CONESTOGA-ROVERS
& ASSOCIATES

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September 2, 2011 Reference No. 241735

Ms. Libby Goldstein
Washington State Department of Ecology
Northwest Regional Office
3190 160th Avenue Southeast
Bellevue, Washington 98008

Re: Vapor Investigation Work Plan
Jiffy Lube Facility
4902 25th Avenue Northeast
Seattle, Washington
VCP No.: NW2079

Dear Ms. Goldstein:

Please find the enclosed Vapor Intrusion Work Plan for the Jiffy Lube facility located at 4902 25th Avenue Northeast, Seattle, Washington. We are requesting Ecology's review and opinion on this report. If you have any questions regarding the contents of the enclosed document, please contact Christina McClelland at (425) 563-6514.

Sincerely,

CONESTOGA-ROVERS & ASSOCIATES

Christina McClelland

CM/cd/2
Encl.

Vapor Intrusion Work Plan

cc: Perry Pineda, SOPUS
Mark Bergquist, Property Owner

VAPOR INTRUSION INVESTIGATION WORK PLAN

JIFFY LUBE FACILITY NO. 2075
4902 25th AVENUE SE
SEATTLE, WASHINGTON

SAP CODE	171156
INCIDENT NO.	97605414
AGENCY NO.	41675877
VCP NO.	NW2079

Prepared by:
Conestoga-Rovers & Associates

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SEPTEMBER 2, 2011
REF. NO. 241735 (10)
This report is printed on recycled paper.

VAPOR INTRUSION INVESTIGATION WORK PLAN

JIFFY LUBE FACILITY NO. 2075
4902 25th AVENUE SE
SEATTLE, WASHINGTON

SAP CODE	171156
INCIDENT NO.	97605414
AGENCY NO.	41675877
VCP NO.	NW2079

Brian Peters, LG

Christina McClelland

Prepared by:
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TABLE OF CONTENTS

Page

LIST OF FIGURES
(Following Text)

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 SITE INFORMATION

Site Name:	Jiffy Lube Facility No. 2075
Site Address:	4902 25th Avenue Southeast, Seattle
Voluntary Cleanup Program Number:	NW2079
Project Consultant:	Conestoga-Rovers & Associates
Project Consultant Contact Information:	Christina McClelland 20818 44th Avenue W., Suite 190 Lynnwood, Washington, 98036 Office – 425.563.6500 Direct – 425.563.6514
Current Owner/Operator:	Ruth A. Bergquist, et al

1.2 PURPOSE

Conestoga-Rovers and Associates (CRA) prepared this work plan on behalf of Equilon Enterprises LLC dba Shell Oil Products US (SOPUS) for the purpose of collecting the additional information necessary to complete the remedial investigation in accordance with Washington Administrative Code (WAC) 173-340-350 at 4902 25th Avenue Southeast, Seattle, King County, Washington.

1.3 SITE DESCRIPTION AND DISCOVERY

The Site is an active Jiffy Lube facility located on the east side of 25th Avenue Northeast between Northeast 49th Street and Northeast Blakely Street in Seattle, King County, Washington (Property, Figure 1). The Property contains a split-level structure, with the Jiffy Lube facility and parking stalls at street level, and a storage room (used by Jiffy Lube) and two offices located partially below street level. The offices were formerly used as a day care facility.

Facilities on the Property currently include a station building with two service bays and nine aboveground storage tanks (ASTs) installed in 1995. The ASTs currently stored on-Property include five new oil ASTs (ranging in size from 110 gallons to 1,500 gallons), one 650-gallon waste-oil AST, one 150-gallon anti-freeze AST, one

150-gallon used anti-freeze AST, and one 275-gallon automatic transmission fluid AST. The ASTs are located in the storage room between the two offices (Figure 2).

In 1995, the decommissioning of two underground storage tanks (UST) facilitated a preliminary Site investigation of the areas next to the former waste oil UST and underneath the new oil UST, including collection of soil samples from each excavation. Laboratory results from analyzed soil samples collected in the area of the former waste oil UST indicated petroleum hydrocarbon-impacted soil above the Washington State Department of Ecology (Ecology) Model Toxics Control Act (MTCA) Method A cleanup levels (Figure 2). Due to the location of the waste oil UST it was closed in place and soil containing petroleum hydrocarbons exceeding the MTCA Method A Cleanup Levels was left in place. A summary of the previous investigations is included as Appendix A.

2.0 DATA GAP IDENTIFICATION

Concentrations exceeding the MTCA Method A cleanup levels have been detected in soil and grab groundwater collected beneath the offices and storage room beneath the Jiffy Lube Facility. Soil impacts associated with the closed-in-place former waste oil UST located in the service pit area were left in place due to Site constraints. Although highly unlikely due to the physical nature of the constituents detected, the residual soil and groundwater impacts could potentially volatilize and migrate into the overlying building via vapor intrusion. Based on the current Property use, and the presence of offices beneath the Jiffy Lube Facility, the potential for vapor intrusion requires investigation.

3.0 SCOPE OF WORK

All work will be conducted according to the *Draft Program Sampling and Analysis Plan* dated September 24, 2009, the Standard Operating Procedures in Section 4 and Appendix B, and Ecology's *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* dated October 2009 (draft). The scope of work may be amended based on observations during field work indicating the need to further advance locations beyond the anticipated depth and/or add additional locations to define impacts associated with the Site. If impacts are observed using field screening techniques at the specified sample depths and locations noted below, field staff will contact the Project Manager to coordinate additional actions.

The proposed scope of work outlined in the following sections of this work plan addresses the data gaps described in Section 2.

3.1 TASK 1 – VAPOR PROBE INSTALLATION

CRA proposes installing three sub-slab vapor probes. The location of the proposed vapor probes is depicted in Figure 2. Based on the occurrence of shallow groundwater (approximately 2 to 3 feet bgs), the vapor probes will not extend more than 3 inches into soil underlying the concrete building slab to avoid short circuiting.

The three vapor probes will be installed using a rotary hammer drill or equivalent method to advance one borehole for each vapor probe. The vapor probe will be installed to a target depth of approximately 3 inches below the slab bottom. First, a 1-inch diameter hole will be drilled several inches into the slab. From this depth, an approximate 3/8-inch diameter hole will be drilled through the bottom of the slab and through a minimum of 3 inches of sub-slab material. The probe will be installed into the hole. A non-volatile sealing material (e.g. Portland Cement) will be placed within the one-inch opening to surface grade to seal the probe. Each vapor probe will be completed at surface grade and the tubing at surface grade will be terminated with a valve connection. CRA's standard operating procedures specifically related to soil vapor sampling, as well as a typical sub-slab vapor probe construction detail are presented in Appendix B.

3.2 TASK 2 – VAPOR SAMPLING

Sampling will not be performed during or within 48 hours of a significant rainfall event [e.g., ≥0.5 inches]. Although a rainfall event is not expected to significantly affect vadose zone moisture content, and thus soil vapor quality conditions beneath a building slab, this precaution is still considered warranted to ensure the collection of soil vapor samples representative of average conditions. CRA proposes conducting one sampling event. If vapor concentrations are detected above the MTCA Method B soil gas screening levels, up to two additional sampling events will be conducted, no less than 2 weeks apart, to ensure that results are consistent.

Written documentation of all field activities, conditions, and sampling processes, including names of field personnel, dates and times, etc. will be recorded. Documentation will include tenant occupancy, tenant activities including an evaluation of smoking, solvent use, an inventory of chemicals stored within enclosed areas, and any other obvious chemical use or emissions, weather conditions (temperature, barometric pressure, wind direction and speed, and humidity), and groundwater elevation measurements in Site monitoring wells.

3.2.1 PRE-SAMPLING PURGE

Prior to sample collection, soil vapor probe purging will be conducted at a maximum flow rate of 200 milliliters per minute (mL/min). A maximum of three soil vapor probe "dead volumes" will be purged to remove potentially stagnant air from the internal volume of the soil vapor probe and ensure that soil vapor representative of the formation is drawn into the probe. Since the vadose zone at the Site is comprised of fine-grained soils, limiting the purging to 3 probe volumes is recommended to minimize potential short-circuiting during sample collection. The soil vapor probe "dead volumes" will be calculated based on field measurements of probe construction. Further details regarding the soil vapor sampling protocol are presented in Appendix B.

3.2.2 SAMPLE COLLECTION

The soil vapor samples will be collected using 1-liter capacity Summa™ canisters. The canisters will be fitted with a laboratory-calibrated critical orifice flow-regulation device sized to limit the soil vapor sample collection flow rate to allow for a maximum flow rate of 200 mL/min, which is recommended to limit volatile organic compound (VOC) stripping from soil, prevent the short-circuiting of air through the probe seal that may dilute or contaminate the soil vapor sample, and increase confidence regarding the location from which the soil vapor sample is obtained. Based on a flow rate of 200 mL/min, each sample should take no less than 5 minutes to fill 1-liter capacity. Sampling duration will be recorded during sampling to verify that the sample was not collected too quickly.

3.2.3 SAMPLE ANALYSIS

The soil vapor samples will be submitted to a Washington-certified laboratory. The soil vapor samples will be analyzed for the full suite of VOCs using EPA Method TO-15, and total petroleum hydrocarbons (TPH) fractions using EPA Method TO-3 or another equivalent TPH method (ie. Massachusetts TPH). Canisters will be batch certified in accordance with standard laboratory reporting protocol for EPA Method TO-15 and/or

TO-3. Subsequent sampling events, if necessary, may employ a reduced parameter list depending on initial sampling results.

3.2.4 QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance/quality control (QA/QC) measures implemented during the soil vapor sampling event will include leak testing, maintaining a minimum residual negative pressure in the Summa™ canisters of approximately 1 to 5 inches of mercury following sample collection, collection of two field duplicate samples and one blank sample. Further details regarding the soil vapor probe sampling QA/QC measures are presented in Appendix B. A brief description of the leak testing procedures is provided below.

Leak testing will be performed to determine whether ambient air has infiltrated the sample collection system during sampling. The leak testing will consist of a two-step process. The first step, conducted prior to sample collection, will involve vacuum testing the sampling equipment after assembly to test the air-tightness of the assembly connections. The second step, conducted prior to sample collection, will involve leak detection of the soil vapor probe using helium as a tracer compound and above ground sampling assembly connections to the soil vapor probe.

Step One Leak Testing

The sampling assembly will be connected to include the purge pump in a valved tee-connection before connecting to the Summa™ canister. Prior to purging the vapor probe, the valve to the purge pump will be opened leaving closed the valve to the Summa™ canister and the valve to the vapor probe. The pump will be operated to ensure that it draws no air from the sampling assembly (i.e. creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are air tight. Purging of the vapor probe will then commence. Once purging is completed, the valve to the purge pump will be closed, and the second leak test step described below will be implemented. The valve to the Summa™ canister will then be opened and sample collection will commence.

Step Two Leak Testing

A shroud (i.e. bucket or plastic sheeting) will be placed atop the soil vapor probe. Helium gas will be introduced within the shroud via tubing, and the helium concentration under the shroud will be measured using a helium meter (parts per billion detection level), and recorded as a percentage. The helium meter will then be connected to the soil vapor probe sampling assembly to monitor for leaks during sample collection.

Detection of helium within the sampling assembly of greater than 5 percent of the helium concentration beneath the shroud will be considered indicative of a substantial leak that would compromise the soil vapor sample. Should this occur, the sampling assembly should be dismantled and then re-assembled. The leak testing procedure will be repeated. In the event that the leak testing fails a second time, the probe should be decommissioned and replaced.

