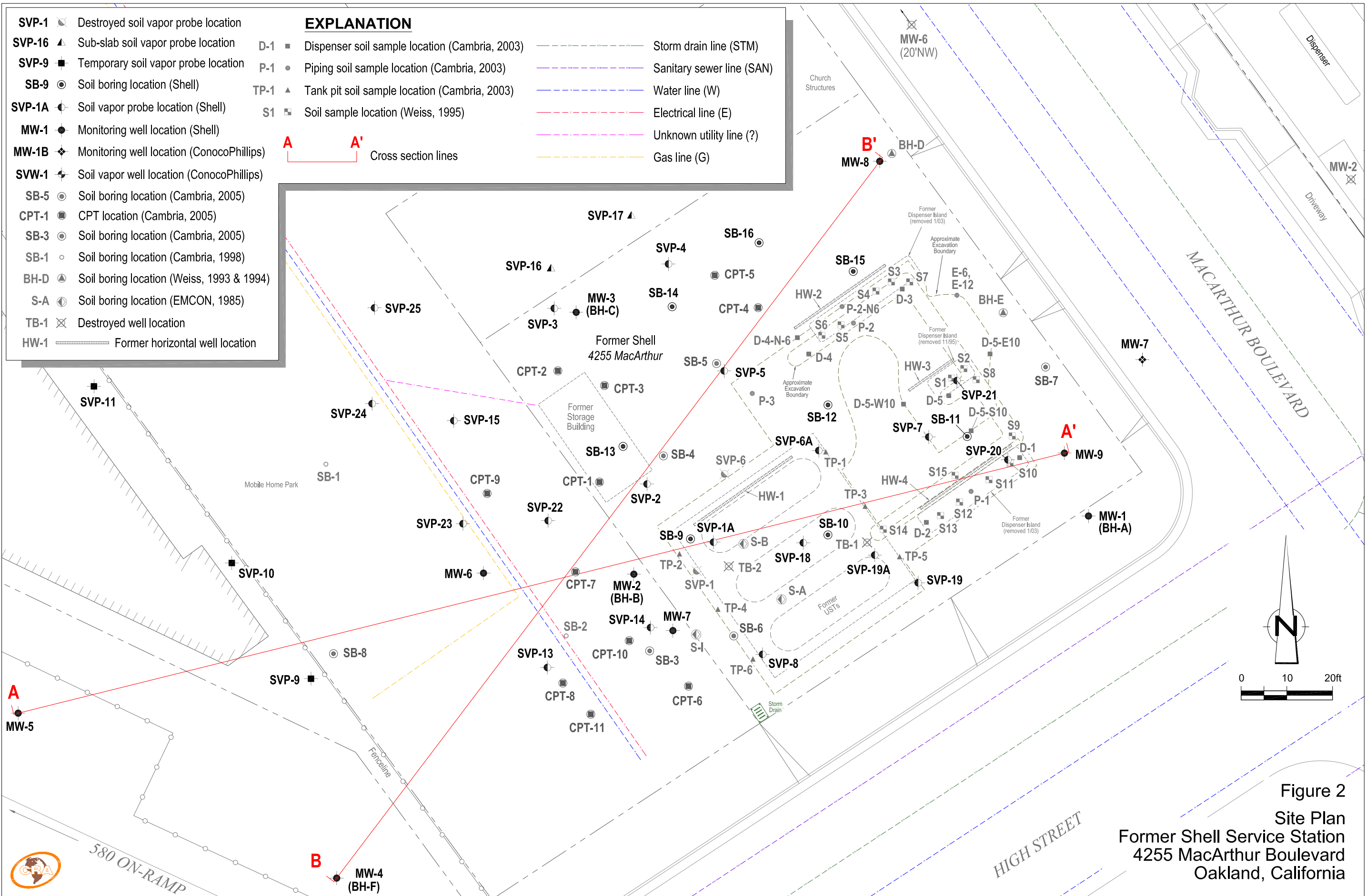
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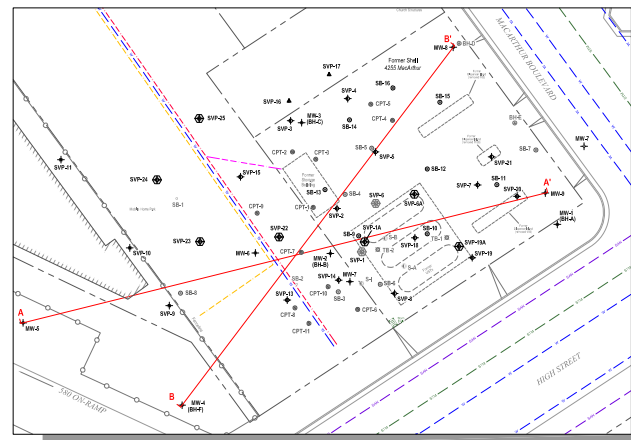
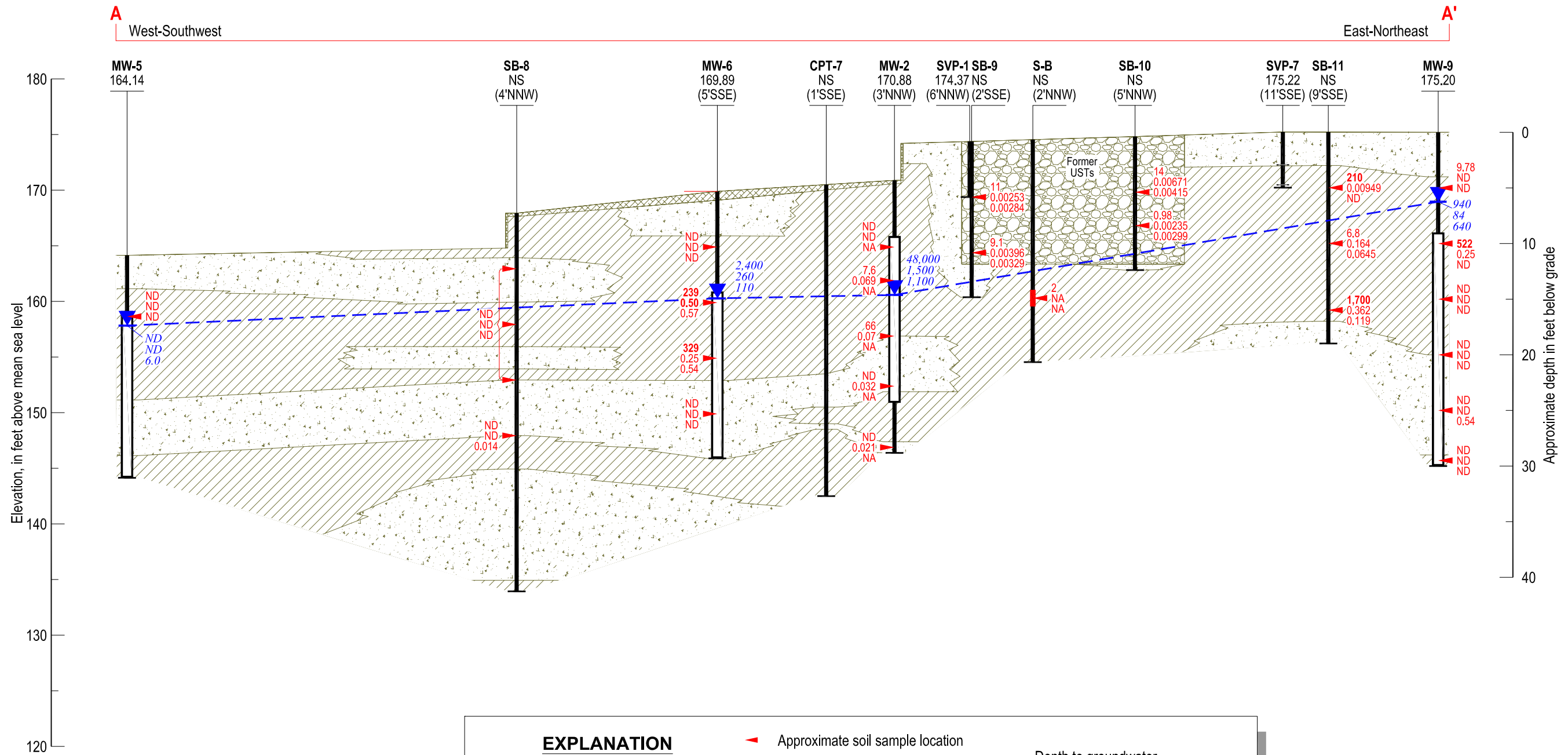
Former Shell Service Station
 4255 MacArthur Boulevard
 Oakland, California



