

Field Study of High-Density Passive Sampler and Large-Volume Purge Methods to Characterize Subslab Vapor Plumes

Former Al Phillips Cleaners
515 Lagoon Drive, Honolulu, Oahu, Hawaii

Prepared by:

**State of Hawaii Department of Health
Hazard Evaluation and Emergency Response Office
2385 Waimano Home Rd., Uluakupu Building 4
Pearl City, HI 96782**



July 2017

With Assistance from:

**Tetra Tech, Inc.
737 Bishop St., Suite 2340
Honolulu, Hawaii 96813-3201**

FOREWORD

The research presented in this report was carried out under a grant to the Hawai'i Department of Health, Hazard Evaluation and Emergency Response Office, from the U.S. Environmental Protection Agency, Region 9. The conclusions of the study are those of the authors only, however, and may not necessarily represent those of the funding agency.

This report will be updated in the future to include a summary of a soil investigation subsequently carried out at the study site to determine the source of the chlorinated solvent vapors identified beneath the building pad and used to design a remedial action.

EXECUTIVE SUMMARY

This report presents a field study of high-density, passive sampler deployment and Large-Volume Purge (LVP) methods to characterize vapors beneath building slabs. A former dry cleaner was used as a study site. Past investigations of the site based on traditional, passive and active soil vapor sampling methods identified tetrachloroethylene (PCE) vapors beneath the building slab, but were inconsistent in terms of the magnitude and extent of the vapor plume. This inconsistency is believed to be due at least in part to random, small-scale variability of PCE concentrations within the vapor plume and the small volume of vapor represented by single, “discrete” vapor sample points (e.g., one liter).

The use of data for small-volume, “discrete” vapor samples to reliably characterize the distribution of volatile organic compounds (VOC) within a subslab vapor plume requires two important assumptions: 1) A relative uniformity of VOC concentrations within the immediate area of a sample collection point and 2) A linear trend of concentrations between individual data points. Failing one or both of these requirements can result in erroneous patterns of subsurface vapors and poor decision making. If the first assumption is not true, then data for a single point cannot be assumed to be representative of the immediate area where the sample was collected since collection of a second sample from the same area could yield an entirely different result and interpretation. If the concentration trend between sample points is not linear, then isoconcentration contours drawn between individual data points will not be reliable beyond perhaps very gross, large-scale patterns. Apparent contaminant patterns within the plume might differ dramatically if a second, independent set of vapor samples were to be collected. In combination, these factors can lead to erroneous estimations of indoor air-subslab vapor attenuation factors (Brewer et al. 2014) or premature conclusions that the vapor intrusion model being employed “doesn’t work,” when in fact it is the modeler, or rather the data employed, that are in error. Such errors have also been recognized in the use of discrete sample data to characterize contaminated soil (Brewer et al. 2017a, b).

Although the implications have yet to be fully appreciated, such small-scale heterogeneity within subsurface vapor plumes is well documented and was not investigated in detail as part of this study. The study instead focuses on innovative approaches to both acknowledge and address this heterogeneity and provide more reliable data for assessment of vapor intrusion risks at sites where existing buildings overlie soil or groundwater contaminated with VOCs. Two approaches were investigated: 1) High-density deployment of and combination of passive samplers of identification of large-scale, VOC patterns beneath a building slab; and, 2) LVP methods for the collection of samples representative of very large, risk-based volumes of vapors under slabs an assessment of potential vapor intrusion risks.

Field Study Part 1

Part I of field study includes the combined use of high-density passive sampler deployment and “Multi Increment-type” sampling methods to represent vapors within small cells of the dry cleaner study site. An approximately 90-by-90-foot area of the slab was divided into 25 grid cells (five rows and five columns). Each grid cell was 18 feet by 18 feet in size. The work plan included installation of four passive samplers in each of 24 of the 25 cells (one sampler in each of four, equal quadrants). A full set of passive samplers could not be installed in several cells along the perimeter of the slab, however due to an increased slab thickness in these areas. The sampler vials were installed immediately beneath the base of the slab and at the top of a ½ inch, open hole drilled to a depth of 3 feet. The extended hole ensured that there nothing was present immediately beneath a sampler that might block the diffusion of gases and also to help create a pathway for gases to enter the sampling hole from all sides.

The samplers were allowed to equilibrate with subslab vapors for eight days. The samplers were subsequently collected and the carbon strips from each grid cell were combined for testing by the laboratory (total of 25 analyses). Two additional sets of samplers (replicates) were installed in three cells in order to test the field precision of any given set of samplers (total three sets of four samplers for each of the three cells).

Multiple samplers were installed in the remaining cell in the same manner and again allowed to equilibrate for eight days. The samplers were then removed and individually tested in order to gain information on the relative magnitude of small-scale variability within a cell. Installation of nine samplers was initially planned. Only six samplers could ultimately be installed, however, again due to an increase of the slab thickness in this area.

Data for the triplicate, passive sampler sets indicated good to very good field precision of sampler sets to represent the concentration of VOCs within each targeted grid cell. Relative standard deviations of 11%, 14% and 18% were calculated for PCE data. Relative standard deviations for trichloroethene (TCE) triplicate data were higher, but still acceptable ($\leq 35\%$), at 21%, 23% and 36%. Although limited in nature, the replicate data suggest that the reported masses of PCE and TCE in the four-sampler sets are reasonably representative of the vapors beneath each grid cell area.

The passive sampler data identified an extensive vapor plume immediately beneath the southeast half of the slab. The greatest mass of PCE, up to 45,000 micrograms (μg) PCE and 4,000 μg TCE, was reported for passive sampler sets installed beneath the area of the pad where dry cleaning machinery was formerly located. Assuming for initial screening purposes that the average mass reported for individual sampler sets approximates the actual concentration of VOCs in vapors, the data suggest mean concentrations of approximately 45,000 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) PCE and 4,000 $\mu\text{g}/\text{m}^3$ TCE in the highest impact area.

Field Study Part 2

Part 2 of the study included collection of five LVP samples from a single vapor point installed in the center of the slab. The screen of the vapor point was set at 0-18 inches beneath the base of the slab. A Shop-Vac® was used to draw five consecutive, 7,000-liter purges of subslab vapors from the vapor point. Each purge was intended to approximate a “Decision Unit (DU)” volume of subslab vapors assumed to enter a building over a single day based on the U.S. Environmental Protection Agency default vapor entry rate for vapor intrusion risk of four to five liters per minute (USEPA 2004, 2015a). A representative sample of each purge was collected by continuously drawing vapors from the purge stream into a six-liter Summa canister attached to the sampling train until the targeted DU volume had been reached. The Shop-Vac® was then turned off, a new Summa canister connected to the sampling train and the purge restarted. Duplicate LVP samples were collected during the first purge in order to verify sample representativeness. The LVP samples were then submitted for TO-15 analyses.

The concentration of PCE reported for the LVP samples progressively increased from 17,000 $\mu\text{g}/\text{m}^3$ to 54,000 $\mu\text{g}/\text{m}^3$ with successive purges, well above the Hawaii Department of Health (HDOH) subslab vapor action level of 4,100 $\mu\text{g}/\text{m}^3$ for potential vapor intrusion risks at commercial or industrial sites. Carbon dioxide and oxygen data for the samples suggested minimal breakthrough to outdoor air. The increasing trend is interpreted to reflect progressive encroachment of the draw area into the higher concentration area of vapors in the northeast corner of the slab, identified by the passive sampler data. A former fuel pipeline which passes beneath the slab in the vicinity of the LVP sampling point to the former dry cleaning machine area is speculated to have served as a preferential pathway during collection of the LVP samples.

The results of the field study suggest that high-density, passive sampler data provide superior resolution of subslab vapor plumes in comparison to traditional small-volume “discrete” passive sampler and active sampler data. Similar results could likely have been obtained with a high density of small-volume active (e.g., Summa) samples, although combination of individual samples for testing at the lab and controlling analytical cost could be problematic. Importantly, the collection of replicate sampler sets from multiple grid cells (e.g., 10% of total) allows the field precision of any given grid cell sampler set to be tested. The collection of LVP subslab vapor samples from risk-based “Decision Unit” volumes of subslab vapor adheres to a basic requirement of sampling theory that the exact volume of media to be tested should be specified prior to sample collection, and that the targeted volume be supported by well-thought-out, investigation objectives. The LVP sampling approach, even in the absence of a high-density passive sampler investigation, offers a far superior, science-based and reliable method for assessment of potential

vapor intrusion risk in comparison to traditional small-volume “discrete” vapor sample methods most commonly employed today. Whether LVP approaches will prove to be reliable indicators of subslab-to-indoor air attenuation factors remains to be seen, since vapor entry points beneath slabs are notoriously difficult to identify.

CONTENTS

<u>Section</u>	<u>Page</u>
FOREWORD	i
EXECUTIVE SUMMARY	ii
LIST OF ACRONYMS AND ABBREVIATIONS.....	VI
1.0 INTRODUCTION	1-1
2.0 STUDY SITE BACKGROUND.....	2-1
2.1 STUDY SITE SETTING AND BACKGROUND	2-1
2.1.1 Historical Use	2-1
2.1.2 Physical Setting and Hydrogeology	2-1
2.2 PREVIOUS ENVIRONMENTAL INVESTIGATIONS	2-2
2.2.1 EnviroServices & Training Center, 2002a, b.....	2-2
2.2.1.1 Soil Data	2-2
2.2.1.2 Groundwater Data.....	2-3
2.2.1.3 Soil Vapor Data	2-3
2.2.2 AECOM, 2013	2-4
2.2.2.1 Soil Data	2-4
2.2.2.2 Groundwater Data.....	2-4
2.2.3 CH2M, 2016-2017	2-5
2.2.3.1 Soil Data	2-5
2.2.3.2 Soil Vapor Data	2-6
2.2.3.3 Groundwater Data.....	2-6
3.0 STUDY IMPETUS, OBJECTIVES AND DESIGN	3-1
3.1 PROBLEM STATEMENT	3-1
3.2 STUDY OBJECTIVES.....	3-3
3.3 GENERAL STUDY DESIGN.....	3-4
3.3.1 Vapor Plume Characterization.....	3-4
3.3.2 Vapor Intrusion Risk.....	3-5
4.0 EQUIPMENT AND METHODS	4-1
4.1 COLLECTION OF PASSIVE SOIL GAS SAMPLE.....	4-1
4.1.1 Sampler Description and Installation Methods.....	4-1
4.1.2 Sampler Retrieval and Testing.....	4-1
4.2 COLLECTION OF LARGE-VOLUME PURGE SAMPLES.....	4-2
4.2.1 Bench Study	4-2
4.2.2 Extraction Point Installation and Field Pilot Test	4-3
4.2.3 LVP Sampling Event	4-5
4.2.4 Quality Control	4-6
5.0 RESULTS AND DISCUSSION	5-1
5.1 PASSIVE SOIL GAS DATA	5-1
5.1.1 Standard Sample Set Results	5-1
5.1.2 Discrete Sample Variability.....	5-2
5.1.3 Replicate Sample Data	5-2
5.1.4 HDOH 2016 Passive Sample Data vs. 2002 Passive Sample Data	5-2