3.3 TASK 3 – SCREENING ASSESSMENT

As an initial assessment of the chemical concentration detections, if any, the soil vapor samples will be compared to the MTCA Method B soil gas screening levels for Indoor Air Cleanup. This initial screening will be used to identify whether any Site-related VOCs are present in soil vapor at concentrations above the screening levels that warrant further activities (i.e. indoor air quality sampling). Should any Site-related VOCs be detected in soil vapor at concentrations greater than the screening levels, these VOCs will be identified as potential COCs, and concentrations will be input into a vapor model (ie. Johnson-Ettinger model, or Ecology-specific model) to determine if indoor air sampling is warranted. Based on the results of the modeling, collection of indoor air samples may be required to further evaluate the vapor intrusion pathway. Indoor air sampling, if necessary, will be proposed in a subsequent work plan.

4.0 STANDARD OPERATING PROCEDURES

Based on the proposed scope of work, possible deviations to the scope and observations of current Site conditions, the following standard operating procedures will be used.

4.1 HEALTH AND SAFETY PLAN

CRA will prepare a comprehensive Site-Specific Health and Safety Plan to protect Site workers. The plan will be reviewed and signed by each Site worker and kept on the Site during field activities.

4.2 UTILITY CLEARANCE

Washington Utilities Coordinating Council (WUCC) will be notified prior to drilling; however, the proposed locations are located within the building structure on private property and therefore, utility companies will only mark applicable utilities outside of the building. A private utility locating service will be used to verify clearance of each boring from subsurface utilities or other obstructions. The final locations of completed borings will be based on the clearance of utilities.

4.3 INVESTIGATION-DERIVED WASTE (IDW)

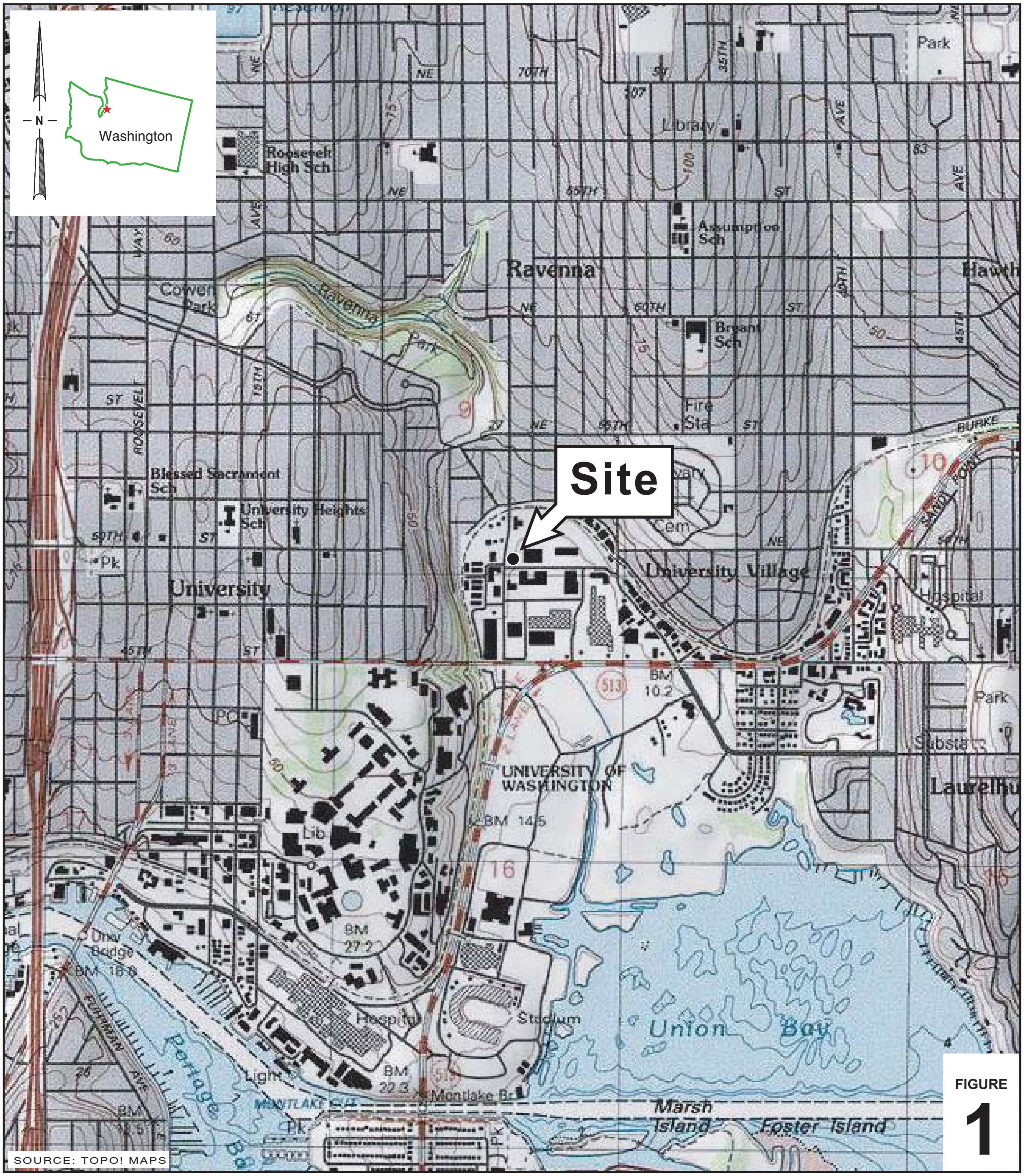
IDW will include personal protective equipment, and decontamination fluids. All IDW will be placed in properly labeled 55-gallon drums and stored on-Site pending removal coordination. The IDW will be disposed of according to SOPUS procedures and applicable regulatory requirements.

4.4 CERTIFICATION

The scope of work described in this work plan will be performed under the supervision of a Washington state licensed geologist.

FIGURES

02/16/10



I:\EVERETT.SHELL\WA SHELL SITES\\6-char\2417--\241735-4902 25th Avenue NE Seattle\241735-FIGURES\241735 VICINITY.AI

0 1/8 1/4 1/2 1

SCALE : 1" = 1/4 MILE

Jiffy Lube Facility

4902 25th Avenue N.E.

Seattle, Washington

CONESTOGA-ROVERS & ASSOCIATES

Vicinity Map

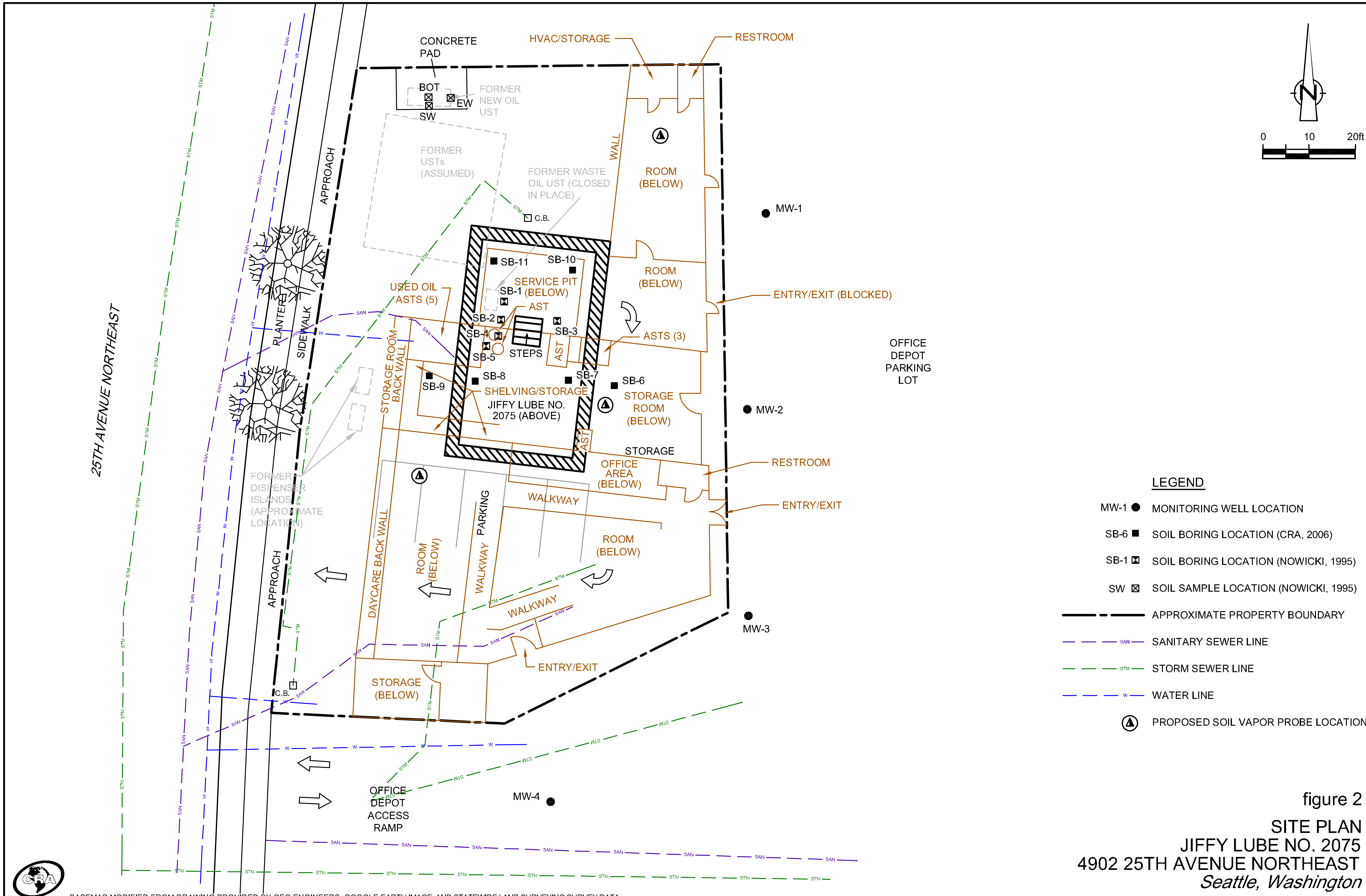
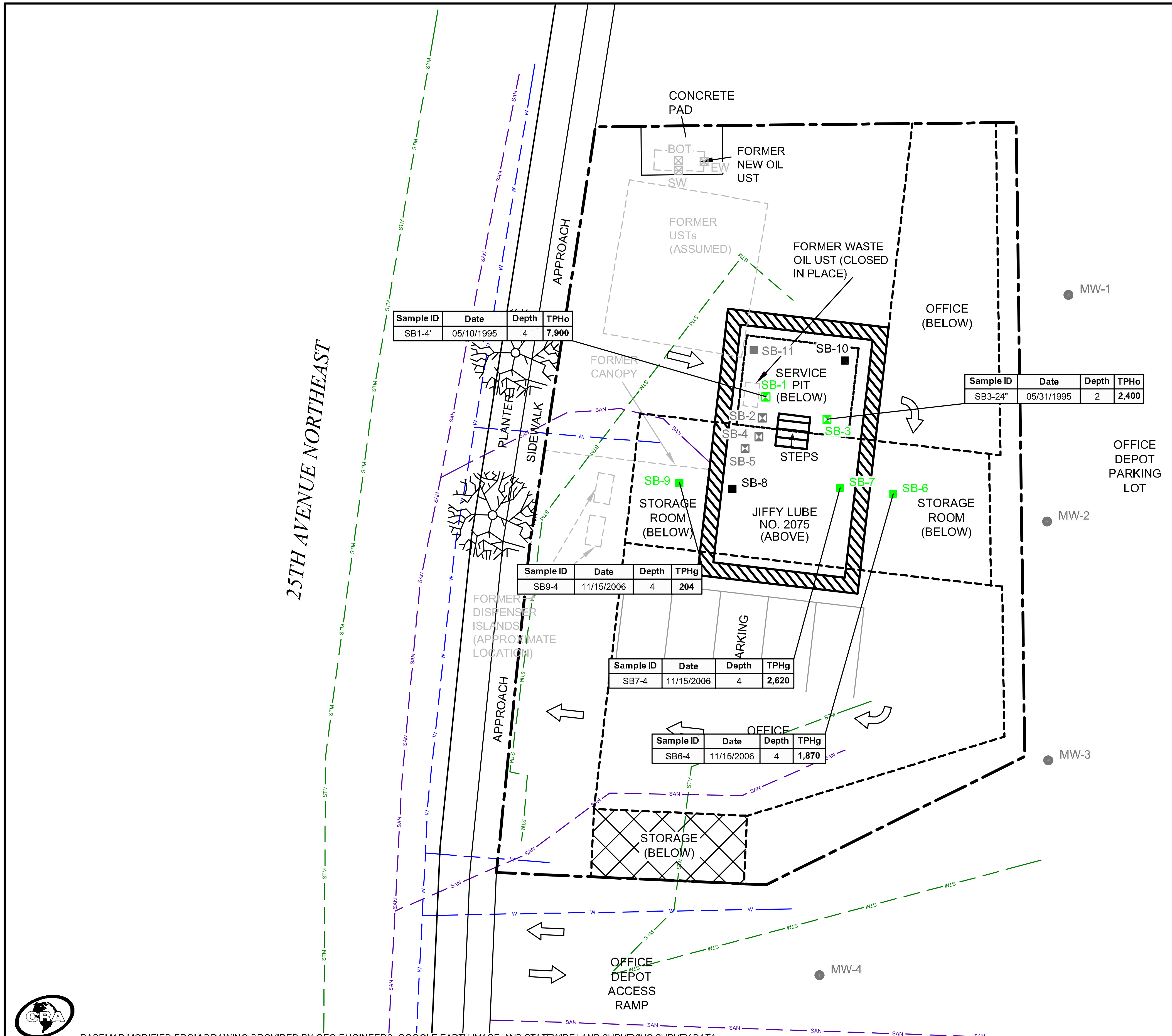