CONESTOGA-ROVERS & ASSOCIATES

Vicinity Map





EXPLANATION

ID	Well or boring designation	▲	Approximate soil sample location	▼	Depth to groundwater (01/23/2013)
Elev.	Top of casing elevation, in feet above mean sea level (where available)	↕	Interval of discrete soil sample results (grouped for clarity)	---	Inferred groundwater depth (01/23/2013)
(offset)	Offset distance and direction projected to cross-section line	▬	Soil sample location range	TPHg	Concentrations in soil, in milligrams per kilogram (mg/kg)
NS	Not surveyed	TPHg	Concentrations in soil, in milligrams per kilogram (mg/kg)	Benzene	Concentrations in groundwater, in micrograms per liter (µg/L); sampled 01/23/2013
▬	Groundwater monitoring well or soil boring	MTBE	Concentrations in soil, in milligrams per kilogram (mg/kg)	NA	Not analyzed
▬	Well screen interval	ND	Not detected for any or all constituents	NDa	Not detected; elevated reporting limit
▬	Bottom of boring	▨	Asphalt/Baserock	▨	UST Pit
fbg	Feet below grade	▨	Fine-Grained Soils (CL, ML)	▨	Coarse-Grained Soils (GC, GM, GW, GP, SM, SW)

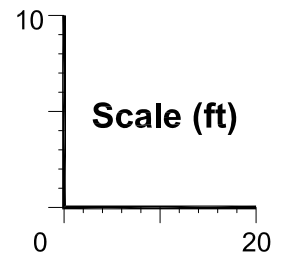
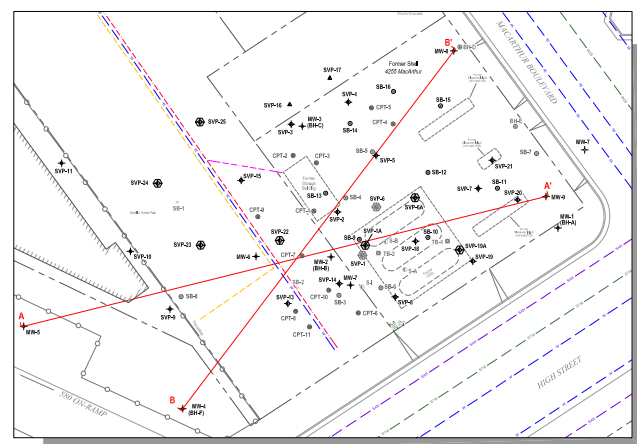
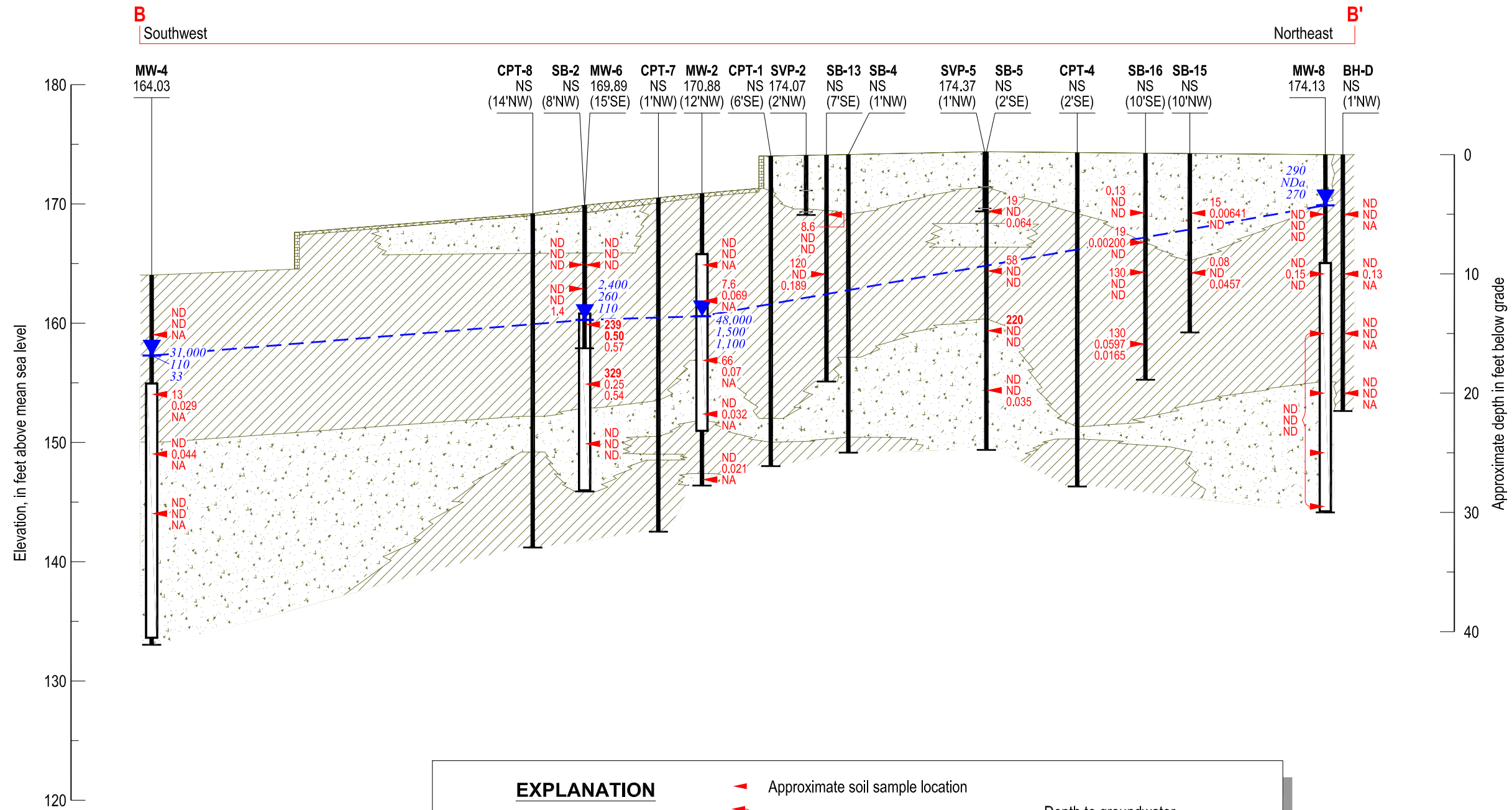