5.2	LVP RESULTS.....	5-3
6.0	DISCUSSION.....	6-1
7.0	REFERENCES	7-1

FIGURES

- Figure 1-1. Example of vapor plume heterogeneity beneath a building slab (Luo et al. 2009)
- Figure 2-1. Site location at 515 Lagoon Drive in Honolulu, Hawaii (modified from AECOM 2013a)
- Figure 2-2. Dry cleaner operating at the site until 1997 (AECOM 2013a)
- Figure 2-3. Original layout of former dry cleaning operations (modified from AECOM 2013a)
- Figure 2-4. Site Stratigraphy
- Figure 2-5. Summary of EST (2002b) soil vapor data, includes AECOM (2013) soil and groundwater data (modified from summary map presented in AECOM 2013)
- Figure 2-6. Isoconcentration map of 2002 passive soil vapor data (EST 2002b); a) PCE vapors; b) TCE vapors
- Figure 2-7 (pending). Designation of DUs for 2016-2017 MIS investigation of subslab soil (CH2M 2017)
- Figure 2-8 (pending). Preparation of borehole DU MI samples by collection of regularly spaced, five-gram plugs from the entire core; plugs combined in methanol in the field or frozen for combination and extraction at the laboratory
- Figure 2-9 (pending). Preparation of DU layer MI samples by collection of regularly spaced, five-gram plugs from individually targeted layers across all DU boreholes (placed in methanol in the field or frozen for combination and extraction at the laboratory)
- Figure 2-10 (pending). Summary of row and column MI data collected during the 2016-2016 site investigation (CH2M 2017; preliminary data)
- Figure 2-11. Summary of 2016 active soil gas data (CH2M 2017; preliminary data)
- Figure 3-1. Example of subslab vapor plume heterogeneity beneath approximate 40,000 ft² industrial building slab (image provided by Chuck Schmidt)
- Figure 3-2. Subdivision of the targeted slab area into 25 grid cells for testing and identification of large-scale, vapor plume patterns beneath the slab
- Figure 3-3. Triplicate design for passive samplers
- Figure 3-4. Sampler installation design for evaluation of small-scale, subslab vapor variability in Grid Cell 10
- Figure 3-5. Hypothetical vapor entry point in a build slab to be used for the collection of Large Purge Volume (LVP) subslab vapor samples
- Figure 4-1. Passive vapor sampler produced by Beacon Environmental
- Figure 4-2. Passive sampler installation schematic
- Figure 4-3. Passive sampler installation
- Figure 4-4. Schematic of Large-Volume Purge sample train

Figure 4-5. Detailed design of LVP purge stream

Figure 4-6. Close-up of LVP purge valves

Figure 4-7. Latex, weather balloon used to check flow rate meters and evaluate purge times required to reach target, 7,000-liter purge volumes (target volume reached when balloon diameter = 2.4 m or 7.8 ft)

Figure 4-8. Data plot of well point vacuum versus time

Figure 4-9. Installation of LVP vapor extraction point

Figure 4-10. Completed field LVP sample collection set up

Figure 4-11. Sealing of slab drains and utility gaps in within immediate vicinity of vapor extraction point

Figure 4-12. Weather balloon (vinyl) field test used to cross-check the purge volumes estimated from by flow rate meters

Figure 5-1. Summary of passive sampler data, based on assignment of reported PCE mass for individual grid cells

Figure 5-2. Summary of passive sampler data, based on assignment of reported TCE mass for individual grid cells (note different color scale)

Figure 5-3. Alternative interpretation of the PCE passive sampler data by Beacon Environmental Services

Figure 5-4. Alternative interpretation of the TCE passive sampler data by Beacon Environmental Services

Figure 5-5. Variability of six, passive samplers installed in Grid Cell 10 and individually tested

TABLES

Table 2-1. Summary of 2002 soil investigation ¹data (EST 2002a)

Table 2-2. Summary of 2002 groundwater investigation ¹data (EST 2002a)

Table 2-3. Summary of 2002 groundwater investigation data (EST 2002a)

Table 2-4. Summary of 2013 soil investigation ¹data (AECOM 2013b)

Table 2-5. Summary of 2013 groundwater investigation ¹data (AECOM 2013b)

Table 2-6. Summary of 2017 Row and Column data for subslab soil (CH2M 2017; *pending*)

Table 2-7. Summary of 2016 active soil vapor data (CH2M 2017; preliminary data)

Table 4-1. Summary of samplers installed, retrieved and combined for testing in each grid cell

Table 4-2. Pilot test of vapor point vacuum versus purge rate based on time required to fill a weather balloon to 7,000 liters (used to check precision of flow meters)

Table 5-1. Unadjusted total mass of PCE and TCE reported for individual, grid cell sampler sets

Table 5-2. Total mass per grid cell sampler set adjusted with respect to the number of samplers included in each set (see Table 5-1)

Table 5-3. Grid Cell 10 passive sampler data

Table 5-4. Passive sampler replicate data

Table 5-5. Summary of LVP subslab vapor data for VOCs

Table 5-6. Summary of LVP subslab vapor data for oxygen and carbon dioxide

APPENDICES

- A. EnviroServices & Training Center Site Investigation, 2002
- B. AECOM Phase II Environmental Site Assessment, 2013
- C. CH2M Soil Vapor Study, 2016 (*pending*)
- D. Beacon Passive Soil Gas Survey - Analytical Report, 2016 (Note: includes field deployment protocol, raw data summary, composite data summary, and PCE/TCE Isopleth Maps)
- E. Dwyer Pitot Tube Manufacturer Specification Sheet
- F. Pitot Tube Flow Calculation Spreadsheet
- G. Large Volume Purge Sample - Field Data Sheets
- H. Summa Sample Laboratory Reports, 2016 - Eurofins Air Toxics, Inc.

LIST OF ACRONYMS AND ABBREVIATIONS

>	Less than
%	Percent
bgs	Below ground surface
°C	Degrees centigrade
cm	Centimeters
CO	Carbon monoxide
CO ₂	Carbon dioxide
DCE	Dichloroethylene
DU	Decision units
DU-MI	Decision unit-multi increment
EAL	Environmental action level
ft ²	Square foot
HDOH	Hawaii Department of Health
HEER	Hazard Evaluation and Emergency Response
in-H ₂ O	Inches of water (vacuum)
µg/m ³	Micrograms per cubic meter
µg/L	Micrograms per liter
LVP	Large-volume purge
m ²	Square meters
m ³ /min	Cubic meters per minute
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
mg/m ³	Milligram per cubic meter
msl	Mean sea level
ng	Nanograms
O ₂	Oxygen
PAH	Polynuclear aromatic hydrocarbons
PCE	Tetrachloroethene
PID	Photoionization detector
ppbV	Part per billion by volume
PVC	Polyvinyl chloride
QA	Quality Assurance
QC	Quality Control
RPD	Relative percent difference
RSD	Relative standard deviation
TCE	Trichloroethene
TPH	Total petroleum hydrocarbons
TPHd	Total petroleum hydrocarbons as diesel
TPHg	Total petroleum hydrocarbons as gasoline
TPHrf	Total petroleum hydrocarbons as residual fuels
USEPA	U.S. Environmental Protection Agency
VOC	Volatile organic compound

1.0 INTRODUCTION

Most current state and U.S. Environmental Protection Agency (USEPA) vapor intrusion guidance recommends the collection of small-volume “active” or “passive” vapor samples collected from single points to characterize vapor plumes under building slabs and assess potential vapor intrusion risk (e.g., ITRC 2007; CAEPA 2015; HDOH 2016a; USEPA 2015a,b). Such “discrete”, point-by-point sampling methods have their origin in environmental investigation guidance published in the 1980s for soil (e.g., USEPA 1985, 1986). The reliability of these approaches has been questioned for decades, but only recently investigated in detailed field studies (Brewer et al. 2017a,b). Discrete sample data can be useful for approximation of large-scale contaminant patterns in soil or soil vapor if “enough” samples are collected. Use of the data to depict smaller-scale patterns within a soil or soil vapor plume requires that the concentration of targeted volatile organic compounds (VOCs) be highly uniform at the scale (volume) of the sample collected or otherwise represented by a single data point.

This important assumption has, to the authors’ knowledge, never been fully explored in the field and is unlikely to be the case under most site scenarios. The magnitude of random variability between co-located, discrete vapor samples could be significant, based on small-scale differences in soil type, moisture, vapor permeability and heterogeneity in the source area. Studies clearly demonstrate that vapor plumes beneath building slabs are not uniform at a large scale (Brewer et al. 2014). Examples of subslab vapor plume heterogeneity are depicted in Figure 1-1. Attempts to use single, small-volume sample points to estimate subslab-to-indoor air attenuation factors are thus fraught with unquantifiable error. Statistical evaluation of databases built on these types of data is of no help, since this only measures the precision of the particular statistical test employed to estimate a mean or other value for the data set provided. The precision and representativeness of individual data points and the database as a whole cannot be directly assessed. Testing of a small volume of vapors from another area of the slab or even in close proximity to the original sample could yield dramatically different results.

The study presented in this report side-steps the issue of random, small-scale variability of VOC concentrations in subslab vapor plumes, and instead focuses on methods to better address and represent this variability as part of a vapor intrusion investigation. Two approaches to improve the quality of subslab vapor data were tested: 1) The use of high-density, “Multi Increment-type” passive sampler deployment to identify large-scale vapor plume patterns beneath a slab; and, 2) The use of Large-Volume Purge (LVP) sampling methods to better represent potential vapor intrusion risks at a given, known or hypothetical vapor entry point in a building slab.

2.0 STUDY SITE BACKGROUND

2.1 STUDY SITE SETTING AND BACKGROUND

2.1.1 Historical Use

The one-half acre study site is located in a light industrial and commercial area of Honolulu, Hawai'i, at 515 Lagoon Drive (Figure 2-1). Al Phillip's dry cleaner began operation at the site in 1978-1979 (AECOM 2013a). The property was occupied by an 18,000 square-foot (ft²) commercial building during operation of the dry cleaner (Figure 2-2). Figure 2-3 depicts the original layout of dry cleaning operation. A 1,000-gallon diesel fuel tank was installed under the parking lot in the southern portion of the property. A pipeline from the tank crossed under the slab at a diagonal angle to the former boiler room area. Dry cleaning was carried out in the northern portion of the warehouse. Tetrachloroethylene (PCE) was used in the operation. Stoddard solvent or other non-chlorinated solvents are not known to have ever been used at the site.

The dry cleaning operation was closed in 1997. A site inspection in 1999 identified remaining drums of solvents on the property, some of which appeared to be leaking. The drums were removed shortly after the inspection. The building was demolished in 2014 to prepare the site for redevelopment as a light-rail transit station. The slab underlying the building was temporarily left in place, however, and used for general storage and parking. Power and water to the site had been cut off by the time of the field study. Associated subslab utilities were still in place, however, as was the diesel fuel tank and associated piping under the slab.

2.1.2 Physical Setting and Hydrogeology

The study site is located at 515 Lagoon Drive, in a commercial and light-industrial area of Honolulu, on the southern side of the island of O'ahu (Figure 2-1). A Phase I report was prepared for the site as part of a property transaction (AECOM 2013a).

The property is flat and lies at an elevation of approximately 10 feet above mean sea level. The distance to the nearest, shoreline area is approximately 1,500 feet. The shoreline area is capped with several feet of coralline fill, in part derived from past dredging of Honolulu Harbor and Pearl Harbor, in addition to material from inland sources (USDA 1972). A summary of the shallow stratigraphy of the site is provided in Figure 2-4. The site is capped by approximately five feet of coralline sand and gravel fill material and original sediment (CH2M 2017). This is underlain by a one- to six-foot thick layer of native, silty, clay loam (EST 2002a, b), assumed to represent marine sediment and/or fine-grained sediments derived from upland, volcanic rocks. The loam is underlain by a second sequence of coralline sand and gravel. This represents the upper part of a thick sequence of poorly consolidated, clastic, marine sediments and limestone interlayered with alluvial material collectively referred to as the "caprock" (MacDonald et al. 1983). The sediments blanket the southern flank the underlying, Ko'olau volcanic complex and are estimated to be over 400 feet thick in the study site area (USGS 1998).