figure 2

SITE PLAN
JIFFY LUBE NO. 2075
4902 25TH AVENUE NORTHEAST
Seattle, Washington

241735-95(010)GN-WA001 MAY 24/2011



LEGEND

- MW-1 ● MONITORING WELL LOCATION
- SB-6 ■ SOIL BORING LOCATION (CAMBRIA, 11/06)
- SB-1 ⊠ SOIL BORING LOCATION (1995)
- SW ⊠ SOIL SAMPLE LOCATION (1995)
- APPROXIMATE PROPERTY BOUNDARY
- SANITARY SEWER LINE
- STORM SEWER LINE
- WATER LINE
- INDICATES ALL CONCENTRATIONS WERE BELOW LABORATORY REPORTING LIMITS
- INDICATES AT LEAST ONE CONCENTRATION WAS DETECTED ABOVE THE LABORATORY REPORTING LIMITS, BUT NO CONCENTRATION EXCEEDED THE MTCA METHOD A SCREENING LEVELS
- INDICATES AT LEAST ONE CONCENTRATION EXCEEDED ECOLOGY'S MTCA METHOD A SCREENING LEVELS

NOTES:

1. ALL CONCENTRATIONS ARE IN MILLGRAMS PER KILOGRAM
2. TPHG = TOTAL PETROLEUM HYDROCARBONS AS GASOLINE
3. TPHD = TOTAL PETROLEUM HYDROCARBONS AS DIESEL
4. TPHO = TOTAL PETROLEUM HYDROCARBONS AS HEAVY OIL
5. BOLDED CONCENTRATIONS INDICATE THE CONCENTRATION VALUE EXCEEDED THE WASHINGTON STATE DEPARTMENT OF ECOLOGY MODEL TOXICS CONTROL ACT (MTCA) METHOD A SCREENING LEVELS
6. ID = SOIL SAMPLE IDENTIFICATION NUMBER
7. DEPTH = FEET BELOW GROUND SURFACE

figure 3

SOIL INVESTIGATION DATA MAP
JIFFY LUBE NO. 2075
4902 25TH AVENUE NORTHEAST
Seattle, Washington

BASEMAP MODIFIED FROM DRAWING PROVIDED BY GEO ENGINEERS, GOOGLE EARTH IMAGE, AND STATEWIDE LAND SURVEYING SURVEY DATA

241735-95(010)GN-WA002 MAY 24/2011

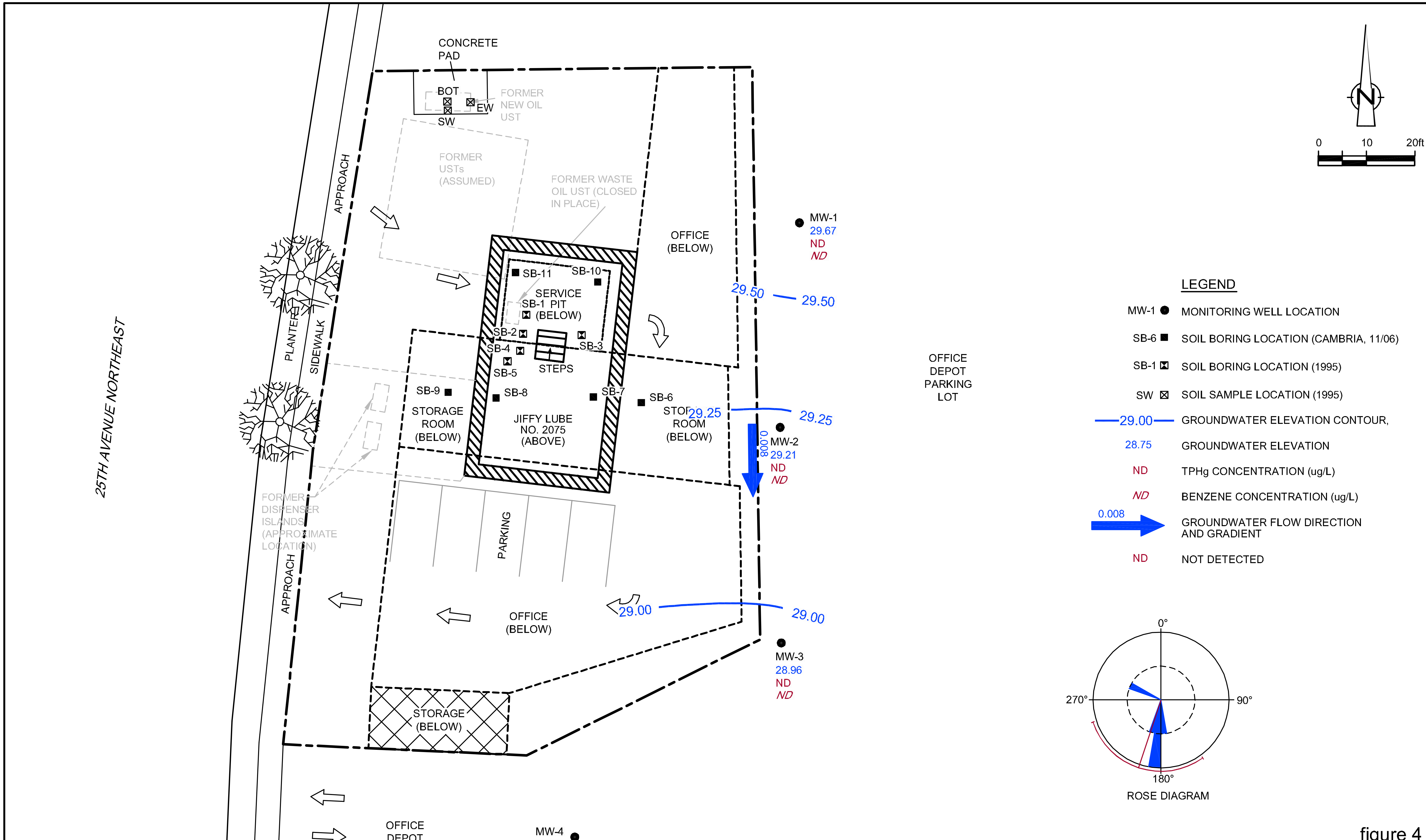


figure 4

GROUNDWATER CONTOUR AND CHEMICAL CONCENTRATION MAP - MAY 11, 2009
JIFFY LUBE NO. 2075
4902 25TH AVENUE NORTHEAST
Seattle, Washington