Figure 3
Geologic Cross Section A-A'
Former Shell Service Station
4255 MacArthur Boulevard
Oakland, California





EXPLANATION

ID	Well or boring designation	◀	Approximate soil sample location	▼	Depth to groundwater (01/23/2013)
Elev.	Top of casing elevation, in feet above mean sea level (where available)	↕	Interval of discrete soil sample results (grouped for clarity)	---	Inferred groundwater depth (01/23/2013)
(offset)	Offset distance and direction projected to cross-section line	TPHg	Concentrations in soil, in milligrams per kilogram (mg/kg)	TPHg	Concentrations in groundwater, in micrograms per liter (µg/L); sampled 01/23/2013
NS	Not surveyed	Benzene	NA	Not analyzed	Benzene
▬	Groundwater monitoring well or soil boring	MTBE	ND	Not detected for any or all constituents	MTBE
▬	Well screen interval				NDa
▬	Bottom of boring				
fbg	Feet below grade	▨	= Asphalt/Baserock	▨	= Coarse-Grained Soils (GC, GM, GW, GP, SC, SP, SM, SW)
		▨	= Fine-Grained Soils (CH, CL, MH, ML)		

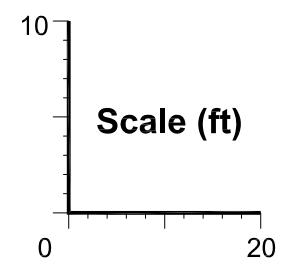


Figure 4
 Geologic Cross Section B-B'
 Former Shell Service Station
 4255 MacArthur Boulevard
 Oakland, California



TABLE

TABLE 1
HISTORICAL SOIL ANALYTICAL DATA
FORMER SHELL SERVICE STATION
4255 MACARTHUR BOULEVARD, OAKLAND, CALIFORNIA

<i>Sample ID</i>	<i>Date</i>	<i>Depth (ftg)</i>	<i>TPHg (mg/kg)</i>	<i>B (mg/kg)</i>	<i>T (mg/kg)</i>	<i>E (mg/kg)</i>	<i>X (mg/kg)</i>	<i>MTBE (mg/kg)</i>	<i>TBA (mg/kg)</i>	<i>DIPE (mg/kg)</i>	<i>ETBE (mg/kg)</i>	<i>TAME (mg/kg)</i>	<i>Total Lead (mg/kg)</i>
S-1	6/10/1985	13.5-15	ND a	---	---	---	---	---	---	---	---	---	---
S-1	6/10/1985	18.5-20	ND a	---	---	---	---	---	---	---	---	---	---
S-A	6/10/1985	4-5.5	15,800 a	---	---	---	---	---	---	---	---	---	---
S-A	6/10/1985	8.5-10	2 a	---	---	---	---	---	---	---	---	---	---
S-A	6/10/1985	10-11.5	ND a	---	---	---	---	---	---	---	---	---	---
S-B	6/10/1985	13.5-15	2 a	---	---	---	---	---	---	---	---	---	---
BH-A (MW-1)	11/3/1993	6	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-A (MW-1)	11/3/1993	10.5	24	0.4	0.028	0.12	0.62	---	---	---	---	---	---
BH-A (MW-1)	11/3/1993	14	26	0.028	0.02	0.062	0.32	---	---	---	---	---	---
BH-A (MW-1)	11/3/1993	18	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-A (MW-1)	11/3/1993	22	<1	0.0063	0.0094	0.0097	0.057	---	---	---	---	---	---
BH-B (MW-2)	11/3/1993	6	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-B (MW-2)	11/3/1993	9	7.6	0.069	<0.0025	0.044	0.11	---	---	---	---	---	---
BH-B (MW-2)	11/3/1993	14	66	0.07	0.44	0.53	2.6	---	---	---	---	---	---
BH-B (MW-2)	11/3/1993	18.5	<1	0.032	0.012	0.0042	0.02	---	---	---	---	---	---
BH-B (MW-2)	11/3/1993	24	<1	0.021	0.023	0.0037	0.021	---	---	---	---	---	---
BH-C (MW-3)	11/4/1993	6.5	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-C (MW-3)	11/4/1993	11.3	1,700	1.1	2.5	33	44	---	---	---	---	---	---
BH-C (MW-3)	11/4/1993	16	610	3.3	5.7	6.9	33	---	---	---	---	---	---
BH-C (MW-3)	11/4/1993	22.5	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-D	11/3/1994	5	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-D	11/3/1994	10	<1	0.13	<0.0025	0.011	0.01	---	---	---	---	---	---
BH-D	11/3/1994	15	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-D	11/3/1994	20	<1	<0.0025	<0.0025	<0.0025	0.015	---	---	---	---	---	---
BH-E	11/3/1994	5	5,900	23	160	120	430	---	---	---	---	---	---
BH-E	11/3/1994	10	<1	0.031	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-E	11/3/1994	15	<1	0.0053	0.0033	<0.0025	0.007	---	---	---	---	---	---
BH-E	11/3/1994	20	<1	<0.0025	0.0077	<0.0025	0.015	---	---	---	---	---	---
BH-F (MW-4)	11/3/1994	5	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
BH-F (MW-4)	11/3/1994	10	13	0.029	0.14	0.17	0.54	---	---	---	---	---	---
BH-F (MW-4)	11/3/1994	15	<1	0.044	0.0033	0.017	0.032	---	---	---	---	---	---
BH-F (MW-4)	11/3/1994	20	<1	<0.0025	<0.0025	<0.0025	<0.0025	---	---	---	---	---	---
S1	11/17/1995	3	3,200	<5.0	27	39	250	---	---	---	---	---	---
S2	11/17/1995	2	7,800	<15	51	71	540	---	---	---	---	---	---
S3	11/17/1995	2	7,300	<12	14	42	500	---	---	---	---	---	---
S4	11/17/1995	2.5	1.5	0.052	<0.005	0.021	0.0069	---	---	---	---	---	---
S5	11/17/1995	3	1.1	<0.005	<0.005	<0.005	0.013	---	---	---	---	---	---
S6	11/17/1995	2.5	1.1	0.19	<0.005	0.046	0.020	---	---	---	---	---	---
S7	11/17/1995	3	10	0.12	0.030	0.24	0.98	---	---	---	---	---	---
S8	11/17/1995	3	2,800	<5.0	5.1	25	140	---	---	---	---	---	---
S9	11/17/1995	3.5	6.5	<0.005	<0.005	<0.005	0.021	---	---	---	---	---	---
S10	11/17/1995	3.5	44	<0.05	<0.05	0.051	0.22	---	---	---	---	---	---
S11	11/17/1995	3.5	2.6	0.026	<0.005	0.011	0.014	---	---	---	---	---	---
S12	11/17/1995	4	39	0.26	<0.05	0.42	1.7	---	---	---	---	---	---
S13	11/17/1995	4	12	0.85	0.46	0.31	1.5	---	---	---	---	---	---
S14	11/17/1995	4	300	<0.5	<0.5	3.8	10	---	---	---	---	---	---