Groundwater is situated eight to 10 feet below the ground surface. The groundwater is unconfined and is part of the caprock aquifer complex (Mink and Lau 1990). The ground is brackish and not considered to be a potential source of drinking water. Groundwater flow is to the southeast, in the direction of Ke'ehi lagoon (AECOM 2013b). Groundwater within the underlying, fractured basalts of the Ko'olau volcanic sequence is confined and considered a potential source of drinking water. No water supply wells are located within 1/4th of a mile of the study site (AECOM 2013a).

The shallow stratigraphy of the site itself is summarized in Figure 2-4 (after AECOM 2013b, CH2M 2017). The slab is underlain by approximately 25 centimeters (cm) of coralline and basaltic gravel fill material.

This is underlain by a 1.5 to 2.0 meter-thick sequence of coralline sand and gravel, interpreted to represent native, unconsolidated, marine sediment. The sand and gravel are underlain by a fine-grained sequence of interlayered silt and clay that extend below the water table to a depth at least 3 meters.

2.2 PREVIOUS ENVIRONMENTAL INVESTIGATIONS

2.2.1 EnviroServices & Training Center, 2002a, b

Two limited investigations were carried out at the site in 2002 (EST 2002a, b). Soil, groundwater, and soil vapor samples were collected. Boring locations and a summary of groundwater and passive soil vapor data are provided in Figure 2-5. A more detailed summary of the data is provided in Appendix A.

2.2.1.1 Soil Data

Continuous cores were collected from 10 borings installed to the top of the water table, at a depth of seven to eight feet below ground surface (bgs; EST 2002a). Cores were screened in the field with a photoionization detector (PID). No obvious signs of petroleum or solvent contamination were observed. Discrete soil samples were collected immediately above the top of the water table using Encore® device. Each sample comprised approximately five grams of soil. Samples were tested for Total Petroleum Hydrocarbons (TPH) and chlorinated solvents.

A summary of the soil data is presented in Table 2-1. TPH as diesel (TPHd) was detected in low concentrations in eight of the ten samples (TPHd <100 milligrams per kilogram [mg/kg]), with concentrations of 110 mg/kg and 350 mg/kg reported for two samples. Reported concentrations of TPHd did not exceed current Hawaii Department of Health (HDOH) action levels in any of the samples. Although sample mass and coverage was very limited, the data as well as field observations confirm a lack of extensive petroleum contamination at the site. This is presumably due in part to absence of the past use of Stoddard solvent at the site for dry cleaning.

Tetrachloroethylene and/or related breakdown products trichloroethylene (TCE), cis- and trans-dichloroethylene (DCE) were, however, identified in four of the 10 samples. A maximum concentration of 0.48 mg/kg was reported for PCE, below the HDOH, commercial/industrial soil action level for potential vapor intrusion risk of 0.72 mg/kg (HDOH 2016a). The maximum concentration of TCE reported for the samples was 0.23 mg/kg, again below HDOH vapor intrusion action level of 0.62 mg/kg. A concentration of 0.41 mg/kg was reported for trans 1,2-DCE in the same sample, well below the vapor intrusion action level of 25 mg/kg. Note that these action levels are intended to apply to the mean or more correctly the “true” concentration of contaminants within in a specifically designated volume of soil, rather than data for individual, discrete soil samples (refer to HDOH 2016b).

The subsequent identification of widespread, high concentrations of PCE in vapors beneath the slab suggests the presence of a significant source of contamination at the site, with low, milligram-per-kilogram concentrations likely present in soil (EST 2002b; AECOM 2013b, CH2M 2017). This highlights the unreliability of small-mass, discrete soil sample data for characterization of subsurface soils and prediction of vapor intrusion risk (see also USEPA 2015a, b). Given the small mass of soil tested, five grams or approximately equal to the size and mass of a 1.5cm diameter glass marble, discrete sample data should be considered adequate to at best determine presence or absence of the targeted contaminant. HDOH guidance recommends the use of Decision Unit (DU) and Multi Increment sample (MIS) investigation methods for characterization of soil suspected to be contaminated with VOCs (HDOH 2016b). Although the representativeness of the data will be greatly improved, HDOH guidance recommends the additional collection of soil vapor samples at all sites where significant releases of VOCs are suspected to have

occurred (HDOH 2016a, 2016b). This is related to uncertainty in vapor intrusion models for soil to accurately predict the concentration of VOCs in vapors based on input soil data.

2.2.1.2 Groundwater Data

Four borings were converted into 1-inch diameter groundwater monitoring wells. The wells were screened from approximately five to 15 feet bgs (EST 2002a). A single groundwater sample was collected from each well. All samples were tested for TPH and chlorinated solvents.

A summary of the groundwater data is presented in Table 2-2. Petroleum was not identified above laboratory detection limits in any of the samples. Trace levels of chlorinated solvents were identified in samples from two of the wells, with PCE reported at 7.2 micrograms per liter ($\mu\text{g/L}$) and 1.7 $\mu\text{g/L}$ and TCE reported in one sample at 4.9 $\mu\text{g/L}$. No other breakdown products of PCE were reported.

Although limited, the data do not indicate significant contamination of groundwater beneath the site. “Discrete” groundwater sample data are considered by HDOH to be more representative of overall conditions in the immediate area where a sample is collected than typical of soil sample data (see Brewer et al. 2017a, b). Diffusion of contaminants should reduce, but not necessarily eliminate, the magnitude of random, small-scale variability in comparison to soil data. The reliability of this assumption in terms of decision making for potential vapor intrusion risks has not been extensively tested, however. In all likelihood, a detailed investigation of small-scale variability of dissolved-phase contaminants within a plume of contaminated groundwater would suggest that while “discrete” groundwater sample data are reasonably reliable for identification of large-scale contaminant patterns, significant, random variability over very short distances can indeed occur under some conditions. This is the subject for a future, HDOH field study.

2.2.1.3 Soil Vapor Data

A total of 24 VaporTech® passive samplers were installed under the building to a depth of 18 inches, at a spacing of approximate 30 feet, and in a systematic grid pattern (EST 2002b; see Figure 2-5). The samplers were retrieved and tested after a two-week period.

A summary of the soil vapor data is provided in Table 2-3. Petroleum as TPHd was not reported in any of the samples. PCE was identified in 19 of the 24 samplers. TCE was identified in seven samples. Isoconcentration maps of the passive sampler data for PCE and TCE are presented in Figure 2-6a in Figure 2-6b. A maximum mass of 18,000 nanograms (ng) and 480 ng were reported for PCE and TCE, respectively. Although not directly translatable into concentrations, mass is sometimes used a rough surrogate of concentration in terms of micrograms per cubic meter ($\mu\text{g/m}^3$) for initial screening purposes. The current HDOH subslab vapor action levels for PCE and TCE under a commercial/industrial setting are 8,000 $\mu\text{g/m}^3$ and 7,000 $\mu\text{g/m}^3$, respectively (HDOH 2016a).

The maps imply a limited vapor plume under the slab, centered on a “hot spot” based on data for a single sampler. Co-located vapor samples were not collected to test the representativeness of data for any given sample point. “Hot spots” on the maps generated by single data points could well be artifacts of random, small-scale heterogeneity of VOC concentrations in vapors beneath the slab. Such heterogeneity is implied by a limited number of co-located samples collected as part of the HDOH field study and presented in Section 3 of this report.

2.2.2 AECOM, 2013

A second investigation of the property was carried out at the site in 2013 (AECOM 2013b). Additional soil and groundwater samples were collected. Soil vapor samples were not collected. A summary of the data, and expanded evaluation of contamination beneath the building slab, is provided below. Sample location points and resulting data are depicted in Figure 2-5. A more detailed summary of the data is provided in Appendix B.

2.2.2.1 Soil Data

Five boreholes were installed in suspect contaminated areas beneath the building pad based on the data collected in 2002, as well as in the vicinity of a floor drain (see Figure 2-5). The borings were installed to depths of 15 to 18 feet bgs. Continuous cores were collected and screened for VOCs in the field using a photoionization detector (PID). Two discrete soil samples were collected from each borehole, one from the vadose zone (3-5 feet bgs) and one from the capillary fringe area (8-11 feet bgs). Five-gram samples were collected for VOC analysis. Discrete samples to be tested for non-volatile contaminants were placed in a four-ounce jar, representing an estimated 100 to 200 grams. Each soil sample was tested for VOCs, TPH as gasoline (TPHg), TPH as residual fuels (TPHrf), TPHd, polynuclear aromatic hydrocarbons (PAHs) and RCRA metals.

Soil data obtained during the investigation are summarized in Table 2-4 (TPH and PCE-related VOCs only). Very low concentrations of TPH were reported in one sample (maximum 150 mg/kg TPHrf). Trace levels of PCE and related breakdown VOCs were again reported in several samples (maximum 0.003 mg/kg PCE). Reported concentrations are again well below screening levels for potential vapor intrusion and other concerns.

Note that as of 2009 discrete sampling methods for VOCs were no longer recommended in the HDOH *Technical Guidance Manual* (HDPH 2016b) for other than very gross screening purposes, due to the limited mass of soil represented by each sample (typically five grams). As was the case for the 2002 site investigation (EST 2002a), it is unlikely that the soil data collected during the 2013 investigation are representative of larger-scale patterns of VOC contamination beneath the pad that presumably serve as the source of vapors identified in the 2002 investigation (EST 2002b) and in a follow-up investigation in 2016, including the study presented in this report.

2.2.2.2 Groundwater Data

A 1.5-inch diameter pre-packed well was installed in each of the five boreholes and used as a temporary monitoring well (see Figure 2-5). Samples could ultimately not be collected from two of the wells due to insufficient groundwater recharge. Samples collected from the remaining wells were tested for VOCs, TPHd, TPHrf, PAHs, and RCRA metals. Groundwater samples were also collected from the 2002 wells and tested for the same suite of contaminants. The newly installed wells were plugged and abandoned after sample collection.

A summary of the groundwater data collected is presented in Table 2-5 (TPH and PCE-related VOCs only). Trace levels of chlorinated VOCs were reported in two of the newly installed, temporary wells, maximum concentration of 10 µg/L PCE reported for one of the samples. Although limited, the data again do not indicate widespread, significant contamination of shallow groundwater by chlorinated solvent compounds.

2.2.3 CH2M, 2016-2017

A more in-depth investigation of soil, soil vapor and groundwater contamination was carried out at the site in 2016 and early 2017 by CH2M, in preparation for development as a terminal station for a light rail network. The building had been removed by this time but the slab still remained. Draft data have been reviewed by the Hazard Evaluation and Emergency Response (HEER) office but were not available to the public at the time this report was prepared. A final, site investigation report has not been prepared as of March 2017, but will be summarized in tables and detailed data provided in Appendix C when available.

Data presented below should be considered preliminary, but are believed to be more indicative of actual conditions at the site. The data indicate a significantly larger plume of VOC vapors under the slab than estimated in the 2002 investigation. The HEER office reached agreement with the Hawaii Rapid Transit Authority to remove 80% of the PCE mass beneath the pad in order to address potential future vapor intrusion concerns. A modified “row and column” and Decision Unit-Multi Increment (DU-MI) investigation approach was to be used to target an appropriate area for removal. A brief summary of the investigation as carried out is provided below.

2.2.3.1 Soil Data

The northern, 10,000 square-foot (ft²) area of the pad was divided into six DUs for the collection of MI samples (Figure 2-7). Each DU was divided into four stratigraphic layers, in part reflecting the stratigraphy depicted in Figure 2-4. The upper two feet of the coralline gravel and sand unit immediately underlying the slab was designated as Layer A. The remainder of the gravel and sand unit down to the top of the silt and clay unit was designated as Layer B. Layer C encompassed the top of the silt and clay unit to a depth of 8 feet, the approximate top of the water table. Decision Unit Layers B and C varied in thickness between borings, depending on the depth that the silt and clay unit was encountered. Layer D comprised the remaining silt, clay and sand below the water table to a depth of 10 feet bgs.