BASEMAP MODIFIED FROM DRAWING PROVIDED BY GEO ENGINEERS, GOOGLE EARTH IMAGE, AND STATEWIDE LAND SURVEYING SURVEY DATA

241735-95(010)GN-WA003 MAY 24/2011

TABLES

TABLE 1

SUMMARY OF HISTORICAL SOIL ANALYTICAL DATA
JIFFY LUBE FACILITY NO. 2075
4902 25TH AVENUE NE
SEATTLE, WASHINGTON

				HYDROCARBONS			*PRIMARY VOCs*						*LEAD*	*OXYGENATES*	*PAHs*		*PCBs*
Sample ID	*Consultant*	*Sample Date*	*Sample Depth*	*TPHg*	*TPHd*	*TPHo*	*B*	*T*	*E*	*X*	*EDB*	*EDC*	*Total*	*MTBE*	*Naphthalene*	*cPAHs*	*PCBs*
		MTCA Method A	*Screening Level*	*30/100*	*2,000*	*2,000*	*0.03*	*7*	*6*	*9*	*0.005*	*N/A*	*250*	*0.1*	*5*	*0.1*	1
			feet	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*	*mg/kg*
BOT	NOWICKI 1995	3/29/1995	9.5	--	<25	<50	--	--	--	--	--	--	--	--	--	--	--
EW	NOWICKI 1995	3/29/1995	5	--	<25	<50	--	--	--	--	--	--	--	--	--	--	--
SW	NOWICKI 1995	3/29/1995	5	--	<25	<50	--	--	--	--	--	--	--	--	--	--	--
SB1-4'	NOWICKI 1995	5/10/1995	4	--	1,600 a	**7,900**	--	--	--	--	--	--	--	--	--	--	--
SB2-30"	NOWICKI 1995	5/10/1995	2.5	--	64 a	370	--	--	--	--	--	--	--	--	--	--	--
SB3-24"	NOWICKI 1995	5/31/1995	2	--	800 a	**2,400**	--	--	--	--	--	--	--	--	--	--	--
SB4-24"	NOWICKI 1995	6/5/1995	2	--	34 a	90	--	--	--	--	--	--	--	--	--	--	--
SB5-22"	NOWICKI 1995	6/5/1995	1.83	--	53 a	99	--	--	--	--	--	--	--	--	--	--	--
SB6-2	CRA 2007	11/15/2006	2	<4.29	24.7	146	<0.02	<0.09	<0.09	<0.26	<0.04 b	<0.04	9.32	<0.43 b	<0.0115	0.020815	<0.0583
SB6-4	CRA 2007	11/15/2006	4	**1870 c**	345	1,630	<0.03	<0.13	<0.13	<0.38	<0.06 b	<0.06	4.68	0.64 b	0.402	0.032175	<0.0618
SB7-4	CRA 2007	11/15/2006	4	**2620 c**	431	1,820	<0.02	<0.09	<0.09	<0.26	<0.04 b	<0.04	4.83	0.44 b	0.181	0.023776	<0.0599
SB7-6	CRA 2007	11/15/2006	6	14.4 c	<12.7	<31.8	<0.02	<0.10	<0.10	<0.29	<0.05 b	<0.05	1.77	0.49 b	<0.0125	0.022625	0.1
SB9-2	CRA 2007	11/15/2006	2	48.4	13.4	<29.4	<0.02	<0.10	<0.10	<0.29	<0.05 b	<0.05	76.7	0.49 b	0.0145	0.02172	<0.0595
SB9-4	CRA 2007	11/15/2006	4	**204 c**	24.4	<29.4	<0.02	<0.08	0.23	<0.25	<0.04 b	<0.04	18.2	0.42 b	0.135	0.020815	<0.0574
SB11-2	CRA 2007	11/15/2006	2	35.2 c	26.7	185	<0.02	<0.09	<0.09	<0.26	<0.04 b	<0.04	165	0.44 b	<0.0241	0.043621	<0.0599
SB11-3	CRA 2007	11/15/2006	3	4.82	42.6	185	<0.02	<0.10	<0.10	<0.29	<0.05 b	<0.05	51.8	0.48 b	<0.0124	0.029038	<0.0618
MW1@3'	CRA 2008	5/5/2008	3	0.073	16	39	<0.0052	<0.0052	<0.0052	<0.0052	<0.0041	<0.0052	4.43	<0.0052	--	--	--
MW2@2.5'	CRA 2008	5/5/2008	2.5	0.17	28	69	<0.0092	<0.0092	<0.0092	<0.0092	0.0073 b	<0.0092	8.19	<0.0092	--	--	--
MW3@2.5'	CRA 2008	5/5/2008	2.5	0.46	17	78	<0.0081	<0.0081	<0.0081	<0.0081	0.0065 b	<0.0081	4.7	<0.0081	--	--	--
MW4@4.5'	CRA 2008	5/5/2008	2.5	<0.11	14	36	<0.0076	<0.0076	<0.0076	<0.0076	0.0061 b	<0.0076	13	<0.0076	--	--	--

Notes/Abbreviations
TPHg = Total petroleum hydrocarbons as gasoline range organics
TPHd = Total petroleum hydrocarbons as diesel range organics
TPHo = Total petroleum hydrocarbons as heavy oil range organics
BTEX = Benzene, toluene, ethylbenzene, xylenes
MTBE = Methyl tertiary butyl ether
EDB = 1, 2 Dibromoethane
EDC= 1, 2 Dichloroethane
VOCs = Volatile organic compounds
PAHs = Polycyclic aromatic hydrocarbons
cPAHs = Cacogenic polycyclic aromatic hydrocarbons
PCB = Polychlorinated biphenyl
All results in milligrams per kilogram (mg/kg) unless otherwise indicated.
Shaded sample locations were excavated and no longer present
-- = Not analyzed
Results in bold indicate an exceedence of the MTCA Method A Screening Level.
<x = Not detected at reporting limit x
a = Diesel results is due to end of gasoline range product and front of oil range product eluting in diesel range
b = Laboratory reporting limit was above the MTCA Method A Screening Level.
c = The chromatogram for this sample does not resemble a typical gasoline pattern.

TABLE 2

SUMMARY OF GROUNDWATER MONITORING DATA
JIFFY LUBE FACILITY NO. 2075
4902 25TH AVENUE NORTHEAST
SEATTLE, WASHINGTON

					HYDROCARBONS			*PRIMARY VOCs*						*OXYGENATES*					*LEAD*
Sample ID	*Date*	*TOC*	*DTW*	*GWE*	*TPHg*	*TPHd*	*TPHo*	*Benzene*	*Toluene*	*Ethyl-benzene*	*Total Xylenes*	*EDB*	*EDC*	*MTBE*	*TBA*	*DIPE*	*ETBE*	*TAME*	*Total*
		MTCA Method A Screening Levels			800/1000	500	500	5	1000	700	1000	0.01	5	20					15
MW-1	05/21/08	32.11	3.00	29.11	<50	<250	<400	<1.00	<1.00	<1.00	<1.00	---	---	<1.00	<5	<1	<1	<1	**94.2**
MW-1	08/14/08	32.11	3.40	28.71	<100	<100	---	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2	<2	<2	**75.6**
MW-1	11/26/08	32.11	2.75	29.36	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2	<2	<2	**44.1**
MW-1	02/05/09	32.11	2.66	29.45	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2.0	<2.0	<2.0	<1.00
MW-1	05/11/09	32.11	2.44	29.67	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2.0	<2.0	<2.0	<1.00
MW-1	08/31/09	32.11	3.03	29.08	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<1.00
MW-1	11/05/09	32.11	2.63	29.48	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-2	05/21/08	31.72	2.84	28.88	<50	<250	<400	<1.00	<1.00	<1.00	<1.00	---	---	<1.00	<5	<1	<1	<1	**23.4**
MW-2	08/14/08	31.72	3.51	28.21	<100	<100	---	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2	<2	<2	**27.2**
MW-2	11/26/08	31.72	3.16	28.56	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2	<2	<2	**21.8**
MW-2	02/05/09	31.72	3.41	28.31	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2.0	<2.0	<2.0	<1.00
MW-2	05/11/09	31.72	2.51	29.21	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2.0	<2.0	<2.0	<1.00
MW-2	08/31/09	31.72	3.43	28.29	---	---	---	---	---	---	---	---	---	---	---	---	---	---	<1.00
MW-2	11/05/09	31.72	3.43	28.29	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-3	05/21/08*	30.89	2.44	28.45	73	<250	<400	<1.00	<1.00	<1.00	<1.00	---	---	<1.00	<5	<1	<1	<1	**111**
MW-3	08/14/08*	30.89	2.75	28.14	<100	<100	---	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2	<2	<2	**67.6**
MW-3	11/26/08*	30.89	2.34	28.55	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2	<2	<2	**43.3**
MW-3	02/05/09*	30.89	2.14	28.75	100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2.0	<2.0	<2.0	<1.00
MW-3	05/11/09*	30.89	1.93	28.96	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2.0	<2.0	<2.0	<1.00
MW-3	08/31/09**	30.89	2.50	28.39	---	---	---	<0.50	<0.50	<0.50	<0.50	<0.010	<0.50	<0.50	<10	<0.50	<0.50	<0.50	<1.00
MW-3	11/05/09	30.89	2.33	28.56	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-4	05/21/08*	32.47	4.08	28.39	<50	<250	<400	<1.0	<1.0	<1.0	<1.0	---	---	<1.00	<5	<1	<1	<1	**53.9**
MW-4	08/14/08*	32.47	4.39	28.08	<100	210 a	---	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2	<2	<2	**55.8**
MW-4	11/26/08*	32.47	3.85	28.62	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2	<2	<2	**53.0**
MW-4	02/05/09*	32.47	3.76	28.71	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2.0	<2.0	<2.0	<1.00
MW-4	05/11/09*	32.47	3.65	28.82	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	<1.0	<10	<2.0	<2.0	<2.0	<1.00
MW-4	08/31/09**	32.47	4.11	28.36	---	---	---	<0.50	<0.50	<0.50	<0.50	<0.010	<0.50	<0.50	<10	<0.50	<0.50	<0.50	<1.00
MW-4	11/05/09	32.47	3.78	28.69	<100	<100	<100	<0.50	<1.0	<1.0	<1.0	---	---	---	---	---	---	---	---

TABLE 2

SUMMARY OF GROUNDWATER MONITORING DATA
JIFFY LUBE FACILITY NO. 2075
4902 25TH AVENUE NORTHEAST
SEATTLE, WASHINGTON

Sample ID	*Date*	*TOC*	*DTW*	*GWE*	*TPHg*	*TPHd*	*TPHo*	*Benzene*	*Toluene*	*Ethyl-benzene*	*Total Xylenes*	*EDB*	*EDC*	*MTBE*	*TBA*	*DIPE*	*ETBE*	*TAME*	*Total*
		MTCA Method A Screening Levels			800/1000	500	500	5	1000	700	1000	0.01	5	20					15
SB6	11/15/2008*,**	---	2.0	---	**2,310**	<245	<490	<0.500	<0.500	<0.500	<3.00	<0.500	<0.500	<5.00	<50.0	<1.00	<1.00	<1.00	7.86
SB7	11/15/2008*,**	---	3.2	---	**1,660**	<253	<505	<0.500	<0.500	4.35	2.96	<0.500	<0.500	<5.00	<50.0	<1.00	<1.00	<1.00	3.47
SB9	11/15/2008*,**	---	2.7	---	85.5	<243	<505	<0.500	<0.500	<0.500	<3.00	<0.500	<0.500	<5.00	<50.0	<1.00	<1.00	<1.00	8.3

Notes:

DTW = Depth to Water in feet

GWE = Groundwater Elevation in feet above mean sea level.

TOC = Top of Casing in feet above mean sea level.

All results in micrograms per liter (μg/L) unless otherwise indicated.

TPHg = Total petroleum hydrocarbons as gasoline analyzed by NWTPH-Gx.

TPHg[a] = The higher value is based on the assumption that no benzene is present in the groundwater sample. If any detectable amount of benzene is present in the groundwater sample, then the lower TPHg screening level is applicable.

TPHd = Total petroleum hydrocarbons as diesel, analyzed by NWTPH-Dx with silica gel cleanup unless otherwise noted

TPHo = Total petroleum hydrocarbons as oil, analyzed by NWTPH-Dx with silica gel cleanup unless otherwised noted.

Benzene, toluene, ethylbenzene, and xylenes analyzed by EPA Method 8260B unless otherwise noted.

EDB = 1,2-Dibromoethane analyzed by EPA Method 8011

EDC = 1,2-Dichloroethane analyzed by EPA Method 8260B

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

TBA = Tertiary-butanol 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

Total Lead analyzed by EPA Method 6020

<x = Not detected at laboratory reporting limit x

--- = Not analyzed

* indicates the samples were additionally analyzed for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) analyzed by EPA Method 8270C-SIM; all of these analyte concentrations were below the MTCA Method A cleanup levels.

**indicates the samples were additionally analyzed for Polychlorinated biphenyls (PCBs) analyzed by EPA Method 8082; all of these analyte concentrations were below the MTCA Method A cleanup levels.

SB6, SB7, and SB9 are grab groundwater samples

a = The sample chromatographic pattern for TPH does not match the chromatographic pattern of the specified standard. Quantitation of the unknown hydrocarbon(s) in the sample was based upon the specified standard.

