

Prepared for:

Astoria Area-Wide PRP Group

SUB-SLAB SOIL GAS INTRUSION ASSESSMENT

**PORT OF ASTORIA OFFICE BUILDING
ASTORIA AREA-WIDE PETROLEUM SITE
ASTORIA, OREGON
DEQ ECSI FILE #2277**

Prepared by:

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September 10, 2007
(Revised May 29, 2008)

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1. INTRODUCTION

1.1 Terms of Reference

Geosyntec Consultants, Inc. (Geosyntec) has prepared this report on behalf of the Astoria Area-Wide PRP Group to present the results of the Sub-Slab Soil Gas Vapor Intrusion Assessment conducted at the Port of Astoria office building located at the Astoria Area-Wide Petroleum Site in Astoria, Oregon. Following completion of the Phase 1 Remedial Investigation/Feasibility Study (RI/FS) for the site, the vapor intrusion pathway was identified as a potentially complete exposure pathway in site buildings overlying petroleum-impacted soil and groundwater. Soil gas investigations were conducted in October and December 2004 to evaluate the vapor intrusion pathway near the Port of Astoria office building (EnviroLogic Resources & GeoSyntec, 2005a). The Port office building was selected for the vapor intrusion assessment because of the presence of free-phase petroleum hydrocarbon in ground-water monitoring wells near the Port office building. Following review of these data, additional site evaluation was proposed directly beneath the Port office building.

A sub-slab soil gas investigation work plan (EnviroLogic Resources & GeoSyntec, 2005b) was submitted to and approved by the Oregon Department of Environmental Quality (DEQ). This investigation was conducted in July 2005 and September 2006.

1.2 Background

The Astoria Area-Wide site includes facilities and properties located at and near the Port of Astoria, as shown on **Figure 1**. The site is bounded by Portway to the northeast, the Columbia River to the northwest, Hamburg Street (including the former Chevron/McCall bulk plant) to the southwest and Marine Drive to the southeast (**Figure 2**).

This area in and around the Port of Astoria has been used for petroleum storage and distribution since the 1920s. Aboveground storage tanks (ASTs), underground storage tanks (USTs), and pipelines were present on several of the facilities subject to this investigation. Historically, the area was home to at least four bulk petroleum storage facilities and five vehicle fueling or service stations between West Marine Drive and the Columbia River in the Property. Inactive pipelines associated with several of the former bulk fuel storage facilities extend onto Pier 2. A complete site history and a

summary of remedial actions completed at the Astoria Area-Wide site are presented in the RI/FS and IRAM Development Work Plan, Phase 1 (RI/FS Work Plan) (EnviroLogic Resources, 2002).

Based on a review of the boring logs completed as part of the Phase 1 soil characterization activities, most of the Astoria Area-Wide site is underlain by gray and light brown fill sand. Lenses of silt and clay are present in the fill as well as gravel, wood, and other organics. In addition, two native materials were encountered beneath the site: native river deposits and the Astoria Formation. The native materials were encountered at depth, consistent with the conceptual hydrogeologic model presented in the RI/FS Work Plan.

Groundwater is generally encountered between 7 and 11 feet below ground surface (bgs) at the site, except along West Marine Drive. The three sites along West Marine Drive have a ground surface elevation approximately 15 feet above the remainder of the site and the depth to groundwater is generally about 22 feet bgs. The depth to water varies seasonally. The occurrence of free product or light non-aqueous phase liquids (LNAPL) has been documented at several locations within the Astoria Area-Wide site. Boring logs and a summary of physical and engineering parameters of selected soil samples are presented in the technical memorandum Phase 1 Source/Soil Characterization (EnviroLogic Resources, 2003).

Soil gas samples were collected at a depth of 5 feet bgs from four monitoring points near the Port office building in October and December 2004. Petroleum hydrocarbons and methane were detected in soil gas samples collected near the perimeter of the building with higher concentrations of petroleum hydrocarbons detected near the southwest corner of the building. A preliminary evaluation of these results indicate that benzene concentrations measured in two soil gas monitoring points may exceed site-specific soil vapor risk-based concentrations (RBCs) calculated for vapor intrusion to commercial buildings. Based on these findings, the heating, ventilation and air conditioning (HVAC) system in the Port office building was upgraded to maintain a positive pressure inside the building and sub-slab soil gas samples were proposed to be collected.

2. INVESTIGATION SCOPE

The investigation was conducted following review of the results of the soil gas investigation completed in October and December 2004. This earlier investigation evaluated shallow soil gas surrounding the Port of Astoria Office Building. Sub-slab soil gas was sampled and analyzed to provide a more detailed assessment of subsurface vapor intrusion. This approach is preferable over indoor air sampling because background sources of hydrocarbons (outdoor air or indoor sources) will have limited influence on sub-slab vapors.

The Port office building is a two-story structure with a footprint of approximately 8,200 square feet (ft²). The western 5,500 ft² of the building consists of slab-on-grade construction while the eastern portion has a crawl space. The sub-slab sample locations were selected to assess the soil gas concentrations throughout the portion of the building built with a slab foundation. Two of the sub-slab probes were selected to target the southwestern portion of the building where the higher soil gas concentrations were detected in the previous investigation.

The scope of work included the installation, pneumatic testing, and sampling of seven sub-slab probes (SSPs) at the Port office building to assess the risk of subsurface vapor intrusion to indoor air. Additionally, outdoor air samples were collected to provide an indication of background ambient air quality while sub-slab samples were collected. Barometric data were collected inside the building during the investigation.

At the request of DEQ, areas identified as potential collection/accumulation areas for subsurface methane gas around the inside and outside of the Port office building were screened for methane. Nineteen locations around and within the building were identified and screened using a landfill gas detector for methane concentration and percent of lower explosive limit (LEL).

3. METHODS

This section describes the methods used during the investigation.

3.1 Summary of Sub-Slab Probe Installation and Sampling Procedures

SSPs were installed at seven locations throughout the Port office building as shown in **Figure 3**. Three SSPs were installed during the July 2005 event (SSP-01, -03, and -04). An attempt was made to install SSP-02 during this event; however, the thickness of the concrete slab was greater than 15 inches and a SSP could not be installed at this location with the equipment available during the field activities. Equipment to drill through the building slab was brought to the site during the September 2006 sampling event and SSP-02 plus three additional probes (SSP-05, -06, and -07) were installed. The procedure for the installation and collection of sub-slab samples is described in the Geosyntec Suggested Operating Procedure for Sub-Slab Soil Gas Monitoring included as **Appendix A**.

Helium was added to a shroud around the ground surface of each probe prior to sample collection. The concentration of helium in the shroud and collected samples were recorded with a portable meter to assess the extent of any atmospheric air leakage into the sample.

3.2 Development and Field Screening

Sub-slab probes were allowed to equilibrate over night following installation. Prior to sampling, sub-slab probes were purged until a minimum of 5 to 7 liters (L) of soil gas were removed and the field screening results stabilized in at least three successive 1-1.5 L purges. This was done to remove atmospheric air that may have entered the borehole during the drilling and installation procedure and to promote the collection of reproducible samples.

Field screening samples were collected in 3 L Tedlar[™] bags using a lung box and screened using a MiniRae 2000 photoionization detector (PID), Landtec Gem 2000 landfill gas meter and Dielectric MGD2002 helium detector (for tracer gas), all calibrated according to manufacturer's instructions.

3.3 Sub-Slab Soil Gas Permeability

The gas permeability of geologic materials surrounding the sub-slab probes (i.e., beneath the concrete slab) was evaluated by measuring the flow rate of sub-slab gas through the probe and the resulting vacuum on the probe. These data were analyzed using the radial vapor flow equation (Johnson et al., 1990) to calculate the soil gas permeability.

3.4 Sample Collection

Samples for laboratory analysis were collected from the sub-slab probes by connecting the final Tedlar[™] bag sample to a 1-L Summa canister with a 5-micron inline filter using a secure compression fitting. The contents of the Tedlar[™] bag were then transferred into the Summa canister by opening the valves on both the bag and the canister.

An outdoor air sample was also collected approximately 75 ft northwest of the Port office building each day the sub-slab samples were collected to characterize the ambient air. The outdoor air samples were collected in a 6-L Summa canister fitted with a 5-micron particulate filter and flow controller to collect a 6-L sample in eight hours.

The samples were sent to Calscience Environmental Laboratories, Inc. of Garden Grove, California and analyzed for the following constituents:

Compounds	Method
Benzene, toluene, ethylbenzene, xylenes, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene	EPA Method TO-15
TPH-g [*]	EPA Method TO-3
Oxygen, carbon dioxide, methane, and nitrogen	ASTM-D1946

^{*} Note: Analytical methods to analyze air sample for diesel range TPH are not available from Calscience.

A residual vacuum was left in all canisters and recorded in the field at the time of sampling and at the laboratory at the time of reception to ensure the integrity of the sample was not compromised during shipping

3.4.1 Quality Assurance/Quality Control

Two field duplicate samples were collected. In July 2005, a duplicate sample was collected from SSP-01, and in September 2006, a duplicate sample was collected from SSP-06. These samples were submitted to the laboratory as blind duplicates. These samples as well as additional laboratory control checks were used to assist in the provision of accurate and precise analytical data. Quality assurance/quality control (QA/QC) procedures were implemented by the incorporation of laboratory blanks and laboratory standards or references.

3.5 Barometric and Differential Pressure Measurements

During the July 2005 sampling event, a digital recording barometer was set inside the Port of Astoria Office Building for the duration of the sample period to monitor local barometric pressure fluctuations. Additionally, a differential micromanometer was set up to monitor the pressure across the foundation. The micromanometer was connected to SSP-03 for over 21 hours after probe installation and connected to SSP-04 for approximately 4 hours.

3.6 Methane Screening

Nineteen locations in and around the Site building (**Figure 3**) were identified as potential collection areas for subsurface methane gas (electrical boxes, well casings, crawlspaces, storm sewers manholes, etc.). The areas were screened for methane concentration and percent LEL using a Landtec Gem 2000 Landfill gas meter by placing the inlet tubing of the meter into the area, while minimizing the disruption of natural conditions (e.g. opening access point as slightly as possible to insert sample tube).

4. RESULTS

4.1 Development and Field Screening

The results of the sub-slab and soil gas development and purging data are summarized in **Table 1**. During purging, field screening measurements of volatile organic compounds (VOCs) were taken using a PID and biodegradation indicators (oxygen, carbon dioxide, and methane) were taken using a landfill gas meter. Carbon dioxide is a product of subsurface aerobic biodegradation of hydrocarbons and an increase in carbon dioxide concentration along with a decrease in oxygen concentration in soil gas indicates that natural degradation of hydrocarbons is occurring in soils beneath the site. Methane may be generated due to anaerobic biodegradation. The landfill gas meter became inoperable midway through the September 2006 sampling event and purge samples were not monitored for biodegradation indicators at all locations. Note that the landfill gas meter does not speciate methane and the reported field screening concentrations for this compound are likely biased high.

PID readings ranged from 0.0 to 3.6 parts per million by volume (ppmv) at SSP-02, -03, -04, -05, and -07. These values are near the lower limit of concentrations that can be reproducibly measured with a PID. At SSP-01 and -06, PID readings ranged from 154 to 317 ppmv.

Carbon dioxide readings ranged from 8.5 (SSP-03) to 15.8 (SSP-4) percent and oxygen readings ranged from 0.4 (SSP-01) to 8.1 (SSP-03) percent. As discussed above, these readings suggest that subsurface biodegradation of petroleum hydrocarbons is occurring. Methane readings collected during development and purging ranged from 0.0 (SSP-04 and SSP-03) to 13.1 percent (SSP-01).

Helium concentrations measured during purging from the sub-slab probes and beneath the shroud are summarized in **Table 1**. These helium measurements are collected as part of the leak test during sampling. Field screening readings in Tedlar[™] bags were less than 5 percent of the corresponding concentrations in the shroud, indicating that the samples were greater than 95 percent representative of subsurface gas, with no significant leakage of atmospheric air.

4.2 Sub-Slab Soil Gas Permeability

A summary of the gas permeability calculations and results is included in **Table 2**. Calculated gas permeability values for sub-slab probes (SSP-1 to SSP-7) ranged from 2×10^{-11} to 1×10^{-9} square meters (m^2). These values correspond to sub-slab soils composed of coarse sands to gravelly sands.

4.3 Laboratory Analytical Results

The results of laboratory analyses from samples collected from the sub-slab probes and the outdoor air sample for petroleum volatile organic compounds and for biodegradation parameters are summarized in **Tables 3 and 4**, respectively. Laboratory reports of analysis are provided in **Appendix B**.

Elevated concentrations of petroleum hydrocarbons were detected in SSP-01 and SSP-06. These probes are located in the southwestern portion of the building. Maximum concentrations for Total Petroleum Hydrocarbons as gasoline (TPH-G; 1,900 ppmv¹), toluene (3,200 microgram per cubic meter [$\mu g/m^3$]), and xylenes ($4,500 \mu g/m^3$) were detected in SSP-01 and maximum concentrations for benzene ($7,400 \mu g/m^3$) and 1,2,4-trimethylbenzene ($1,500 \mu g/m^3$) were detected in SSP-06. Low concentrations of petroleum hydrocarbons (i.e., TPH-g <20 ppmv and individual constituents < $100 \mu g/m^3$) were detected in the other SSPs sampled during this investigation. In the ambient air samples, petroleum hydrocarbons were not detected above the reporting limit.

Results of the field duplicate analyses indicate reasonable reproducibility for the results. The relative percent differences for the constituents detected in the field duplicate samples were less than 50 percent. Samples were collected during both sampling events at three locations. Concentrations during both events were generally consistent, although the reported concentrations during the September 2006 event were slightly lower than those for the July 2005 event.

¹ The laboratory reports TPH-g concentrations in ppmv. Assuming an average molecular weight of 100 g/mol, the maximum TPH-G concentration is $7,800 mg/m^3$.

Concentrations of biodegradation indicators are presented in **Table 4**. Oxygen concentrations in sub-slab samples ranged from 1.4 percent (SSP-01) to 13.7 percent (SSP-05) and carbon dioxide concentrations ranged from 3.5 (SSP-05) to 16.7 percent (SSP-04).

Methane was detected in samples collected from SSP-01 and SSP-06 at concentrations of 1.7 and 1.42 percent, respectively. Note that the methane concentrations reported by the laboratory were lower than those reported by the field instrument. The field instrument detects non-methane hydrocarbons to some degree, so the laboratory measurements for methane are believed to be more representative of site concentrations. The elevated methane concentrations in SSP-01 and SSP-06 reported by the analytical laboratory are approximately 30 – 35 percent of the LEL². However, these samples were collected beneath the foundation where no ignition source is present and field screening (discussed in Section 4.5) did not indicate accumulation of methane within the building.

A Level II data validation was performed on Calscience Work Order No.: 05-07-1353 for EPA TO-15, EPA TO-3 and ASTM D-1946 analytical methods. Compliant to the QAPP, the data deliverable included: a case narrative, sample analytical results, laboratory duplicate and blank results, sample custody and where applicable laboratory control samples. Examination of the Chain-of-Custody and the analytical results forms indicated that all of the technical holding times were met. Laboratory quality assurance samples including method blanks, laboratory duplicates, and laboratory control samples and laboratory control duplicates, were all within method specified acceptance criteria. No validation qualifiers were applied to the data and the results are suitable for use as reported.

4.4 Barometric and Differential Pressure Measurement Results

Results for the barometric pressure and differential pressure measurements taken during the July 2005 sampling and differential pressure measurements collected in February 2006³ are provided in **Appendix C**. A slight increase in barometric pressure was

² The LEL for methane is approximately 5 percent.

³ February 2006 differential pressure measurements were collected by EnviroLogic Resources, Inc.

measured during the morning of July 22, 2005. The weather at the site was clear on July 21, 2005. Light rain fell during the early morning of July 22, 2005 and the weather was overcast to partly cloudy after approximately 8:00 am.

During the July 2005 monitoring event, the cross-slab pressure difference measured at SSP-03 was negligible; typically ranging from -0.01 to +0.01 in H₂O (-2.5 to +2.5 Pa) and the cross-slab pressure differential measured at SSP-04 was slightly negative (indoor air pressure less than sub-slab pressure) with the greatest pressure differential equal to -0.032 in H₂O (-8 Pa).

During the February 2006 monitoring, a special effort was made to limit the time that perimeter doors and windows were left open. The cross-slab pressure difference measured during this event was slightly positive (approximately 0.0025 in H₂O or 0.6 Pa) while the HVAC system was operating.

4.5 Methane Screening Results

Results for methane screening are provided in **Table 5**. Methane was detected in four locations: the well boxes for MW-3 and MW-9 on the north side of the building and a valve box and electrical access box on the southern side of the building. Note that the methane concentration in the electrical access box was just above the method detection limit. Methane was not detected in any of the potential accumulation points identified inside the building.

5. DATA EVALUATION

5.1 Risk Based Concentrations

Sub-slab soil gas RBCs for vapor migration to indoor air have been calculated to evaluate the data collected during this investigation. The approach used in the development of the sub-slab soil gas RBCs is consistent with DEQ and United States Environmental Protection Agency (USEPA) guidance.

The RBCs for the soil and groundwater to indoor air pathways calculated by DEQ are calculated using the example equations provided in the Standard Guide for Risk-Based Corrective Action at Petroleum Release Sites (ASTM, 1995). These models are based on the Johnson and Ettinger vapor intrusion model (Johnson and Ettinger, 1991), but assume that the convective contribution to the vapor migration is small and can be neglected. More recent guidance on the evaluation of this pathway (USEPA, 2002, 2003) suggests that both the diffusive and convective contributions to vapor transport should be considered. Consequently, the site-specific RBCs will be calculated using the Johnson and Ettinger Model considering both transport mechanisms.

The soil gas RBC is determined by:

$$RBC_{\text{soil gas}} = RBC_{\text{air}} / \alpha \quad (1)$$

Where RBC_{air} , the risk based concentration in air, is the value listed in Appendix A of the DEQ risk-based decision making guidance (DEQ, 2003) and α , the vapor intrusion attenuation factor, is defined as the ratio of the indoor air and soil gas concentrations.

The attenuation factor is calculated using the Johnson Ettinger Model:

$$\alpha = \frac{\frac{D_T^{\text{eff}} A_B}{Q_B L_{cb}} \times \text{Exp}\left(\frac{Q_{\text{soil}} L_{crk}}{D_{crk}^{\text{eff}} A_{crk}}\right)}{\text{Exp}\left(\frac{Q_{\text{soil}} L_{crk}}{D_{crk}^{\text{eff}} A_{crk}}\right) + \frac{D_T^{\text{eff}} A_B}{Q_B L_{cb}} + \frac{D_T^{\text{eff}} A_B}{Q_{\text{soil}} L_{cb}} \left(\text{Exp}\left(\frac{Q_{\text{soil}} L_{crk}}{D_{crk}^{\text{eff}} A_{crk}}\right) - 1 \right)} \quad (2)$$

Where:

D_t^{eff}	=	Soil effective diffusion coefficient (cm ² /s)
A_B	=	Area of building (cm ²)
Q_B	=	Building ventilation rate (cm ³ /s)
L_{cb}	=	Depth of soil gas sample below slab (cm)
Q_{soil}	=	Soil gas volumetric flow rate (cm ³ /s)
L_{crk}	=	Foundation thickness (cm)
D_{crk}^{eff}	=	Effective diffusion coefficient through foundation crack (cm ² /s)
A_{crk}	=	Area of foundation cracks (cm ²)

The effective diffusion coefficient is calculated using:

$$D_t^{eff} = \frac{D_{air} n_{air}^{10/3} H + D_w n_w^{10/3}}{H n^2} \quad (3)$$

Where

D_{air}	=	Diffusion coefficient in air (cm ² /s)
D_w	=	Diffusion coefficient in water (cm ² /s)
n_{air}	=	Soil air-filled porosity (cm ³ /cm ³)
n_w	=	Soil water-filled porosity (cm ³ /cm ³)
n	=	Soil porosity (cm ³ /cm ³)
H	=	Henry's law coefficient (cm ³ /cm ³)

and the building volumetric flow rate is calculated by:

$$Q_B = \frac{A_B L_B ER}{86,400 \text{ s/day}} \quad (4)$$

Where:

A_B	=	Area of building (cm ²)
L_B	=	Height of rooms in building (cm)
ER	=	Building air exchange rate (day ⁻¹)

All parameters in Equations 2-4 are defined in the Oregon DEQ guidance, except for the volumetric flow rate of soil gas to indoor air, Q_{soil} . While this parameter may be calculated from site-specific parameters (e.g., soil permeability, building pressure,

depth of cracks, length of cracks), recent research and guidance suggests typical values for this parameter are in the range of 1 to 10 L/min per 100 m² of building footprint (Johnson et. al, 1999; USEPA, 2002; and Johnson, 2005). For the Astoria Area-Wide Petroleum Site evaluation, a value of 5 L/min per 100 m² building footprint is used for Q_{soil}. Using Equation 4 above, the building volume flow rate, Q_B, was calculated to be 870,000 cm³/s (52,000 L/min).