TABLE 1
HISTORICAL SOIL ANALYTICAL DATA
FORMER SHELL SERVICE STATION
4255 MACARTHUR BOULEVARD, OAKLAND, CALIFORNIA

<i>Sample ID</i>	<i>Date</i>	<i>Depth (ft)</i>	<i>TPHg (mg/kg)</i>	<i>B (mg/kg)</i>	<i>T (mg/kg)</i>	<i>E (mg/kg)</i>	<i>X (mg/kg)</i>	<i>MTBE (mg/kg)</i>	<i>TBA (mg/kg)</i>	<i>DIPE (mg/kg)</i>	<i>ETBE (mg/kg)</i>	<i>TAME (mg/kg)</i>	<i>Total Lead (mg/kg)</i>
S15	11/17/1995	5	210	0.28	<0.25	1.9	6.4	---	---	---	---	---	---
SB-1 - 5.0	2/13/1998	5	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.025 b/<0.10	---	---	---	---	---
SB-1 - 7.0	2/13/1998	7	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.025 b/<0.10	---	---	---	---	---
SB-2 - 5.0	2/13/1998	5	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.025 b/<0.10	---	---	---	---	---
SB-2 - 7.0	2/13/1998	7	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	1.4 b/0.88	---	---	---	---	---
MW-5	11/12/2001	5.5	<1.0	<0.005	<0.005	<0.005	<0.005	<0.5	---	---	---	---	---
TP-1	1/27/2003	10.5	91	0.31	0.074	1.3	5.9	<0.5	---	---	---	---	3.35
TP-2	1/27/2003	10	2.0	<0.005	<0.005	<0.005	<0.005	<0.5	---	---	---	---	<0.500
TP-3	1/27/2003	11	<1.0	0.048	<0.005	0.010	0.0089	<0.5	---	---	---	---	1.13
TP-4	1/27/2003	10	1.6	<0.005	<0.005	<0.005	0.0086	<0.5	---	---	---	---	1.58
TP-5	1/27/2003	10	380	1.7	0.45	3.7	15	1.2	---	---	---	---	0.836
TP-6	1/27/2003	10	2.1	<0.005	<0.005	<0.005	<0.005	1.2	---	---	---	---	<0.500
D-1	1/30/2003	3	260	0.64	<0.005	3.9	5.0	1.2	---	---	---	---	5.55
D-2	1/30/2003	4	<1.0	0.0080	<0.005	0.0052	0.0081	<0.5	---	---	---	---	4.95
D-3	1/30/2003	3	130	<0.025	0.030	1.2	8.8	<0.5	---	---	---	---	5.45
D-4	1/30/2003	3	51	0.11	<0.025	0.59	0.12	<0.5	---	---	---	---	4.24
P-1	1/30/2003	3	130	0.058	<0.025	1.5	1.4	<0.5	---	---	---	---	11.3
P-2	1/30/2003	3	420	1.5	0.36	8.6	21	<0.5	---	---	---	---	4.96
P-3	1/30/2003	3	<1.0	0.0079	<0.005	0.0084	0.0050	<0.5	---	---	---	---	3.15
D-1-6.5	1/31/2003	6.5	87	0.11	<0.025	0.58	0.51	<0.5	---	---	---	---	---
D-2-5.5	1/31/2003	5.5	3.7	0.22	<0.005	0.064	0.073	0.6	---	---	---	---	---
D-3-8	1/31/2003	8	53	0.27	<0.025	0.13	0.38	<0.5	---	---	---	---	---
D-4-8	1/31/2003	8	1,100	2.2	<0.050	10	9.9	<0.5	---	---	---	---	---
D-5-6.0	1/31/2003	6	2,200	2.0	6.5	28	110	<0.5	---	---	---	---	---
P-1-5.5	1/31/2003	5.5	<1.0	<0.005	<0.005	<0.005	<0.005	<0.5	---	---	---	---	---
P-2-8	1/31/2003	8	910	1.2	<0.050	16	32	<0.5	---	---	---	---	---
P-3-8	1/31/2003	8	420	0.46	<0.050	5.2	13	<0.5	---	---	---	---	---
D-4-12	2/4/2003	12	2.9	0.19	<0.005	0.036	0.17	<0.5	---	---	---	---	---
D-4-N6	2/4/2003	6	5.5	0.024	0.10	0.025	0.11	<0.5	---	---	---	---	---
D-5-14	2/4/2003	14	<1.0	<0.005	<0.005	<0.005	<0.005	<0.5	---	---	---	---	---
D-5-S10	2/4/2003	10	<1.0	<0.005	<0.005	<0.005	<0.005	0.9	---	---	---	---	---
D-5-W10	2/4/2003	10	160	0.40	<0.025	0.035	<0.050	<0.5	---	---	---	---	---
D-5-E10	2/4/2003	10	35	0.035	<0.005	0.051	0.017	<0.5	---	---	---	---	---
P-2-12	2/4/2003	12	<1.0	<0.005	<0.005	<0.005	<0.005	<0.5	---	---	---	---	---
P-2-N6	2/4/2003	6	42	0.12	0.063	0.45	3.6	<0.5	---	---	---	---	---
E-6	2/4/2003	6	1.9	0.030	0.076	0.069	0.33	<0.5	---	---	---	---	---
E-12	2/4/2003	12	21	<0.005	<0.005	0.062	0.42	<0.5	---	---	---	---	---
SB-5	10/28/2005	5	19	<0.023	<0.023	0.11	0.030	0.064	0.083	<0.046	<0.023	<0.023	---
SB-5	10/28/2005	10	58	<0.55	<0.55	<0.55	<0.55	<0.55	<2.8	<1.1	<0.55	<0.55	---
SB-5	10/28/2005	15	220	<0.50	<0.50	1.9	2.1	<0.50	<2.5	<1.0	<0.50	<0.50	---
SB-5	10/28/2005	20	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	0.035	<0.010	<0.010	<0.0050	<0.0050	---