Continuous cores were collected from 30 borings installed in each DU. Two types of samples were collected. An initial set of MI samples was prepared for each targeted layer within a DU, representing “rows”. A second set samples was prepared for each borehole within the DU, representing “columns”. Samples were tested for TPHg, TPHd, TPHrf, heavy metals, and VOCs. This report only summarizes the collection of samples to be tested for VOCs. Data for rows (DU layers) are intended to identify the vertical distribution of VOCs within the DU as a whole. Data for columns (individual borings) are intended to identify the approximate lateral distribution of contaminants with the DU. In combination, the data can be used to identify the approximate location of the main mass of contamination within a DU.

A single sample was immediately prepared from each borehole after the core was extracted. The sample was prepared by removing five-gram plugs of soil from the entire length of the core using a two-inch spacing (Figure 2-8). This generated a total of 30 borehole samples per DU (approximately 300 grams per sample). Plugs from a single core were combined in methanol or individually frozen in the field for later combination in methanol at the laboratory.

A second set of five-gram plugs was collected from each targeted layer within a boring, and placed in a jar of methanol dedicated to that layer, or frozen for combination at the laboratory with plugs for the targeted layer that were removed from other borings in the DU (Figure 2-9). This generated four DU layer samples per DU.

Preliminary DU layer and borehole data for each DU are summarized in Table 2-6 and Figure 2-10. The highest concentrations of PCE were identified in borings installed in DU-1 (up to 2 mg/kg). Data for DU layers in that DU suggested that the main mass of contamination was contained in the upper two layers,

representing the gravely and sandy fill and native sediments immediately beneath the slab. A smaller amount of PCE was identified in DU-2, with most of the mass in the uppermost layer.

In combination, these layers were estimated to incorporate 80% of total VOC mass present at the site and were targeted for removal. Soil removal took place in January 2017. A report documenting soil testing and removal is anticipated for March 2017.

2.2.3.2 Soil Vapor Data

Eleven active soil gas samples were collected as part of the 2016-2017 investigation, seven of which were located within the slab area targeted for the field study presented in this report. Samples were collected using one-liter Summa canisters. Five samples were collected from immediately beneath the slab. The second set of six samples was collected from vapor points installed to depths of three to five feet bgs.

A summary of the soil vapor data for PCE and TCE is provide in Table 2-7 and depicted in Figure 2-11. The data indicate a substantially larger vapor plume beneath the slab than identified in the 2002 investigation. Vapors are dominated by PCE, with a maximum reported concentration of 186,000 $\mu\text{g}/\text{m}^3$. Less than 10% of the vapors are on average comprised by TCE and other breakdown products of PCE. This support the apparent lack of significant petroleum contamination beneath the slab, since dramatic degradation of chlorinated solvents is typically noted in cases where releases of both two types of chemicals are intermingled.

Oxygen and carbon dioxide measurements were taken in the field prior to the collection of Summa canister samples (see Table 2-7). The concentration of oxygen was low as 16.5% immediately beneath the slab and as low as 12.5% at a depth of three to five feet. Measured carbon dioxide (CO_2) levels were as high as 2.6% immediately beneath the slab and up to 6.0% at deeper levels.

The extent of the PCE vapor plume that exceeds the current, commercial-industrial action level for vapor intrusion of 8,000 $\mu\text{g}/\text{m}^3$ cannot be determined based on the data. The reason for the discrepancy between the 2002 passive sampler data and the 2016 active sample data is unclear, but could in part be due to a random, small-scale heterogeneity of VOC concentrations within the vapor plume as a whole or to subsequent expansion of the plume over time.

2.2.3.3 Groundwater Data

Groundwater samples were collected from the existing wells at the site as part of the 2016-2017 investigation. A summary of the data is currently not available. Based on discussions with CH2M trace levels of VOCs were again reported in some samples, but significant, widespread contamination of groundwater was not identified.

3.0 STUDY IMPETUS, OBJECTIVES AND DESIGN

3.1 PROBLEM STATEMENT

Defensible conclusions drawn from environmental investigations requires both “verification” that samples collected are representative of the questions being asked, and “validation” that the data received from the laboratory are representative of the sample provided (USEPA 2002). Although not clearly expressed in the referenced, USEPA document, the intent of “Data verification” most reasonably refers the need to answer the question: *“Is the sample collected representative of the field condition under investigation?”* This is carried out in coordination with the field technicians who designed the investigation work plan and carried out the collection of samples. “Data validation” is similarly intended to address the question: *“Are the data reported representative of the sample provided?”* This is carried out in coordination with laboratory technicians through pre-specified, quality control measures. Validated laboratory data are thus of little use if the representativeness of the samples from which the data are derived is not first verified.

Field verification is the essence of sampling theory (Pitard 1993; ITRC 2012; HDOH 2016b). Sampling theory begins with a deceptively simple question: *“What is the sample intended to represent?”* A three-step process is required to answer this question: 1) *“What is the specific objective of the investigation?”*; 2) *“What is the specific area/volume/mass of the media to be targeted for collection of a sample?”*, referred to as a “Decision Unit (DU),” and 3) *“What is the most appropriate method for collection of a representative sample from the targeted DU?”*

Verification and validation of data are equally important to ensure the representativeness of the sample data obtained as part of an environmental investigation and enable the questions under investigation to be confidently addressed. Until recently, however, the concept of “data verification” has been almost entirely absent in the environmental industry. Data validation at the laboratory is a routine part of environmental investigations. Verification of the representativeness of the sample collected and even a clear statement of what the sample and the resulting data are intended to represent is rarely, if ever, considered (Hadley and Sedman 1992; Pitard 1993, 2005, 2009; Ramsey and Hewitt 2005; Hadley and Petrisor 2013). As a result, most of the error in environmental investigations occurs in the field, not in the laboratory. This error often goes unseen unless additional sampling is carried out to “verify” the effectiveness of remedial actions or the site is re-investigated as part of a future property transaction.

The unreliability or “un-verifiability” of discrete soil sample data, for example, has slowly gained recognition over the past 10 years (Brewer et al. 2017a,b). Discrete soil sample data are unreliable for final decision making for a relatively simple reason – the mass represented by the sample collected and the laboratory data provided is far too small to overcome the type of random, small-scale heterogeneity of contaminants in soil. In the field, this leads to premature termination of site investigations, “failed” confirmation samples, confusion over seemingly isolated “hot spots” and “cold spots”, and hidden uncertainty in estimates of the “average” or “true” concentration of a targeted area as part of a risk assessment.

A similar understanding is slowly developing regarding the use of “discrete” small volumes of vapor collected beneath building slabs to assess vapor intrusion risk (Brewer et al. 2014). Consider, for example, the isoconcentration map of a vapor plume underlying a building in Figure 3-1. Isoconcentration mapping programs are typically used to identify small- and large-scale draw patterns of VOC concentrations in the subsurface, based on the discrete vapor sample data. The representativeness of these programs relies on two key assumptions: 1) Data for individual sample points are reasonably representative of the immediately surrounding area; and, 2) The concentration trend between individual data points is linear.

Large-scale, concentration patterns generated by mapping programs might indeed be real if supported by multiple data points. The representativeness of small-scale patterns depicted by a single sample, or even a small cluster of samples, is much less reliable, however, because the concentration of VOCs at the scale of a typical, discrete vapor sample (e.g., 1 liter) around a single point could vary significantly and in a random manner. This could be due to small-scale differences in soil type, moisture, degradation and other difficult-to-measure factors. This violates both of the above requirements for the reliability of patterns generated by isoconcentration mapping programs. Similar map patterns might be generated from an independent set of samples collected in the same manner, but the locations of individual, small-scale “hot spots” and “cold spots” could be entirely different. This is a classic signal of small-scale, random heterogeneity of contaminants in the environment (Brewer et al. 2017a,b).

In the case of the anonymous site depicted in Figure 3-1, the consultant who carried out the investigation in fact had additional information on past operations at the site that together with the sample data suggested that the “hot spots” noted are likely to be real. The representativeness of such data is, however, rarely “verified” in terms of replicate field data. This is typically due to a lack of additional funds to collection additional samples, but also to the lack of awareness of potential errors and pitfalls in computer-based isoconcentration maps.

Published studies of the small-scale variability of VOC concentrations in vapors in the immediate area of sample collection point are not readily available, however. This is surprising given implications for the interpretation of soil vapor data as part of a vapor intrusion investigation. Discussion with field workers who have periodically collected and compared “co-located” vapor samples suggests that VOC concentrations can vary by orders of magnitude over a distance of a few feet. The inability to reliably correlate indoor air data and subslab soil vapor data likewise suggests that traditional, small-volume vapor samples are not reliable indicators of the overall concentration a VOC in vapors within the immediate area of a sampling point.

This enigma is the basis for concerns regarding the reliability of the USEPA’s “empirical database” to estimate attenuation factors for impacts to indoor air caused by the intrusion of subsurface vapors through the building slab or foundation (USEPA 2012, 2015a). The database is comprised of data for hundreds of paired, subslab vapor and indoor air samples. The attenuation factor is assumed to be represented by the concentration of the chemical in indoor air to the concentration of the chemical in the vapor sample collected under the slab. The subslab vapor plume is typically represented by a single, one-liter sample. Use of this approach requires field verification of at least on one two necessary elements: 1) Concentrations of targeted chemicals at the scale of the sample collected are “uniform” throughout the vapor plume source; or, 2) The precise vapor entry point (or points) is known, and a single, small-volume sample collected at that point will be representative of vapors intruding the building and resulting in the measured impacts to indoor air.

Neither of these key assumptions have been verified in the field to support vapor attenuation factors extracted from the USEPA database, and recommended for use in vapor intrusion investigations. Detailed studies of vapor plumes under building slabs consistently identify significant large- and small-scale heterogeneity, similar to, although perhaps of less magnitude than, observations made for soil. The unspoken assumptions that underlie interpretation of the USEPA vapor intrusion database are thus unverifiable, as are the attenuation factors extracted from that database.

Alternative, better-tested and more verifiable methods for estimation of subslab vapor attenuation factors are readily available and should be used (refer to Brewer et al. 2014). Compilation and evaluation of the database was an important and necessary step in the development of better tools to characterize subsurface vapor plumes and more accurately assess vapor intrusion risk. Moving laterally, and development of

alternative, more reliable, and scientifically sound approaches to characterize plumes and assess risk, is a natural part of the scientific method, and the focus of the field research presented in this study.

3.2 STUDY OBJECTIVES

The objectives of this study are twofold: 1) Develop a more reliable approach for characterization of large-scale, VOC distribution patterns in vapor plumes that directly underlie building slabs; and, 2) Develop a more reliable approach for the collection of subslab vapor data that more directly reflect the volume of vapors potentially tied to observed or hypothetical impacts to indoor air over a specified period of time. The first objective identifies the location and relative strength of the vapor plume. The second objective tests specific portions of the plume for potential vapor intrusion risk.