Note that in the limit as Q_{soil} approaches zero, Equation 2 reduces to Equation B-129 of the Oregon DEQ risk-based decision making guidance (ODEQ, 2003). Also, in the limit as L_{cb} approaches zero (as is the case for sub-slab samples), Equation 2 reduces to:

$$\alpha = \frac{Q_{soil}}{Q_B} \quad (5)$$

The parameters used in the soil gas RBC calculations are summarized in **Table 6**. Oregon DEQ default parameters are primarily used in the RBC calculations; however, site-specific data for L_{cb} and A_B are included in the vapor intrusion calculations. The calculated sub-slab soil gas RBCs are summarized in **Table 7**.

5.2 Area-Weighted Average Concentrations

Area-weighted average sub-slab soil gas concentrations were calculated using the Thiessen polygon method. This method is applied by assigning polygons around each sub-slab probe location to identify the area over which the measured concentrations are representative. Based on the area of each polygon and the reported concentrations for each SSP, an area-weighted average for each contaminant was calculated. If multiple samples were collected at a probe, the maximum concentration was used in the calculations. Also, if the measured concentration was below the reporting limit, then one-half of the maximum reporting limit was used. Details of these calculations as well as the calculated area-weighted average sub-slab soil gas concentrations are provided in **Table 8**.

5.3 Comparison of Measured Sub-Slab Soil Gas Concentrations and RBCs

As a screening-level evaluation, the maximum and area-weighted average sub-slab soil gas concentrations for the constituents of concern at the site are compared to the calculated site-specific RBCs (**Table 9**). The maximum measured sub-slab soil gas

concentrations for benzene and TPH-g slightly exceed the RBCs. The maximum benzene concentrations exceeds the RBC by a factor of 2.3 and the maximum TPH-g concentration exceeds the RBC by a factor of 1.4. Exceedances of the RBCs were detected only in SSP-01 and SSP-06 which are located in the southwestern portion of the building. However, the area-weighted average sub-slab soil gas concentrations beneath the building are all below their respective RBCs.

6. SUMMARY

The following findings were made as a result of the Port of Astoria Office Building sub-slab soil gas investigation:

- The highest concentrations of petroleum hydrocarbons in sub-slab soil gas were found in the southwestern portion of the building in SSP-01 and SSP-06.
- Elevated concentrations of methane in potential accumulation areas were limited to three locations outside of the perimeter of the building.
- Maximum concentrations for TPH-g and benzene slightly exceeded the site-specific sub-slab soil gas RBCs. However, the area-weighted average concentrations for these constituents are below the RBCs. The sub-slab soil gas concentrations for all other constituents of concern are well below the RBCs.

The results of this investigation do not indicate that sub-slab soil gas concentrations at the Port of Astoria Office building pose an unacceptable human health risk due to chronic exposures.

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TABLES

TABLE 1
SUMMARY OF SUB-SLAB SAMPLING FIELD PARAMETERS
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

Subslab Number	Date	Elapsed Time (min)	Purge Rate (L/min)	Bag Volume (L)	Cumulative Volume Purged (L)	Well Head Vacuum (inches H ₂ O)	Helium Tracer Gas (%)		Parameters								Sample Identifications			
							Shroud		Sample	CO ₂ (%)		O ₂ (%)		CH ₄ (%)		VOCs (ppm _v)	Sample ID	Summa Cannister Number	Initial Vacuum (in Hg)	Final Vacuum (in Hg)
							Minimum	Maximum		Field	Lab	Field	Lab	Field	Lab					
SSP-01	22-Jul-05	5	0.2	1.0	1.0	0.1	80	100	0.00	13.2		1.1		13.0		297	SSP-01 SSP-0X	LC012 LC138	-30.7 -30.6	-2.9 -4.8
		10	0.2	1.0	2.0	0.1	80	100	0.30	13.7	14.7	0.4		13.1		290				
		15	0.2	1.0	3.0	0.1	80	100	0.17	13.7		0.6	1.4	13.0	1.7	292				
		30 *	0.2	3.0	6.0	-	70	100	0.13	13.7		0.6		10.0		290				
	19-Sep-06	5	0.2	1.0	1.0	-	60	80	0.70	12.7		3.7		2.2		257	SSP-01-GS	LC1174	-29.4	-2.2
		10	0.2	1.0	2.0	-	60	80	0.06	14.1	13.8	2.9	2.5	2.8	0.32	313				
		15*	0.2	1.0	3.0	-	50	60	0.10	13.9		2.9		2.7		317				
SSP-02	20-Sep-06	5	0.2	1.0	1.0	-	60	80	0.24	-		-		-		0.0	SSP-02-GS	LC1031	-29.9	-3.4
		10	0.2	1.0	2.0	-	60	80	0.72	-	7.7	-	5.4	-	<0.15	0.0				
		14*	0.2	0.8	2.8	-	50	60	0.65	-		-		-		0.0				
SSP-03	22-Jul-05	5	0.3	1.5	1.5	0.9	80	100	0.00	8.5		8.1		0.0		0.8	SSP-03	1062 (LC078)	-30.3	-2.8
		10	0.3	1.5	3.0	0.9	80	100	1.50	8.7	9.6	7.4		0.0	<0.2	3.3				
		15	0.2	1.0	4.0	0.6	70	100	3.40	8.5		7.2		0.0		3.5				
		25 *	0.3	2.5	6.5	-	60	100	4.90	8.6		7.1		0.0		3.4				
	20-Sep-06	5	0.2	1.0	1.0	-	50	70	0.40	-		-		-		3.6	SSP-03-GS	LC1136	-29.6	-2.4
		10	0.2	1.0	2.0	-	40	60	0.90	-	7.8	-	10.9	-	<0.14	3.2				
		14*	0.2	0.8	2.8	-	40	60	1.10	-		-		-		0.9				
SSP-04	22-Jul-05	5	0.3	1.5	1.5	1.6	80	90	0.00	15.6		1.4		0.0		0.4	SSP-04	LC043	-30.4	-4.7
		10	0.3	1.5	3.0	1.3	80	90	0.00	15.8		1.1		0.0		1.1				
		15	0.2	1.0	4.0	0.9	80	90	0.00	15.7	16.7	1.3	2.1	0.0	<0.2	0.6				
		25 *	0.2	2.0	6.0	-	70	90	0.0	15.6		1.2		0.0		1.0				
	20-Sep-06	5	0.2	1.0	1.0	-	40	50	0.80	-		-		-		0.0	SSP-04-GS	LC1161	-29.9	-3.3
		10	0.2	1.0	2.0	-	30	40	0.90	-	10.0	-	9.6	-	<0.15	0.0				
		14*	0.2	0.8	2.8	-	30	40	1.00	-		-		-		0.0				
SSP-05	20-Sep-06	5	0.2	1.0	1.0	-	60	80	0.30	-		-		-		0.0	SSP-05-GS	LC1163	-29.9	-3.3
		10	0.2	1.0	2.0	-	60	80	0.70	-	3.5	-	13.7	-	<0.15	0.0				
		14*	0.2	0.8	2.8	-	40	60	0.60	-		-		-		0.0				
SSP-06	20-Sep-06	5	0.2	1.0	1.0	-	40	60	0.30	-		-		-		154.0	SSP-06-GS SSP-XX-GS	LC1135 LC1208	-29.5 -30	-1.9 -3.8
		10	0.2	1.0	2.0	-	40	60	0.80	-	10.4	-	3.9	-	1.4	192.0				
		14*	0.2	0.8	2.8	-	30	50	0.90	-		-		-		196.0				
SSP-07	20-Sep-06	5	0.2	1.0	1.0	-	60	80	0.21	-		-		-		0.0	SSP-07-GS	LC1189	-29.9	-0.8
		10	0.2	1.0	2.0	-	60	80	0.65	-	11.7	-	4.1	-	<0.14	0.0				
		14*	0.2	0.8	2.8	-	40	50	1.10	-		-		-		0.0				

Notes:
min - minutes
L/min - litres per minute
L - litres
in H₂O - inches of water
% - percent
ppmv - parts per million - volume
in Hg - inches of mercury
- - not measured
* - sample collected for laboratory analysis
Landfill gas meter became inoperable during September 2006 sampling. All samples were not field-screened for CO₂, O₂, and CH₄.

TABLE 2
SUMMARY OF SUB-SLAB PNEUMATIC TESTING DATA
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

Subslab Probe Number	Date	Barometric Pressure (in Hg)	Elapsed Time (min)	Flow Rate (L/min)	Well Head Vacuum (inches H ₂ O)	Cumulative Volume (L)	Specific Capacity (L/min/in H ₂ O)	Range	Gas Permeability (m ²)
SSP-01	22-Jul-05	30.00	1.0	0.2	0.02	0.2	10.0	1.92e-10, 2.34e-10	2 x 10 ⁻¹⁰
			2.0	0.5	0.07	0.7	7.1	1.37e-10, 1.67e-10	
			3.0	1.0	0.12	1.7	8.3	1.60e-10, 1.95e-10	
			4.0	5.0	0.90	6.7	5.6	1.07e-10, 1.30e-10	
	19-Sep-06	30.17	1.0	0.2	<0.00	0.2	0.0	nc	1 x 10 ⁻⁹
			2.0	0.5	0.005	0.7	100.0	1.92e-9, 2.34e-9	
			2.5	1.0	0.04	1.2	25.0	4.80e-10, 5.84e-10	
SSP-02	20-Sep-06	-	2.75	5.0	0.55	2.5	9.1	1.74e-10, 2.12e-10	8 x 10 ⁻¹¹
			1.0	0.2	0.05	0.2	4.0	7.68e-11, 9.35e-11	
			2.0	0.5	0.13	0.7	3.8	7.38e-11, 8.99e-11	
			3.0	1.0	0.25	1.7	4.0	7.68e-11, 9.35e-11	
SSP-03	22-Jul-05	29.97	1.0	0.2	0.17	0.2	1.2	2.26e-11, 2.75e-11	2 x 10 ⁻¹¹
			2.0	0.5	0.40	0.7	1.3	2.40e-11, 2.92e-11	
			3.0	1.0	1.00	1.7	1.0	1.92e-11, 2.33e-11	
	20-Sep-06	-	1.0	0.2	0.08	0.2	2.5	4.80e-11, 5.84e-11	5 x 10 ⁻¹¹
			2.0	0.5	0.24	0.7	2.1	4.00e-11, 4.87e-11	
			3.0	1.0	0.50	1.7	2.0	3.84e-11, 4.67e-11	
SSP-04	22-Jul-05	29.98	1.0	0.2	0.22	0.2	0.9	1.74e-11, 2.12e-11	2 x 10 ⁻¹¹
			2.0	0.5	0.70	0.7	0.7	1.37e-11, 1.67e-11	
			3.0	1.0	1.40	1.7	0.7	1.37e-11, 1.67e-11	
	20-Sep-06	-	1.0	0.2	0.20	0.2	1.0	1.92e-11, 2.34e-11	2 x 10 ⁻¹¹
			2.0	0.5	0.45	0.7	1.1	2.13e-11, 2.60e-11	
			3.0	1.0	0.85	1.7	1.2	2.26e-11, 2.75e-11	
SSP-05	20-Sep-06	-	1.0	0.2	0.02	0.2	10.0	1.92e-10, 2.34e-10	1 x 10 ⁻¹⁰
			2.0	0.5	0.06	0.7	8.3	1.60e-10, 1.95e-10	
			3.0	1.0	1.10	1.7	0.9	1.75e-11, 2.12e-11	
SSP-06	20-Sep-06	-	1.0	0.2	0.025	0.2	8.0	1.54e-10, 1.87e-10	1 x 10 ⁻¹⁰
			2.0	0.5	0.070	0.7	7.1	1.37e-11, 1.67e-11	
			3.0	1.0	0.125	1.7	8.0	1.54e-10, 1.87e-10	
SSP-07	20-Sep-06	-	1.0	0.2	0.025	0.2	8.0	1.54e-10, 1.87e-10	1 x 10 ⁻¹⁰
			2.0	0.5	0.080	0.7	6.3	1.20e-10, 1.46e-10	
			3.0	1.0	0.170	1.7	5.9	1.13e-10, 1.37e-10	

TABLE 2
SUMMARY OF SUB-SLAB PNEUMATIC TESTING DATA
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

Notes:

in Hg - inches of mercury
inches H₂O - inches of water
min - minutes
L/min - litres per minute
L - litres
L/min/in H₂O - litres per minute per inches of water
m² - square meters

$$k = \frac{Q}{H} \frac{\mu}{P_w \pi} \frac{\ln(R_w / R_I)}{[1 - (P_{atm} / P_w)^2]}$$

parameter	definition	value	conversion factor / comment
k	- permeability	calculated	1 m ² = 1x10 ⁴ cm ²
Q	- flow rate	measured	1 cm ³ /s = 1L/min x (1000 cm ³ /L) / (60 s/min)
H	- screened interval	5.1	
μ	- gas viscosity	0.000182	
P _w	- well pressure	measured	P _w = (406.8 in H ₂ O - well vacuum[in H ₂ O]) x (1.01 x 10 ⁶ g/cm/s ²) / (406.8 in H ₂ O)
P _{atm}	- atmospheric pressure	1.01E+06	1.01x10 ⁶ g/cm/s ² = 406.8 in H ₂ O
R _w	- well radius	0.64	
R _I	- radius of influence	100.0	permeability calculation is not sensitive to selected value for R _I

TABLE 3
SUMMARY OF PETROLEUM VOLATILE ORGANIC COMPOUND ANALYTICAL RESULTS
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

Sample Location	Sample Date	Petroleum Volatile Organic Compounds															
		TPH (gasoline)		Benzene		Toluene		Ethylbenzene		o-Xylene		m/p-Xylene		1,2,4-Trimethylbenzene		1,3,5-Trimethylbenzene	
units		ppmv	mg/m3	ppbv	µg/m³	ppbv	µg/m³	ppbv	µg/m³	ppbv	µg/m³	ppbv	µg/m³	ppbv	µg/m³	ppbv	µg/m³
SSP-01	7/22/2005	1900	7800	1900	6100	840	3200	<260	< 1100	270	1200	750	3300	<560	< 2800	<260	< 1300
	7/22/2005 *	1500	6100	1600	5100	510	1900	<200	< 870	<200	< 870	470	2000	<400	< 2000	<200	< 990
	9/19/2006	870	3600	830	2700	<5.8	< 22.0	<5.8	< 25	<5.8	< 25	39	170	<12	< 59	<5.8	< 29
SSP-02	9/20/2006	9.4	39	<0.76	< 2.4	<0.76	< 2.9	<0.76	< 3.3	<0.76	< 3.3	<1.5	< 6.5	<1.5	< 7.4	<0.76	< 3.7
SSP-03	7/22/2005	<4.5	<18	1.3	4.2	1.8	6.8	<0.75	< 3.3	<0.75	< 3.3	<1.5	< 6.5	14	69	2.6	13.0
	9/20/2006	<4.2	<17	<0.70	< 2.2	1.1	4.2	<0.70	< 3.0	<0.70	< 3.0	1.7	7.4	3.4	17	0.81	4.0
SSP-04	7/22/2005	<4.8	<20	4.7	15.0	1.3	4.9	<0.80	< 3.5	<0.80	< 3.5	<1.6	< 7.0	<1.6	< 7.9	<0.80	< 3.9
	9/20/2006	<4.6	<19	<0.77	< 2.5	0.87	3.3	<0.77	< 3.4	<0.77	< 3.4	<1.5	< 6.5	<1.5	< 7.4	<0.77	< 3.8
SSP-05	9/20/2006	<4.6	<19	<0.76	< 2.4	7.3	28	<0.76	< 3.3	3.0	13.0	5.5	24	11	54	5.3	26
SSP-06	9/20/2006	660	2700	2300	7400	<30	< 110	<30	< 130	<30	< 130	<60	< 260	300	1500	<30	< 150
	9/20/2006 *	630	2600	1700	5400	<31	< 120	<31	<130	<31	< 130	74	320	370	1800	<31	< 150
SSP-07	9/20/2006	18	74	17	54	1.6	6.1	1.0	4.4	0.95	4.1	2.3	10	<1.4	< 6.9	<0.69	< 3.4
AA01	7/22/2005	<4.6	<19	<0.76	< 2.4	<0.76	< 2.9	<0.76	< 3.3	<0.76	< 3.3	<1.5	< 6.5	<1.5	< 7.4	<0.76	< 3.7
	9/20/2006	<4.3	<18	<0.72	< 2.3	<0.72	< 2.7	<0.72	< 3.1	<0.72	< 3.1	<1.4	< 6.1	<1.4	< 6.9	<0.72	< 3.5
Method Blank	7/22/2005	<3.0	<12	<0.50	<1.6	<0.50	<1.9	<0.50	<2.2	<0.50	<2.2	<1.0	<4.4	<1	<4.9	<0.50	<2.5

* Duplicate Sample

Concentration Units Conversion Factor

$C[\text{ug/m}^3] = C[\text{ppbv}] * \text{MW}/24.4$

MW = Molecular Weight

Compound	MW	MW/24.4
Benzene	78.1	3.2
Toluene	92.1	3.8
Ethylbenzene	106.2	4.4
Xylene	106.2	4.4
Trimethylbenzene	120.2	4.9
TPH	100	4.1

Note: Molecular weight for TPH is estimated

TABLE 4
SUMMARY OF FIXED GASES ANALYTICAL RESULTS
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

Constituent	Sample Date	Biodegradation Indicators		
		Oxygen	Methane	Carbon Dioxide
units		%	%	%
SSP-01	7/22/2005	1.4	1.7	14.7
	7/22/2005 *	1.4	1.7	14.7
	9/19/2006	2.53	0.319	13.8
SSP-02	9/20/2006	5.36	<0.151	7.65
SSP-03	7/22/2005	8.0	<0.2	9.6
	9/20/2006	10.9	<0.139	7.83
SSP-04	7/22/2005	2.1	<0.2	16.7
	9/20/2006	9.63	<0.153	10.0
SSP-05	9/20/2006	13.7	<0.152	3.50
SSP-06	9/20/2006	3.86	1.42	10.4
	9/20/2006 *	4.26	1.35	10.3
SSP-07	9/20/2006	4.09	<0.137	11.7
AA01	7/22/2005	21.9	<0.2	<0.2
	9/20/2006	21.9	<0.143	<0.143
Method Blank	7/22/2005	<0.1	<0.1	<0.1

* Duplicate Sample

TABLE 5
SUMMARY OF METHANE SCREENING RESULTS
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

ID	Location	CH ₄ (%)	LEL (%)	Comments
CH4-01	SVP-02 Protective Casing	0.0	0.0	Well casing full of water.
CH4-02	Storm Sewer Grate	0.0	0.0	
CH4-03	MW-4 Protective Casing	0.0	0.0	Casing half full of water.
CH4-04	SVP-01 Protective Casing	0.0	0.0	Well casing full of water.
CH4-05	Storm Sewer Grate	0.0	0.0	
CH4-06	MW-41 Protective Casing	0.0	0.0	Casing half full of water.
CH4-07	MW-3 Protective Casing	15.5 (max)	OR	Casing half full of water.
CH4-08	MW-9 Protective Casing	6.5	OR	Casing half full of water.
CH4-09	Under Building at Crawl Space	0.0	0.0	
CH4-10	SVP-04 Protective Casing	0.0	0.0	Casing half full of water.
CH4-11	Unknown Access Hole	0.0	0.0	
CH4-12	MW-34 Protective Casing	0.0	0.0	Casing half full of water.
CH4-13	Electrical Access	0.3	5.0	
CH4-14	SVP-03 Protective Casing	0.0	0.0	Well casing full of water.
CH4-15	Valve Box	14.1	OR	Well casing full of soil. No sign of valves.
CH4-16	Control Valve Box	0.0	0.0	
CH4-17	Sanitary Sewer	0.0	0.0	
CH4-18	Crawl Space Access	0.0	0.0	Dropped tubing ~ 4' down into crawl space.
CH4-19	Electrical Outlet Hole in Break Room	0.0	0.0	