TABLE 1
HISTORICAL SOIL ANALYTICAL DATA
FORMER SHELL SERVICE STATION
4255 MACARTHUR BOULEVARD, OAKLAND, CALIFORNIA

<i>Sample ID</i>	<i>Date</i>	<i>Depth (ft)</i>	<i>TPHg (mg/kg)</i>	<i>B (mg/kg)</i>	<i>T (mg/kg)</i>	<i>E (mg/kg)</i>	<i>X (mg/kg)</i>	<i>MTBE (mg/kg)</i>	<i>TBA (mg/kg)</i>	<i>DIPE (mg/kg)</i>	<i>ETBE (mg/kg)</i>	<i>TAME (mg/kg)</i>	<i>Total Lead (mg/kg)</i>
SB-6	10/28/2005	5	<1.0	<0.0050	<0.0050	<0.0050	0.011	<0.0050	<0.010	<0.010	<0.0050	<0.0050	---
SB-6	10/28/2005	10.5	160	<0.50	<0.50	<0.50	<0.50	<0.50	<2.5	<1.0	<0.50	<0.50	---
SB-6	10/28/2005	15	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	0.067	1.6	<0.010	<0.0050	<0.0050	---
SB-6	10/28/2005	20	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	0.19	0.19	<0.010	<0.0050	<0.0050	---
SB-6	10/28/2005	25	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	0.0073	<0.010	<0.010	<0.0050	<0.0050	---
SB-7	10/28/2005	5	220	0.59	<0.50	2.9	10	1.2	<2.5	<1.0	<0.50	<0.50	---
SB-7	10/28/2005	10	2,600	13	17	45	270	0.95	<2.5	<1.0	<0.50	<0.50	---
SB-7	10/28/2005	15	260	1.4	3.7	2.6	13	<0.50	<2.5	<1.0	<0.50	<0.50	---
SB-7	10/28/2005	20.5	<4.6	<0.023	<0.023	<0.023	0.069	0.097	0.12	<0.046	<0.023	<0.023	---
SB-7	10/28/2005	25	9.0	0.087	0.087	0.14	0.82	0.27	0.088	<0.010	<0.0050	<0.0050	---
SB-7	10/28/2005	30	1.2	0.023	0.038	0.031	0.15	0.077	0.030	<0.010	<0.0050	<0.0050	---
SB-7	10/28/2005	35	<1.0	0.031	0.028	0.020	0.089	0.10	0.024	<0.010	<0.0050	<0.0050	---
SB-7	10/28/2005	40	<1.0	0.017	0.015	0.0078	0.033	0.019	<0.010	<0.010	<0.0050	<0.0050	---
SB-8	10/28/2005	5	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.010	<0.0050	<0.0050	---
SB-8	10/28/2005	10	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.010	<0.0050	<0.0050	---
SB-8	10/28/2005	15	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.081	<0.010	<0.0050	<0.0050	---
SB-8	10/28/2005	20	<1.0	<0.0050	<0.0050	<0.0050	<0.0050	0.014	0.020	<0.010	<0.0050	<0.0050	---
MW-6	6/16/2006	5	<4.00	<0.07	<0.07	<0.07	<0.22	<0.37	<3.7	<0.37	<0.37	<0.37	---
MW-6	6/16/2006	10	239	0.50	<0.08	3.5	17	0.57	<4.0	<0.40	<0.40	<0.40	---
MW-6	6/16/2006	15	329	0.25	<0.08	0.77	2.9	0.54	<3.9	<0.39	<0.39	<0.39	---
MW-6	6/16/2006	20	<4.00	<0.07	<0.07	<0.07	<0.22	<0.37	<3.7	<0.37	<0.37	<0.37	---
MW-7	6/20/2006	5	4.57	<0.07	<0.07	<0.07	<0.22	0.46	<3.7	<0.37	<0.37	<0.37	---
MW-7	6/20/2006	10	111	0.41	<0.07	1.2	4.5	3.1	<3.6	<0.36	<0.36	<0.36	---
MW-7	6/20/2006	15	62.1	1.4	0.56	16	43	1.5	<3.8	<0.38	<0.38	<0.38	---
MW-7	6/20/2006	20	<4.00	<0.07	<0.07	<0.07	<0.22	<0.37	<3.7	<0.37	<0.37	<0.37	---
MW-7	6/20/2006	25	<3.97	<0.08	<0.08	<0.08	<0.23	<0.38	<3.8	<0.38	<0.38	<0.38	---
MW-7	6/20/2006	29.5	<3.97	<0.08	<0.08	<0.08	<0.23	<0.39	<3.9	<0.39	<0.39	<0.39	---
MW-8	6/19/2006	5	<4.00	<0.08	<0.08	<0.08	<0.24	<0.40	<4.0	<0.40	<0.40	<0.40	---
MW-8	6/19/2006	10	<4.00	0.15	<0.08	<0.08	<0.23	<0.38	<3.8	<0.38	<0.38	<0.38	---
MW-8	6/19/2006	15	<4.00	<0.07	<0.07	<0.07	<0.22	<0.37	<3.7	<0.37	<0.37	<0.37	---
MW-8	6/19/2006	20	<4.00	<0.08	<0.08	<0.08	<0.23	<0.38	<3.8	<0.38	<0.38	<0.38	---
MW-8	6/19/2006	25	<4.00	<0.07	<0.07	<0.07	<0.22	<0.36	<3.6	<0.36	<0.36	<0.36	---
MW-8	6/19/2006	29.5	<4.00	<0.07	<0.07	<0.07	<0.22	<0.37	<3.7	<0.37	<0.37	<0.37	---
MW-9	6/19/2006	5	9.78	<0.07	<0.07	<0.07	0.97	<0.36	<3.6	<0.36	<0.36	<0.36	---
MW-9	6/19/2006	10	552	0.25	0.11	4.7	20	<0.40	<4.0	<0.40	<0.40	<0.40	---
MW-9	6/19/2006	15	<4.00	<0.08	<0.08	<0.08	<0.24	<0.40	<4.0	<0.40	<0.40	<0.40	---
MW-9	6/19/2006	20	<4.00	<0.08	<0.08	<0.08	<0.23	<0.38	<3.8	<0.38	<0.38	<0.38	---
MW-9	6/19/2006	25	<4.00	<0.08	<0.08	<0.08	<0.23	0.54	<3.8	<0.38	<0.38	<0.38	---
MW-9	6/19/2006	29.5	<4.00	<0.08	<0.08	<0.08	<0.23	<0.38	<3.8	<0.38	<0.38	<0.38	---
SB-9	11/15/2011	5	11 c	0.00253	0.00613	0.0143	0.0518	0.00284	<0.0473	<0.00189	<0.00473	<0.00189	---
SB-9	11/15/2011	10	9.1 c	0.00396	0.0121	0.0255	0.0889	0.00329	<0.0493	<0.00197	<0.00493	<0.00197	---
SB-10	11/15/2011	5	14 c	0.00671	0.0225	0.0297	0.137	0.00415	<0.0420	<0.00168	<0.00420	<0.00168	---
SB-10	11/15/2011	8	0.98	0.00235	0.00506	0.0104	0.0578	0.00299	<0.0466	<0.00186	<0.00466	<0.00186	---
SB-11	11/16/2011	5	210	0.00949	<0.00172	0.725	0.0800	<0.00172	<0.0429	<0.00172	<0.00429	<0.00172	---
SB-11	11/16/2011	10	6.8	0.164	0.00208	0.153	0.210	0.0645	<0.0460	<0.00184	<0.00460	<0.00184	---
SB-11	11/16/2011	16	1,700	0.362	<0.0916	0.264	0.365	0.119	<2.29	<0.0916	<0.229	<0.0916	---