Traditional investigation methods rely on data for individual sample points to identify large-scale trends of VOC concentrations in vapors beneath a slab. Consider again the isoconcentration map of PCE vapors beneath a large, building slab in Figure 3-1. Each sample point represents data for a 1-liter vapor sample. Assuming an air-filled porosity of 20%, approximately 3,000 liters of vapors are present in the upper 25cm of each 58-square meter (m^2) (25-by 25-foot) grid area. As discussed above, use of data for a single, one-liter sample to represent this area requires a high degree of small-scale uniformity within the plume. Such uniformity has never been demonstrated in the field to the knowledge of the authors of this report. While large-scale patterns might be reasonably accurate, slight relocation and retesting of individual sample points could result in dramatically different, small-scale patterns due to random variability within any given, 3,000-liter volume of vapors. As a result, seemingly isolated “hot spots” and “cold spots” extrapolated by the computer program from individual data points and depicted on the map could be entirely artificial and not representative of actual, subslab vapor conditions in those areas.

This is identical to problem hypothesized and then verified in the field for “small-volume” discrete soil sample data in an earlier study carried out by HDOH (HDOH 2014a, b; Brewer et al. 2017a, b). Hundreds of co-located discrete samples were collected and tested as part of that study. Random variability of contaminant concentrations of over two orders of magnitude was observed in some sample sets. This variability is addressed in sampling theory by designation of specific areas and volumes or “Decision Units” of soil for characterization and collection of a single, large-volume (mass) sample from a large number of points (“Multi Increment” sample) in a systematic, random manner from each DU (HDOH 2016b). Replicate samples can be collected in the same manner to test the field precision of the resulting data. The DU area/volume of soil designated for sample collection is based on the resolution of the investigation desired for characterization, risk assessment and/or remediation purposes.

Such DU-MIS approaches for soil have become sufficiently well-developed and cost-effective over the past 10 years. Similar methods for the characterization of subslab vapor plumes have yet to be fully developed, however. This is due in part on a similar problem that has hampered expansion of DU-MIS approaches in other areas of the United States – an understandable, yet misguided desire to generate highly detailed maps of contamination distribution within a targeted area that allows the concentration of a contaminant at any given, random point within the area to be predicted. This is both unachievable from a technical standpoint, and unnecessary in terms of assessing risk, as is a search for the mythical, “maximum” contamination concentration within the area (see Brewer et al. 2017a, b).

The same is true for the characterization of vapor plumes under building slabs. More thought is required on the resolution of data that can be realistically obtained for subslab vapor plumes from a technical standpoint, and perhaps more importantly the resolution necessary to assess potential vapor intrusion risk. This desired resolution is almost certainly greater than the one-liter, discrete vapor samples routinely collected as part of a vapor intrusion investigation. As was the case for the past collection of discrete soil samples in four-ounce jars, the mass/volume of soil represented by a sample was dictated by the requirements of the

laboratory for testing rather than requirements in the field to collect samples representative of clearly stated, investigation objectives.

As is the case for soil, the volume of soil vapor that can be submitted to a laboratory for testing is limited by physical and financial constraints related to shipping, storage and disposal. Like soil, however, it is possible to collect a soil vapor sample in a manner that allows the sample to be representative of a significantly larger volume than the volume actually shipped to the laboratory for testing. This study investigates two approaches to achieve this goal, and allow data to be obtained at a resolution set by sampling theory and the needs of the site investigation, rather than the needs of the laboratory.

The first approach involves division of a targeted slab area into multiple cells and the installation and combined testing of multiple passive vapor samplers within each cell in order to determine large-scale vapor patterns beneath the slab. Combination of multiple samples from single grid cells allows potential random, small-scale heterogeneity within the cell to be captured and represented in larger-scale patterns, while reducing the occurrence of artificial hot spots and cold spots that distract from site investigation objectives, thereby leading to erroneous conclusions regarding potential source areas and vapor intrusion risk.

The second approach explores the resolution of subslab vapor data necessary to assess potential vapor intrusion risk to indoor air. As discussed below, the volume of vapors estimated to intrude a leak-prone, under-pressured structure on a given day is in the range of thousands of liters. Assessment of potential short-term health risks over a few days thus requires data for very large volumes of soil vapor. Data representative of millions of liters of vapor are necessary for direct assessment of long-term, chronic health risks over a period of many years.

Incorporation of risk-based objectives and consideration of short-term (small-scale) variability into sample collection designs for characterization of indoor air quality is well underway for characterization of indoor air, although it has yet to be clearly discussed in terms of sampling theory. Conclusions regarding health risks posed by contaminants in indoor air are unlikely to be made based on data for a single, 1-liter or even 6-liter sample collected instantaneously from a single point within a building. Samples must instead be collected in a manner that allows the resulting data to be representative of millions of liters of air, a daunting but achievable objective. Corresponding sample collection methods that consider both risk and heterogeneity should and can be developed for the investigation vapors under buildings that are hypothesized to be the cause of impacts to indoor air quality.

3.3 GENERAL STUDY DESIGN

3.3.1 Vapor Plume Characterization

Characterization of the approximate extent and strength (concentration distribution) of the vapor plume known to underlie the building slab at the Lagoon Drive study site was carried out in three steps: 1) Subdivision of the square, approximately 10,000 ft² slab area into individual cells for sample collection; 2) Installation of multiple, passive samplers into each cell; and, 3) Combination of samplers from individual cells for testing as a single sample at the laboratory.

This approach is similar to the concept of “Decision Unit”. Discrete sampling approaches attempt to characterize an area on a point-by-point basis. This in theory generates a map that allows prediction of contaminant concentrations at any single point within the targeted media at the scale of the initial samples tested (e.g., 100 grams soil sample or one-liter vapor sample). In practice and as discussed above, this approach is highly prone to error due to testing of masses/volumes of media too small to overcome random, small-scale variability. An alternative approach that better adheres to sampling theory concepts long employed in other sampling intensive industries subdivides the targeted media into pre-specified,

masses/volumes for individual testing. Like pixels in a digital photograph, increasing the number of cells tested within the slab area increases the resolution of the resulting investigation.

The targeted slab area of the study site was divided into 25 grid cells (Figure 3-2). The approximate dimensions of each grid cell were 18 feet by 18 feet, with the exception of the five cells on the eastern edge of the slab, which were approximately 16.25 feet by 18 feet. Vapors in soil within 1 foot of the base of the slab were targeted for characterization. Assuming an air-filled porosity of 20%, each cell represents a subslab vapor volume of approximately 65 cubic feet (ft³) or 1,800 liters (1,700 liters for cells on eastern edge of slab). Under ideal circumstances, the entire volume of vapors represented by each cell would be collected as a single “sample” and submitted to the laboratory for analysis. This is of course not feasible due to the volume of vapors involved and the fact that the vapor plume would shift as individual samples were collected. A representative sample must instead be collected.

How a sample is collected and how the representativeness of the sample is tested are critical components of sampling theory that are rarely incorporated into environmental investigations. For the purpose of this investigation, four passive samplers were installed in each cell and combined for testing as a single sample. Both the number of cells designated (25) and the number of passive samplers deployed in each cell (up to 4) were determined in part by the desired spatial resolution of the data as well as the available budget. As is often the case, the latter was an important driving factor. The project budget could accommodate up to 25 analyses (approximately \$200 each). The laboratory agreed to combine carbon strips from up to four samplers for testing.

Triplicate sets of samplers were collected in three grid cells in order to test the field precision of any single set of samplers (Figure 3-3). Cells 13, 17 and 24 were selected for replicate testing, based on past soil vapor data and the likely presence of PCE vapors in these areas (see Figure 3-2). Replicates were to be installed in the same manner and number as the initial set, consisting of four individual samplers combined at the laboratory for testing.

The potential representativeness of a four-point sampler set for a single cell was unknown ahead of time, due to a lack of published studies regarding the small-scale variability of VOC concentrations in vapors at the scale of an individual sampler (i.e., random variability within the immediate vicinity of a sampling point). In a limited effort to assess this issue, the study also included the installation and individual testing of up to nine passive samplers in a single cell located over a known area of PCE vapors. The resulting data were to be used to evaluate the relative magnitude and nature of small-scale variability within a single cell. Although minimal in terms of the total volume of vapor present, the resulting data would provide insight on the potential magnitude of error associated with isoconcentration maps based on traditional, discrete vapor sample data, both passive and active. Grid Cell 10 was selected for testing, based on past data that suggested elevated levels of PCE in vapors underlying the slab in this area (Figure 3-4). It is anticipated that more detailed studies of variability between co-located active and passive soil vapor sample data has been carried out in other areas. References for published studies have not been identified at this time, however.

3.3.2 Vapor Intrusion Risk

Investigation designs for site characterization versus assessment of risk can differ. The question posed by the former is: “*What is the concentration of the target VOC in vapors under the specified area(s) of the slab?*” The design noted above is intended to address this investigation objective. The resolution of the investigation in terms of the sizes and number of area targeted for sample collection is necessarily site-specific, and takes into consideration factors that include the identification of suspect source areas, clearance of anticipated clean areas and optimization of remedial design (refer to Section 3 of the HEER Technical Guidance Manual; HDOH 2016b).

The question posed for assessment of risk in this case is “*What is the concentration of the target VOC in vapors that will intrude or could intrude Point X in the slab over a stated period of time?*” Short-term, acute risk is typically assessed based on an exposure period of one day to two weeks (Chou et al. 1998). Intermediate or sub-chronic health risk is assessed over 15 days to one year. Long-term chronic risk, used to develop the USEPA Regional Screening Levels, is assessed based on average, daily exposure over a period of many years (USEPA 2016).

The default vapor intrusion rate into under-pressured structures with leaky floors in terms of volume per unit time can initially be estimated by consideration of the default rate incorporated into the USEPA and similar vapor intrusion models of five liters per minute (USEPA 2004; Brewer et al. 2014). This equates to a daily vapor intrusion rate of approximately 7,000 liters, and reflects, in terms of risk, the minimum “Decision Unit” volume of vapors for which data is required. This value serves as the useful target subslab vapor volume for sample collection and assessment of potential short-term impacts to indoor air posed to vapor entry through a known, or more likely hypothetical, entry point in a building slab. For example, sample data collected for a series of five consecutive 7,000-liter purges of vapor from the point could be assumed to represent the concentration of the target VOC in vapors that could potentially intrude through the point over a five-day period, or a total of 35,000 liters. Direct assessment of longer-term sub-chronic and chronic impacts to indoor air quickly becomes problematic, since the volume of vapors assumed to intrude over a single year exceeds several million liters. Perhaps more importantly, most of these vapors have yet to be generated by the advective intrusion and subsequent contamination of outdoor air under the slab. Even if the collection and testing of such a large volume of vapors was possible, the vapors under most site scenarios would have not yet been generated.

Factors to be considered for designation of a vapor sample collection point or points include (CalEPA 2015; USEPA 2015a,b): 1) Location of known or suspect vapor entry points through the slab; 2) Locations of known or suspect source areas beneath the slab; 3) Apparent high-concentration areas of the vapor plume based on existing data; or 4) Center point of the slab in the absence of other information regarding the anticipated distribution of vapors beneath the slab. Consideration the first factor, if known, is most appropriate for assessment of vapor intrusion risk under current site conditions. Consideration of the second or third factors is intended assess worst-case vapor intrusion scenarios that might or not be realistic of current or even future site conditions. Only the location of the vapor entry point requires designation (Figure 3-5).

This type of subslab vapor sample collection is referred to as “Large-Volume Purge” or “LVP” for use in this field study. The approach is based largely on “High Purge Volume” vapor sample collection methods that have been used in some parts of the country for many years (McAlary et al. 2010). The LVP investigation methods described below take this approach one step further by inclusion of the concept of “Decision Units” in sampling theory and consideration of existing assumptions regarding risk in designation of target vapor volumes for sample collection. Note that the source area of the vapors beneath the slab is *unimportant* in terms of the question being asked. The indoor air “does not care” where the vapor came from beneath the slab. Only the volume of the intruding vapor and concentration of the targeted VOC in the vapor are important. Under an LVP sampling approach, the DU is in effect directly brought to the surface for sample collection.