Notes:

% - percent

CH₄ - methane

LEL - lower explosive limit

OR - out of range

TABLE 6
SUB-SLAB SOIL GAS RISK BASED CONCENTRATION CALCULATION INPUT PARAMETERS
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

Parameter	Symbol	Default Value	Reference
Air Risk Based Concentration ($\mu\text{g}/\text{m}^3$)	RBC_{air}	Chemical-Specific	DEQ, 2003 Appendix A. Listed in Table 7
Area of Building (cm^2)	A_B	4.9E+06	53 ft x 100 ft area of building with slab
Soil gas volumetric flow rate (L/min)	Q_{soil}	24.6	Based on 5 L/min per 100 m ² building area; USEPA Vapor Intrusion Guidance (USEPA, 2002)
Depth to soil gas sample (cm)	L_{cb}	15.5	0.5 ft x 30.5 cm/ft - sub-slab sample
Foundation wall thickness (cm)	L_{crk}	15	DEQ, 2003 Appendix C
Foundation crack fraction	f_{crk}	0.001	DEQ, 2003 Appendix C
Soil porosity	n	0.38	DEQ, 2003 Appendix C
Soil air filled porosity	n_a	0.26	DEQ, 2003 Appendix C
Soil water filled porosity	n_w	0.12	DEQ, 2003 Appendix C
Crack air filled porosity	n_{acrk}	0.26	DEQ, 2003 Appendix C
Crack water filled porosity	n_{wcrk}	0.12	DEQ, 2003 Appendix C
Building air exchange rate (1/day)	ER	48	DEQ, 2003 Appendix C
Building height (cm)	L_B	320	Direct building measurement
Henry's law coefficient	H	Chemical-Specific	DEQ, 2003 Appendix D
Diffusion coefficient in air (cm^2/s)	D_{air}	Chemical-Specific	DEQ, 2003 Appendix D
Diffusion coefficient in water (cm^2/s)	D_{water}	Chemical-Specific	DEQ, 2003 Appendix D

TABLE 7
SUB-SLAB SOIL GAS RISK BASED CONCENTRATIONS
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

	CAS No.	Mol. Wt.	RBC_air	α	RBC_soil gas	
Chemical		g/mol	$\mu\text{g}/\text{m}^3$		$\mu\text{g}/\text{m}^3$	ppbv
Benzene	71432	78	1.5	4.7E-04	3,190	998
Toluene	108883	92	1600	4.7E-04	3,400,000	902,000
Ethylbenzene	100414	106	4200	4.7E-04	8,930,000	2,050,000
o-Xylene	95476	106	420	4.7E-04	893,000	205,000
m/p-Xylene	108383					
	106423	106	420	4.7E-04	893,000	205,000
1,2,4 Trimethylbenzene	95636	120	25	4.7E-04	53,100	10,800
1,3,5 Trimethylbenzene	108678	120	25	4.7E-04	53,100	10,800
				4.7E-04		
TPH-g	TPH-G	100	2600	4.7E-04	5,530,000	1,340,000

Notes:

RBC_air taken from ODEQ RBDM Guidance Document

Vapor intrusion attenuation factor, α , calculated using Johnson Ettinger Model with parameters listed in Table 6

$\text{RBC}_{\text{soil gas}} = \text{RBC}_{\text{air}} / \alpha$

TABLE 8
 AREA-WEIGHTED AVERAGE CONCENTRATIONS USING THIESSEN METHOD
 Remedial Investigation/Feasibility Study
 Astoria Area-Wide Petroleum Site
 Astoria, Oregon

ID	Probe ID	Area (ft ²)	TPH (gasoline) (µg/m ³)	Benzene (µg/m3)	Toluene (µg/m3)	Ethylbenzene (µg/m3)	o-Xylene (µg/m3)	m/p-Xylene (µg/m3)	1,2,4- Trimethylbenzen (µg/m3)	1,3,5- Trimethylbenzen (µg/m3)
1	SSP-01	490	7,800,000	6100	3200	550	1200	3300	1400	650
2	SSP-02	498	39,000	1.2	1.45	1.65	1.65	3.25	3.7	1.85
3	SSP-03	1615	9,000	4.2	6.8	1.65	1.65	7.4	69	13
4	SSP-04	3439	9,500	15	4.9	1.75	1.75	3.5	3.95	1.95
5	SSP-05	307	9,500	1.20	28	1.65	13	24	54	26
6	SSP-06	768	2,700,000	7400	60	65	65	320	1800	75
7	SSP-07	1084	74,000	54	6.10	4.40	4.1	10	3.45	1.7
Total Area (ft ²)		8200								
Sumproduct			6041898740	8786595	1656568	333975	655379	1905233	2214776	414282
Area Weighted Average			736,817	1072	202	41	80	232	270	51

$$\text{Sumproduct} = \sum (\text{Area} \times \text{Concentration})$$

$$\text{Area Weighted Average} = \text{Sumproduct} / \text{Total Area}$$

Thiessen Polygons used for averaging

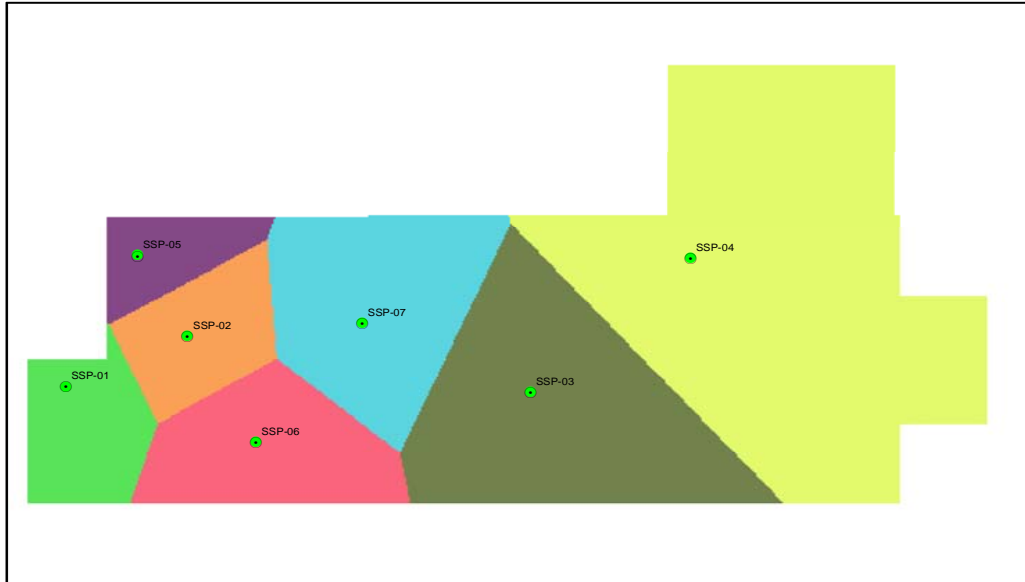


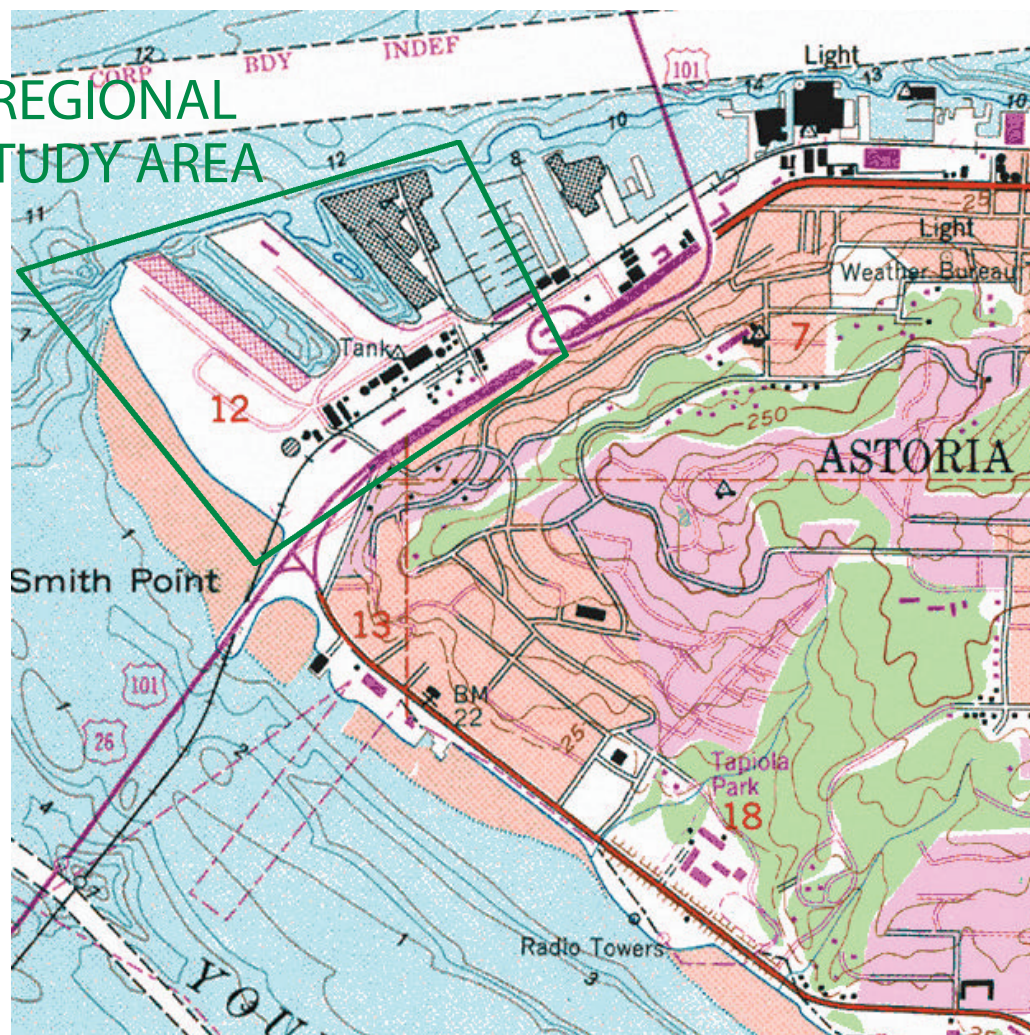
TABLE 9
RISK-BASED CONCENTRATION SCREENING
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site
Astoria, Oregon

	RBC_soil gas	Maximum Concentration	Area-Weighted Average Concentration	Max. RBC Exceedance?	Avg. RBC Exceedance?
Chemical	µg/m3	µg/m3	µg/m3		
Benzene	3,190	7400	1100	Yes	No
Toluene	3,400,000	840	202	No	No
Ethylbenzene	8,930,000	550 ^A	41	No	No
o-Xylene	893,000	1200	80	No	No
m/p-Xylene	893,000	3300	230	No	No
1,2,4 Trimethylbenzene	53,100	1800	270	No	No
1,3,5 Trimethylbenzene	53,100	650 ^A	51	No	No
TPH-g	5,530,000	7,800,000	740,000	Yes	No

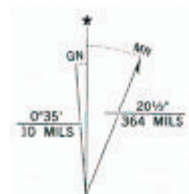
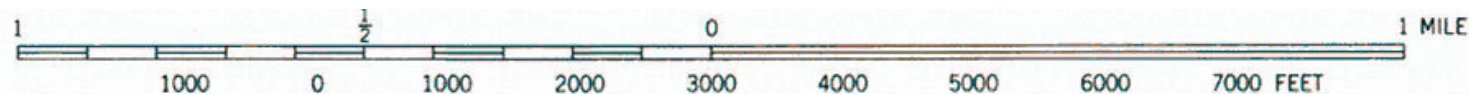
^A Compound not detected. One-half the maximum detection limit listed.

FIGURES

REGIONAL
STUDY AREA



(from USGS, Astoria {1984}, OR 7.5' Quadrangles)

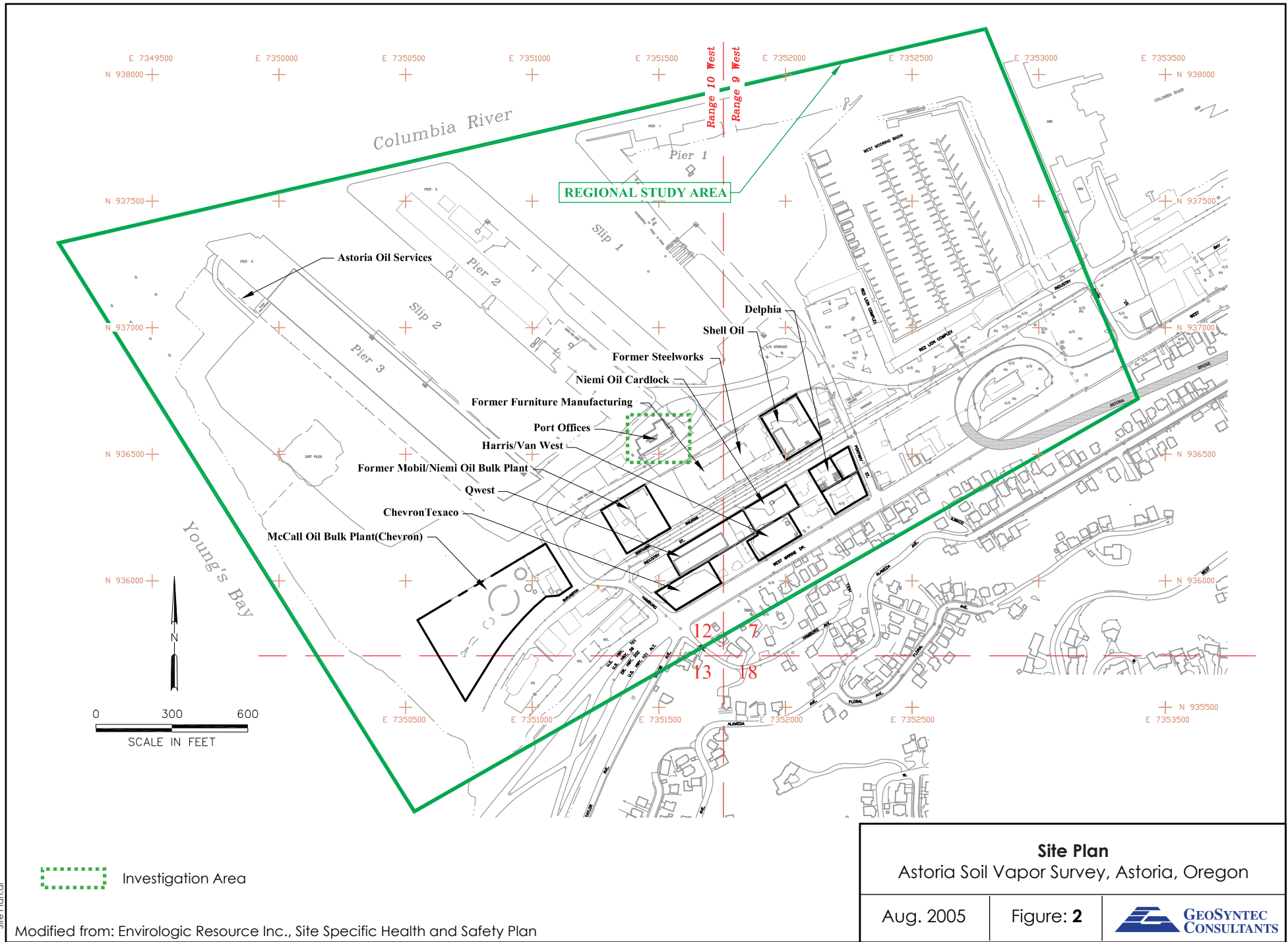


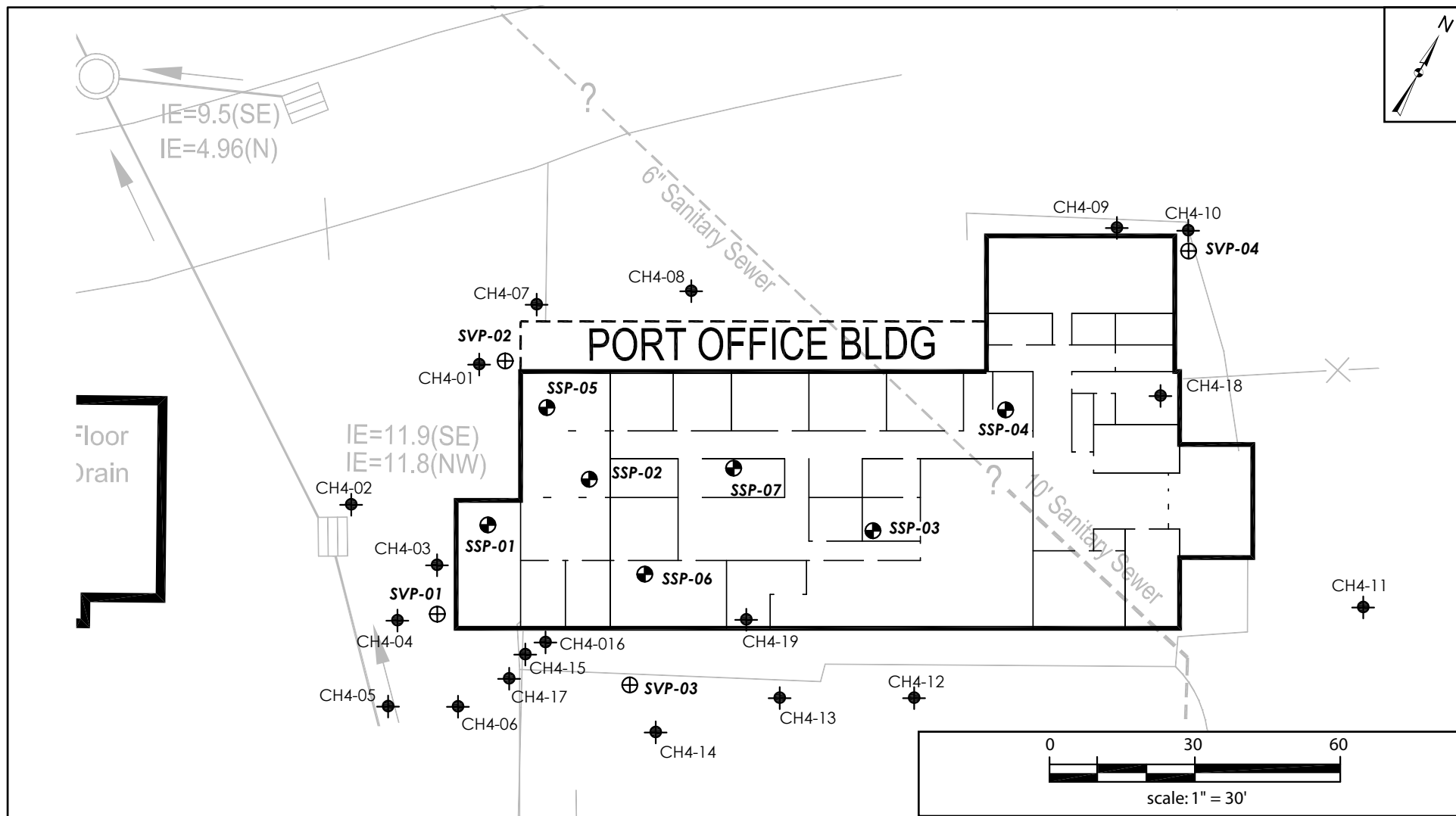
Site Location
Astoria Soil Vapor Survey, Astoria, Oregon

Aug. 2005

Figure: 1







Legend

- SVP-04** ⊕ Soil Vapor Probe Location
- SSP-04** ⊙ Existing Sub-Slab Probe Location
- CH4-03** ⊕ Methane Monitoring Location

Soil Vapor Sample Locations
Remedial Investigation/Feasibility Study
Astoria Area-Wide Petroleum Site, Astoria, Oregon

Geosyntec 
consultants

Guelph

February 2007

**Figure
3**

Source: Envirologic Resource Inc., Site Specific Health and Safety Plan

APPENDIX A

GEOSYNTEC SUGGESTED OPERATING PROCEDURE FOR SUB-SLAB SOIL GAS MONITORING

SUGGESTED OPERATING PROCEDURE SUB-SLAB SOIL GAS MONITORING

This document describes the suggested operating procedure (SOP) for sub-slab soil gas monitoring for the purpose of assessing the potential for subsurface vapor intrusion into indoor air. Sub-slab monitoring may include: subsurface gas sample collection for field screening and potential laboratory analysis, pneumatic monitoring to assess pressure differentials across the slab, and pneumatic testing to assess the gas permeability of the sub-slab materials. This SOP is intended to ensure high quality data collection, and identify possible biases and ways that they can be avoided.