TABLE 1
HISTORICAL SOIL ANALYTICAL DATA
FORMER SHELL SERVICE STATION
4255 MACARTHUR BOULEVARD, OAKLAND, CALIFORNIA

<i>Sample ID</i>	<i>Date</i>	<i>Depth (fbg)</i>	<i>TPHg (mg/kg)</i>	<i>B (mg/kg)</i>	<i>T (mg/kg)</i>	<i>E (mg/kg)</i>	<i>X (mg/kg)</i>	<i>MTBE (mg/kg)</i>	<i>TBA (mg/kg)</i>	<i>DIPE (mg/kg)</i>	<i>ETBE (mg/kg)</i>	<i>TAME (mg/kg)</i>	<i>Total Lead (mg/kg)</i>
SB-12	11/16/2011	5	2.5	0.0746	0.00192	0.0980	0.00958	0.0811	0.0899	<0.00187	<0.00467	<0.00187	---
SB-12	11/16/2011	10	540	1.13	0.0203	6.30	15.1	0.292	0.338	<0.00196	<0.00490	<0.00196	---
SB-12	11/16/2011	14	100 c	0.496	0.00625	0.394	0.323	0.442	0.291	<0.00190	<0.00475	<0.00190	---
SB-13	11/15/2011	5	8.6	<0.0909	<0.0909	<0.0909	<0.227	<0.0909	<2.27	<0.0909	<0.227	<0.0909	---
SB-13	11/15/2011	10	120	<0.0917	<0.0917	<0.0917	<0.229	0.189	<2.29	<0.0917	<0.229	<0.0917	---
SB-14	11/15/2011	5	1.5	<0.00182	<0.00182	<0.00182	<0.00455	<0.00182	<0.0455	<0.00182	<0.00455	<0.00182	---
SB-14	11/15/2011	10	3.7	0.0511	<0.00192	0.0235	<0.00479	0.0456	<0.0479	<0.00192	<0.00479	<0.00192	---
SB-15	11/15/2011	5	15 c	0.00641	0.0547	0.00827	0.375	<0.00185	<0.0461	<0.00185	<0.00461	<0.00185	---
SB-15	11/15/2011	10	0.08	<0.00169	<0.00169	<0.00169	<0.00422	0.0457	<0.0422	<0.00169	<0.00422	<0.00169	---
SB-16	11/15/2011	5	0.13	<0.00169	<0.00169	<0.00169	<0.00424	<0.00169	<0.0424	<0.00169	<0.00424	<0.00169	---
SB-16	11/15/2011	7.5	19 c	0.00200	<0.00188	<0.00188	<0.00471	<0.00188	<0.0471	<0.00188	<0.00471	<0.00188	---
SB-16	11/15/2011	10	130 c	<0.00170	<0.00170	0.00242	<0.00426	<0.00170	<0.0426	<0.00170	<0.00426	<0.00170	---
SB-16	11/15/2011	16	130 c	0.0597	0.0512	1.01	4.12	0.0165	<0.0439	<0.00176	<0.00439	<0.00176	---
<i>Shallow Soil (≤10 fbg) ESL^d:</i>			500	1.2	9.3	4.7	11	8.4	110	NA	NA	NA	320
<i>Deep Soil (>10 fbg) ESL^d:</i>			1,000	1.2	9.3	4.7	11	8.4	110	NA	NA	NA	320

Notes:

TPHg = Total petroleum hydrocarbons as gasoline analyzed by EPA Method 8260B; before 2001, analyzed by EPA Method 8015.

BTEX = Benzene, toluene, ethylbenzene, and total xylenes analyzed by EPA Method 8260B; before 2001, analyzed by EPA Method 8020.

MTBE = Methyl tertiary-butyl ether analyzed by EPA Method 8260B unless otherwise noted

TBA = Tertiary-butyl alcohol analyzed by EPA Method 8260B

DIPE = Di-isopropyl ether analyzed by EPA Method 8260B

ETBE = Ethyl tertiary-butyl ether analyzed by EPA Method 8260B

TAME = Tertiary-amyl methyl ether analyzed by EPA Method 8260B

fbg = Feet below grade

mg/kg = Milligrams per kilogram

ND = Not detected; detection limit unknown

<x = Not detected at reporting limit x

--- = Not analyzed

ESL = Environmental screening level

NA = No applicable ESL

a = Sample analysis method unknown

b = Analyzed by EPA Method 8020

c = Analyte detected in the associated method blank

d = San Francisco Bay Regional Water Quality Control Board commercial/industrial ESL for soil where groundwater is not a source of drinking water (Table B or D of *User's Guide: Derivation and Application of Environmental Screening Levels*, California Regional Water Quality Control Board, Interim Final 2013).

Results in **bold** equal or exceed applicable ESL

Shading indicates that soil sample location was subsequently excavated; results are not representative of residual soil

APPENDIX A

SITE HISTORY

SITE HISTORY

1985 Subsurface Investigation: In June 1985, Emcon Associates (Emcon) drilled two soil borings (S-A and S-B) and installed one groundwater monitoring well (S-1) adjacent to the underground storage tanks (USTs). Up to 15,800 milligrams per kilogram (mg/kg) total petroleum hydrocarbons as gasoline (TPHg) were detected in the shallow soil samples from inside the UST area. In July 1992, GeoStrategies, Inc. performed a site reconnaissance and verified that the original monitoring well had been destroyed during the 1985 UST replacement. Investigation results are presented in Emcon's July 26, 1985 letter to Gettler-Ryan, Inc.

1985 UST Replacement: In December 1985, the USTs were replaced, and approximately 938 cubic yards of hydrocarbon-bearing soil were transported to a disposal facility. Up to 22,000 mg/kg total volatile hydrocarbons, 500 mg/kg benzene, 2,200 mg/kg toluene, and 4,500 mg/kg xylenes were detected in the soil samples from the excavation.

1993 Subsurface Investigation: In November 1993, Weiss Associates (WA) drilled three soil borings (BH-A, BH-B, and BH-C), which were converted into monitoring wells (MW-1, MW-2, and MW-3). Soil samples contained up to 1,700 mg/kg TPHg, 3.3 mg/kg benzene, 5.7 mg/kg toluene, 33 mg/kg ethylbenzene, and 44 mg/kg xylenes. WA's March 14, 1994 *Subsurface Investigation* report details the investigation results.

1994 Subsurface Investigation: In November 1994, WA drilled two on-site soil borings (BH-D and BH-E) and one off-site boring (BH-F) which was subsequently completed as a monitoring well (MW-4). Soil samples contained up to 5,900 mg/kg TPHg, 23 mg/kg benzene, 160 mg/kg toluene, 120 mg/kg ethylbenzene, and 430 mg/kg xylenes (BH-E at 5 feet below grade [fbg]). WA's January 26, 1995 *Subsurface Investigation* report presents details of the investigation.

1994-1997 Separate-Phase Hydrocarbon (SPH) Removal: SPHs were observed periodically in wells MW-2 and MW-3 between 1994 and 1997. During that time, an estimated total of 19.6 pounds of SPHs was removed from monitoring wells by bailing.

1995 Dispenser and Piping Removal and Sampling: In November 1995, WA collected 15 soil samples during dispenser and piping replacements. The soil samples contained up to 7,800 mg/kg TPHg, 0.85 mg/kg benzene, 51 mg/kg toluene, 71 mg/kg ethylbenzene, and 540 mg/kg xylenes. During the dispenser replacements, horizontal wells HW-1 through HW-4 were installed in the vadose zone at approximately 5 fbg and adjacent to the former piping and dispensers to facilitate future removal of petroleum hydrocarbons from the impacted soil. Approximately 68 cubic yards of soil were excavated for off-site disposal from the area of the

pipng and dispensers. Dispenser and piping investigation results are discussed in WA's April 1, 1996 *Dispenser Replacement Sampling* report.