A point in the approximate center of the slab (center of Grid Cell 13) was selected for collection of a series of samples from five consecutive 7,000-liter purges (see Figure 3-2). Under ideal circumstances, the entire targeted DU volume of vapors would be collected and submitted to the laboratory for analysis, with a single concentration of each target, volatile chemical reported. Given the large volumes in question under an LVP approach, this will of course not be practical in most cases. As an alternative, and as described in Section 4, a continuous sample of the vapors can instead be drawn from the purge (“slip”) stream into a Summa canister as the targeted DU volume of vapors is being drawn from the targeted vapor entry point. This

approach allows the data received from the laboratory to represent any desired volume of vapors, rather than being locked to size of the canister provided by the laboratory for sample collection. The ability to detect significant leaks to indoor or outdoor air and multiple other important factors must be taken into consideration for this approach to subslab vapor plume investigation, but this is far outweighed by the overall representativeness and usability of the resulting data.

4.0 EQUIPMENT AND METHODS

4.1 COLLECTION OF PASSIVE SOIL GAS SAMPLE

4.1.1 Sampler Description and Installation Methods

Passive vapor samplers produced by Beacon Environmental Services (Beacon) were selected for use in the study (Figure 4-1). Each sampler consists of two sorption strips placed inside of a glass vile. Design of the passive sampler deployment was carried out with the assistance of Eric Jensen from the Tetra Tech, Inc. office in Honolulu and Harry O'Neil with Beacon Environmental Services in Delaware.

Samplers were installed on August 18, 2016. A detailed overview of the installation of the passive samplers is included with the Beacon report in Appendix D (see Attachment 2 of Beacon report). Passive soil vapor samples were installed in five steps (Figure 4-2):

- 1) 1.5-inch diameter boring drilled through slab;
- 2) 0.5-inch diameter boring drilled to 12-inch depth below slab (target vapor zone 0.5-12 inches);
- 3) 1-inch diameter aluminum tube (four-inch length) inserted into hole and tamped down one inch into underlying soil;
- 4) Passive sampler lowered into aluminum tube (wire hanger attached over lip of tube to suspend sampler);
- 5) Top of hole sealed with ball of aluminum foil and a half-inch seal of neat Portland cement.

Photos of sampler installation are provided in Figure 4-3. The original, plastic cap of each sampler vile was replaced with a vapor-permeable cap immediately prior to installation. Sample points were marked on the slab ahead of time. Installation of the samplers took approximately four hours, with a crew of two drilling the boreholes and a crew of three installing samplers and sealing the holes.

The final number of samplers installed in each grid cell is noted in Table 4-1. A total 111 of an initially planned 129 samplers were installed and/or retrieved. A complete set of samplers could not be installed in Grid Cells 1, 2, 3, 4 and 5 due to the presence of a thickened footing (>12 inches thick) within one to two feet of the slab perimeter (see Figure 3-2; one to two of planned four samplers installed). Only six of a planned nine samplers were installed in Grid Cell 10 for the same reason. Installation of the samplers beneath the footing was determined to be inappropriate, since the investigation specifically targeted the "Decision Unit" volume of vapors immediately beneath and within 12 inches of the primary slab area. In addition, a complete set of samplers could not be installed in Grid Cells 14 and 15 due to the presence of loose gravel immediately beneath the pad and an inability to keep the drilled holes open (two and three of planned four samplers installed, respectively).

4.1.2 Sampler Retrieval and Testing

Samplers were retrieved on August 26, 2016, and shipped to Beacon Environmental Services for analysis. One of the four samplers installed in Grid Cell 6 could not be retrieved. One of the four samplers installed in Grid Cells 16 and 23 broke on retrieval and the sorbent media could not be recovered. In total, 109 of the 111 installed samplers were retrieved and submitted for combination and analysis in accordance with the methodology outlined in Section 3.3.

Each sampler location was abandoned by removing the aluminum tube insert, and filling the hole with bentonite pellets to a depth of approximately two to three inches below concrete surface grade. The remaining hole was then capped off with a neat Portland cement slurry.

4.2 COLLECTION OF LARGE-VOLUME PURGE SAMPLES

4.2.1 Bench Study

The system used to collect Large-Volume Purge (LVP) subslab vapor samples was designed by Eric Jensen with Tetra Tech's Honolulu office, with assistance from Greg Swanson (Tetra Tech; San Diego, California) and David Berestka (Tetra Tech; Denver, Colorado). The system was modeled largely after an approach published by McAlary et al. (2010), and is similar to designs used for a soil vapor extraction pilot test.

A schematic of the LVP design is provided in Figure 4-4. The basic configuration consists of a two-inch polyvinyl chloride (PVC) pipe connected to a vapor sampling point installed in the center of the slab. A Shop-Vac® was used to produce a vacuum on the sample point and purge the targeted volumes of vapors. Multiple sample ports installed into the PVC piping allowed the vacuum on the well point and vapor flow rate to be monitored, as well as continuous draw of a sample from the purge stream into up to two, six-liter Summa canisters.

A bench study was setup indoors prior to the field sampling event, using a 6.5 HP Shop-Vac® Contractor vacuum (Figures 4-4 through 4-6). The components of the setup included (upstream to downstream; see Figure 4-5a):

- two-inch Schedule 40 PVC;
- ¼-inch wedge valve near the intake “T”, with tubing connected to a Dwyer Magnehelic Gauge (0-100 in-H₂O) pressure/vacuum gauge;
- Summa sample valve (1/4-inch wedge valve with Teflon tubing);
- PID meter and O₂/CO₂ meter port (1/4-inch wedge valve equipped with Teflon tubing to the PID meter) – opposite side of Summa Port (peristaltic pump to be used to draw influent to the PID and O₂/CO₂ meter port);
- Pitot Tube port (3/8-inch ID threaded pipe, ½-inch length);
- Flow meter port (3/8-inch ID threaded pipe, one-inch length).

The bench test was used to optimize the design of the system and evaluate the purge rate under different vacuums imposed on the vapor entry point. Purges were directed into a latex-rubber weather balloon. This was done in order to verify the accuracy of flow meters to be used during actual sample collection and estimate the time required to reach the target 7,000-liter purge volume. This volume was reached when the diameter of the balloon reached approximately 2.4 meters (7.8 feet; see Figure 4-7). An estimate of the time required to reach the target purge volume was needed in order to set the sample collection rate for Summa canisters to be connected to the purge line.

A summary of the vacuum-simulation data table is provided in Table 4-2. The vacuum imposed on the vapor intake point was artificially varied by progressively closing a ball valve fitted to the intake end of the system. Vacuums between 0 and 35 inches of water (in-H₂O), in five in-H₂O increments were tested, and the time required to purge a target subslab vapor volume of approximately 7,000 liters recorded. The fill times for the bench study ranged from approximately 2.5 minutes (0 in-H₂O vacuum) to eight minutes (35 in-H₂O). A data plot of vacuum versus time illustrates a distinct curve and good correlation for estimation of purge times in the field (Figure 4-8). A vacuum of between 30 and 40 in-H₂O was anticipated to be realistic in the field (personal communication Todd McAlary; see also McAlary et al. 2010). This corresponds to an estimated fill time in the range of six to nine minutes.

A maximum vacuum of 40 in-H₂O was observed at complete closure of the ball valve. Note that this is well below the maximum recommended vacuum to be applied to a vapor sample point of 100 in-H₂O or seven

inches of mercury (in-Hg), intended to avoid stripping of vapors from free product entrained in soil (CAEPA 2015; HDOH 2016b).

Additional indoor and outdoor tests were run using a seven-foot diameter PVC vinyl weather balloon (approximately 6,200-liter volume), which was selected due to the anticipated durability for multiple test runs. The latex rubber balloon was not expected to be used more than one time under field conditions, due to sun/heat and susceptibility to perforation if contact with a rough surface (i.e. asphalt or concrete).

The final system design included a Dwyer TS-300 Flow Sensor, Averaging Pitot Tube (“Pitot tube”) port upstream of the TSI flow meter port. The purpose of the Pitot tube was for confirmation of the thermal anemometer flow meter readings (i.e., TSI brand flow meter used). The Pitot tube port was 3/8-inch ID threaded pipe, which allowed for direct connection of the Pitot tube via a compression fitting. The complete specification sheet for the Dwyer Pitot tube is presented in Appendix E.

The PID sample port was placed immediately opposite the summa sample port for the final system design (see Figure 4-5). This was done to ensure that PID readings were representative of the collected samples. In addition, the final design used a 10-pipe-diameter separation between the Pitot tube and the summa sample port (distance upstream of the Pitot tube), per manufacturer recommendations (minimum 10 pipe diameters upstream and five pipe diameters downstream between any other fittings or ports which could affect flow). A 10-pipe-diameter separation distance was also used between the Pitot tube and the TSI flow meter. A Five-pipe-diameter separation distance was used downstream of the TSI meter, prior to the flow adjustment valve. These distances were used to alleviate the effects of any turbulence on the flow readings, as the key to the overall test was accurate measurement of the purge volume of approximately 7,000 liters.

For the final design, Fernco flexible couplings were used to connect the various PVC sections. This provided for secure seals and allowed for ease of field set-up and break-down. A limited amount of low-volatile (non-chlorinated) PVC cement was used in minor portions of the piping, as necessary, in order to ensure secure fittings. A PID was used during bench testing to confirm there were no VOCs present in the system piping and fittings. The vapor purge system was allowed to stabilize and aerate for several weeks prior to use in the field.

4.2.2 Extraction Point Installation and Field Pilot Test

The primary purpose of the initial field pilot test was to determine the likely flow rate and purge times under real site conditions, as well as to test the system and equipment in the field and make adjustments as necessary. Actual vacuum and flow data was required prior to ordering the summa canisters. This is because the summa canisters are event-specific, and require a vacuum duration that is *pre-set* by the laboratory prior to deployment, at the time of shipping.

The extraction point used for the field pilot test as well as the sampling event was installed in the approximate center of the concrete pad (center of Grid Cell 13; see Figure 3-2). The point was installed on the date of passive sampler installation (August 18, 2016), in order to allow sufficient time for stabilization of subsurface conditions and setting of the seal prior to the pilot and sampling events, scheduled for August 29, 2016 and September 14, 2016, respectively.

The extraction point was constructed as a two-inch PVC well, set within an eight-inch diameter steel casing installed in the concrete slab (Figure 4-9). The steel casing extended approximately six inches above the top of the concrete pad as a protective casing, which was secured with a steel bolt-down cover to prevent tampering. The well was constructed with 10-slot screened PVC with a solid end-cap. The well screen extended from the base of the concrete pad (which was approximately six inches thick at the well location) to a depth of 12 inches below the *base* of the concrete slab. The two-inch length solid endcap extended

from approximately 12-14 inches below the base of the concrete, with the well screen interval terminating at a depth of approximately 12 inches below the base of the concrete pad. A #3 sand pack was emplaced around the well screen, and solid PVC extended approximately three inches above the top of the concrete pad, and a solid PVC screw cap was used to secure the top of the well. An approximately two-inch layer of bentonite was placed above the sand pack, and Portland cement was emplaced inside the casing to the level of the approximate top of the concrete pad. The outer rim of the casing was likewise sealed with cement in order to minimize any potential leakage during sample collection.

Note that installation of a protective casing around a vapor point is not normally required for one-time sample collection (see McAlary et al. 2010). A steel casing was deemed necessary for this study to protect the vapor point over the course of the study. It is imperative that the vapor extraction point be well sealed to prevent leakage of outside air under the slab during sample collection.