1. OVERVIEW

Beneath most concrete floor slabs is a layer of granular fill material that is highly permeable and well-drained for structural purposes. This layer is normally also relatively permeable to soil gas, so in most cases, it is relatively simple to drill through the concrete floor and extract a sample of the sub-slab soil gas via vacuum for chemical analysis. Vapor intrusion assessments often benefit from collecting vertical profiles of vapor concentrations, and O₂/CO₂, so this SOP includes a method for installation of deeper probes also.

In some cases, the slab may be poured directly over on natural geologic materials, which may have a low permeability that inhibits soil gas flow and make sample collection difficult. This condition can be assessed with a simple pneumatic test, which is included in this SOP.

Depending on building ventilation and barometric pressure fluctuations, air can flow from below the floor slab to indoor air, or vice-versa, or flow intermittently in either direction. Pressure differentials across the floor slab can be assessed by instantaneous or continuous monitoring methods, which are also described in this SOP.

2. PROBE DESIGN AND INSTALLATION

Sub-slab probes (**Figure 1**, after EPA, 2004) are installed into the concrete slab to directly monitor the sub-slab soil gas. The probes have an insert consisting of a brass or stainless steel pipe. The pipe does not extend beyond the bottom of the slab. The probes have an air-tight fitting on the top that allows a threaded cap to seal the pipe and are set flush with the floor surface to minimize any trip hazard. The cap should be secured any time the probe is not being used for monitoring. The cap is removed and replaced with a brass or stainless steel valve with

male NPT threads on one side and a 1/4-inch compression or barb fitting on the other side. All threaded couplings should be wrapped with Teflon™ tape to ensure air-tight seals.

Concrete floors are best drilled using a heavy-duty electrical hammer-drill. At least two different diameters of drill bits are required. 5/8-inch and 1-inch diameters. The 5/8-inch bit must be long enough to penetrate the floor slab (typically 6 inches, but occasionally up to 12 inches in industrial buildings). The 1-inch bit only needs to be a few inches in length.

Probe locations that are centrally located within areas of roughly 10 m by 10 m are generally recommended. This corresponds roughly to the footprint of a single-family residence. In large houses or commercial buildings, multiple samples may be appropriate to provide adequate assessment of spatial variability. The building owner should be consulted prior to deciding locations and which floor materials are acceptable to penetrate. Pre-tensioned concrete floors or subsurface utilities could be damaged by drilling or coring, so construction diagrams should be reviewed prior to selecting sample locations. Concrete dust generated during drilling should be collected during and after drilling using a wet/dry vacuum cleaner. If the floor is covered with carpet, a flap should be neatly cut with a sharp knife and lifted to access the concrete beneath, which can be secured after monitoring is complete with double-sided tape. If floor tiles are present, they should be cut with a tile-knife and lifted before drilling to avoid chipping to the extent practicable.

2.1 Installing Probe

A 5/8-inch diameter hole should be drilled until it punctures the floor slab and barely enters the underlying granular fill materials, but should not continue into the underlying geologic materials. A significant increase in the rate of the drill-bit penetration or decrease in resistance will usually indicate the bottom of the slab. The upper few inches of the hole should be reamed using a 1-inch bit. Dust will fall into the 5/8-inch hole as the reaming progresses, so the 5/8-inch bit should be used to clear the hole to the bottom of the slab after reaming the upper few inches. Upon completion of drilling, reaming, and clearing, the insert should be installed and sealed promptly to minimize any potential air flow into or out of the drilled hole. If the insert is not installed immediately the drilled hole should be plugged using plastic food wrap, tightly wedged into the hole to form an air-tight seal. Do not use any kind of tape with adhesives that may give off vapors.

The probe insert will be set in the drilled hole through the concrete and grouted into place using a swelling cement, commonly referred to as hydro-cement (available at building supply stores and normally used to seal cracks in concrete foundations). This cement expands as it sets, to form a good seal. Do not use silicone sealants, caulking, or any other material that could

potentially give off vapors. If the drilled hole diameter is large enough to allow the pipe to move freely, this may pose a risk that cement may flow down to the bottom of the pipe and plug the opening, in which case, wrap Teflon tape around the pipe near the bottom until it has sufficient diameter to contact the insides of the drilled hole tightly enough to prevent cement leakage past this “gasket”. Set the pipe so that the threads are below the floor grade, and the cap is flush with the floor grade. The seal must be placed to allow the cap to be removed during monitoring events.

Cement seals should be allowed to set before sampling (typically less than an hour for fast-setting cement).

3. MEASUREMENT OF AMBIENT PRESSURE DIFFERENTIAL

The ambient pressure differential can be measured by connecting a valve to the probe insert, and attaching a vacuum gauge to the valve for an instantaneous reading, or attaching a digital micro-manometer with a pressure transducer and data-logger for continuous monitoring. In either case, the vacuum gauge should be zeroed and leveled according to the manufacturer’s instructions prior to testing, and the zero should be confirmed after disconnecting the instrument at the end of the measurement period. If the zero shows any measurable drift, a drift correction may be necessary.

In most cases, the ambient pressure differential will be very small (typically less than 10 pascals (Pa), or 0.001 psi, or 0.03 in-H₂O. Manometers and diaphragm gauges are generally not capable of recording these small pressure differentials. Digital micro-manometers have been developed specifically for this range of measurement. Digital micro-manometers can be programmed to integrate readings over a period of time to minimize fluctuations attributable to minor transient air currents.

Monitoring the ambient pressure differential from sub-slab to indoor air can be combined with monitoring of barometric pressure trends over time to assess whether and to what degree barometric pumping influences the sub-slab to indoor air pressure differential. Digital barometers are also available that record barometric pressure (and temperature) over time. Monitoring of this kind may help with interpretation of indoor air quality data, providing the micro-manometer, barometer, and indoor air sample collection periods are all coincidental.

A list of suggested monitoring devices is provided in **Attachment 1**. The suggested equipment can be substituted with equivalent equipment, but it is the responsibility of the user to ensure that substitute equipment meets the requirements.

4. FLOW AND VACUUM CHECK

In most cases, the sub-slab materials are high-permeability granular fill materials, which yield soil gas under vacuum readily. However, a simple test can be conducted to confirm that the permeability of the sub-slab materials is sufficient to yield a representative sample in a reasonable period of time without excessive vacuum.

Soil gas samples for field screening or laboratory analysis typically require a volume of approximately 1 to 6 liters (L). Sample collection over 10 minutes to 1 hour is a reasonable period of time; therefore, a reasonable flow rate should be at least 200 millilitres per minute (mL/min). The flow rate will be proportional to the applied vacuum. Excessive vacuum can change the partitioning of vapors between pore water and soil gas; therefore, it should be avoided. Excessive vacuum will also increase the risk of leakage at the connection between the probe and the sample container, which can result in sample bias by the ingress of indoor air. Vacuum levels less than 1 in-H₂O should be low enough to avoid both concerns. Higher-level vacuum may be acceptable, but should be recorded and discussed with the data interpretation. Where a flowrate of at least 200 mL/min cannot be sustained with a vacuum less than 10 in-H₂O, it may be advisable to install and monitor an additional sub-slab probe to increase the confidence in the data.

To measure the soil gas flow and corresponding vacuum, the equipment should be assembled as shown on **Figure 2**, and in the photograph below:



1. Un-cap the probe and connect the monitoring attachment, which is comprised of a ball-valve with a ¼-inch compression fitting. Attach the most sensitive vacuum gauge, open the valve and record the ambient pressure or vacuum reading, along with the date and time. The vacuum gauge should be leveled and zeroed prior to connecting the tubing.
2. Assemble the components of the soil sampling equipment in the configuration shown on **Figure 2** (Vacuum and Flow Check Arrangement). Use new ¼-inch diameter HDPE, Teflon™ or Nylon tubing. Rotameters and vacuum gauges of several different ranges should be available, to ensure accurate readings, regardless of the gas permeability of the subsurface materials, which can span several orders of magnitude (see equipment list in **Attachment 1**)
3. A “shut-in” test should be conducted to ensure that there are no leaks prior to starting the flow and vacuum check. With the probe valve closed, create a vacuum of 50 to 100 in-H₂O within the sampling equipment apparatus by turning on the vacuum pump and then closing the ball valve on the influent side of the vacuum pump to maintain (i.e., “shut-in”) the vacuum. Observe the vacuum gauge for at least 1 minute and if the vacuum does not dissipate, proceed to step 4. Otherwise, adjust each connection until there are no measurable vacuum decreases.

4. Release the vacuum in apparatus by opening the vent adjacent to the vacuum gauge. After the vacuum has dissipated, close the vent and open the ball valve on the monitoring attachment. Connect the most sensitive vacuum gauge and rotameter initially, followed by the others in succession, only if vacuum levels go beyond the scale.
5. Ensure the top fitting of the rotameter is connected to the valve on the vacuum pump intake and the direction of air-flow through the rotameter is from bottom to top. Flow is controlled by a valve at the influent to the vacuum pump, and fine-tuning valves integral to the rotameters. Fully open the rotameter valve initially and fully close the valve at the inlet of the vacuum pump before starting the pump. Set the flow rate to slightly higher than 1 liter per minute (L/min) using the valve at the pump intake, then use the rotameter valve to reduce the flow to about 200 mL/min. The rotameters must be vertical to accurately measure flow.
6. Record the flow rate and vacuum level as soon as both stabilize (typically within seconds). Depending on the gas permeability of the subsurface materials, it may be necessary to change the vacuum gauge (i.e., replace zero-to-0.25 in-H₂O gauge with zero-to-5 in-H₂O gauge) to ensure that both flow and vacuum are clearly measurable within the scales of the vacuum gauge and rotameter. If so, the valve at the top of the probe should be closed before any changes are made, to prevent any vacuum induced in the sub-slab region from pulling air backward through the sampling train, and the “shut-in” test should be repeated to confirm the absence of any noticeable leak.
7. Increase the flow rate to about 500 mL/min record the steady vacuum (typically after a few seconds of pumping). The ratio of flow rate divided by vacuum should be approximately constant and should be higher than 0.001 L/min/in-H₂O (i.e. >100 mL/min flow with <10 in-H₂O vacuum), otherwise, it may be appropriate to install another sub-slab probe to verify whether this low-permeability condition is localized (possibly even a plugged probe) or laterally continuous.
8. The flow and vacuum readings will stabilize almost instantaneously; therefore, the total volume of soil gas removed during the flow and vacuum test will be minimal. This is desirable, because excessive purging could potentially cause indoor air to flow into the sub-slab void space through any nearby discontinuities that may exist in the floor slab. A total volume of no more than a few liters should be removed during this test.
9. If indoor air sampling is also planned for the same site visit, exhaust gas from the vacuum pump should be routed to an outside location by an adequate length of tubing or through a trap filled with activated carbon. This will ensure that the subsequent indoor air

samples are not positively biased by any VOC vapors removed during the soil gas flow and vacuum test.

5. PURGING AND SAMPLE COLLECTION

Purging and sampling can proceed any time after the probe seal has set and the flow and vacuum measurements have been confirmed. The objective of purging is to ensure the collection of a “fresh” sample of sub-slab gas, not gas that has been stagnant within the probe or possibly introduced during the drilling and installation process. Field screening should generally be used to confirm steady readings, and to verify that the sample is reproducible. Tracer gas should also be used to ensure that there are no leaks in the probe seals, in addition to confirming absence of leaks using the “shut-in” test.

The recommend tracer gas is helium because it is non-toxic, readily available, easily field-screened using a portable instrument, and not a chemical that is known to be present in the subsurface at concentrations that could interfere with the portable instrument readings. The total volume of tracer gas to be added to the air-space under the shroud does not have to be large to be effective. For example, a helium cylinder open for several seconds will generally be sufficient to create concentrations in the shroud that are above 40% by volume. The air under the shroud should be screened with the portable monitoring device after adding the tracer, which can be done through a hole in the shroud. Other tracer gases that may be used include isobutylene, butane, or propane, providing the site does not have hydrocarbon vapors that could interfere with these compounds. The ionization potential of butane and propane are higher than most photoionization detector (PID) lamps, so a high-energy PID lamp, a flame ionization detector (FID), or a mobile gas chromatograph (GC) would be required.

Sampling for laboratory analysis will typically be performed using Summa canister. Summa canister samples can be collected by two methods: 1) connecting the Summa canister directly to the sub-slab probe after purging has demonstrated reproducible field screening readings, or 2) collecting a soil gas sample in a Tedlar bag, and then connecting the Tedlar bag to the Summa canister to transfer the sample to the Summa canister. The latter is recommended, because it allows the Tedlar bag to be screened for consistent FID or PID readings and presence of tracer gas before the Summa canister sample is collected, and if the tracer gas screening indicates a leak, the leak can be fixed and the purging and sampling repeated prior to sampling for laboratory analysis. The former method also requires a flow controller on the Summa canister, otherwise the strong vacuum of the Summa canister can draw moisture or particles into the canister. Flow controllers have a set flowrate that cannot be adjusted in the field, and may

not be appropriate for certain gas permeability conditions, which are typically not known in advance.

5.1 Preparation

Assemble the apparatus as shown in **Figure 2**, and the photograph below:



1. Connect the discharge of the vacuum pump to tubing that runs to an outdoor location to prevent any extracted gas from causing potential positive bias in any subsequent indoor air samples. If this is not practicable, the pump discharge can be collected in a large plastic garbage bag, secured to the pump discharge pipe with a hose-clamp during purging and sampling, and carried outside prior to emptying.
2. Calibrate field instruments, or perform a calibration check by measuring zero gas and span gas samples, each stored in dedicated Tedlar bags. Field screening should be done using an FID or PID at a minimum, but may also include O_2/CO_2 readings, an explosimeter, etc., depending on the site-specific chemicals of concern. A helium meter is also recommended for tracer gas screening.
3. Perform an equipment blank screening to ensure the absence of detectable PID or FID readings. Attach the Tedlar bag to the tubing inside the lung-box and open the Tedlar bag's valve and connect to an appropriate length (1 to 2 ft.) of 1/4-inch HDPE, Teflon™ or Nylon tubing (sufficient to connect the lung box to the sub-slab probe without kinks). Secure the lid of the lung box and evacuate the lung box using the vacuum pump to fill

the Tedlar bag with ambient air. When the Tedlar bag is almost full, turn off vacuum pump, remove the Tedlar bag from the lung-box and screen the Tedlar bag for VOCs with the PID. If the Tedlar bag contains detectable VOCs, empty the bag and repeat this step until there are no measurable readings or replace the Tedlar bag and tubing with new materials and repeat.

4. In advance of purging, prepare the Summa canister. One-litre Summa canisters are preferred, because this volume is sufficient for the detection limits required to meet screening levels, and they are easier to handle and are less subject to risks of over-purging than 6-litre Summa canisters. Record the registration number on the sample log form. Remove the cap from the Summa canister, making sure that the valve is still closed. Attach the vacuum gauge via Swagelock™ fitting and turn ¼ turn past snug. Open the valve and record the initial vacuum, which should be about 27 to 30 inches of mercury (otherwise, the Summa canister may have leaked during shipping and should not be used). Close the valve, remove the vacuum gauge and connect the 5-micron stainless steel filter via Swagelock™ fitting and turn ¼-turn past snug.
 - a. If the Summa canister sample will be collected by sub-sampling from a Tedlar bag sample, use a compression fitting to attach the septum to the 5-micron filter via Swagelock™ fitting, turned ¼ turn past snug, in preparation for attachment to the Summa canisters.
 - b. If the Summa canister sample will be collected by direct connection to the sub-slab probe, connect a laboratory-certified flow controller to the 5 micron filter via Swagelock™ fitting, and turn ¼ turn past snug.

5.2 Purging and Field Screening

1. Connect a short (~1 ft) length of new, ¼-inch HDPE or Nylon tubing to the ball valve on the top of the probe using compression or barbed fitting. Slide the tubing through a 1/4-inch hole drilled through the top of a large (3 to 10 L) clear plastic container, which will act as a shroud for the tracer gas, attach this to a ball valve. Connect another short (~4 inch) length of new, ¼-inch HDPE, Teflon™ or Nylon tubing to the other side of this ball valve, and slide it through the wall of the lung box using a compression fitting, as shown in **Figure 2**. Attach a 1L Tedlar bag to the end of this tubing with a compression or barbed fitting, open the valve on the Tedlar bag, and secure the bag within the lung box.
2. Open the valve at the top of the sub-slab probe, and position the shroud centrally over the probe and valve, adjusting the tubing to minimize any tension.

3. Connect the evacuation port on the lung box to the vacuum pump. The tubing for this can be re-used, because the sample never comes into contact with the gas that will be sampled.
4. Inject helium into the shroud through the injection port on one side of the shroud, and monitor the concentration of helium inside the shroud by inserting the intake of the helium meter into the sampling port on the other side of the shroud. Continue adding helium until the concentration within the shroud is in the range of 60 to 100% by volume.
5. Check that the valve at the inlet of the vacuum pump is closed, then turn on the pump and open the valve at the head of the pump slowly, until the rotameter reading is in the range of 200 to 500 mL/min, preferably with a vacuum of <1 in H₂O. The flow and vacuum test procedure (described above) should be used to select the best compromise between flow-rate and vacuum, if the gas permeability is low.
6. When the Tedlar bag is nearly full, close the valve outside the shroud in the line between the probe and the Tedlar bag, then turn off the pump, vent the lung box (crack the seal to relieve the vacuum), and disconnect the tubing from the compression or barbed fitting at the downstream end of the valve outside the shroud. Connect the tubing from the Tedlar bag to the calibrated field instruments (helium meter, PID or FID, O₂/CO₂, explosimeter, etc.) in sequence and record the time and stable readings on the sampling form (attached).
7. It is important that the Tedlar bag contents be at ambient pressure for both calibration and screening readings. If the bag is pressurized, the flow rate through the portable instrument may increase and result in variable readings. Any remaining Tedlar bag contents should be exhausted to outdoor air, so indoor air samples are not positively biased by emptying the Tedlar bag indoors.
8. If the concentration of helium in the Tedlar bag sample from the sub-slab probe is greater than 5% of the concentration in the shroud in two successive Tedlar bag samples, the probe seal and valve should be reviewed to determine whether there is a leak. If there appears to be a leak through the probe seal, it may be possible to minimize the leak by adding water to the seal between the probe and the floor slab or a paste of bentonite and water around the top of the probe. Otherwise the probe may need to be replaced.
9. Repeat the purging and field screening procedure for a minimum of 3 readings. PID/FID readings should be stable, indicating a reproducible sample. If PID/FID readings are decreasing, it may indicate the influx of indoor air (even in the absence of significant levels of tracer gas in the sample, possibly due to a crack in the floor just outside the

shroud). An atmospheric air leak may also be indicated by decreasing O₂ and increasing CO₂ concentrations at sites with aerobically degradable compounds. If atmospheric air leaks are suspected by these trends in the field screening data, the probe should be allowed to re-equilibrate for at least an hour, and subsequent sampling should be completed after purging of a single Tedlar bag sample. If there are no detectable PID or FID readings it is not possible to confirm steady readings, but the absence of significant concentrations of tracer gas will verify that the samples are representative of the sub-slab zone.