1997 Soil Vapor Extraction (SVE) Test: In August 1997, Cambria Environmental Technology, Inc. (Cambria) performed short-term SVE tests using an internal combustion engine on horizontal vapor extraction wells HW-1 through HW-4 and monitoring wells MW-2 and MW-3. Cambria measured vapor extraction flow rates, the vacuum applied to the wellheads, and the vacuum influence in nearby wells. Cambria calculated an effective radius of influence of 35 to 50 feet during testing of wells MW-2 and MW-3. Cambria concluded that the relatively high TPHg removal rates measured in horizontal wells HW-1 through HW-4 were most likely temporary and were not representative of site conditions due to extensive well screen in permeable fill material and that the low hydrocarbon removal rates in wells MW-2 and MW-3 were likely more representative of native soil conditions. Cambria's February 23, 1997 *Soil Vapor Extraction Test Report* presents SVE test results.

1998 Subsurface Investigation: In February 1998, Cambria drilled two off-site borings (SB-1 and SB-2) in the mobile home park adjacent to the Shell site. No TPHg or benzene was detected in the soil samples. Soil samples contained up to 1.4 mg/kg methyl tertiary-butyl ether (MTBE) and 7,210 mg/kg total organic carbon. Grab groundwater samples contained up to 7,700 micrograms per liter ($\mu\text{g/L}$) TPHg, 210 $\mu\text{g/L}$ benzene, and 46,000 $\mu\text{g/L}$ MTBE (SB-2). Two soil samples (SB-1 and SB-2 at 5.5 fbg) were analyzed for physical parameters: total porosity was 35.2 percent (%) and 37.4%, and specific permeability was 181 millidarcies (md) and 71 md, respectively. However, the laboratory noted that due to fine fractures that developed in the samples upon drying, the measured specific permeability values were an order of magnitude or more too high. The soil boring investigation results are presented in Cambria's March 19, 1998 *Subsurface Investigation* report.

1999-2003 Groundwater Extraction (GWE): From April 1999 until September 2003, Cambria conducted monthly GWE using a vacuum truck. Mobile GWE removed an estimated 15.1 pounds of liquid-phase hydrocarbons and 26.8 pounds of liquid-phase MTBE. GWE was discontinued at the site after September 2003 due to low pumping volumes. Quarterly groundwater monitoring reports during this period summarize GWE operations and mass removal.

2000-2003 Dual-Phase Vapor Extraction (DVE): From November 2000 to June 2001, from April 2002 to September 2003, and from July 2003 to September 2003, Cambria conducted mobile DVE using a vacuum truck. DVE was discontinued after September 2003 due to decreased mass removal. DVE removed an estimated 26.4 pounds of vapor-phase hydrocarbons. DVE dates and mass removal are provided in the quarterly groundwater monitoring reports during this period.

2001 Sensitive Receptor Survey (SRS), Conduit Study, and Site Conceptual Model (SCM): Cambria's SRS identified 25 monitoring wells, 4 cathodic protection wells, and 1 domestic well within one-half mile of the site. Cambria's conduit study concluded that nearby sewer, storm drain, and water lines located between 8 to 13 fbg could serve as preferential pathways for petroleum hydrocarbon and MTBE migration. However, Cambria did not identify any nearby conduits down gradient from the site. The SRS, conduit study, and SCM are included in Cambria's May 31, 2001 *First Quarter 2001 Monitoring Report, Sensitive Receptor Survey, and Site Conceptual Model*.

2001 Subsurface Investigation: In November 2001, Cambria installed one down-gradient monitoring well (MW-5) approximately 200 feet southwest of the site, on the Caltrans right-of-way adjacent to the I-580 on-ramp. No TPHg, benzene, toluene, ethylbenzene, and total xylenes (BTEX), or MTBE was detected in the soil sample collected during the investigation. Cambria's January 10, 2002 *Off-Site Monitoring Well Installation Report* presents the investigation results.

2003 Tank Removal and Soil Excavation: In January and February 2003, L.A. Perks Plumbing and Heating removed all surface features, USTs, fuel dispensers, associated product piping, two tank backfill wells (TB-1 and TB-2), and four horizontal wells (HW-1 through HW-4). Cambria collected 31 soil samples and 1 grab groundwater sample and supervised over-excavation of hydrocarbon-impacted soils. Approximately 875 cubic yards of soil were removed from the site during the tank pull and over-excavation activities. Approximately 4,600 gallons of groundwater were pumped to dewater the UST excavation prior to removing the tanks. Soil samples from the former UST area contained up to 380 mg/kg TPHg, 1.7 mg/kg benzene, and 1.2 mg/kg MTBE (TP-5). The grab groundwater sample (TP-1-Water) from the former tank excavation area contained 11,000 µg/L TPHg, 410 µg/L benzene, and 5,200 µg/L MTBE. Soil samples from soil remaining in soil in the former dispenser areas contained up to 980 mg/kg TPHg, 1.2 mg/kg benzene, and 0.9 mg/kg MTBE. Following over-excavation, approximately 720 pounds of oxygen-releasing compound were mixed in the excavation base before backfilling with 1.5-inch drain rock to 4 fbg. The remainder of the excavation was backfilled and compacted with Class II road base material. Cambria's April 28, 2003 *Tank Closure and Soil Excavation Report* provides details of these activities.

2003-2011 SPH Removal: SPHs were observed periodically in wells MW-2, MW-3, and MW-4 between 2003 and 2011. An estimated total of 28.53 pounds of SPHs have been removed from monitoring wells by manual bailing, with a skimmer bailer, and using SPH-absorbent canisters. In September 2009, Conestoga-Rovers & Associates (CRA) conducted mobile GWE on wells MW-2 and MW-3, which yielded approximately 44 gallons of water from each well with negligible SPHs.

April 2005 Subsurface Investigation: In April 2005, Cambria drilled 11 cone penetrometer test (CPT) borings (CPT-1 through CPT-11) and 2 direct-push borings (SB-3 and SB-4). At each CPT location, an ultraviolet-induced fluorescence module was used to identify hydrocarbons in the subsurface. No soil samples were submitted for laboratory analysis. Based on the data collected during this investigation, it appeared that no SPHs were present at these locations, but that dissolved-phase hydrocarbons are present at most locations at two distinct depths: a shallow zone in the silt and clay above 17 fbg and a deeper zone in the silt, clay, and sand from approximately 19 to 20 fbg to the bottom of the borings at 25 fbg. Cambria's June 6, 2005 *Subsurface Investigation Report* presents details of this investigation.

October 2005 Subsurface Investigation: In October 2005, Cambria drilled four soil borings (SB-5 through SB-8). Soil samples contained up to 2,600 mg/kg TPHg, 13 mg/kg benzene, 17 mg/kg toluene, 45 mg/kg ethylbenzene, 270 mg/kg xylenes, 1.2 mg/kg MTBE, and 1.6 mg/kg tertiary-butyl alcohol. Cambria's December 14, 2005 *Subsurface Investigation Report* presents details of the investigation.