APPENDIX A

SITE ACTIVITIES HISTORY

SUMMARY OF PREVIOUS INVESTIGATIONS

1995 University Village Q Lube UST Closure Site Assessment: On March 29, 1995, Nowicki & Associates (Nowicki) oversaw the removal of one 3,000-gallon new oil UST and the in-place closure of a 500-gallon used-oil UST. Soil samples were collected and analyzed for total petroleum hydrocarbons (TPH) as oil (TPHo) and TPH as diesel (TPHd). TPHo was detected above the Washington State Department of Ecology's (Ecology) Model Toxics Control Act (MTCA) Method A cleanup levels in soil samples SB1-4 and SB3-24" at depths of 4 and 2 feet below ground surface (bgs), respectively. Approximately 30 tons of impacted soil was excavated from the new oil UST pit and disposed of off-Site. Due to the location of the waste oil UST it was closed in place by filling the UST with concrete slurry; soil containing petroleum hydrocarbons exceeding the Washington State Department of Ecology's (Ecology) Model Toxics Control Act (MTCA) Method A Cleanup Levels was left in place adjacent to the waste oil UST. More information is available in Nowicki's *University Village Q Lube UST Closure Site Assessment* dated June 20, 1995.

2006 Phase I Environmental Site Assessment: In March 2006, FINEnvironmental, Inc. completed a Phase I Environmental Site Assessment at the Site. The assessment indicated that the Property was a former fuel service station operated by Ritchfield Service and Village Arco from 1959 to the mid-1970s. They concluded that the Property contains a former new oil UST and a closed-in-place waste oil UST, and identified the presence of above ground storage tanks (ASTs). More information is available in FINEnvironmental's *Phase I Environmental Site Assessment* dated March 20, 2006.

2006 Site Investigation: In November 2006, CRA drilled six boring (SB-6 through SB-11) at the Site, in the vicinity of the former waste oil UST. Borings SB-8 and SB-10 were attempted but not completed due to hand auger refusal immediately beneath the concrete floor. Soil samples were analyzed for TPH as gasoline (TPHg), TPHd, TPHo, benzene, toluene, ethylbenzene, and xylenes (BTEX), MTBE, 1,2-dichloroethane (EDC), 1,2-dibromoethane (EDB), polychlorinated biphenyl (PCBs), polycyclic aromatic hydrocarbons (PAHs) carcinogenic PAHs (cPAHs), volatile petroleum hydrocarbons (VPH), extractable petroleum hydrocarbons (EPH), and total lead. TPHg exceeded the MTCA Method A cleanup levels in soil samples SB6-4, SB7-4, and SB9-4 at 4 feet bgs. No other analytes were detected above MTCA Method A cleanup levels. Groundwater was collected from borings SB-6, SB-7, and SB-9 and analyzed for TPHg, TPHd, TPHo, BTEX, MTBE, EDB, EDC, PCBs, PAHs, cPAHs, and total lead. TPHg exceeded the MTCA Method A cleanup levels in groundwater samples SB6 and SB7. More information is available in CRA's Site Investigation Report dated June 12, 2007.

APPENDIX B

STANDARD OPERATING PROCEDURES

TABLE OF CONTENTS

Page

LIST OF FIGURES

1.0 SOIL GAS SAMPLING STANDARD OPERATING PROCEDURES

1.1 SOIL GAS PROBE INSTALLATION

1.1.1 GENERAL

The procedures described in this section pertain to the installation of permanent sub-slab soil gas probes for collecting soil gas samples to assess the vapor intrusion pathway. Permanent soil gas probes are preferable to allow for multiple soil gas sampling events. More than one soil gas sampling event is often required when assessing vapor intrusion to address seasonal variations and temporal variability commonly observed in soil gas concentrations.

1.1.2 PRIOR PLANNING AND PREPARATION

When designing and constructing soil gas probes the following questions will be considered:

1. What is the purpose of the soil gas probes?
2. What are the potential health and safety hazards?
3. What type(s) of soil gas probe construction materials are to be used?
4. What kinds of analyses are required (e.g., VOCs, petroleum hydrocarbon fractions)?
5. What are the geologic/hydrogeologic conditions at the site?
6. What are the seasonally high water table levels?
7. Do perched conditions exist at the site?
8. What is the anticipated total depth of the probes?
9. Are nested soil gas probes required?

Note: If field staff are not aware of and able to answer all of the above noted questions before undertaking work in the field, the work plan must be reviewed in detail with the Project Coordinator/Manager.

1.1.3 SAFETY AND HEALTH

CRA is committed to conducting field activities with sound safety and health practices. CRA adheres to high safety standards to protect the safety and health of all employees, subcontractors, customers, and communities in which they work. The safety and health of our employees takes precedence over cost and schedule considerations.

Field personnel are required to implement the Safety Means Awareness Responsibility Teamwork (SMART) program as follows:

- Assure the Health and Safety Plan (HASP) is specific to the job and approved by a Regional Safety & Health Manager.
- Confirm that all HASP elements have been implemented for the job.

- A Job Safety Analysis (JSA) for each task has been reviewed, modified for the specific site conditions and communicated to all appropriate site personnel. The JSAs are a component of the HASP.
- Incorporate Stop Work Authority; Stop, Think, Act, Review (STAR) process; Safe Task Evaluation Process (STEP); Observations process; Near Loss and Incident Management process in the day-to-day operations of the job.
- Review and implement applicable sections of the CRA Safety & Health Policy Manual.
- Confirm that all site personnel have the required training and medical surveillance , as defined in the HASP.
- Be prepared for emergency situations, locating safety showers, fire protection equipment, evacuation route, rally point, and first aid equipment before you begin working, and make sure that the equipment is in good working order.
- Maintain all required Personal Protective Equipment (PPE), safety equipment, and instrumentation necessary to perform the work effectively, efficiently and safely.
- Be prepared to call the CRA Incident Hotline at 1-866-529-4886 for all incidents involving injury/illness, property damage, and vehicle incident and/or significant Near Loss.

It is the responsibility of the Project Manager to:

- Ensure that all CRA field personnel have received the appropriate health and safety and field training and are qualified to complete the work.
- Provide subcontractors with a Job Hazard Analysis to enable them to develop their own HASP.
- Ensure that all subcontractors meet CRA's (and the Client's) safety requirements.

1.1.4 QUALITY ASSURANCE/QUALITY CONTROL

A well-designed Quality Assurance/Quality Control (QA/QC) program will:

- Ensure that data of sufficient quality are obtained in order to facilitate good site management;
- Allow for monitoring of staff and subcontractor performance; and
- Verify the quality of the data for the regulatory agency.

The QA/QC program is developed on a site-specific basis. QA/QC requirements are discussed in detail in Section 1.2.1.

1.1.5 EQUIPMENT DECONTAMINATION

Prior to use between gas probe locations, drilling and sampling equipment must be decontaminated in accordance with the Work Plan, the Quality Assurance Project Plan (QAPP), or the methods presented in the following section.

The minimal was procedures for decontamination of drilling or excavating equipment are:

1. High pressure hot water detergent wash (brushing as necessary to remove particulate matter).
2. Potable, hot water, high pressure rinse.

Cover clean equipment with clean plastic sheeting to prevent contact with foreign materials.

On environmental sites, soil sampling equipment (e.g., split-spoons, trowels, spoons, shovels, and bowls) is typically cleaned as follows:

1. Wash with clean potable water and laboratory detergent, using a brush as necessary to remove particulates.
2. Rinse with potable water.
3. Rinse with deionized water.
4. Air dry for as long as possible.

Caution: *Confirm the cleaning protocol for the QAPP. The use of incorrect cleaning protocol can invalidate chemical data.*

1.1.6 INSTALLATION PROCEDURES

1.1.7 FIELD PROCEDURES

The following presents the field procedure requirements and techniques for the installation of soil gas probes.

1.1.7.1 DESIGN CONSIDERATIONS

Diameter

The soil gas probe casing diameter should be kept to a minimum to reduce the volume of soil gas that must be purged from the probe during sampling. A maximum casing diameter of 3/4-inch (19 mm) to 1-inch (25 mm) will be used for solid piping casing material [e.g., polyvinyl chloride (PVC)], although casing diameters this large are not recommended for deep soil gas probes [e.g., greater than 15 feet (4.6 m)] since large purge volumes will result. Casing diameters of 1/4 inch (6.4 mm) to 3/8-inch (9.5 mm) are typical when flexible tubing is used for the casing material (e.g., Teflon® or nylon).

Screened Interval and Sand Pack Material

The perforated section should be consistent with the desired monitoring interval and geologic conditions encountered. Usually a 6-inch (0.15 m) to 1-foot (0.3 m) perforated section is applied. The application of prefabricated stainless steel screen impacts is common. Alternatively, the screened interval can be created from casing material by hand-cutting slots, or hand-drilling holes, into the casing at a regular pattern.

For hand-cut or hand-drilled screened intervals, the preferred sand pack material for soil gas probes is pea gravel. For prefabricated screens, the preferred sand pack material is inert 10/20 silica sand.

Monitoring Parts

Airtight stainless steel or brass compression fittings (e.g., Swagelok®) with valves will be installed at ground surface on all gas probes to allow for an airtight connection to soil gas sampling equipment. The valve is required to isolate the soil gas sampling assembly from the soil gas probe while sampling assembly airtightness tests are conduct prior to soil gas probe purging and sampling (see Section 1.2.4).

Casing Materials

The materials selected for soil gas probe casing construction must be compatible with the volatile chemicals anticipated to be present in soil gas. Experience has shown that PVC casing is suitable when VOCs are present. However, as described above, PVC is typically not available in small enough diameters to provide practical soil gas probe purge volumes. To minimize purge volumes, small diameter [e.g., 1/4-inch (6.4 mm) to 3/8-inch (9.5 mm)] flexible tubing (e.g., Teflon® or nylon) is more commonly applied as the soil gas probe casing. Where solid casing is used (i.e., PVC), threaded piping will be used to avoid any possible contamination from solvent cement.

1.1.7.2 GENERAL INSTALLATION PROCEDURES

Annular Space

The borehole diameter must be of sufficient size such that the soil gas probe construction can proceed without any major difficulties. Particular attention should be paid to preventing bridging of fill or seal materials.

Instrumentation Details

The length of each soil gas probe assembly (i.e., perforated section and riser components) must be measured and recorded prior to insertion into the augers or borehole.

Sand Pack

For soil gas probes, the screened interval and sand pack are to be placed:

- preferably at a minimum 3 feet (1 m) below the ground surface to reduce the potential for drawing ambient air into the screened interval during sampling. This depth may vary depending upon the ground surface (i.e., if the ground surface is paved or concrete covered, this depth could be reduced);

- in a soil strata with a notably higher permeability than the surrounding geologic strata. Coarse-textured strata with higher permeabilities have a greater potential for soil gas migration and therefore should be monitored; and
- above the seasonally high water table.

A common problem with the installation of soil gas probes is flooding of gas probes, which prevents their sampling. The problem is especially pronounced at sites with perched water tables. Soil gas probes are typically installed in more permeable strata where perched water tables are more likely to exist. A thorough understanding of the hydrogeology of the site is necessary to install effective soil gas probes.

As with monitoring wells, the sand pack of a soil gas probe should not extend through a confining layer causing two or more separate permeable layers to become connected.

When placing the sand pack into the borehole, 1 inch (2.5 cm) of filter pack material will be placed under the bottom of the probe screen to provide a firm footing. The sand pack will extend to 6 inches (15 cm) above the screened interval.

Bentonite Seal (Plug)

A seal will be placed on top of the filter pack. This seal will consist of a high solids, pure bentonite material. Bentonite in either pellet or granular form is acceptable. Typically, pouring of the bentonite is acceptable in shallow gas probes where the annular space is large enough to prevent bridging and to allow measuring to ensure that the bentonite has been placed at the proper intervals. The bentonite seal will be placed above the filter pack and to a 1-foot (0.3 m) thickness. Since gas probes are installed above the water table, potable water will be used to hand-hydrate the bentonite.