5.3 Summa Canister Sample Collection

1. If field screening readings are stable after 3 Tedlar bag samples, samples should be collected for laboratory analysis. Collect the Summa canister sample first, via one of the following two options:
 - a. Preferred Option: collect one additional Tedlar bag sample, screen it with the helium meter to confirm absence of leaks, and then connect the Tedlar bag directly to the Summa canister using compression fittings. Open the Summa canister valve slowly and close it again before the bag is completely drained.
 - b. Alternate Option: Lift the shroud, close the valve at the top of the sub-slab probe, remove the tubing and connect the flow controller of the Summa canister to the probe valve directly with compression or barb fittings to as short as possible piece of ¼-inch HDPE, Teflon™ or Nylon tubing to minimize the dead volume. Open the valve on the probe, then open the valve on the canister. The Summa canister should fill within 5 minutes if the flow controller was set to 200 ml/min (recommended), unless the gas permeability of the subsurface materials is low, in which case, additional time should be allowed, using judgment and review of the flow and vacuum testing data. After allowing sufficient time for the sample to be collected, close the valve on the Summa canister, then close the valve on the probe.
2. Remove the 5-micron filter (and flow controller, if used) from the Summa canister, and replace it with the vacuum gauge (¼ turn past snug). Re-open the valve on the Summa canister and record the final vacuum (should be less than a few inches of mercury, but may also be zero). Close the Summa valve, remove the vacuum gauge, and replace the cap on the Summa canister valve in preparation for return shipping. Double check that the cap and valve on the Summa are tightly closed. Record the final vacuum on the sampling form and the chain of custody.

3. The label tag on the Summa canister should be filled-out with the site name, sample ID#, sampler's name, project code, and date and time of sample.
4. Remove the valve from the sub-slab probe replace it with the cap, freshly wrapped with new Teflon tape.

This procedure should be repeated for each sub-slab soil gas probe.

6. CHAIN OF CUSTODY AND SAMPLE HANDLING

The label tag on the mini-Summa canister should be filled-out with the site name, sample ID #, sampler's name, project code, date and time of sample, initial and final vacuum levels, and analysis requested. A chain of custody (COC) form should be completed with each sample shipment. The COC should include the sample ID, canister number, analysis requested, and any special instructions. The laboratory will confirm the final vacuum level for each Summa canister upon receipt to verify that the Summa canister valve and cap did not leak during shipment. Canisters do not need to be refrigerated, but should be shipped with sufficient padding to prevent damage if the container is accidentally dropped.

The COC form should be signed by the sampler and placed in the shipping container, then the shipping container should be wrapped securely using packing tape. The sampler should sign the packing tape across the seam of the lid of the container, so it cannot be opened without damaging the signature. Upon arrival, the laboratory will confirm the signature to be intact, and complete the COC form. Analyses should be scheduled with the analytical laboratory to be completed within acceptable holding times. Summa canisters should be analyzed within 2 weeks.

7. FIELD QC SAMPLES FOR SOIL GAS SAMPLE COLLECTION

Field quality control (QC) samples should be collected to monitor sampling and analytical performance. A complete record of all QC samples collected must be maintained as a part of the sampling documentation. The definition and purpose of each type of QC sample, and the procedures for their collection and handling are described in the paragraphs below.

Ambient Air Screening: Before field screening at each soil gas probe, an ambient air sample will be screened by drawing ambient air into a PID or FID over a period of at least one minute

and recording the range of readings occurring during that time period. This ambient air screening should provide no detectable concentrations, but any readings observed may be useful to identify background conditions and evaluate potential biases.

Equipment Blanks: Prior to purging, an equipment blank should be performed to ensure the absence of measurable VOC vapors. Disconnect the tubing from the valve on top of the soil gas probe, and fill the Tedlar Bag with zero gas (preferred) or outdoor air through the tubing. Equipment blank readings should be made using a PID or FID, calibrated to span gas and zero gas according to manufacturers instructions. Atmospheric air may be used as zero gas in areas of generally good air quality, but should be avoided in high traffic areas, smog areas, or areas with any noticeable odors. If the equipment blank reading is above the FID or PID detection limit, repeat the equipment blank step with a new Tedlar bag and new length of tubing. If this does not result in a blank with no detectable VOCs, the FID or PID calibration should be repeated and the equipment blank process repeated. If this still does not provide an equipment blanks below the FID or PID detection limit, a project management decision will be required regarding whether to proceed with sampling, or whether to replace or perform service on the FID or PID.

Field Duplicate Sample: During the soil gas probe sampling, a field duplicate sample will be collected using regular sampling procedures immediately after collecting the investigative sample. The field duplicate sample will be analyzed to identify sample variability. The duplicate sample will be submitted for analyses without indication of which sample the duplicate represents (i.e., blindly). If the monitoring program includes multiple samples (i.e. Summa canister for VOCs, possibly Radon, etc.), the duplicate should also include the entire suite. Field duplicate samples are recommended at a frequency of one for every 10 investigative samples.

8. EQUIPMENT CLEANING

New or dedicated materials are preferred to minimize the risk of cross-contamination or carry-over from one sample to the next. The Tedlar bag may be re-used for field screening, but should be flushed using atmospheric air and completely drained three times between uses and verified clean by the equipment blank procedure. New or dedicated Tedlar bags are necessary if a Summa canister sample is to be drawn from a Tedlar bag after field screening. Brass and stainless steel valves should be heated and flushed with ample amounts of air to strip any residual VOCs between sampling events.

9. DOCUMENTATION

Field documentation will include instrument calibration information; date, time and location of readings; purging rate and vacuum induced; number of Summa canisters filled; sampler's name; and a detailed description of the equipment set up for each location. The series of field screening readings will be recorded on the sampling log sheets. A list of the soil gas probes sampled and the sampling order for all samples and QA/QC samples will be recorded on the sampling field records. Photographs are recommended to aid in recording equipment set-up.

For each sampling day, the following information will be recorded on the daily field logs

- name and number of project;
- name of field personnel;
- date and time of sampling event;
- list of the primary activities performed;
- identification of probes screened;
- time when soil gas samples were collected; and,
- all related information (weather, attendees, equipment problems, any departures from standard procedures and the reasons and responses) observed throughout the day.
- Field instrument information and calibration data;
- Value of probe dead space volume for each soil gas probe;
- Time, probe soil gas readings (and tubing blank reading) for each probe volume (or Tedlar™ bag filled); and
- Time and reading for each instrument calibration check.

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Attachment 1: Recommended Equipment

Tubing: High Density Polyethylene (HDPE) tubing is generally acceptable for low sorption (Barcelona et. al., 1983), and works well with compression fittings or barbed fittings. Nylon tubing is considered equally appropriate. Teflon™ tubing is considerably less flexible than HDPE and may not work as well with barbed fittings. Tubing may also be stainless steel or copper, which forms air-tight seals when used with Swagelock™ fittings, but is more expensive and less flexible than HDPE. Soft flexible tubing should be avoided (except for the discharge line from the pump discharge to an outdoor location, if used), because vapors tend to adsorb more strongly to them.

Rotameter-Style Flowmeters: Dwyer Model RMB-5-49 with a range up to 5 standard cubic feet per hour (SCFH) (2.4 L/min), and Model RMB-5-52 with a range up to 50 SCFH (24 L/min).

Vacuum Gauges: Dwyer Magnehelic™ gauges, which are available in several ranges, including zero to 0.25 in-H₂O, zero to 5 in-H₂O, and zero to 100 in-H₂O.

Vacuum Pump: GAST, DOA-P101-AA piston pump

Lung Box: Xitech Instruments, Inc. Model 1060 1 L Bag Sampler

Helium Meter: Mark 9822 helium detector

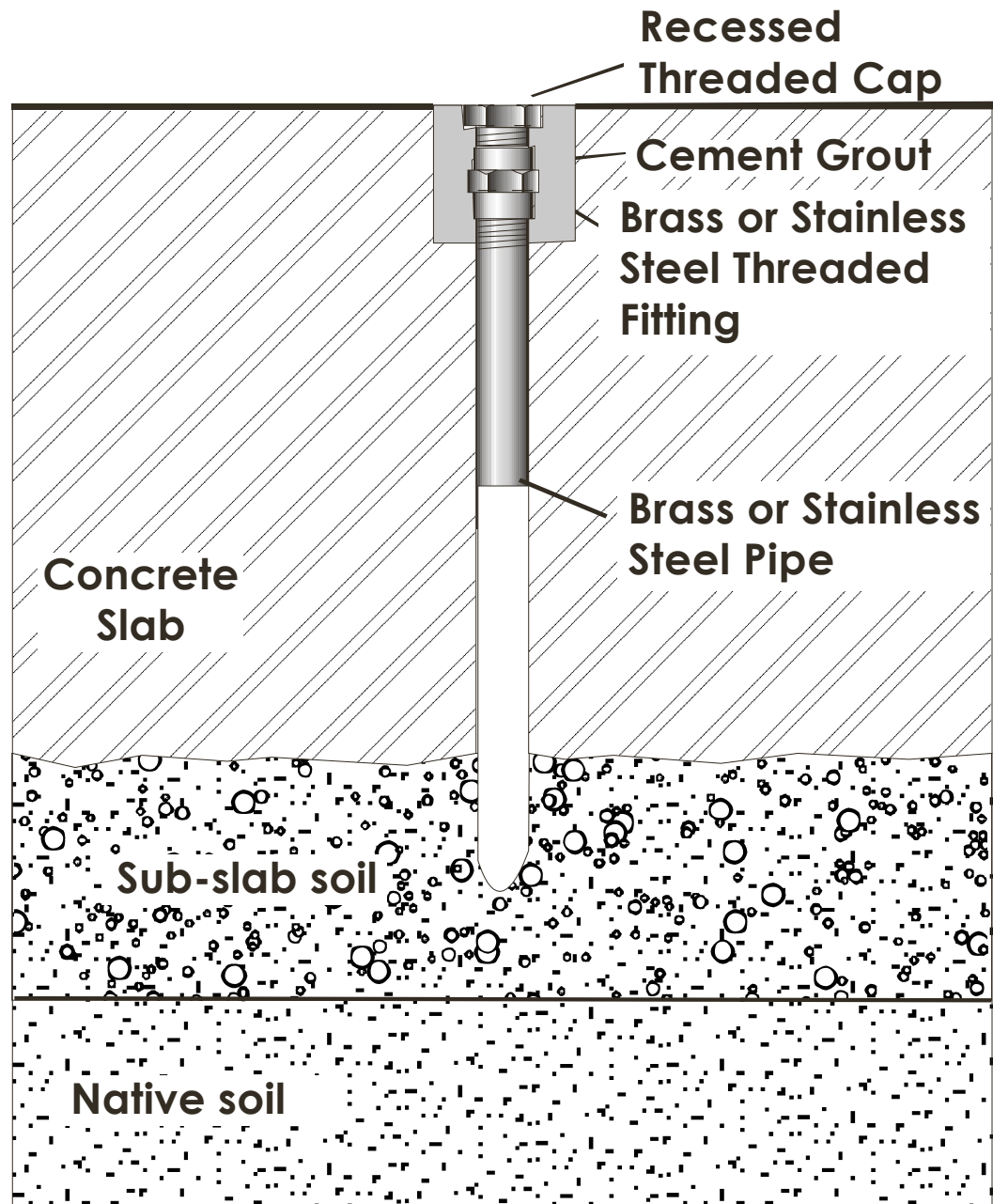
Portable FID/PID: Foxboro TVA 1000 FID/PID, miniRAE 2000, ppbRAE, Photovac Microtip.

Personal Sampling Pump: Sensidyne Gilian GilAir-3 Constant Flow Sampling Pump

ATD Tubes: supplied by laboratory, after discussion of target chemicals, relative concentrations, target detection limits, and potential ranges of concentrations.

Micro-manometer: Logtech DP-Calc digital micro-manometer

Barologger: Barnstead ERTCO Barometric Pressure data recorder.



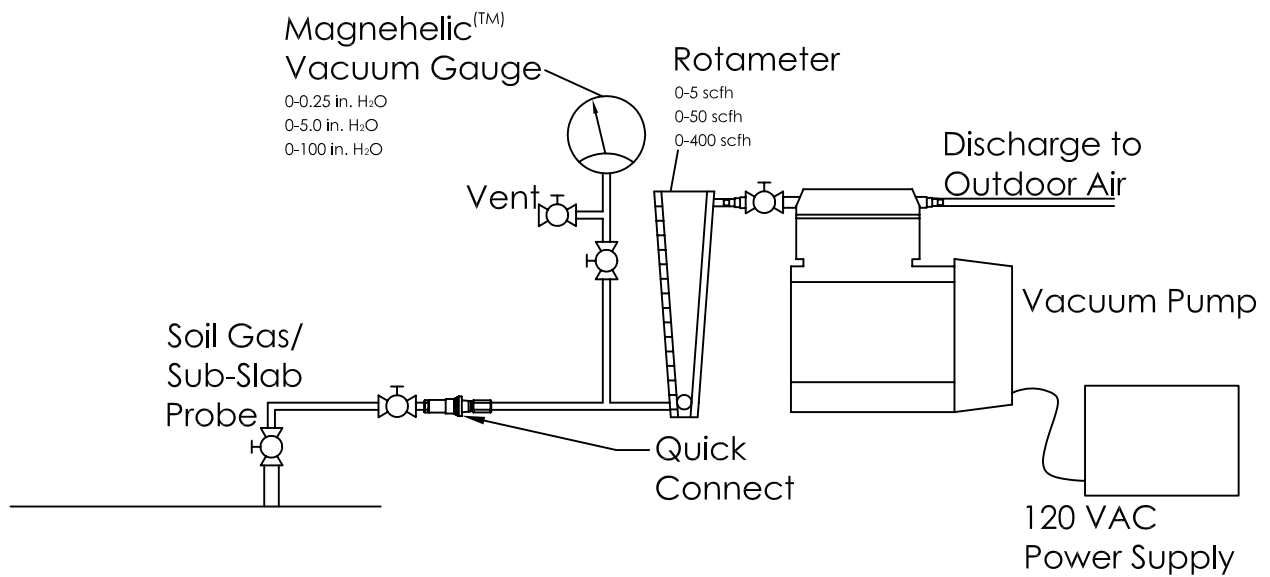
Sub-Slab Probe
 GeoSyntec Consultants,
 Suggested Operating Procedure

Jan 2005

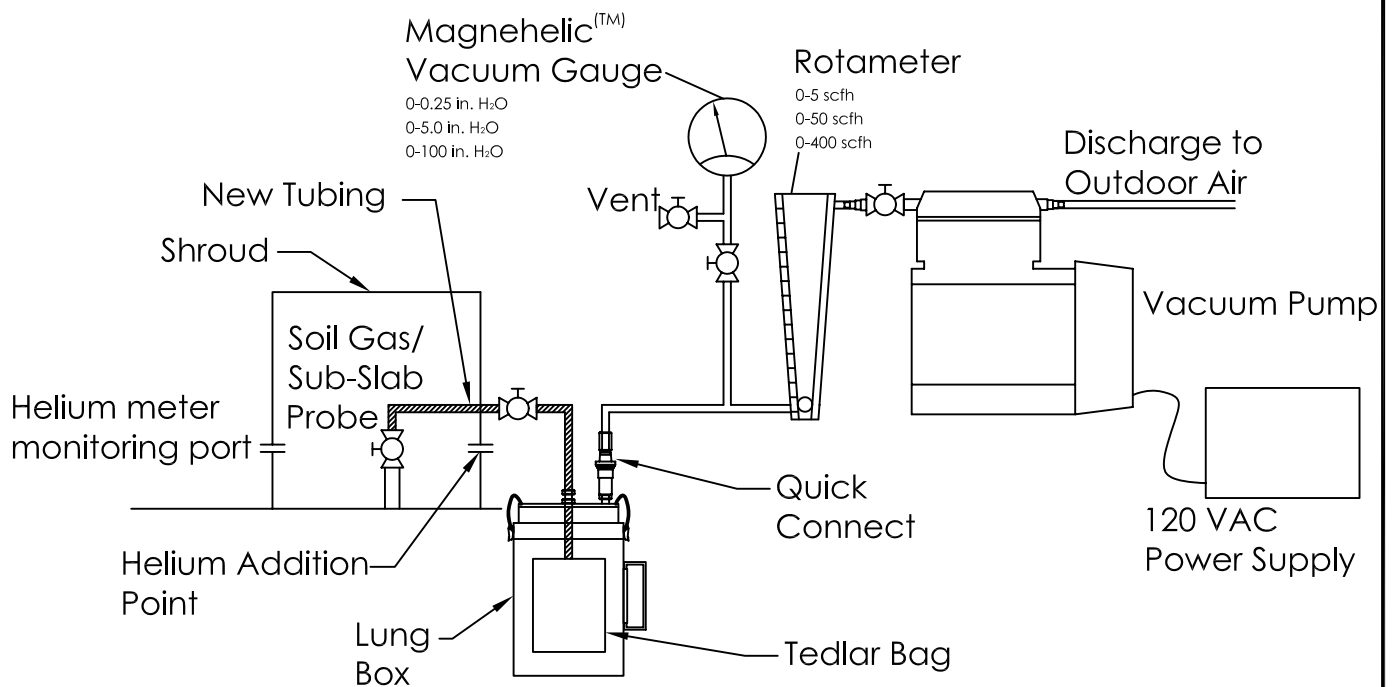
Figure: 1



modified from EPA, 2004



A - Flow and Vacuum Check



B - Purging and Sample Collection

 High Density Polyethylene Tubing (HDPE), Nylaflow™, Teflon, Stainless Steel

 Low Density Polyethylene Tubing (LDPE)

Soil Gas Sampling Apparatus

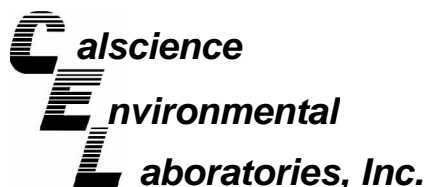
Jan. 2005

Figure: 2



APPENDIX B

LABORATORY REPORTS OF ANALYSES



August 05, 2005

Robbie Ettinger
GeoSyntec Consultants
924 Anacapa Street
Suite 4A
Santa Barbara, CA 93101-2177

Subject: **CalScience Work Order No.: 05-07-1353**
Client Reference: HX0186

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 7/25/2005 and analyzed in accordance with the attached chain-of-custody.

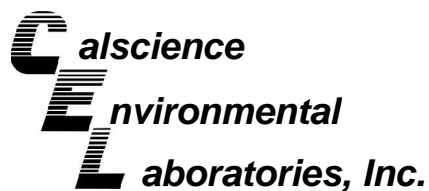
Unless otherwise noted, all analytical testing was accomplished in accordance with the guidelines established in our Quality Assurance Program Manual, applicable standard operating procedures, and other related documentation. The original report of any subcontracted analysis is provided herein, and follows the standard CalScience data package. The results in this analytical report are limited to the samples tested and any reproduction thereof must be made in its entirety.

If you have any questions regarding this report, please do not hesitate to contact the undersigned.

Sincerely,

A handwritten signature in black ink, appearing to read 'S. Nowak', is written over a horizontal line.