2006 Subsurface Investigation: In June 2006, Cambria installed four groundwater monitoring wells (MW-6 through MW-9). Soil samples from the well borings contained up to 552 mg/kg TPHg, 1.4 mg/kg benzene, and 3.1 mg/kg MTBE. Cambria's September 6, 2006 *Well Installation Report* presents details of the investigation.

2011 Subsurface Investigations: In February 2011, CRA installed eight nested soil vapor probes (SVP-1 through SVP-8) with screens at approximately 3 and 5 fbg. Soil vapor samples from the probes contained up to 270,000,000 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) TPHg, 650,000 $\mu\text{g}/\text{m}^3$ benzene, 420,000 $\mu\text{g}/\text{m}^3$ ethylbenzene, 1,500 $\mu\text{g}/\text{m}^3$ total xylenes, and 4,600 $\mu\text{g}/\text{m}^3$ MTBE. No toluene was detected in the soil vapor samples. CRA's April 25, 2011 *Soil Vapor Probe Installation and Sampling Report* details this investigation.

In August 2011, CRA collected samples from six of the soil vapor probes, which contained up to 230,000,000 $\mu\text{g}/\text{m}^3$ TPHg, 310,000 $\mu\text{g}/\text{m}^3$ benzene, 140,000 $\mu\text{g}/\text{m}^3$ ethylbenzene, 88,000 $\mu\text{g}/\text{m}^3$ total xylenes, and 66,000 $\mu\text{g}/\text{m}^3$ MTBE. No toluene was detected in the soil vapor samples. CRA's January 9, 2012 *Soil Vapor Sampling Report* details these results.

In November 2011, CRA drilled eight soil borings (SB-9 through SB-16) to further evaluate on-site soil and groundwater conditions. Only the TPHg soil detections in boring SB-11 at 16 fbg and the TPHg, ethylbenzene, and total xylenes detections in SB-12 at 10 fbg exceed the San Francisco Bay Regional Water Quality Control Board environmental screening levels

(ESLs)¹ for soil where groundwater is not a drinking water source. No significant residual vadose zone BTEX source was identified during this investigation. Six grab groundwater samples were collected from borings SB-9 through SB-11 and SB-14 through SB-16. TPHg and/or BTEX concentrations exceeded ESLs in four of the six grab groundwater samples, with the maximum concentrations detected in the sample collected from boring SB-16. Fuel oxygenate concentrations in the grab groundwater samples did not exceed ESLs. One soil sample (SB-13) was collected for analysis of physical parameters. CRA's January 6, 2012 *Subsurface Investigation Report* provides investigation details.

2012 Subsurface Investigations: In April 2012, CRA installed and sampled four temporary soil vapor probes (SVP-9 through SVP-12) at the residential care facility located at 4240 Redding Street, Oakland. All constituent of concern (COC) detections were below ESLs for residential land use in all soil vapor samples. Investigation results are provided in CRA's May 4, 2012 *Subsurface Investigation Report*.

In October 2012, CRA installed three nested soil vapor probes (SVP-13 through SVP-15) in the mobile home park west of the site, two sub-slab soil vapor probes (SVP-16 and SVP-17) within the church building north of the site, and four nested soil vapor probes (SVP-18 through SVP-21) on site. Soil vapor samples from the probes installed within the mobile home park contained up to 36,000,000 µg/m³ TPHg and exceeded the ESL in probes SVP-14 and SVP-15. No BTEX, naphthalene, or MTBE was detected in these samples; however, reporting limits were elevated due to TPHg concentrations. Concentrations in samples collected from 2.5 fbg in probes SVP-14 and SVP-15 were lower than concentrations in samples collected from 5 fbg, demonstrating vertical attenuation of TPHg. No COCs exceeded ESLs in the sub-slab soil vapor samples. Soil vapor samples from the probes installed on site contained up to 230,000,000 µg/m³ TPHg. No BTEX, naphthalene, or MTBE concentrations exceeded ESLs, with the exception of 1,500,000 µg/m³ benzene and 300,000 µg/m³ ethylbenzene detected in the soil vapor sample from probe SVP-19 at 5 fbg. CRA was unable to collect a sample from SVP-19 at 2.5 fbg due to water in the probe. CRA attempted to sample existing nested soil vapor probes SVP-1, SVP-2, and SVP-6 on November 14 and December 20, 2012. Due to water in the probes, we were unable to collect samples from the probes, with the exception of SVP-2 at 3 fbg on December 20, 2012. Investigation results are presented in CRA's January 10, 2013 *Subsurface Investigation Report*.

2013 Subsurface Investigation: In August and September 2013, CRA installed three on-site (SVP-1A, SVP-6A, and SVP-19A) and four off-site (SVP-22 through SVP-25) nested soil vapor probes, drilled three sets of temporary soil vapor probes (SVP-14-Temp, SVP-15-Temp, and

¹ *User's Guide: Derivation and Application of Environmental Screening Levels*, San Francisco Bay Regional Water Quality Control Board, Interim Final - December 2013

SVP-22-Temp), conducted surface flux measurements at the three temporary probe locations and at the locations of three of the new off-site soil vapor probes (SVP-23 through SVP-25), and collected soil vapor samples from on-site soil vapor probes and off-site soil vapor probes and sub-slab soil vapor probes. On-site soil vapor probes SVP-1 and SVP-6 were properly destroyed. Soil vapor samples from the on-site probes contained up to 310,000,000 $\mu\text{g}/\text{m}^3$ TPHg, 930,000 $\mu\text{g}/\text{m}^3$ benzene, and 370,000 $\mu\text{g}/\text{m}^3$ ethylbenzene. No toluene, total xylenes, or naphthalene concentrations were detected above ESLs. No TPHg, BTEX, or naphthalene detections exceeded ESLs in soil vapor samples from the sub-slab probes installed inside the adjacent church building (SVP-16 and SVP-17). No BTEX or naphthalene concentrations were detected above ESLs in soil vapor samples from the permanent probes installed off site in the adjacent trailer park (SVP-13 through SVP-15 and SVP-22 through SVP-25). Up to 75,000,000 $\mu\text{g}/\text{m}^3$ TPHg was detected in the soil vapor samples from permanent probes SVP-14 and SVP-15. Soil vapor samples from the temporary soil vapor probes installed contained up to 2,400,000 $\mu\text{g}/\text{m}^3$ TPHg and 47 $\mu\text{g}/\text{m}^3$ benzene. No toluene, ethylbenzene, total xylenes, MTBE, or naphthalene concentrations exceeded ESLs. Vertical profiles of soil vapor results from the temporary probes generally showed decreasing soil vapor concentrations as depth decreases. TPHg, benzene, and toluene were the only COCs detected in surface flux vapor samples. Based on comparing the surface flux data to ESLs, the calculated residential human health risk for benzene was 2.0E-06 or less and the calculated residential human health hazard for TPHg, benzene, and toluene ranged from 0.00063 to 0.24 with a maximum cumulative hazard of 0.24. CRA's December 12, 2013 *Subsurface Investigation Report* details soil vapor investigation results.

Groundwater Monitoring Program: Groundwater sampling began in November 1993. Historically, SPHs have been observed intermittently in wells MW-2 and MW-3. SPHs were also observed in MW-4 during a single sampling event in August 2010, and since the December 2008 sampling event, no SPHs have been observed in MW-3. Groundwater is currently monitored and sampled semiannually during the first and third quarters.