The completed field setup of the LVP sample collection system is shown in Figure 4-10. Note that the power supply was a portable Honda generator, placed approximately 50 feet downwind of the extraction point. The field pilot test was run for only 60 seconds, so as to minimize disturbance of subslab conditions. In addition, the actual sampling event was scheduled to allow two weeks for subsurface conditions to equilibrate following the pilot test. The pilot test data is presented in Table 4-2. The system discharge for the pilot test was directed to the weather balloon. Discharge was directed to a 10-foot tall PVC stack for the actual sampling event that was placed downwind, to ensure that any potential vapors were directed away from the worker breathing zone.

The pilot test indicated a flow of approximately 28 cubic feet per minute (cfm). Flow was confirmed with the TSI flow meter and cross-checked with the Pitot tube. Note that a spreadsheet is required to calculate the flow rate using the Pitot tube. The Pitot tube calculations are based on the pressure differential between upper and lower ports, with the pressure differential readings obtained via the TSI flow meter. A copy of the spreadsheet used and associated parameter is included in Appendix F. A vacuum of approximately 42 in-H₂O was recorded during the pilot test.

A balloon test was successfully performed as a cross-check regarding the purge volume as related to measured flow rates (Figure 4-12). However, wind conditions indicated that use of the weather balloon during the actual sampling event would likely not be possible. It was very difficult to control the balloon, even in standard light to moderate trade wind conditions. Based upon the information obtained during the bench study, as well as field flow readings recorded during the pilot test (using both the TSI flow meter and the Pitot tube cross-check), the accuracy of the field equipment negated the necessity to use a weather balloon in the field during the sampling event for purge volume confirmation.

Based on the field pilot test, a purge time of seven to nine minutes was estimated to be required for an approximately 7,000-liter purge. However, the minimum duration vacuum setting for a summa canister draw is 20 minutes; therefore, based upon the pilot test, for the actual sampling event, the summa canisters were pre-set by the laboratory for a 20-minute sample time. The laboratory recommended the use of six-liter Summa canisters in order to ensure that the volume of vapor collected for sufficient for analytical needs. The lab recommended that a Summa canister be filled to at least one-third capacity (i.e., two liters), as measured by a minimum one-third reduction in the initial vacuum applied to canister (e.g., reduction from 28 in-Hg to 20 in-Hg). As noted below, this was easily accomplished for each of the six Summa canister samples ultimately collected.

Floor drains, gaps around utilities that penetrated the slab and large deep cracks in the concrete pad were sealed with bentonite pellets and Portland cement slurry in a manner similar to that used to abandon the passive sampler borings in an effort to minimize short-circuiting during the pending LVP study (Figure 4-11). Two vaults, approximately one-foot square and up to 1-foot deep, were located near the center of the

slab. Gaps around PVC and steel piping and conduits were sealed with bentonite pellets and Portland cement slurry. Existing soil vapor sampling ports (approximately ¼-inch diameter tubing, extending from the concrete pad) were capped (See Figure 4-11). One vapor point located approximately 30 feet from the LVP extraction point was inadvertently left uncapped during the collection vapor samples, but as discussed below this does not appear to have served as a significant leakage point for outdoor air during LVP sample collection.

4.2.3 LVP Sampling Event

A total of seven batch-certified six-liter volume summa canisters and associated lab-set controllers were ordered for up five consecutive purges, with the first purge run as a duplicate, plus a background sample canister. For the duplicate, two summa canisters were connected via a Tee adapter, to ensure true split samples (see setup in Figure 4-10). As previously discussed, based upon the pilot test, the summa controllers for the purge samples were set to the minimum 20-minute draw time allowed for the canisters.

The collection of a series of five (5) LVP samples was carried out on September 14, 2016. An outdoor air, background sample was also collected during the sampling event. Based on the estimated purge time of seven to nine minutes, and five consecutive runs, the controller for the background summa canister was set for a purge time of 60 minutes. The background canister was placed approximately 50 feet east and crosswind of the extraction point at the eastern edge of the slab (Grid Cell 15; see Figure 3-2).

Clean rags soaked in 91% isopropyl alcohol (standard rubbing alcohol) were placed around the wellhead extraction point connection, the Fernco flexible fittings just upstream of the vacuum gauge, and immediately downstream of the vacuum gauge (just before the sample and PID valve ports) in order to test for system leaks (see Figure 4-10). As discussed in the Results section, below, an absence of significant isopropyl alcohol in the samples implies minimal leakage at these points. This is supported by depleted oxygen and elevated carbon dioxide in the samples, consistent with data for earlier subslab vapor samples.

Continuous flow data was recorded for each of the five purges. Flow was measured via a TSI flow meter and Pitot tube cross-check. The Pitot tube ports were connected to the TSI flow meter via Teflon tubing, which recorded the pressure differential between the upper and lower tube ports. As previously discussed, the pressure differential is input into a spreadsheet to calculate a flow rate. Vacuum was recorded for each of the five purges using a Dwyer magnehelic gauge.

A vacuum of approximately 40 to 42 in-H₂O was recorded for each of the purges, with flow generally between approximately 20 and 23 cfm. The Pitot tube flow calculations were within approximately 10-15% of the TSI flow meter readings, confirming the flow rate data. Each of the five purges was run for 11 to 13 minutes, based upon the recorded flow rate for the individual purge event. The LVP data was recorded on field sheets (Appendix G). Note that the upper and lower pressure differential ports of the Pitot Tube were connected via Teflon tubing to ports on the TSI flow meter, with the TSI Flow meter providing a pressure differential value, which in turn was entered, while in the field, into an excel spreadsheet which calculates a relative flow rate in cfm.

In addition to the above-discussed parameters, the starting and final pressure in the summa canisters were recorded on the field sheets. The starting pressure for each of the canisters was approximately 30 inches-Hg (approximately 400 inches-water). The pressure at the end of each purge was between approximately 17 and 23.5 in-Hg (230 to 320 in-H₂O). This implies that the canisters were filled to approximately 22% to 43% capacity or 1.3 to 2.6 liters of vapor. This was adequate to meet testing requirements at the laboratory.

The time between each purge event was minimal, less than approximately two minutes. The gate valve located immediately downstream of the TSI flow meter port and before the Shop-Vac® was closed between

purges (see Figure 4-10). The Shop-Vac® was also shut off between each purge event. Closure of the main in-line valve, all in-line wedge valves, and the Pitot tube ports secured the extraction point such that the system was effectively sealed between purge events.

The initial plan included continuous monitoring using a MultiRae® photoionization detector (PID) via a peristaltic pump, to overcome the system vacuum. The MultiRae® is a PID with data logger, which could also monitor oxygen (O₂), carbon monoxide (CO), and CO₂. However, the meter immediately failed upon initiation of sampling. Data for CO, CO₂ and O₂ could therefore not be recorded. The laboratory was, however, able to analyze the summa canister samples for O₂ and CO₂. This proved very valuable as an indicator of potential leakage of surface air into the extraction point during sample collection.

All summa canister samples were submitted to Eurofins Air Toxics, Inc. (Folsom, California), a NELAP Certified Laboratory, for analysis via USEPA Modified TO-15, including Total Petroleum Hydrocarbons as the sum of C₃-C₁₂ compounds (TPH; referenced to gasoline and herein referred to as “TPHg”). Quantification of TPHg by Modified TO-15 is based on a single-point, gasoline, calibration standard analyzed with each analytical batch. The concentration of TPHg is determined for each sample by summing the area of the total ion chromatogram of the Gas Chromatogram/Mass Spectrometer (GC/MS) run and subtracting non-petroleum related components from the total area. This total area approximates the C₃ to C₁₂ range.

4.2.4 Quality Control

Field quality control included the following: 1) Collection of a duplicate LVP sample for the first purge during the sampling event; 2) Leak testing using isopropyl alcohol throughout each of the five purge events; 3) Collection of a background outdoor air sample; and, 4) Comparison of O₂ and CO₂ Summa data to previous subslab vapor data and data for the background outdoor air.

As discussed below in the Results section, there was excellent correlation between the duplicate samples, the leak tests indicated only minimal leakage, and none of the analytes detected in the background sample were detected in any of the five purge samples.

5.0 RESULTS AND DISCUSSION

5.1 PASSIVE SOIL GAS DATA

Summary of passive sampler data are provided in Tables 5-1, 5-2, 5-3, and 5-4. The full laboratory report is provided in Appendix D (Beacon Environmental 2016). The laboratory initially reports to mass of the target VOC sorbed to the combined grid cell set of carbon strips (Table 5-1). Four carbon strips, representing four samplers, were initially planned for combination and testing as a single sample for each cell. The combined carbon strips represent the sample for that grid cell. A full set of samplers was successfully installed, retrieved and combined for testing in 15 of the 25 grid cells targeted, including full, triplicate sets of samplers in three of the grid cells (see Section 4.1 and Table 4.1). Only one to three of the planned four samplers were able to be installed in ten of the grid cells, due to the presence of a thickened slab (>12 inches) under a portion of those cells, or due to the presence of gravel immediately beneath the pad, which prevented the drilled hole from remaining open to allow installation.

Data for grid cells where different numbers of samples were collected cannot be directly compared, since the laboratory reports the total mass of the targeted VOCs sorbed to the carbon strips rather than an average of concentrations. For example, the mass sorbed to a single sampler installed in a cell with a VOC concentration of “X” would be one-quarter of the mass reported for four samplers installed in the same cell. Differences in the number of samplers successfully installed and tested in each grid cell were accommodated dividing the mass reported for each grid cell set of samplers by the number of samplers in that set. This generates an average mass-per-sampler for each grid cell and allows direct comparison of data, as summarized in Table 5-2.

Table 5-3 presents a summary of the adjusted data, sorted from lower to higher average masses of sorbed PCE and TCE for each grid cell. The mass reported for samplers was dominated by PCE, representing 76% to 99+% of the total mass present, with an average of 93%. Reported masses of other VOCs were negligible (refer to Appendix D). No distinct pattern is evident in the variability of PCE to TCE reported for individual sets of samplers.

5.1.1 Standard Sample Set Results

Passive sampler data from the study are summarized presented in Table 5-2. Figures 5-1 and 5-2 present summary maps of PCE and TCE distribution within the vapor plume at the resolution of individual grid cells. Beacon Environmental recommends the collection of follow-up active gas samples to estimate actual concentrations of targeted VOCs in soil vapor (Beacon Environmental 2016). Although the concentration cannot be directly estimated from the passive sampler data, comparison of co-located, passive and active (e.g., Summa canister) data at other sites suggests that mass in terms of nanograms often roughly approximate vapor concentration in units of micrograms per cubic meter.

The distribution of PCE within the plume is characterized by a distinct high-concentration core, surrounded by progressively lower concentrations outward from this area (see Figure 5-1). The distribution of TCE within the plume is again characterized by a central core, but noticeably more fragmented and heterogeneous in the outer areas. A mean mass of 19,503 ng PCE was calculated for the sampler data sets as a whole. The data yield a relative standard deviation (RSD) of 86%. The RSD and variability of the TCE data is again noticeably higher, at 112%, again supporting a greater, small-scale variability of TCE distribution beneath the pad than observed for PCE. This could reflect variability in degradation within the plume, as discussed in Section 6.

The maps in these figures represent the true resolution of the study data, because each set of samplers is specifically intended to represent the “true” concentration of VOCs in the 1,800 liters of vapors assumed

to be associated with each grid cell (see Section 3.3.1). The data collected now allows for direct extrapolation of PCE and TCE concentrations within individual cells. As noted below, concentrations of VOCs in vapors at a scale smaller than the individual grid cells appear to become random, making estimation of a VOC concentration at any given point within a cell unreliable.