CalScience Environmental
Laboratories, Inc.
Stephen Nowak
Project Manager



Analytical Report



GeoSyntec Consultants
924 Anacapa Street
Suite 4A
Santa Barbara, CA 93101-2177

Date Received: 07/25/05
Work Order No: 05-07-1353
Preparation: N/A
Method: EPA TO-3(M)

Project: HX0186

Page 1 of 1

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
SSP-01	05-07-1353-1	07/22/05	Air	N/A	07/26/05	050726L01

<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	1900	18	5.92		ppm (v/v)

SSP-03	05-07-1353-2	07/22/05	Air	N/A	07/26/05	050726L01
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<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	ND	4.5	1.5		ppm (v/v)

SSP-04	05-07-1353-3	07/22/05	Air	N/A	07/26/05	050726L01
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<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	ND	4.8	1.6		ppm (v/v)

SSP-0X	05-07-1353-4	07/22/05	Air	N/A	07/26/05	050726L01
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<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	1500	4	1.59		ppm (v/v)

AA01	05-07-1353-5	07/22/05	Air	N/A	07/26/05	050726L01
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<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	ND	4.6	1.52		ppm (v/v)

Method Blank	098-01-005-322	N/A	Air	N/A	07/26/05	050726L01
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<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	ND	3.0	1		ppm (v/v)

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Analytical Report



GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Received: 07/25/05
 Work Order No: 05-07-1353
 Preparation: N/A
 Method: EPA TO-15
 Units: ppb (v/v)

Project: HX0186

Page 1 of 1

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
SSP-01	05-07-1353-1	07/22/05	Air	N/A	07/27/05	050727L01

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	1900	260	518		Toluene	840	260	518	
Ethylbenzene	ND	260	518		1,3,5-Trimethylbenzene	ND	260	518	
o-Xylene	270	260	518		1,2,4-Trimethylbenzene	ND	520	518	
p/m-Xylene	750	520	518						

SSP-03	05-07-1353-2	07/22/05	Air	N/A	07/27/05	050727L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	1.3	0.7	1.5		Toluene	1.8	0.7	1.5	
Ethylbenzene	ND	0.75	1.5		1,3,5-Trimethylbenzene	2.6	0.7	1.5	
o-Xylene	ND	0.75	1.5		1,2,4-Trimethylbenzene	14	1	1.5	
p/m-Xylene	ND	1.5	1.5						

SSP-04	05-07-1353-3	07/22/05	Air	N/A	07/27/05	050727L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	4.7	0.8	1.6		Toluene	1.3	0.8	1.6	
Ethylbenzene	ND	0.80	1.6		1,3,5-Trimethylbenzene	ND	0.80	1.6	
o-Xylene	ND	0.80	1.6		1,2,4-Trimethylbenzene	ND	1.6	1.6	
p/m-Xylene	ND	1.6	1.6						

SSP-0X	05-07-1353-4	07/22/05	Air	N/A	07/27/05	050727L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	1600	200	398		Toluene	510	200	398	
Ethylbenzene	ND	200	398		1,3,5-Trimethylbenzene	ND	200	398	
o-Xylene	ND	200	398		1,2,4-Trimethylbenzene	ND	400	398	
p/m-Xylene	470	400	398						

AA01	05-07-1353-5	07/22/05	Air	N/A	07/28/05	050727L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.76	1.52		Toluene	ND	0.76	1.52	
Ethylbenzene	ND	0.76	1.52		1,3,5-Trimethylbenzene	ND	0.76	1.52	
o-Xylene	ND	0.76	1.52		1,2,4-Trimethylbenzene	ND	1.5	1.52	
p/m-Xylene	ND	1.5	1.52						

Method Blank	095-01-021-3,191	N/A	Air	N/A	07/27/05	050727L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.50	1		Toluene	ND	0.50	1	
Ethylbenzene	ND	0.50	1		1,3,5-Trimethylbenzene	ND	0.50	1	
o-Xylene	ND	0.50	1		1,2,4-Trimethylbenzene	ND	1.0	1	
p/m-Xylene	ND	1.0	1						

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

ANALYTICAL REPORT

GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Sampled: 07/22/05
 Date Received: 07/25/05
 Date Analyzed: 07/25/05

Attn: Robbie Ettinger
 RE: HX0186

Work Order No.: 05-07-1353
 Method: ASTM D-1946
 Page 1 of 3

All concentrations are reported in percent (%) by volume.

<u>Analyte</u>	<u>Concentration</u>	<u>Reporting Limit</u>
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Sample Number: SSP-01

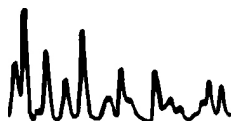
Oxygen (O ₂) + Argon (Ar)	1.4	0.1
Nitrogen (N ₂)	82.2	0.1
Methane (CH ₄)	1.7	0.1
Carbon Monoxide (CO)	ND	0.1
Carbon Dioxide (CO ₂)	14.7	0.1

Sample Number: SSP-03

Oxygen (O ₂) + Argon (Ar)	8.0	0.2
Nitrogen (N ₂)	82.4	0.2
Methane (CH ₄)	ND	0.2
Carbon Monoxide (CO)	ND	0.2
Carbon Dioxide (CO ₂)	9.6	0.2

Sample Number: SSP-04

Oxygen (O ₂)	2.1	0.2
Nitrogen (N ₂)	81.2	0.2
Methane (CH ₄)	ND	0.2
Carbon Monoxide (CO)	ND	0.2
Carbon Dioxide (CO ₂)	16.7	0.2



ANALYTICAL REPORT

GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Sampled: 07/22/05
 Date Received: 07/25/05
 Date Analyzed: 07/25/05

Attn: Robbie Ettinger
 RE: HX0186

Work Order No.: 05-07-1353
 Method: ASTM D-1946
 Page 2 of 3

All concentrations are reported in percent (%) by volume.

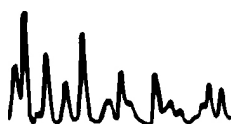
<u>Analyte</u>	<u>Concentration</u>	<u>Reporting Limit</u>
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Sample Number: SSP-0X

Oxygen (O ₂) + Argon (Ar)	1.4	0.2
Nitrogen (N ₂)	82.3	0.2
Methane (CH ₄)	1.7	0.2
Carbon Monoxide (CO)	ND	0.2
Carbon Dioxide (CO ₂)	14.7	0.2

Sample Number: AA01

Oxygen (O ₂) + Argon (Ar)	21.9	0.2
Nitrogen (N ₂)	78.1	0.2
Methane (CH ₄)	ND	0.2
Carbon Monoxide (CO)	ND	0.2
Carbon Dioxide (CO ₂)	ND	0.2



ANALYTICAL REPORT

GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Sampled: N/A
 Date Received: N/A
 Date Analyzed: 07/25/05

Attn: Robbie Ettinger
 RE: HX0186

Work Order No.: 05-07-1353
 Method: ASTM D-1946
 Page 3 of 3

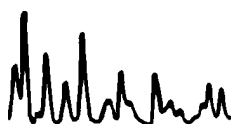
All concentrations are reported in percent (%) by volume.

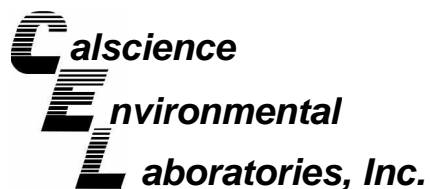
<u>Analyte</u>	<u>Concentration</u>	<u>Reporting Limit</u>
Sample Number: Method Blank		
Oxygen (O ₂)	ND	0.1
Nitrogen (N ₂)	ND	0.1
Methane (CH ₄)	ND	0.1
Carbon Monoxide (CO)	ND	0.1
Carbon Dioxide (CO ₂)	ND	0.1

QA/QC

Sample Number: Laboratory Control Sample

<u>Analyte</u>	<u>Sample Conc.</u>	<u>Duplicate Conc.</u>	<u>%RPD</u>	<u>Control Limits (%)</u>
Oxygen (O ₂) + Argon (Ar)	20.0	20.8	4	0 - 30
Nitrogen (N ₂)	75.5	78.0	3	0 - 30
Carbon Dioxide (CO ₂)	5.11	5.01	2	0 - 30





Quality Control - Duplicate



GeoSyntec Consultants
924 Anacapa Street
Suite 4A
Santa Barbara, CA 93101-2177

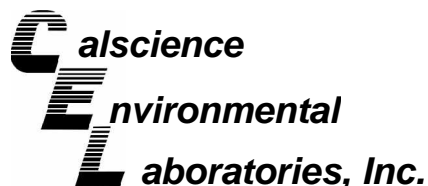
Date Received: 07/25/05
Work Order No: 05-07-1353
Preparation: N/A
Method: EPA TO-3(M)

Project: HX0186

Quality Control Sample ID	Matrix	Instrument	Date Prepared:	Date Analyzed:	Duplicate Batch Number
05-07-1393-4	Air	GC 13	N/A	07/26/05	050726D01

Parameter	Sample Conc.	DUP Conc	RPD	RPD CL	Qualifiers
TPH as Gasoline	6000	6000	1	0-20	

RPD - Relative Percent Difference , CL - Control Limit



Quality Control - LCS/LCS Duplicate



GeoSyntec Consultants
924 Anacapa Street
Suite 4A
Santa Barbara, CA 93101-2177

Date Received: N/A
Work Order No: 05-07-1353
Preparation: N/A
Method: EPA TO-15

Project: HX0186

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
095-01-021-3,191	Air	GC/MS AA	N/A	07/27/05	050727L01

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Benzene	107	106	61-121	0	0-37	
Bromoform	88	85	62-134	3	0-38	
Carbon Tetrachloride	99	100	56-128	1	0-42	
1,2-Dibromoethane	91	86	63-123	5	0-38	
1,2-Dichlorobenzene	94	87	41-149	7	0-62	
1,2-Dichloroethane	101	100	63-123	2	0-37	
1,2-Dichloropropane	107	105	61-121	2	0-37	
1,4-Dichlorobenzene	89	84	51-147	5	0-49	
c-1,3-Dichloropropene	112	105	62-128	6	0-37	
Ethylbenzene	97	88	61-127	10	0-38	
o-Xylene	94	83	58-130	12	0-38	
p/m-Xylene	94	85	57-129	10	0-39	
Tetrachloroethene	85	91	59-119	6	0-40	
Toluene	92	91	60-120	1	0-39	
Trichloroethene	106	107	65-119	1	0-38	
1,1,2-Trichloroethane	113	99	64-124	13	0-37	
Vinyl Chloride	109	107	58-124	1	0-37	

RPD - Relative Percent Difference , CL - Control Limit

Glossary of Terms and Qualifiers



Work Order Number: 05-07-1353

<u>Qualifier</u>	<u>Definition</u>
*	See applicable analysis comment.
1	Surrogate compound recovery was out of control due to a required sample dilution, therefore, the sample data was reported without further clarification.
2	Surrogate compound recovery was out of control due to matrix interference. The associated method blank surrogate spike compound was in control and, therefore, the sample data was reported without further clarification.
3	Recovery of the Matrix Spike or Matrix Spike Duplicate compound was out of control due to matrix interference. The associated LCS and/or LCSD was in control and, therefore, the sample data was reported without further clarification.
4	The MS/MSD RPD was out of control due to matrix interference. The LCS/LCSD RPD was in control and, therefore, the sample data was reported without further clarification.
5	The PDS/PDSD associated with this batch of samples was out of control due to a matrix interference effect. The associated batch LCS/LCSD was in control and, hence, the associated sample data was reported with no further corrective action required.
A	Result is the average of all dilutions, as defined by the method.
B	Analyte was present in the associated method blank.
C	Analyte presence was not confirmed on primary column.
E	Concentration exceeds the calibration range.
H	Sample received and/or analyzed past the recommended holding time.
J	Analyte was detected at a concentration below the reporting limit and above the laboratory method detection limit. Reported value is estimated.
N	Nontarget Analyte.
ND	Parameter not detected at the indicated reporting limit.
Q	Spike recovery and RPD control limits do not apply resulting from the parameter concentration in the sample exceeding the spike concentration by a factor of four or greater.
U	Undetected at the laboratory method detection limit.
X	% Recovery and/or RPD out-of-range.
Z	Analyte presence was not confirmed by second column or GC/MS analysis.



LABORATORIES, INC.

7440 LINCOLN WAY
GARDEN GROVE, CA 92841-1427
TEL: (714) 895-5494 FAX: (714) 894-7501

CAL SCIENCE

CHAIN OF CUSTODY RECORD

Date 22-July-05

Page 1 of 1

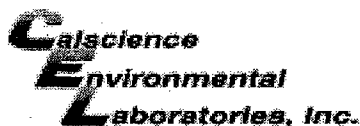
LABORATORY CLIENT: ADDRESS: <u>GEOSYNTEC CONSULTANTS</u> <u>924 Anacapa St Suite 4A</u> CITY: <u>SANTA BARBARA</u> STATE: <u>CA</u> ZIP: <u>93101</u> TEL: <u>805 897 3800</u> FAX: <u>805 899 8629</u> E-MAIL: <u>rettinger@geosyntec.com</u> TURNAROUND TIME: <u>STANDARD</u> <input type="checkbox"/> SAME DAY <input type="checkbox"/> 24 HR <input type="checkbox"/> 48 HR <input type="checkbox"/> 72 HR <input type="checkbox"/> 5 DAYS <input type="checkbox"/> 10 DAYS SPECIAL REQUIREMENTS (ADDITIONAL COSTS MAY APPLY): <input type="checkbox"/> RWQCB REPORTING FORMS <input type="checkbox"/> COELT EDF <input type="checkbox"/> _____ SPECIAL INSTRUCTIONS: <u>TO15 - Benzene, Ethylbenzene, Toluene, Xylene,</u> <u>1,2,4-Trimethylbenzene, 1,3,5-trimethylbenzene,</u> <u>TO3 - TPH-G</u> <u>ASTMD1946 - O₂, CO₂, CH₄, N₂</u>				CLIENT PROJECT NAME / NUMBER: <u>HX0186</u> PROJECT CONTACT: <u>Robbie Ettinger</u> SAMPLER(S): (SIGNATURE) <u>Grant Scholes</u> COELT LOG CODE <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		P.O. NO.: LAB USE ONLY <u>07-1353</u> COOLER RECEIPT TEMP. _____ °C															
REQUESTED ANALYSES																					
LAB USE ONLY	SAMPLE ID	FIELD POINT NAME (FOR COELT EDF)	SAMPLING DATE TIME MATRIX	NO. OF CONT.	TPH (G)	TPH (D) or	BTX / MTBE (8260B) or	OXYGENATES (8260B)	VOCs (8260B)	5035 ENCORE PREP	SVOCs (8270C)	PEST (8081A)	PCBs (8082)	CAC, T22 METALS (6010B) / 747	PNAs (8310) or (8270C)	VOCs (TO-14A) or (TO-15)	TPH (G) (TO-3M)	TO15	TO3	ASTMD 1946	
	SSP-01	X	22-July-05 1317	SOIL GAS	1													X	X	X	
	SSP-02																				
	SSP-03			1155	SOIL GAS	1													X	X	X
	SSP-04			1035	SOIL GAS	1													X	X	X
	SSP-0X			-	SOIL GAS	1													X	X	X
	AA01		1500	AIR	1													X	X	X	
	SSP-05																				
Relinquished by: (Signature) _____					Received by: (Signature) _____					Date: _____		Time: _____									
Relinquished by: (Signature) _____					Received by: (Signature) _____					Date: _____		Time: _____									
Relinquished by: (Signature) <u>Fed EX</u>					Received for Laboratory by: (Signature) <u>Sanfama CEL</u>					Date: <u>7/25/05</u>		Time: <u>1000</u>									

DISTRIBUTION: When with final report, Green to file, Yellow to Client.

Please note that pages 1 and 2 of 2 of our TICs are printed on the reverse side of the Green and Yellow pages respectively.

10/20/04 Revision

QAC Graphic 714-998-9702



WORK ORDER #:

05 - 07 - 1353

Cooler 0 of 0

SAMPLE RECEIPT FORM

CLIENT: Geo SyntecDATE: 7/25/05

TEMPERATURE – SAMPLES RECEIVED BY:

CALSCIENCE COURIER:

- ☐ Chilled, cooler with temperature blank provided.
☐ Chilled, cooler without temperature blank.
☐ Chilled and placed in cooler with wet ice.
☐ Ambient and placed in cooler with wet ice.
☐ Ambient temperature.
☐ °C Temperature blank.

LABORATORY (Other than Calscience Courier):

- ☐ °C Temperature blank.
☐ °C IR thermometer.
☒ Ambient temperature.

Initial: [Signature]

CUSTODY SEAL INTACT:

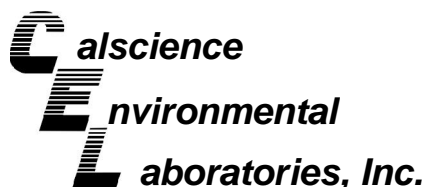
Sample(s): _____ Cooler: _____ No (Not Intact) : _____ Not Applicable (N/A): [Signature]Initial: [Signature]

SAMPLE CONDITION:

	Yes	No	N/A
Chain-Of-Custody document(s) received with samples.....	<u>[Signature]</u>	_____	_____
Sample container label(s) consistent with custody papers.....	<u>[Signature]</u>	_____	_____
Sample container(s) intact and good condition.....	<u>[Signature]</u>	_____	_____
Correct containers for analyses requested.....	<u>[Signature]</u>	_____	_____
Proper preservation noted on sample label(s).....	_____	_____	<u>[Signature]</u>
VOA vial(s) free of headspace.	_____	_____	<u>[Signature]</u>
Tedlar bag(s) free of condensation.....	_____	_____	<u>[Signature]</u>

Initial: [Signature]

COMMENTS:



September 29, 2006

Robbie Ettinger
GeoSyntec Consultants
924 Anacapa Street
Suite 4A
Santa Barbara, CA 93101-2177

Subject: **Calscience Work Order No.: 06-09-1073**
Client Reference: HX0186

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 9/21/2006 and analyzed in accordance with the attached chain-of-custody.

Unless otherwise noted, all analytical testing was accomplished in accordance with the guidelines established in our Quality Systems Manual, applicable standard operating procedures, and other related documentation. The original report of subcontracted analysis, if any, is provided herein, and follows the standard Calscience data package. The results in this analytical report are limited to the samples tested and any reproduction thereof must be made in its entirety.

If you have any questions regarding this report, please do not hesitate to contact the undersigned.

Sincerely,

A handwritten signature in black ink, appearing to read 'S. Nowak', is written over a horizontal line.

Calscience Environmental
Laboratories, Inc.
Stephen Nowak
Project Manager

Analytical Report



GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Received: 09/21/06
 Work Order No: 06-09-1073
 Preparation: N/A
 Method: ASTM D-1946
 Units: %v

Project: HX0186

Page 1 of 2

Client Sample Number	Lab Sample Number				Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
SSP-01-GS	06-09-1073-1				09/19/06	Air	N/A	09/21/06	060921L01
<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Parameter</u>		<u>Result</u>	<u>RL</u>	<u>DF</u> <u>Qual</u>
Methane	0.319	0.144	1.44		Oxygen + Argon		2.53	0.14	1.44
Carbon Dioxide	13.8	0.1	1.44						
SSP-02-GS	06-09-1073-2				09/20/06	Air	N/A	09/21/06	060921L01
<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Parameter</u>		<u>Result</u>	<u>RL</u>	<u>DF</u> <u>Qual</u>
Methane	ND	0.151	1.51		Oxygen + Argon		5.36	0.15	1.51
Carbon Dioxide	7.65	0.15	1.51						
SSP-03-GS	06-09-1073-3				09/20/06	Air	N/A	09/21/06	060921L01
<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Parameter</u>		<u>Result</u>	<u>RL</u>	<u>DF</u> <u>Qual</u>
Methane	ND	0.139	1.39		Oxygen + Argon		10.9	0.1	1.39
Carbon Dioxide	7.83	0.14	1.39						
SSP-04-GS	06-09-1073-4				09/20/06	Air	N/A	09/21/06	060921L01
<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Parameter</u>		<u>Result</u>	<u>RL</u>	<u>DF</u> <u>Qual</u>
Methane	ND	0.153	1.53		Oxygen + Argon		9.63	0.15	1.53
Carbon Dioxide	10.0	0.2	1.53						
SSP-05-GS	06-09-1073-5				09/20/06	Air	N/A	09/21/06	060921L01
<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Parameter</u>		<u>Result</u>	<u>RL</u>	<u>DF</u> <u>Qual</u>
Methane	ND	0.152	1.52		Oxygen + Argon		13.7	0.2	1.52
Carbon Dioxide	3.50	0.15	1.52						
SSP-06-GS	06-09-1073-6				09/20/06	Air	N/A	09/21/06	060921L01
<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Parameter</u>		<u>Result</u>	<u>RL</u>	<u>DF</u> <u>Qual</u>
Methane	1.42	0.15	1.49		Oxygen + Argon		3.86	0.15	1.49
Carbon Dioxide	10.4	0.1	1.49						
SSP-07-GS	06-09-1073-7				09/20/06	Air	N/A	09/21/06	060921L01
<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Parameter</u>		<u>Result</u>	<u>RL</u>	<u>DF</u> <u>Qual</u>
Methane	ND	0.137	1.37		Oxygen + Argon		4.09	0.14	1.37
Carbon Dioxide	11.7	0.1	1.37						
SSP-XX-GS	06-09-1073-8				09/20/06	Air	N/A	09/21/06	060921L01
<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Parameter</u>		<u>Result</u>	<u>RL</u>	<u>DF</u> <u>Qual</u>
Methane	1.35	0.16	1.57		Oxygen + Argon		4.26	0.16	1.57
Carbon Dioxide	10.3	0.2	1.57						

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Analytical Report



GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Received: 09/21/06
 Work Order No: 06-09-1073
 Preparation: N/A
 Method: ASTM D-1946
 Units: %v

Project: HX0186

Page 2 of 2

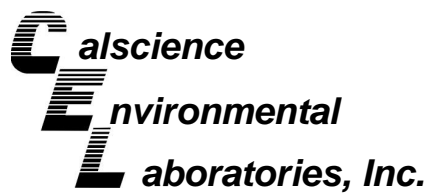
Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
OA-01-GS	06-09-1073-9	09/20/06	Air	N/A	09/21/06	060921L01