Backfill

The annular space between the bentonite seal will be filled with pre-hydrated bentonite cement to 1-foot (0.3 m) below ground surface. The remaining annular space will be filled with concrete in conjunction with setting the surface protective casing.

Aboveground Riser Pipe and Protective Surface Casing

A flush-mount protective surface casing will be used to complete the soil gas probe at ground surface. A flush-mount casing is preferred due to the number of equipment pieces needed for the sampling assembly. Flush-mount casings allow the equipment to be laid on the ground during sampling, otherwise a portable table or other working surface will be needed to support the sampling equipment. The protective casings are cemented in place and usually fitted with locks or bolts, and rubber gaskets. The soil gas probe casing, when installed and grouted, will extend a sufficient distance into the surface casing to allow connection of the soil gas sampling assembly. In the case where flexible tubing is used for the soil gas probe casing, a short length of tubing can be coiled inside the surface casing.

Soil Gas Probe Locations

Soil gas probe locations will primarily be selected in the work plan to provide maximum anticipated soil gas impacts or in close proximity to buildings, and to suit the intended purpose of the study. Soil gas probes are commonly located adjacent to existing monitoring wells to allow an assessment of actual soil gas quality impacts attributable to shallow groundwater impacts detected at the monitoring well. Most often, the locations are not pre-verified to confirm clearance from underground or overhead utilities or to match the site's specific characteristics (i.e., traffic patterns, drainage patterns, etc.). Consequently, it is the Field Coordinator's task to select the exact location for each gas probe consistent with all of the site and study requirements. If a soil gas probe must be moved more that 20 feet (6 m) from the initially identified location, the Field Coordinator must confirm the selected location's suitability with the project coordinator.

To the extent practicable, soil gas probes should be located adjacent to permanent features (i.e., fences, buildings, etc.) that offer some form of protection and a reference point for locating the soil gas probe. Soil gas probes located in high traffic areas or road allowance right of ways are undesirable and should be avoided if possible. Low-lying areas are also undesirable to avoid potential flooding.

Field ties accurately identifying each gas probe location must be taken as soon as each gas probe is completed to insure that no confusion with other well installations occurs.

1.1.7.3 SPECIFIC INSTALLATION PROCEDURES

More specific installation procedures are provided below for sub-slab soil gas probes. A schematic of a typical sub-slab soil gas probe installation detail is presented on Figure B.1.

Sub-slab soil gas probes allow for collection of soil gas samples from directly beneath the slab of a building. Note that sub-slab soil gas probes are not recommended when groundwater is present directly below the slab, as drilling through the slab could allow groundwater to enter the building. A summary of the steps involved in the installation of sub-slab soil gas probes is presented below:

1. Prior to drilling holes into the building floor, the location of utilities coming into the building (e.g., gas, electrical, water, and sewer lines, etc.) will be identified. Avoid installing sub-slab soil gas probes near where utilities penetrate the slab as these may be entry points for downward ambient air migration through the slab during soil gas sampling.
2. A rotary hammer drill or equivalent equipment will be used to drill a "shallow" [approximately 1 inch (2.5 cm) deep] outer hole [approximately 7/8 inches (2.2 cm) in diameter] that partially penetrates the floor slab. Cuttings may be removed using a towel moistened with distilled water or small portable vacuum cleaner.
3. The rotary hammer drill or equivalent equipment will be used to drill a smaller diameter inner hole, within the center of the outer hole, approximately 3/8 inch (9.5 mm) in diameter through the floor material and approximately 3 inches (7.6 cm) into the sub-slab bedding material to create an open cavity. The outer hole will be cleaned a second time with a towel moistened with distilled water.

4. Chromatography grade 316 stainless steel or brass tubing will be cut to a length that allows the probe to float within the slab thickness to avoid obstruction of the probe with sub-slab bedding material. The tubing will be approximately 1/4-inch (6.4 mm) in diameter. Where necessary, the compression fittings will be stainless steel or brass (approximately 1/4-inch O.D. and 1/8-inch NPT) Swagelok® female thread connectors. Whenever possible, the probes will be constructed prior to drilling to minimize exposure time, or venting, of the sub-slab bedding material through the open hole.
5. The sub-slab soil gas probe will be placed in the holes so that the top of the probe is flush with the top of the floor. The top of the probe will have a recessed stainless steel or brass plug. A quick-drying, Portland cement slurry will be injected or pushed into the annular space between the probe and the outer hole. The cement will be allowed to dry for at least 24 hours prior to sampling.

1.1.7.4 INSTALLATION DOCUMENTATION

Details of each soil gas probe installation should be recorded on CRA's standard Stratigraphic Log Overburden, or recorded within a standard CRA field book. This figure must note:

- borehole depth;
- probe perforation intervals;
- filter pack intervals;
- plug intervals;
- grout interval;
- surface cap detail;
- soil gas probe material;
- soil gas probe instrumentation (i.e., riser and screen length);
- soil gas probe diameter;
- filter pack material;
- backfill material detail;
- stickup/flush-mount detail; and
- date installed.

The soil stratigraphy encountered at soil gas probes refuse must be recorded in accordance with CRA's standard borehole advancement methods.

Each soil gas probe installed must have accurate field ties to the center of the gas probe from three adjacent permanent features each located in a different direction from the installation.

Each soil gas probe must be permanently marked to identify the soil gas probe number designation.

1.1.7.5 FOLLOW-UP ACTIVITIES

Once the soil gas probe(s) have been completed, the following activities need to be done:

1. Conduct initial monitoring round of gas probes.
2. All logs will be submitted to CRA's hydrogeology department who will be responsible for the generation of the final well log.
3. Arrange surveyor to obtain accurate horizontal and vertical control.
4. Gas probe/boring locations will be accurately plotted on the site plan, since boring locations may change in the field due to underground/overhead utility interferences or other conditions.
5. Tabulate gas probe and extraction well details.
6. A summary write-up on field activities including, but not necessarily limited to such items as drilling method(s), construction material, site geology.
7. Field book will be kept at the appropriate CRA office.

1.2 SOIL GAS PROBE SAMPLING

1.2.1 QA/QC ACTIVITIES

The level of the QA/QC effort will include:

- a field duplicate; and
- a trip blank.

Field blank and field duplicate samples are analyzed to assess the quality of the data resulting from the field sampling program. A trip blank consisting of an unused Summa™ canister submitted to the analytical laboratory to provide the means to assess the quality of the data resulting from the field sampling program. The trip blank sample will be analyzed to check for procedural contamination at the Site, which may cause sample contamination.

One field duplicate sample will be obtained for each day of sampling or from at least 10 percent of the samples obtained. The duplicate sample will be collected by using a splitter with separate sampling tubes connecting the splitter to two Summa™ canisters. Duplicate samples will be analyzed to check for sampling and analytical reproducibility.

A background outdoor ambient air sample will also be applied for QA/QC purposes to evaluate the presence of background influences on the soil gas sampling results.

The level of QA/QC effort provided by the project laboratory for the samples analyses will correspond to the level of QA/QC effort specified in "The Determination of Volatile Organic Compounds in Ambient Air Using Summa™ Passivated Canister Sampling and Gas Chromatographic Analysis" (U.S. EPA, 1988).

1.2.2 PRIOR PLANNING AND PREPARATION

The following will be considered prior to soil gas sampling:

1. Review the work program, project documents and the Health and Safety requirements with the Project Coordinator.
2. Complete a Field Equipment Requisition Form (QSF-014). Assemble all equipment and supplies required.
3. Assemble site plan, available stratigraphic logs and previous sampling/purging data that will be required for the planned sample event. Determine the number and locations of the points to be sampled.
4. For the laboratory analysis, contact the CRA chemistry group to arrange:
    - QA/QC requirements;
    - SSOW (Simplified Scope of Work);
    - laboratory;
    - sample containers;
    - coolers;
    - required sampling protocol, in addition to the protocol presented here;
    - sample shipping details;
    - provide starting date; and
    - expected duration of sampling.
5. Complete a Vendor Evaluation Form (QSF-012) and file in the Project file for any vendors that do not have full approval status or are not listed on the Approved Vendor List (QSL-004). Completion of a Safety and Health Schedule (QSF-030 for Canadian work QSF-031 for U.S. Work) is necessary for all Vendors who complete field services. Prior to mobilization on site, the Vendor must submit the form to the Regional Safety and Health Manager for review and approval (if not already posted on QSL-004).
6. Evaluate sample notification needs with the project coordinator. Has the regulatory groups, client personnel, landowner, CRA personnel, and laboratory been informed of pending sample events?
7. Arrange access to the site (required keys). Also consider site conditions (e.g., is snow removal required?).

1.2.3 GENERAL FIELD PROCEDURES

Once the prior planning and preparation activities are completed, soil gas sampling can proceed at the respective sample points on sites. The soil gas samplers must familiarize themselves with the equipment available, and understand the equipment limitations and use. The following soil gas collection procedure outlines the most common method used by CRA in assessing the vapor intrusion pathway. The typical series of events that will take place are:

1. Sample location identification/inspection (see below for additional information).
2. Air monitoring (see below for additional information).
3. Decontamination (see below for additional information).
4. Field notes completion, review, checking.
5. Equipment return.
6. Documentation submitted to appropriate staff and files.

Further details regarding items 1 to 3 are provided below.

Sample Location Identification/Inspection

Once at the site and prior to soil gas sampling, confirm that the sample location (i.e., soil gas probe location) has been correctly identified and located. Frequently sites under evaluation have numerous sample locations and misrepresentation can easily occur.

Decontamination

All drilling, soil gas sampling, and monitoring equipment must be decontaminated on site. If the site has a specific cleaning protocol, it must be followed. General cleaning procedures can be found in Section 1.1.5.

1.2.4 SOIL GAS SAMPLING PROTOCOL

The following sections describe the protocol for soil gas sampling from permanent sub-slab soil gas probes.

Soil gas sampling should commence a minimum of 24 hours following installation of the soil gas probes, to allow time for disturbances created by drilling to dissipate and allow the formation to return to an equilibrium condition. In fine-grained soil conditions, consideration should be given to allowing a greater amount of time for equilibrium conditions to become re-established (e.g., 72 hours). Soil gas sampling will not be performed during or within 48 hours of a significant rainfall event [e.g., >0.5 inches after Cal EPA (2003)]. This will avoid the potential that increased moisture content in the unsaturated zone soil could temporarily dampen soil gas concentrations, or possibly prevent soil gas sample collection (i.e., such as in cases where the soil gas probe screened interval could become temporarily saturated due to the passing infiltration front). In fine-grained soil conditions, consideration should be given to allowing a greater amount of time for rainfall events to dissipate. The potential influence of rainfall events on soil gas concentrations is less of concern in cases where the soil gas probes are located beneath impervious ground cover (e.g., pavement or building foundation).

A summary of the steps involved in soil gas sampling is presented below:

1. Soil gas samples for assessing the vapor intrusion pathway will be collected using certified clean Summa™ canisters. Only canisters certified clean at the 100 percent level can be used for soil gas

sampling activities (i.e., pre-cleaned at the laboratory in accordance with U.S. EPA's TO-15 method and documentation of the cleaning activities will be provided by the laboratory). Summa™ canisters typically come in 1-, 1.7-, and 6-liter capacities, depending upon laboratory availability. Consideration should be given to using smaller capacity canisters to reduce sample volume and increase confidence that the soil gas sample is drawn from the formation immediately surrounding the probe screen during sampling. Larger volume samples can promote drawing ambient air down the annulus of the soil gas probe which can dilute the soil gas sample. The use of the smaller canister sizes becomes more critical in fine-grained soil conditions where the formation may not give up significant soil gas volumes (in this case, ambient air infiltration down the soil gas probe annulus can be more problematic).