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Methane	ND	0.143	1.43		Oxygen + Argon	21.9	0.1	1.43	
Carbon Dioxide	ND	0.143	1.43						

Method Blank	099-03-002-153	N/A	Air	N/A	09/21/06	060921L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Methane	ND	0.100	1		Oxygen + Argon	ND	0.100	1	
Carbon Dioxide	ND	0.100	1		Nitrogen	ND	0.100	1	
Carbon Monoxide	ND	0.100	1						

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers



Analytical Report



GeoSyntec Consultants
924 Anacapa Street
Suite 4A
Santa Barbara, CA 93101-2177

Date Received: 09/21/06
Work Order No: 06-09-1073
Preparation: N/A
Method: EPA TO-3(M)

Project: HX0186

Page 1 of 2

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
SSP-01-GS	06-09-1073-1	09/19/06	Air	N/A	09/21/06	060921L01

Parameter	Result	RL	DF	Qual	Units
TPH as Gasoline	870	4	1.44		ppm (v/v)

SSP-02-GS	06-09-1073-2	09/20/06	Air	N/A	09/21/06	060921L01
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Parameter	Result	RL	DF	Qual	Units
TPH as Gasoline	9.4	4.5	1.51		ppm (v/v)

SSP-03-GS	06-09-1073-3	09/20/06	Air	N/A	09/21/06	060921L01
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Parameter	Result	RL	DF	Qual	Units
TPH as Gasoline	ND	4.2	1.39		ppm (v/v)

SSP-04-GS	06-09-1073-4	09/20/06	Air	N/A	09/21/06	060921L01
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Parameter	Result	RL	DF	Qual	Units
TPH as Gasoline	ND	4.6	1.53		ppm (v/v)

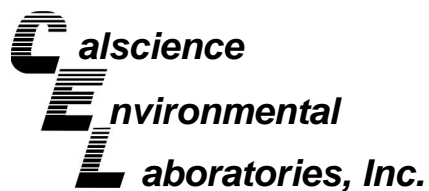
SSP-05-GS	06-09-1073-5	09/20/06	Air	N/A	09/21/06	060921L01
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Parameter	Result	RL	DF	Qual	Units
TPH as Gasoline	ND	4.6	1.52		ppm (v/v)

SSP-06-GS	06-09-1073-6	09/20/06	Air	N/A	09/21/06	060921L01
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Parameter	Result	RL	DF	Qual	Units
TPH as Gasoline	660	4	1.49		ppm (v/v)

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers



Analytical Report



GeoSyntec Consultants
924 Anacapa Street
Suite 4A
Santa Barbara, CA 93101-2177

Date Received: 09/21/06
Work Order No: 06-09-1073
Preparation: N/A
Method: EPA TO-3(M)

Project: HX0186

Page 2 of 2

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
SSP-07-GS	06-09-1073-7	09/20/06	Air	N/A	09/21/06	060921L01

<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	18	4	1.37		ppm (v/v)

SSP-XX-GS	06-09-1073-8	09/20/06	Air	N/A	09/21/06	060921L01
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<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	630	5	1.57		ppm (v/v)

OA-01-GS	06-09-1073-9	09/20/06	Air	N/A	09/21/06	060921L01
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<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	ND	4.3	1.43		ppm (v/v)

Method Blank	098-01-005-661	N/A	Air	N/A	09/21/06	060921L01
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<u>Parameter</u>	<u>Result</u>	<u>RL</u>	<u>DF</u>	<u>Qual</u>	<u>Units</u>
TPH as Gasoline	ND	3.0	1		ppm (v/v)

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Analytical Report



GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Received: 09/21/06
 Work Order No: 06-09-1073
 Preparation: N/A
 Method: EPA TO-15
 Units: ppb (v/v)

Project: HX0186

Page 1 of 3

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
SSP-01-GS	06-09-1073-1	09/19/06	Air	N/A	09/23/06	060923L01

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	830	29	57.6		Toluene	ND	5.8	11.5	
Ethylbenzene	ND	5.8	11.5		1,3,5-Trimethylbenzene	ND	5.8	11.5	
o-Xylene	ND	5.8	11.5		1,2,4-Trimethylbenzene	ND	12	11.5	
p/m-Xylene	39	12	11.5						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	237	57-129		2	1,2-Dichloroethane-d4	122	47-137		
Toluene-d8	40	78-156		2					

SSP-02-GS	06-09-1073-2	09/20/06	Air	N/A	09/22/06	060922L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.76	1.51		Toluene	ND	0.76	1.51	
Ethylbenzene	ND	0.76	1.51		1,3,5-Trimethylbenzene	ND	0.76	1.51	
o-Xylene	ND	0.76	1.51		1,2,4-Trimethylbenzene	ND	1.5	1.51	
p/m-Xylene	ND	1.5	1.51						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	95	57-129			1,2-Dichloroethane-d4	130	47-137		
Toluene-d8	108	78-156							

SSP-03-GS	06-09-1073-3	09/20/06	Air	N/A	09/23/06	060922L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.70	1.39		Toluene	1.1	0.7	1.39	
Ethylbenzene	ND	0.70	1.39		1,3,5-Trimethylbenzene	0.81	0.70	1.39	
o-Xylene	ND	0.70	1.39		1,2,4-Trimethylbenzene	3.4	1.4	1.39	
p/m-Xylene	1.7	1.4	1.39						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	108	57-129			1,2-Dichloroethane-d4	124	47-137		
Toluene-d8	113	78-156							

SSP-04-GS	06-09-1073-4	09/20/06	Air	N/A	09/23/06	060922L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.77	1.53		Toluene	0.87	0.77	1.53	
Ethylbenzene	ND	0.77	1.53		1,3,5-Trimethylbenzene	ND	0.77	1.53	
o-Xylene	ND	0.77	1.53		1,2,4-Trimethylbenzene	ND	1.5	1.53	
p/m-Xylene	ND	1.5	1.53						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	109	57-129			1,2-Dichloroethane-d4	110	47-137		
Toluene-d8	103	78-156							

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Analytical Report



GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Received: 09/21/06
 Work Order No: 06-09-1073
 Preparation: N/A
 Method: EPA TO-15
 Units: ppb (v/v)

Project: HX0186

Page 2 of 3

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
SSP-05-GS	06-09-1073-5	09/20/06	Air	N/A	09/23/06	060922L01

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.76	1.52		Toluene	7.3	0.8	1.52	
Ethylbenzene	ND	0.76	1.52		1,3,5-Trimethylbenzene	5.3	0.8	1.52	
o-Xylene	3.0	0.8	1.52		1,2,4-Trimethylbenzene	11	2	1.52	
p/m-Xylene	5.5	1.5	1.52						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	110	57-129			1,2-Dichloroethane-d4	111	47-137		
Toluene-d8	101	78-156							

SSP-06-GS	06-09-1073-6	09/20/06	Air	N/A	09/25/06	060925L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	2300	150	298		Toluene	ND	30	59.6	
Ethylbenzene	ND	30	59.6		1,3,5-Trimethylbenzene	ND	30	59.6	
o-Xylene	ND	30	59.6		1,2,4-Trimethylbenzene	300	60	59.6	
p/m-Xylene	ND	60	59.6						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	129	57-129			1,2-Dichloroethane-d4	102	47-137		
Toluene-d8	108	78-156							

SSP-07-GS	06-09-1073-7	09/20/06	Air	N/A	09/23/06	060923L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	17	1	1.37		Toluene	1.6	0.7	1.37	
Ethylbenzene	1.0	0.7	1.37		1,3,5-Trimethylbenzene	ND	0.69	1.37	
o-Xylene	0.95	0.69	1.37		1,2,4-Trimethylbenzene	ND	1.4	1.37	
p/m-Xylene	2.3	1.4	1.37						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	100	57-129			1,2-Dichloroethane-d4	123	47-137		
Toluene-d8	101	78-156							

SSP-XX-GS	06-09-1073-8	09/20/06	Air	N/A	09/25/06	060925L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	1700	140	283		Toluene	ND	31	62.8	
Ethylbenzene	ND	31	62.8		1,3,5-Trimethylbenzene	ND	31	62.8	
o-Xylene	ND	31	62.8		1,2,4-Trimethylbenzene	370	63	62.8	
p/m-Xylene	74	63	62.8						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	114	57-129			1,2-Dichloroethane-d4	102	47-137		
Toluene-d8	99	78-156							

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers

Analytical Report



GeoSyntec Consultants
 924 Anacapa Street
 Suite 4A
 Santa Barbara, CA 93101-2177

Date Received: 09/21/06
 Work Order No: 06-09-1073
 Preparation: N/A
 Method: EPA TO-15
 Units: ppb (v/v)

Project: HX0186

Page 3 of 3

Client Sample Number	Lab Sample Number	Date Collected	Matrix	Date Prepared	Date Analyzed	QC Batch ID
OA-01-GS	06-09-1073-9	09/20/06	Air	N/A	09/23/06	060922L01

Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.72	1.43		Toluene	ND	0.72	1.43	
Ethylbenzene	ND	0.72	1.43		1,3,5-Trimethylbenzene	ND	0.72	1.43	
o-Xylene	ND	0.72	1.43		1,2,4-Trimethylbenzene	ND	1.4	1.43	
p/m-Xylene	ND	1.4	1.43						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	105	57-129			1,2-Dichloroethane-d4	108	47-137		
Toluene-d8	100	78-156							

Method Blank	095-01-021-4,205	N/A	Air	N/A	09/22/06	060922L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.50	1		Toluene	ND	0.50	1	
Ethylbenzene	ND	0.50	1		1,3,5-Trimethylbenzene	ND	0.50	1	
o-Xylene	ND	0.50	1		1,2,4-Trimethylbenzene	ND	1.0	1	
p/m-Xylene	ND	1.0	1						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	106	57-129			1,2-Dichloroethane-d4	134	47-137		
Toluene-d8	106	78-156							

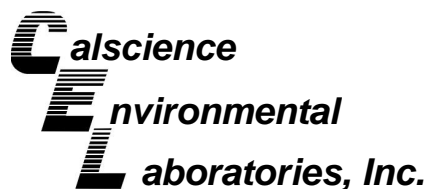
Method Blank	095-01-021-4,206	N/A	Air	N/A	09/23/06	060923L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.50	1		Toluene	ND	0.50	1	
Ethylbenzene	ND	0.50	1		1,3,5-Trimethylbenzene	ND	0.50	1	
o-Xylene	ND	0.50	1		1,2,4-Trimethylbenzene	ND	1.0	1	
p/m-Xylene	ND	1.0	1						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	106	57-129			1,2-Dichloroethane-d4	132	47-137		
Toluene-d8	105	78-156							

Method Blank	095-01-021-4,207	N/A	Air	N/A	09/25/06	060925L01
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Parameter	Result	RL	DF	Qual	Parameter	Result	RL	DF	Qual
Benzene	ND	0.50	1		Toluene	ND	0.50	1	
Ethylbenzene	ND	0.50	1		1,3,5-Trimethylbenzene	ND	0.50	1	
o-Xylene	ND	0.50	1		1,2,4-Trimethylbenzene	ND	1.0	1	
p/m-Xylene	ND	1.0	1						
Surrogates:	REC (%)	Control Limits		Qual	Surrogates:	REC (%)	Control Limits		Qual
1,4-Bromofluorobenzene	94	57-129			1,2-Dichloroethane-d4	108	47-137		
Toluene-d8	89	78-156							

RL - Reporting Limit , DF - Dilution Factor , Qual - Qualifiers



Quality Control - Duplicate



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924 Anacapa Street
Suite 4A
Santa Barbara, CA 93101-2177

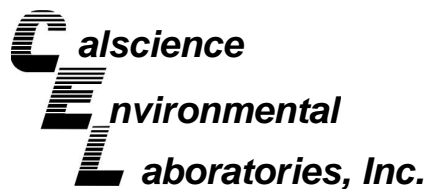
Date Received: 09/21/06
Work Order No: 06-09-1073
Preparation: N/A
Method: EPA TO-3(M)

Project: HX0186

Quality Control Sample ID	Matrix	Instrument	Date Prepared:	Date Analyzed:	Duplicate Batch Number
06-09-1051-1	Air	GC 13	N/A	09/21/06	060921D01

Parameter	Sample Conc.	DUP Conc.	RPD	RPD CL	Qualifiers
TPH as Gasoline	17	16	0	0-20	

RPD - Relative Percent Difference , CL - Control Limit



Quality Control - LCS/LCS Duplicate



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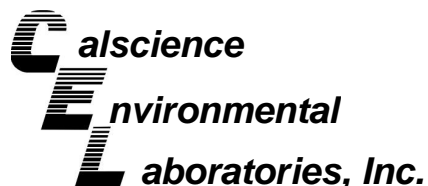
Date Received: N/A
Work Order No: 06-09-1073
Preparation: N/A
Method: ASTM D-1946

Project: HX0186

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
099-03-002-153	Air	GC 34	N/A	09/21/06	060921L01

Parameter	LCS Conc	LCSD Conc	RPD	RPD CL	Qualifiers
Carbon Dioxide	4.90	4.87	1	0-30	
Oxygen + Argon	19.7	19.6	1	0-30	
Nitrogen	73.7	73.4	0	0-30	

RPD - Relative Percent Difference , CL - Control Limit



Quality Control - LCS/LCS Duplicate



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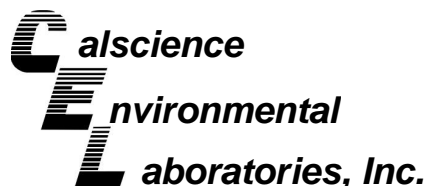
Date Received: N/A
Work Order No: 06-09-1073
Preparation: N/A
Method: EPA TO-15

Project: HX0186

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
095-01-021-4,205	Air	GC/MS II	N/A	09/22/06	060922L01

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Benzene	94	95	60-156	1	0-40	
Carbon Tetrachloride	115	119	64-154	3	0-32	
1,2-Dibromoethane	108	102	54-144	5	0-36	
1,2-Dichlorobenzene	105	109	34-160	4	0-47	
1,2-Dichloroethane	124	130	69-153	5	0-30	
1,2-Dichloropropane	95	99	67-157	4	0-35	
1,4-Dichlorobenzene	107	111	36-156	3	0-47	
c-1,3-Dichloropropene	89	94	61-157	6	0-35	
Ethylbenzene	111	113	52-154	1	0-38	
o-Xylene	123	127	52-148	3	0-38	
p/m-Xylene	111	113	42-156	2	0-41	
Tetrachloroethene	102	95	56-152	7	0-40	
Toluene	119	107	56-146	11	0-43	
Trichloroethene	102	102	63-159	0	0-34	
1,1,2-Trichloroethane	95	108	65-149	13	0-37	
Vinyl Chloride	126	122	45-177	3	0-36	

RPD - Relative Percent Difference , CL - Control Limit



Quality Control - LCS/LCS Duplicate



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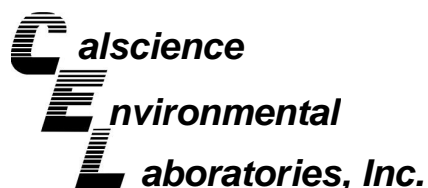
Date Received: N/A
Work Order No: 06-09-1073
Preparation: N/A
Method: EPA TO-15

Project: HX0186

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
095-01-021-4,206	Air	GC/MS II	N/A	09/23/06	060923L01

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Benzene	118	94	60-156	23	0-40	
Carbon Tetrachloride	150	119	64-154	23	0-32	
1,2-Dibromoethane	118	100	54-144	17	0-36	
1,2-Dichlorobenzene	122	102	34-160	18	0-47	
1,2-Dichloroethane	122	118	69-153	3	0-30	
1,2-Dichloropropane	120	93	67-157	25	0-35	
1,4-Dichlorobenzene	126	105	36-156	18	0-47	
c-1,3-Dichloropropene	119	92	61-157	26	0-35	
Ethylbenzene	129	109	52-154	17	0-38	
o-Xylene	141	119	52-148	17	0-38	
p/m-Xylene	126	107	42-156	16	0-41	
Tetrachloroethene	111	94	56-152	16	0-40	
Toluene	119	103	56-146	15	0-43	
Trichloroethene	130	103	63-159	23	0-34	
1,1,2-Trichloroethane	137	106	65-149	26	0-37	
Vinyl Chloride	115	110	45-177	4	0-36	

RPD - Relative Percent Difference , CL - Control Limit



Quality Control - LCS/LCS Duplicate



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Santa Barbara, CA 93101-2177

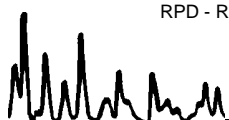
Date Received: N/A
Work Order No: 06-09-1073
Preparation: N/A
Method: EPA TO-15

Project: HX0186

Quality Control Sample ID	Matrix	Instrument	Date Prepared	Date Analyzed	LCS/LCSD Batch Number
095-01-021-4,207	Air	GC/MS II	N/A	09/25/06	060925L01

Parameter	LCS %REC	LCSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Benzene	85	89	60-156	5	0-40	
Carbon Tetrachloride	93	97	64-154	4	0-32	
1,2-Dibromoethane	93	102	54-144	10	0-36	
1,2-Dichlorobenzene	101	112	34-160	11	0-47	
1,2-Dichloroethane	98	98	69-153	1	0-30	
1,2-Dichloropropane	89	93	67-157	4	0-35	
1,4-Dichlorobenzene	102	114	36-156	10	0-47	
c-1,3-Dichloropropene	85	89	61-157	5	0-35	
Ethylbenzene	97	108	52-154	10	0-38	
o-Xylene	98	110	52-148	11	0-38	
p/m-Xylene	92	102	42-156	11	0-41	
Tetrachloroethene	94	102	56-152	9	0-40	
Toluene	95	104	56-146	9	0-43	
Trichloroethene	91	95	63-159	4	0-34	
1,1,2-Trichloroethane	99	104	65-149	5	0-37	
Vinyl Chloride	100	103	45-177	3	0-36	

RPD - Relative Percent Difference , CL - Control Limit



Glossary of Terms and Qualifiers



Work Order Number: 06-09-1073

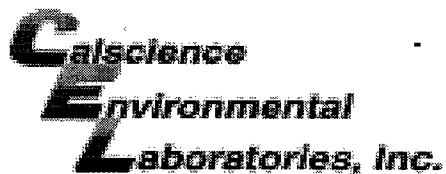
<u>Qualifier</u>	<u>Definition</u>
*	See applicable analysis comment.
1	Surrogate compound recovery was out of control due to a required sample dilution, therefore, the sample data was reported without further clarification.
2	Surrogate compound recovery was out of control due to matrix interference. The associated method blank surrogate spike compound was in control and, therefore, the sample data was reported without further clarification.
3	Recovery of the Matrix Spike or Matrix Spike Duplicate compound was out of control due to matrix interference. The associated LCS and/or LCSD was in control and, therefore, the sample data was reported without further clarification.
4	The MS/MSD RPD was out of control due to matrix interference. The LCS/LCSD RPD was in control and, therefore, the sample data was reported without further clarification.
5	The PDS/PDSD associated with this batch of samples was out of control due to a matrix interference effect. The associated batch LCS/LCSD was in control and, hence, the associated sample data was reported with no further corrective action required.
A	Result is the average of all dilutions, as defined by the method.
B	Analyte was present in the associated method blank.
C	Analyte presence was not confirmed on primary column.
E	Concentration exceeds the calibration range.
H	Sample received and/or analyzed past the recommended holding time.
J	Analyte was detected at a concentration below the reporting limit and above the laboratory method detection limit. Reported value is estimated.
N	Nontarget Analyte.
ND	Parameter not detected at the indicated reporting limit.
Q	Spike recovery and RPD control limits do not apply resulting from the parameter concentration in the sample exceeding the spike concentration by a factor of four or greater.
U	Undetected at the laboratory method detection limit.
X	% Recovery and/or RPD out-of-range.
Z	Analyte presence was not confirmed by second column or GC/MS analysis.