2. The Summa™ canisters will be fitted with a laboratory calibrated critical orifice flow regulation device sized to restrict the maximum soil gas sample collection flow rate to approximately 100 milliliters per minute (mL/min), which corresponds to the lower end of the maximum soil gas sampling flow rate recommended by Cal EPA (2003) of 100 to 200 mL/min. The 100 mL/min maximum flow rate translates to sample collection times of 10, 17, or 60 minutes, respectively, for of 1, 1.7, or 6 liter canister capacities. A maximum flow rate of 100 mL/min is recommended to limit VOC stripping from soil, prevent the short-circuiting of ambient air from ground surface down the soil gas probe annulus that would dilute the soil gas sample. A maximum flow rate of 100 mL/min increases confidence that the soil gas sample is drawn from immediately surrounding the screened interval.

3. A vacuum gauge will be supplied by the laboratory and used during sample collection to measure the initial canister vacuum, canister vacuum during sample collection, and residual canister vacuum at the end of sample collection. The vacuum gauge will be returned to the laboratory and used by the laboratory to measure the residual canister vacuum upon receipt of the canisters by the laboratory. Using the same vacuum gauge throughout the entire sampling process will eliminate discrepancies between vacuum measurements that can arise from using different gauges with a potentially different sensitivity and/or calibration.

4. The canister will be connected to the soil gas probe valve at the surface casing using the sampling assembly that is depicted on Figure B.2. The sampling assembly is connected using short lengths [e.g., 1-foot (0.3 m)] 1/4-inch (6.4 mm) or 3/8-inch (9.5 mm) diameter tubing (the tubing material will be Teflon® or nylon) and airtight stainless steel or brass tee-connectors and tee-valves (e.g., Swagelok® type). The canister will be connected to the soil gas probe along with a vacuum gauge and a personal sampling pump, all in series, using tee-connectors or tee-valves (in the order of soil gas probe, vacuum gauge, pump, and canister). A tee-valve will be used to connect the pump, which will allow the pump to be isolated from the sampling assembly during sample collection. Fresh tubing will be used for each sample.

5. Prior to collecting a soil gas sample, the stagnant air in the sampling assembly tubes and soil gas probe casing/sand pack must be removed. The soil gas probes will be purged prior to sampling using the personal sampling pump at a flow rate of less than 200 mL/min. This ensures that the collected soil gas sample is representative of actual soil gas concentrations within the formation. Measurements of the lengths and inner diameters of the above-ground sampling assembly and below-ground gas probe casing, screen, and sand pack should be used to calculate the "purge volume" (the purge volume will consider the pore volume of the sand pack assuming a 30 percent sand pack porosity). Prior to sample collection, two to three purge volumes should be drawn from the probe/sample assembly, unless otherwise required by the applicable regulatory

guidance. The purge data (calculated purge volume, purging rate, and duration of purging) should be recorded in the field logbook.

6. Prior to purging, a vacuum, or tightness, test will be conducted on the sampling assembly as the first of two leak-testing steps, as described further in Section 1.2.5. Briefly, this first leak-testing step (the vacuum test) will consist of opening the valve to the personal sampling pump leaving the valves to the Summa™ canister and the soil gas probe closed. The pump will then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are airtight. Further details of the vacuum test are described in Section 1.2.5.

7. Prior to purging, and following the vacuum test, the set-up for the second of the two leak-testing steps will be conducted. The second leak-testing step is the tracer compound step. A tracer compound is released at ground surface immediately around the soil gas probe surface casing. The tracer test is used to test for ambient air leakage down the annulus of the soil gas probe and into the soil gas sample. The tracer compound is either monitored for in the field using a meter connected in-line to sampling assembly (e.g., helium), or is included as an analyte in the laboratory analysis of the soil gas samples (e.g., isopropanol). The setup requirements of the tracer compound leak-testing step are described in Section 1.2.5.

8. Following the vacuum test, and the setup for the tracer compound leak-testing step, the soil gas probe purging will commence by opening the valve to the soil gas probe and activating the personal sampling pump (and leaving closed the valve to the Summa™ canister). At the start and the end of the purging period, the total concentration of volatile organic vapors of the personnel sampling pump exhaust gas will be monitored using a portable photoionization detector (PID) meter. The PID meter will be connected in series after the personal sampling pump. Since typical PID instrument flow rates vary from approximately 300 to 500 mL/min (depending on the manufacturer and model), drawing a sample into the PID meter through the personal sampling pump likely will increase the purging flow rate temporarily until a reading from the PID meter is obtained. PID readings will be recorded and entered in the field logbook and chain of custody form. The PID readings will provide the laboratory with an indication of whether a sample could require dilution before analysis.

9. Following purging, the valve to the personal sampling pump will be closed, and the valves to the soil gas probe and Summa™ canister will be opened to draw the soil gas sample into the canister concurrent with continuing to apply the leak-testing tracer compound. The vacuum gauge reading will be recorded during sample collection. Should the vacuum gauge reading remain elevated above 10 inches mercury (Hg) for more than 30 minutes, this will be taken to indicate that the initial vacuum in the canister has not sufficiently dissipated, and that the soil screened by the soil gas probe does not produce sufficient soil gas to permit sample collection.

10. To ensure some residual vacuum in each canister following sample collection, the canister vacuum will be recorded at approximately 80 percent through the expected sample collection duration. With a 100 mL/min maximum flow rate, the expected sample collection duration would be 10, 17, or 60 minutes, respectively, for canister capacities of 1, 1.7, or 6 liters. A maximum residual vacuum of 10-inches Hg is allowed. A canister residual vacuum above this value will require continued sampling until vacuum reading is below this threshold, unless the vacuum remains above 10-inches Hg for more than 30 minutes, as described above. A minimum 0.5 to 1-inch Hg residual vacuum will be required for the sample to be considered valid, or the

sampling will be repeated using a fresh Summa™ canister. Once the vacuum is measured, the safety cap will be securely tightened on the inlet of the Summa™ canister prior to shipment to the laboratory under chain-of-custody procedures.

11. The vacuum gauge provided by laboratory will be returned with the canister samples to check residual vacuum in the laboratory prior to sample analysis and recorded on the analytical data report. This check will ensure sample integrity prior to laboratory analysis, and that the canister has not become compromised during shipment to the laboratory.
12. If the critical orifice flow regulation devices (provided by the laboratory) and sampling assembly fittings/valves are to be re-used during sampling, they will be cleaned in accordance with laboratory requirements by purging with zero air (provided by laboratory) for minimum 45 seconds at minimum 75 psi.
13. The canisters will be labeled noting the unique sample designation number, date, time, and sampler's initials. A bound field logbook will be maintained to record all soil gas sampling data.
14. The canisters will be listed on the chain-of-custody in order of suspected highest to lowest impact, as evidenced by the recorded PID readings. Indicate on the chain-of-custody for the laboratory to analyze the canisters in order from the lowest to highest PID reading.

The soil gas samples will be analyzed for VOCs by the project laboratory using U.S. EPA's TO-15 gas chromatograph/mass spectrometer (GC/MS) methodology, with the mass spectrometer (MS) run in full scan mode. QA/QC measures implemented during the soil gas sampling event will include the two-step leak testing procedure (see Section 1.2.5), maintaining a minimum residual vacuum in the Summa™ canisters following sample collection, collection of one duplicate per sampling event or from at least 10 percent of the samples obtained, and collection of an ambient air sample. As an additional QA/QC measure, the laboratory will conduct a duplicate analysis of the sample collected in one of the canisters.

1.2.5 SOIL GAS PROBE LEAK TESTING

The use of leak testing is recommended as a quality control check to ensure ambient air has not leaked into the soil gas probe or sampling assembly, which may affect (i.e., dilute) the analytical results. Contaminants in ambient air can also enter the sampling system and be detected in a sample from a non-contaminated sampling probe resulting in a "false positive" result. The leak testing will be conducted in the following two steps:

- Step 1 - Vacuum Test: used to ensure that the tubing and fittings/valves that make up the sampling assembly are air tight; and
- Step 2 - Tracer Test: used to ensure that ambient air during soil gas sample collection is not drawn down the soil gas probe annulus through an incomplete seal between the formation and the soil gas probe casing.

The vacuum test and tracer test are detailed below.

Step 1 - Vacuum Test

- The sampling assembly will be connected to the soil gas probe valve at the surface casing. Once connected, the sampling assembly will consist of the soil gas probe, the vacuum gauge supplied by the laboratory, personal sampling pump, and Summa™ canister, all connected in series (i.e., in the order of soil gas probe, vacuum gauge, pump, and canister), using tee-connectors or tee-valves.
- The personal sampling pump will be used to conduct the vacuum test. The vacuum test will consist of opening the valve to the personal sampling pump while leaving closed the valves to the Summa™ canister and the soil gas probe. The pump will then be operated to ensure that it draws no air from the sampling assembly (i.e., creates a negative pressure, or vacuum within the sampling assembly), thus establishing that all assembly connections are airtight. The sampling pump low-flow detect switch will likely activate within 10 to 15 seconds, turning the pump off. A negative pressure, or vacuum, should be established within the sampling assembly, and should be sustained for at least 1 minute.
- If the pump is capable of drawing flow, or if the vacuum is not sustained for at least 1 minute, all fittings and tubing will be checked for tightness (or replaced) and the vacuum test will be repeated.
- The reading from the vacuum gauge pressure will be recorded in field logbook to demonstrate that the pump is able to create a vacuum within the sampling assembly (it will also be noted whether the low-flow detect switch on the pump was activated), and that the vacuum is sustained for at least 1 minute.

Step 2 - Tracer Test

A tracer compound is released at ground surface immediately around the soil gas probe surface casing and is used to test for ambient air leakage down the annulus of the soil gas probe and into the soil gas sample. Two options are described below for the tracer test where either isopropanol (Option A) or helium (Option B) is used as the tracer compound.

Option A - Isopropanol

- For Option A, isopropanol is used as the tracer compound. It is included as an analyte in U.S. EPA's TO-15 method, it is readily available (i.e., as isopropyl rubbing alcohol), and it is safe to use.
- Approximately 1 teaspoon (approximately 4 mL) of isopropanol (rubbing alcohol) will be mixed in 1 gallon of de-ionized water to create an approximate 1/1,000 solution.
- Paper towels soaked in the dilute solution of isopropanol will be wrapped around the soil gas probe surface casing and ground surface immediately surrounding the surface casing. Soil gas probe surface casing then will be covered over using clear plastic sheeting that will be sealed to the ground surface. As the ground surface finish permits, sealing the plastic sheeting to ground surface will be accomplished using tape or by weighting the edges of the plastic sheeting with dry bentonite.
- Immediately before conducting the soil gas probe purging, remove the paper towels from the solution wringing out the towels so they are very damp, but not dripping, before placed them around the vapor probe and sealing them in place using the plastic sheeting.
- The isopropanol solution will be kept fresh, with new solution being made every hour. The solution will be mixed at a central location away from the sampling activities. The isopropanol will be kept

tightly capped and kept away from all sampling equipment. The solution will be kept away from the sampling assembly until immediately before sample collection begins. Sampling personnel will wear latex gloves while handling the solution and soaked paper towels, and will remove the gloves while working with the sampling assembly.