CHAIN OF CUSTODY RECORD

Date 20 Sept 06
Page 1 of 1

LABORATORY CLIENT: <u>ROBBIE ETINGER-GEOSYNTEC CONSULTANTS</u>		CLIENT PROJECT NAME / NUMBER: <u>HX0186</u>		P.O. NO.: <u>HX0186</u>																	
ADDRESS: <u>924 ANACAPA ST SUITE 4A</u>		PROJECT CONTACT: <u>ROBBIE ETINGER</u>		LAB USE ONLY <input checked="" type="checkbox"/> 9 - <input checked="" type="checkbox"/> 10 - <input checked="" type="checkbox"/> 11 - <input checked="" type="checkbox"/> 12 - <input checked="" type="checkbox"/> 13																	
CITY <u>Santa Barbara</u>		STATE <u>CA</u>		ZIP <u>93101</u>																	
TEL: <u>805 897 3800</u>		E-MAIL: <u>retinger@geosyntec.com</u>		COOLER RECEIPT TEMP = <u> </u> °C																	
TURNAROUND TIME: <input type="checkbox"/> SAME DAY <input type="checkbox"/> 24 HR <input type="checkbox"/> 48 HR <input type="checkbox"/> 72 HR <input checked="" type="checkbox"/> 5 DAYS <input checked="" type="checkbox"/> 10 DAYS																					
SPECIAL REQUIREMENTS (ADDITIONAL COSTS MAY APPLY) <input type="checkbox"/> RWQCB REPORTING FORMS <input type="checkbox"/> COELT EDF <input type="checkbox"/>																					
SPECIAL INSTRUCTIONS: <u>VOCs to include only: Benzene, toluene, xylene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, ASTM 1946 - O₂, CO₂, CH₄ only.</u>																					
		REQUESTED ANALYSES																			
LAB USE ONLY	SAMPLE ID	FIELD POINT NAME (FOR COELT EDF)	SAMPLING DATE	SAMPLING TIME	MATRIX	NO. OF CONT.	TPH (G)	TPH (D) or	BTEX / MTBE (8260B) or	OXYGENATES (8260B)	VOCs (8260B)	5035 ENCORE PREP	SVOCs (8270C)	PEST (8081A)	PCBs (8082)	CAC, 122 METALS (6010B) / 747	PNA (8310) or (8270C)	VOCs (TO-14A) or (TO-15)	TPH(G) (TO-3M)	FC's by ASTM D-1946	
1	SSP-01-GS		19 Sep 06	1730	VAR	1													X	X	X
2	SSP-02-GS		20 Sep 06	932		1													X	X	X
3	SSP-03-GS			1530		1													X	X	X
4	SSP-04-GS			1135		1													X	X	X
5	SSP-05-GS			1006		1													X	X	X
6	SSP-06-GS			1250		1													X	X	X
7	SSP-07-GS			1046		1													X	X	X
8	SSP-08-GS			-		1													X	X	X
9	SSP-09-GS			1600		1													X	X	X
Relinquished by: (Signature)		Received by: (Signature/Affiliation)		Date:		Time:															
Relinquished by: (Signature)		Received by: (Signature/Affiliation)		Date:		Time:															
Relinquished by: (Signature)		Received by: (Signature/Affiliation)		Date:		Time:															


 WORK ORDER #: **06** - 0 9 - 1 0 7 3

 Cooler 0 of 0

SAMPLE RECEIPT FORM

 CLIENT: Geo Syntec

 DATE: 9.21.06
TEMPERATURE – SAMPLES RECEIVED BY:
CALSCIENCE COURIER:

- ☐ Chilled, cooler with temperature blank provided.
☐ Chilled, cooler without temperature blank.
☐ Chilled and placed in cooler with wet ice.
☐ Ambient and placed in cooler with wet ice.
☐ Ambient temperature.
☐ °C Temperature blank.

LABORATORY (Other than Calscience Courier):

- ☐ °C Temperature blank.
☐ °C IR thermometer.
☒ Ambient temperature.

 Initial: SC
CUSTODY SEAL INTACT:

 Sample(s): _____ Cooler: _____ No (Not Intact) : _____ Not Applicable (N/A):

 Initial: SC
SAMPLE CONDITION:

	Yes	No	N/A
Chain-Of-Custody document(s) received with samples.....	<u> </u>	<u> </u>	<u> </u>
Sampler's name indicated on COC.....	<u> </u>	<u> </u>	<u> </u>
Sample container label(s) consistent with custody papers.....	<u> </u>	<u> </u>	<u> </u>
Sample container(s) intact and good condition.....	<u> </u>	<u> </u>	<u> </u>
Correct containers and volume for analyses requested.....	<u> </u>	<u> </u>	<u> </u>
Proper preservation noted on sample label(s).....	<u> </u>	<u> </u>	<u> </u>
VOA vial(s) free of headspace.	<u> </u>	<u> </u>	<u> </u>
Tedlar bag(s) free of condensation.....	<u> </u>	<u> </u>	<u> </u>

 Initial: SC
COMMENTS:

APPENDIX C

BAROMETRIC AND DIFFERENTIAL PRESSURE DATA

Figure C1:
Barometric Data Collected Inside the Site Building
Astoria Area-Wide Petroleum Site

GeoSyntec Consultants

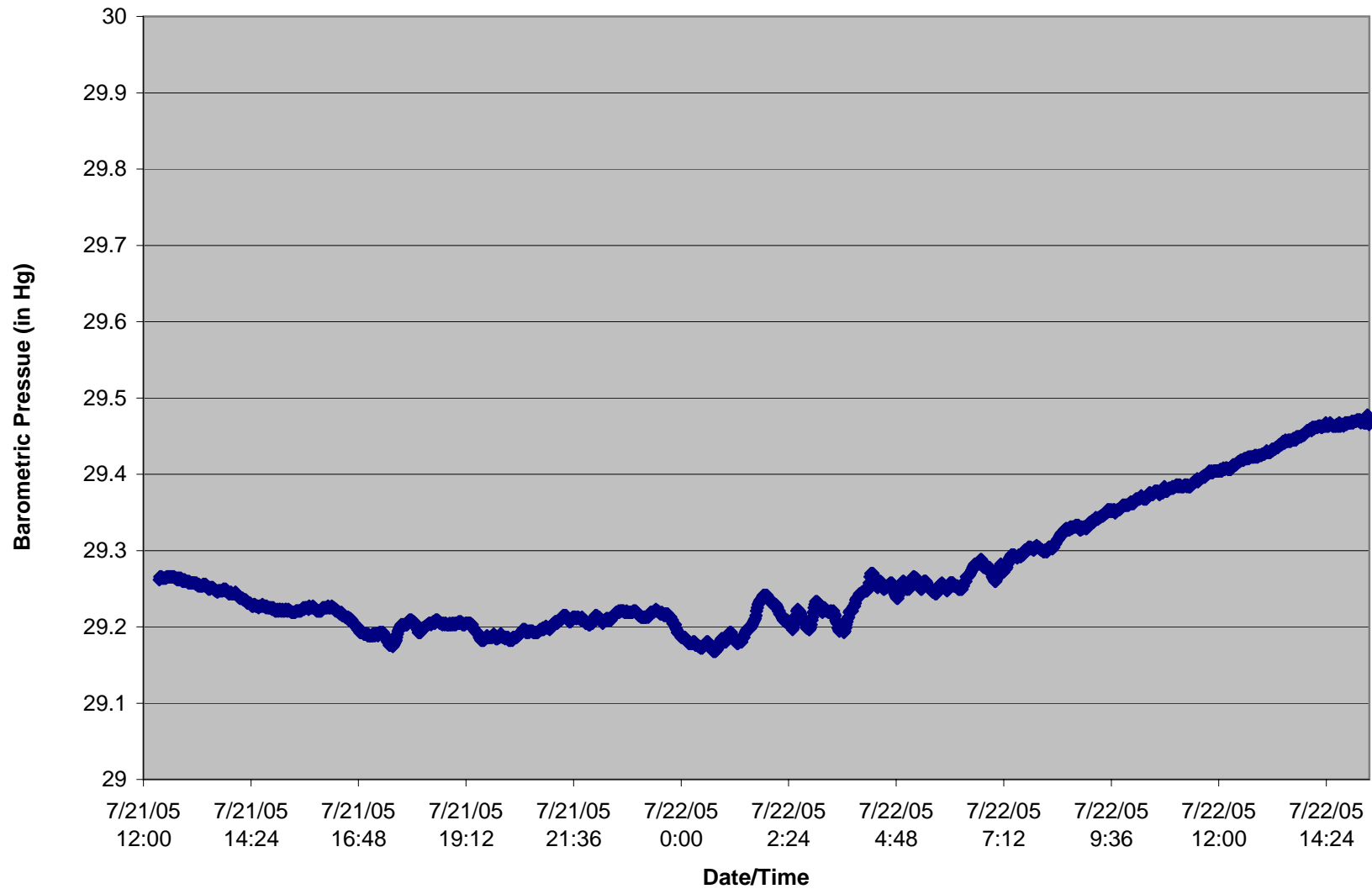


FIGURE C2:
DIFFERENTIAL PRESSURE DATA FOR SSP-03
Astoria Area-Wide Petroleum Site
July 2005

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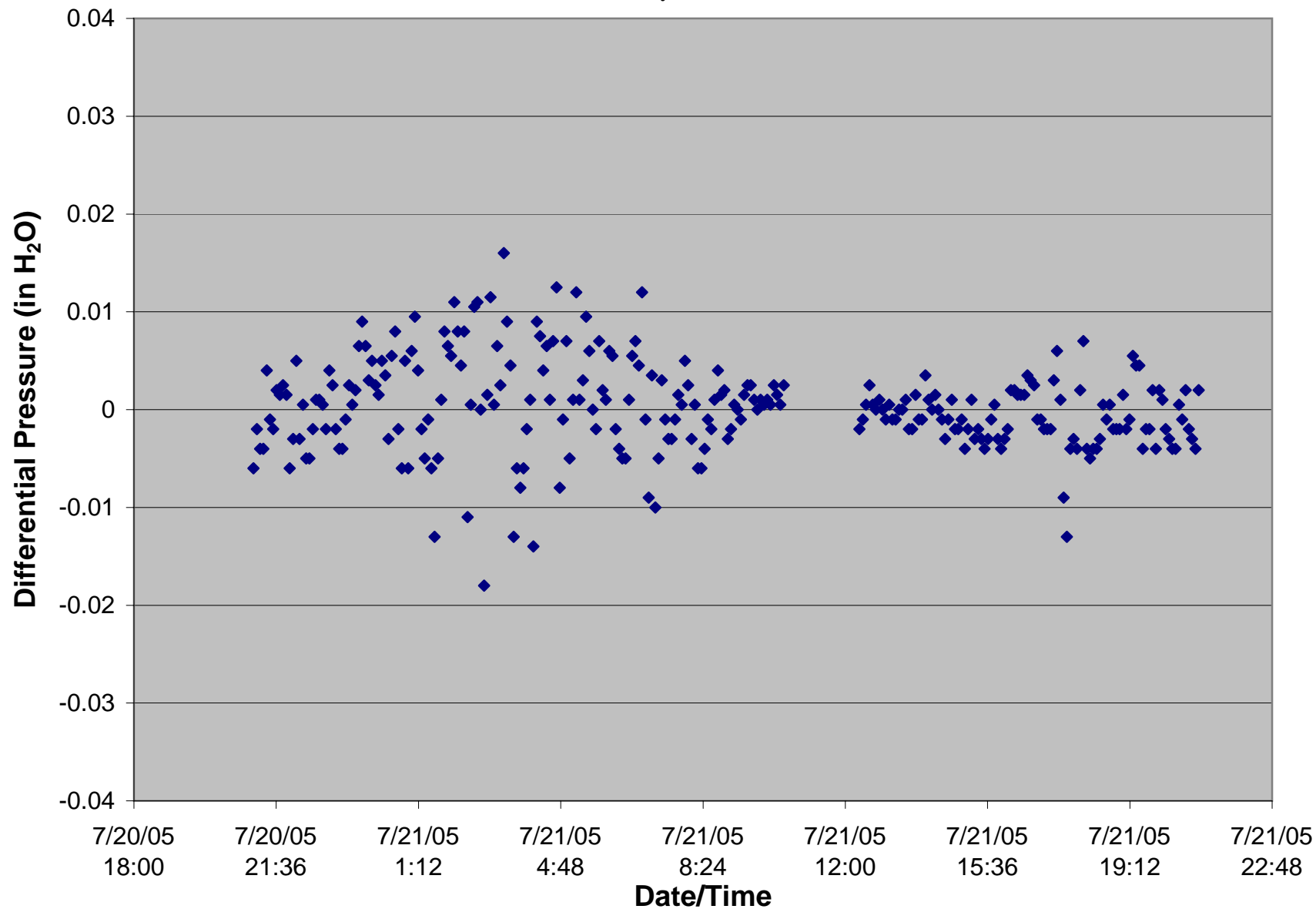
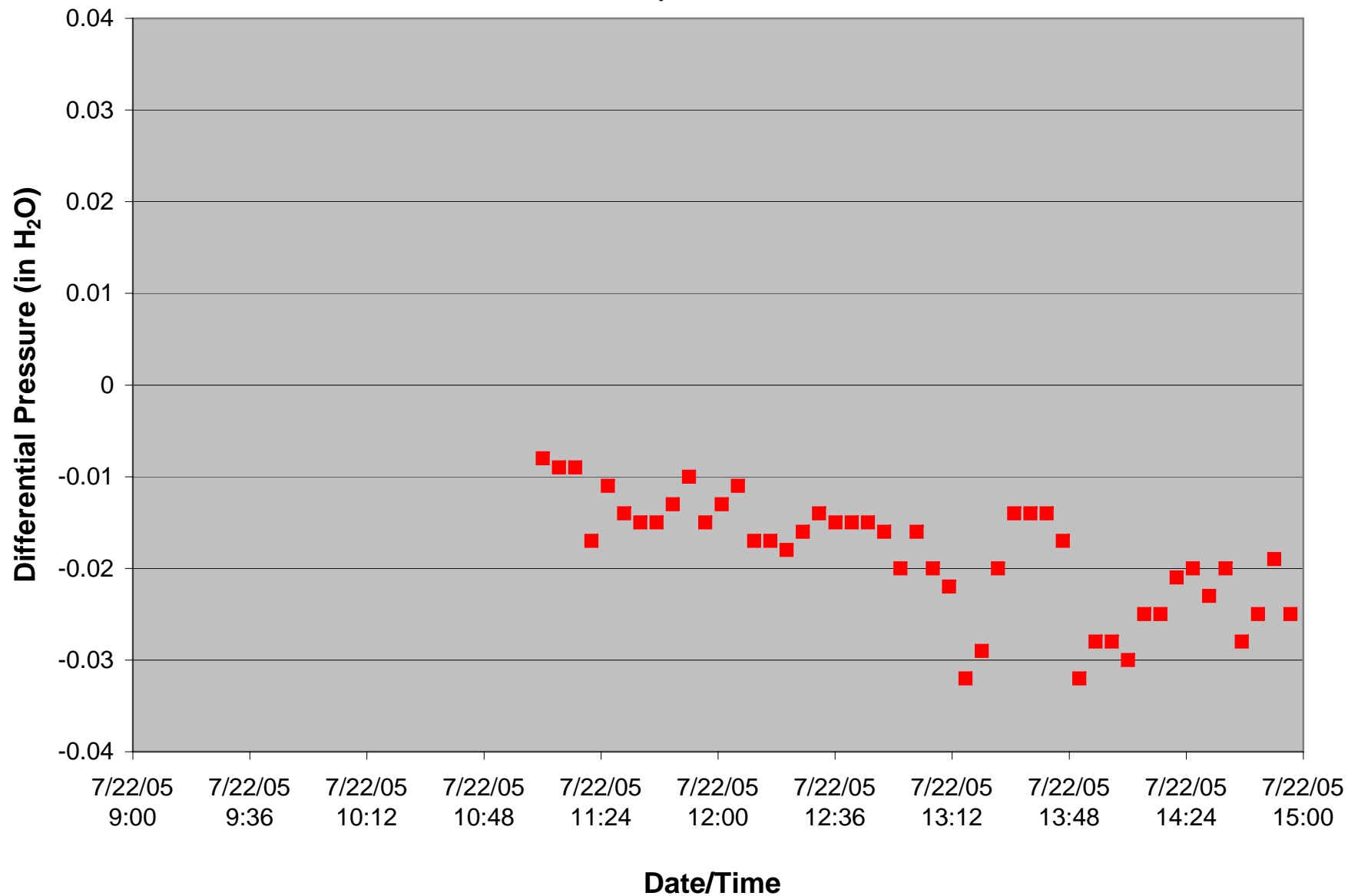


FIGURE C3:
DIFFERENTIAL PRESSURE DATA FOR SSP-04
Astoria Area-Wide Petroleum Site
July 2005

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SSP-03 (Test 2) Pressure Differential

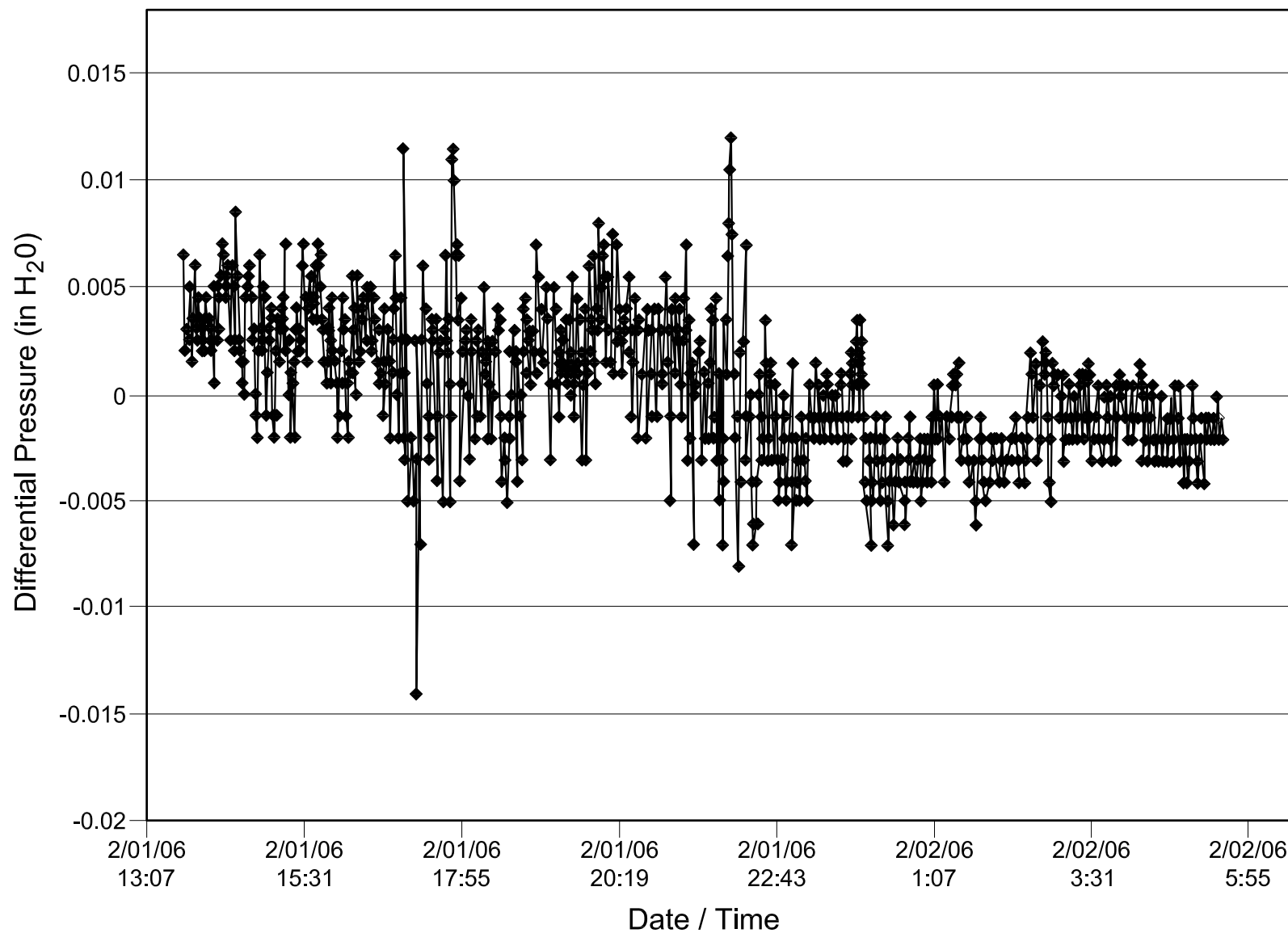


FIGURE 7-2
DIFFERENTIAL PRESSURE GRAPH
 Remedial Investigation/Feasibility Study
 Astoria Area-Wide Petroleum Site
 Astoria, Oregon