- Soil samples with laboratory analytical results for isopropanol that are greater than 10 percent of the starting concentration of isopropanol in the vapors emitted from dilute isopropanol solution will not be considered reliable and representative of soil gas concentrations within the formation (ITRC, 2007). The starting concentration will be calculated based on the concentration of isopropanol in the dilute solution, the vapor pressure of isopropanol, and Henry's law.
- A disadvantage in using isopropanol as the tracer compound is that it will not be known whether a significant leak occurred until after the cost of analyzing the sample has been spent. Elevated levels of isopropanol can also interfere with laboratory analytical method detection limits.

Option B - Helium

- The presence of helium within the sampling assembly will be monitored during purging and soil gas sample collection using a helium meter installed in-line with the sampling assembly just before the personal sampling pump.
- Helium is readily available at a variety of retail businesses, is safe to use, and does not interfere with laboratory analytical method detection limits.
- A containment unit is constructed to cover the soil gas probe surface casing. The containment unit will consist of an overturned plastic pail set into a ring of dry bentonite to create a seal between the ground surface and the rim of the pail. The pail can be set directly on top of the sampling assembly tubing connected to the soil gas probe, which when pressed into the dry bentonite, should create a sufficient seal around the tubing. The pail will have two holes: one to allow for the introduction of helium; and the other to allow for air trapped inside the pail to escape while introducing the helium. The second hole will also allow insertion of the helium meter to measure the helium content within the pail.
- Prior to soil gas probe purging, helium will be introduced into the containment unit to obtain a minimum 50 percent helium content level. The helium content within the containment unit will be confirmed using the helium meter and recorded in the field logbook. Helium will continue to be introduced to the containment unit during soil gas probe purging and sampling, but care will be taken not to increased the pressure within the containment unit beyond that of atmospheric pressure.
- During soil gas probe purging and sampling, the helium meter will be connected in-line with the sampling assembly. In the event that the helium meter measures a helium content with the sampling assembly of greater than 10 percent of the source concentration (i.e., 10 percent of the helium content measured within the containment unit), the soil gas probe will be judged to permit significant leakage such that the collected soil gas sample will not be considered reliable and representative of soil gas concentrations within the formation (ITRC, 2007).
- An advantage of using helium as the tracer compound is that a significant leak can be detected in the field and the cost of analyzing the Summa™ canister can be avoided.

1.2.6 FIELD INSTRUMENTATION CALIBRATION

Sampling or monitoring equipment used in the soil gas and outdoor air sampling program to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specification and requirements. Field calibration of the personal sampling pump and PID meter will be carried out prior to sampling activities.

The vacuum gauge used to measure canister vacuum will be calibrated and provided by the laboratory. The vacuum gauge will be returned to the laboratory for the laboratory to obtained vacuum measurements prior to sample analysis (checking canister integrity was maintained during shipment). Using a common vacuum gauge will avoid variations in vacuum measurements that can arise due to using different vacuum gauges.

1.2.7 FOLLOW-UP ACTIVITIES

The following activities will be performed at the completion of the field work.

1. Review and compare newly obtained data with historic data and flag unusual or extreme readings for review.
2. Soil gas concentrations are reported in units of $\mu g/m^3$ or ppbv. Unlike concentration units for groundwater, these units are not directly interchangeable. The molecular weight of the compound in question is a factor in the conversion from units of mass per unit volume to parts per billion by volume.
3. Ensure site access keys are returned.
4. The equipment will be cleaned and returned to the Equipment Coordinator. All equipment will be cleaned at the site.
5. Monitoring forms and field notes will be sent to the file. The field book will be stored at the appropriate CRA office.

1.3 REFERENCES

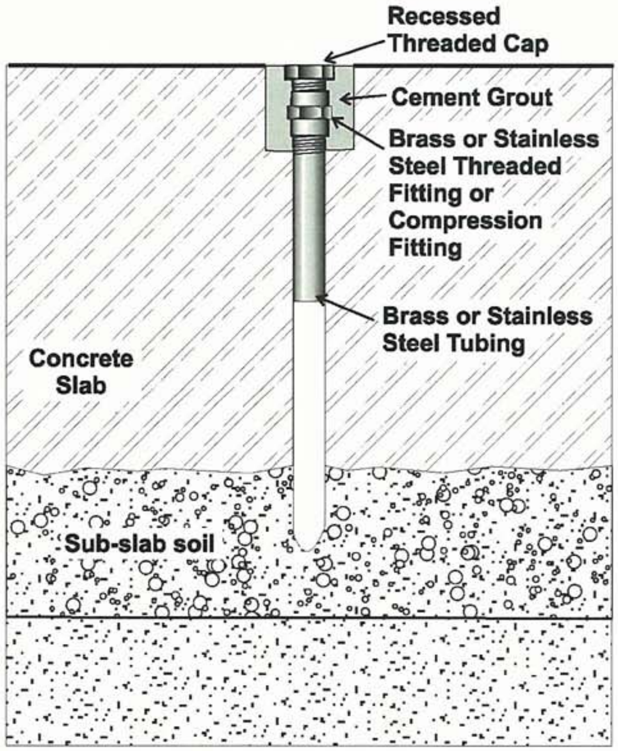
Cal EPA, 2003. Advisory – Active Soil Gas Investigations, Department of Toxic Substances Control, January 28.

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

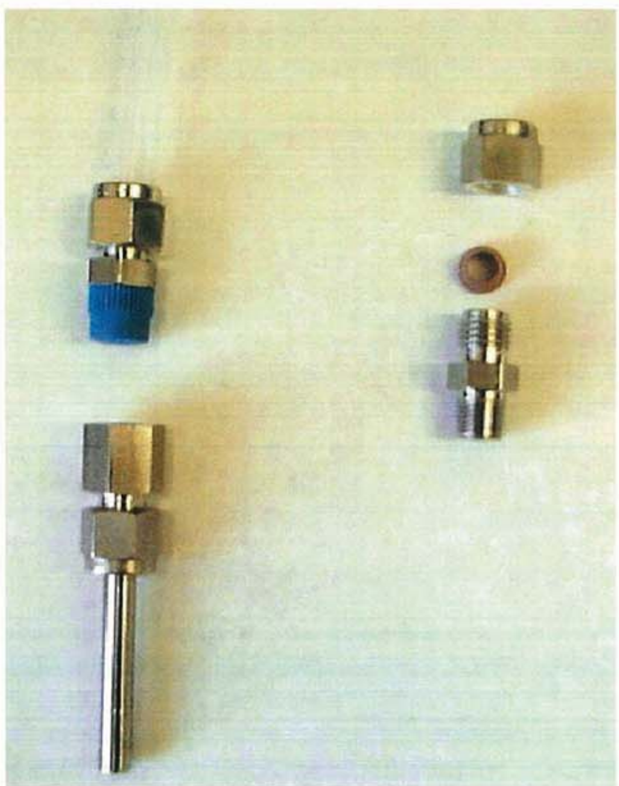
ITRC, 2007. Vapor Intrusion Pathway: A Practical Guide, January.

U.S. EPA, 1988. The Determination of Volatile Organic Compounds in Ambient Air Using Summa™ Passivated Canister Sampling and Gas Chromatographic Analysis, May.

U.S. EPA, 2006. Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples, March 2006. EPA/600/R-05/147.



SCHEMATIC OF TYPICAL SUB-SLAB SOIL GAS PROBE



FITTINGS USED FOR SUB-SLAB SOIL GAS PROBE ASSEMBLY

SOURCE: U.S. EPA (2006)

figure B.1

TYPICAL SUB-SLAB SOIL GAS COMPLETION DETAIL

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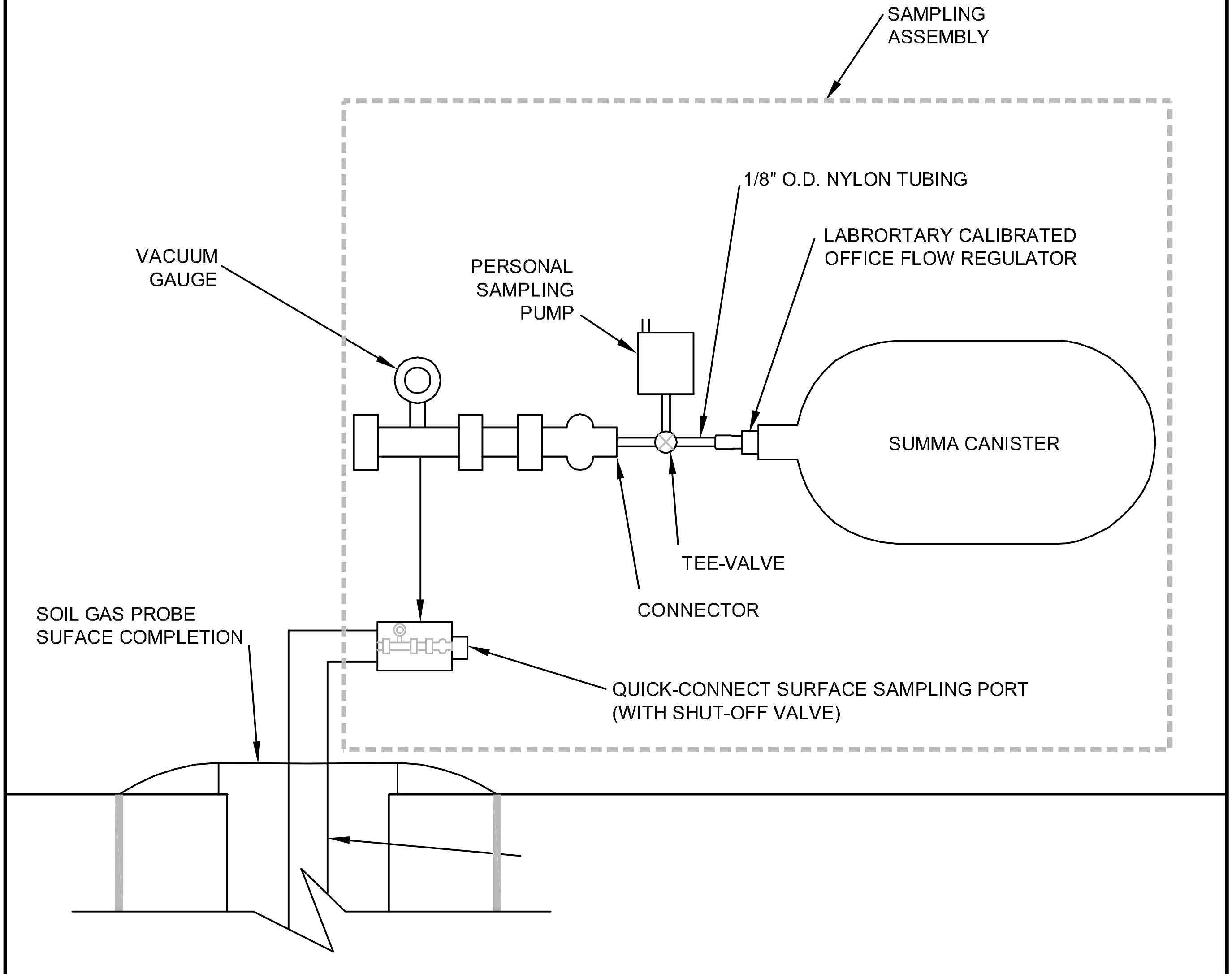

NOT TO SCALE

figure B.2

TYPICAL SOIL GAS SAMPLING ASSEMBLY SCHEMATIC

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