Nonetheless, isopleth maps which attempt to do exactly this are presented in Figures 5-3 and 5-4 (prepared by Beacon Environmental Services). The maps were generated by assigning the sampler-adjusted mass of PCE and TCE calculated for each cell to the center point of the cell and used proprietary software to generate isopleths. Large-scale patterns of PCE and TCE in the vapor plume are in good overall agreement with patterns depicted at the resolution of individual grid cells. Small-scale, intra-cell patterns depicted on the maps could only be considered valid if the trend of the mass (and concentration) of PCE and TCE between individual grid points, and at the scale of a single point, is linear (i.e., not random). As discussed in the next section, this is unlikely to be the case. This issue is further explored in Section 6.

5.1.2 Discrete Sample Variability

Data for the six passive samplers installed in Grid Cell 10, which were individually tested, are included in Table 5-3. Three of the nine planned samplers were not installed due to an increased thickness of concrete along the perimeter of the slab. The samplers were installed at a spacing of approximately four feet.

The mass of PCE reported for the samplers ranged from 28,121 ng to 61,194 ng, a difference of just over two-fold (RSD 26%). Variability in the TCE data for the samplers yields an even higher RSD of 46%. There is no clear pattern in the data (Figure 5-5). Although limited, this serves to illustrate the randomness of sample at the scale of an individual sampler. The same would be true of active (e.g., Summa canister or sorbent time) data when small volumes of vapor are represented by the sample.

5.1.3 Replicate Sample Data

A summary or triplicate passive sampler data collected in Grid Cells 13, 17 and 24 is presented in Table 5-4. Masses of 14, 245 ng, 18,077 ng and 14, 738 ng were reported for PCE in replicate samples collected from Grid Cell 13, reflecting a RSD of just 11%. This implies very good precision of the data. Replicate data for Grid Cells 17 and 24 yielded RSDs of 18% and 14%, again reflecting a very high precision of the four-sampler data sets. The average RSD of replicate data for the three grid cells is 14%. This compares to an RSD of the discrete sample PCE data for Grid Cell 10 of 26%, indicating significantly higher variability between individual discrete vapor samples, in comparison to variability between replicates of multi-sampler data for individual cells.

As was the case for variability between TCE data for individual grid cells, the average RSD of 27% calculated for the TCE replicate data is again distinctly higher than observed for the PCE data (range 21% to 36%; see Table 5-4). This implies that a larger number of sampler points would be required to obtain a field precision for TCE data equivalent to that observed for PCE.

5.1.4 HDOH 2016 Passive Sample Data vs. 2002 Passive Sample Data

The large-scale pattern of PCE and TCE distribution in vapors beneath the building slab differs dramatically from the pattern generated from data for 12 passive samplers installed and tested in 2002 (refer to Figure 2-6). The earlier data depict an isolated “hot spot” based on a single sample in the general vicinity of Grid Cells 17 and 18 for this study (see Figure 5-1 and 5-3). The plume is indicated to quickly dissipate away from this point and be relatively small.

While the concentration of PCE under this area of the pad is indeed elevated, this represents only a small portion of the much larger plume identified. It is possible that the vapor plume grew and spread over time, but the facility had been closed for several years at the time the 2002 samples were collected, and had been in operation for several decades prior to that time. Some of the difference could be attributable to error associated with random small-scale heterogeneity within the plume. If the vapor plume were much the same in 2002 as it is in 2017, however, then the 2002 discrete sample data would be expected to yield multiple, seemingly isolated but entirely artificial “hot spots” (and “cold spots”) within the plume area as a whole. More likely, the 2002 data were affected by other factors, including increased soil moisture beneath the pad. It is also possible that removal of the overlying building and subsequent daily heating of the pad caused additional vapors to be generated and/or caused existing vapors to spread across a larger area and in a more even manner beneath the pad. It is likewise possible that the higher variability is simply related to the relatively lower masses of TCE identified in combination with increased laboratory error as method detection levels are approached.

5.2 LVP RESULTS

The results of the LVP purge data are summarized in Table 5-5. Concentrations of PCE and TCE of 17,000 $\mu\text{g}/\text{m}^3$ and 1,400 $\mu\text{g}/\text{m}^3$, respectively, were reported for the sample collected from the first, 7,000-liter purge. Concentrations of PCE and TCE increased with subsequent purges, to highs of 51,000 $\mu\text{g}/\text{m}^3$ and 2,400 $\mu\text{g}/\text{m}^3$, respectively, for the fifth purge.

Isopropyl alcohol (2-propanol) was reported in each of the LVP vapor samples (see Table 5-5). Concentrations increased from 11 milligrams per cubic meter (mg/m^3) to 340 mg/m^3 during the successive purges, implying an increasing amount of leakage in the system. Isopropyl alcohol was reported at 0.39 mg/m^3 in the outdoor air sample collected during collection of the LVP vapor samples. The canister was not placed in the vicinity of the LVP sample collection system, however, and the concentration of isopropyl alcohol in the ambient air around the system at the time of sample collection is unknown. The smell of isopropyl alcohol in the area was strong, however, implying ambient concentrations well above the odor threshold of 55 mg/m^3 (22 parts per million by volume, NJDOH 2011). (Note – Collection of a second, ambient air sample immediate adjacent to the Summa canisters used for soil vapor would have been very useful and appropriate for assessing the magnitude of leakage.)

Oxygen and carbon dioxide data for the LVP samples are presented in Table 5-6. A concentration of 19% oxygen was reported for the first LVP sample (21% in duplicate sample). The concentration of oxygen in subsequent samples was noticeably lower, at 17%. The higher level of oxygen in the initial sample could reflect the influence of ambient air when the vapor point was first installed. A relatively low concentration of 0.9% carbon dioxide was likewise reported for the initial LVP sample (1.1% in duplicate). The concentration of carbon dioxide was noticeably higher in subsequent samples, ranging from 2.0% to 2.6%.

These levels compare to oxygen and carbon dioxide levels of 21% and 0.042% reported for the ambient air sample (see Table 5-6). As discussed in Section 6, comparison to ambient air data of past levels of oxygen and carbon dioxide in subslab vapor samples and levels reported in this study suggest minimal leakage of the LVP system (i.e., <10% of total sample volume), despite the presence of isopropyl alcohol in the LVP samples.

6.0 DISCUSSION

Data collected during the field study is still being evaluated. Key topics under review are summarized below and will be expanded on in future updates of this report:

- Additional investigation of the variability of VOC concentrations between closely-spaced, passive and active “discrete” subslab vapor samples are needed to better understand the number of sampling points required to overcome potentially random, small-scale variability around a single sampling point. This will also shed light on the reliability of traditional soil vapor isoconcentration maps and, in particular, the interpretation of seemingly isolated single-point “hot spots” and “cold spots” beneath building slabs. As has been demonstrated for discrete soil data, such data points and isoconcentration patterns could represent unreproducible artifacts of heterogeneity.
- Direct passage of the purge stream through a sorbent tube rather than bypassing part of the stream into a Summa canister might be feasible if properly designed. Breakthrough of contaminants due to the high purge flow rate and/or saturation of the sorptive media seem to be important drawbacks in use of this approach, however. The narrow diameter of typical tubes would similarly hinder vapor flow under the conditions used in the field study. If these problems could be overcome, advantages include the ability to capture and test the entire mass of contaminant in the vapor stream, and eliminate potential error associated with the collection and testing of a small sample of the overall, large volume of vapors purged.
- The volume of vapors in the upper one foot (30cm) of soil underlying each 324 ft² (30 m²) grid cell is estimated to be approximately 2,000 liters, assuming an air-filled porosity of 20%. An alternative design might have configured the grid cells to represent a more risk-based vapor volume of 7,000 liters. This could have been accomplished by dividing the targeted area into nine, rather than 25 grid cells, with each grid cell covering an area of approximately 1,225 ft² (110 m²). The spatial resolution of the resulting data would have been lessened, but the study design would have been based more on risk, and still fit within the project budget. More samplers (10) could also have been installed in each grid cell to provide better coverage and improve the precision of data for a given cell.
- Develop more rigorous methods to minimize and evaluate leakage.
- Clarify the leakage rate at which LVP data becomes significantly compromised. A leakage rate of <10% is currently assumed to have minimal impact on final decision making (i.e., <10% error in actual concentration of target VOCs in sample drawn, as affected by leakage of ambient air into the sampling train).

7.0 REFERENCES

AECOM. 2013a. *Phase I Environmental Site Assessment 515 Lagoon Drive, TMK Number (1) 1-1-016:0015, Honolulu, O'ahu, Hawai'i*: AECOM Technical Services, Inc. Prepared for Honolulu Authority for Rapid Transportation. Honolulu. May 2013.

AECOM. 2013b. *Phase II Environmental Site Assessment*: AECOM Technical Services, Inc Prepared for Honolulu Authority for Rapid Transportation. Honolulu. June 2013.

Beacon Environmental. 2016. *Passive Soil Gas Survey Analytical Report, Vapor Plume Heterogeneity Study, Hawaii*: Beacon Environmental Services, Inc. October 11, 2016

Brewer, R., Nagashima, J., Rigby, M., Schmidt, M. and H. O'Neill. 2014. Estimation of Generic Subslab Attenuation Factors for Vapor Intrusion Investigations: *Groundwater Monitoring & Remediation*, 34: 79–92. doi: 10.1111/gwmr.12086

Brewer, R., Peard, J. and M. Heskett. 2017a. A critical review of discrete soil sample reliability, Part 1 – Field study results: *Soil and Sediment Contamination*, 26 (1).

Brewer, R., Peard, J. and M. Heskett. 2017b. A critical review of discrete soil sample reliability, Part 2 – Implications: *Soil and Sediment Contamination*, 26 (1).

CAEPA. 2015. Advisory – Active Soil Gas Investigation: California Environmental Protection Agency, Department of Toxic Substances Control. July 2015.

Chou, S.J., Holler, J. and C.T. de Rosa. 1998. Minimal Risk Levels for Hazardous Substances: *Journal of Clean Technology, Environmental Toxicology and Occupational Medicine*, 7 (1): 1-24.

CH2M. 2017. (pending) *Environmental Site Assessment 515 Lagoon Drive*: Prepared for Honolulu Authority for Rapid Transportation. Honolulu.

EST. 2002a. *Limited Phase II Environmental Site Assessment, Al Phillips Facility, 515 Lagoon Drive, Honolulu, Hawaii*: EnviroServices and Training, Honolulu. April 2002.

EST. 2002b. *Passive Soil Vapor Survey Report, Al Phillips Facility, 515 Lagoon Drive, Honolulu, Hawaii*: EnviroServices and Training, Honolulu. September 2002.

Hadley, P.W. and Sedman, R.M. 1992. How hot is that spot? *J. Soil Cont.* 3: 217–225.

Hadley, P.W. and Petrisor, I.G. 2013. Incremental sampling, challenges and opportunities for environmental forensics: *Environ. Forensics* 14: 109–120.

HDOH, 2014a, *Decision Error Associated with the use of Discrete Soil Sample Data in Environmental Investigations, Part 1: Field Investigation of Discrete Sample Variability*: Hawai'i Department of Health, Hazard Evaluation and Emergency Response. October 2014.

HDOH, 2014b, *Decision Error Associated with the use of Discrete Soil Sample Data in Environmental Investigations, Part 2: Implications*: Hawai'i Department of Health, Hazard Evaluation and Emergency Response. October 2014.

HDOH 2016a. *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater* (Summer 2016 and updates): Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response.

HDOH. 2016b. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*. Interim Final: Hawaii Department of Health Honolulu, Office of Hazard Evaluation and Emergency Response. Updated August 2016.

ITRC. 2007. *Vapor Intrusion Pathway, A Practical Guideline*: Interstate Technology Regulatory Council. January 2007.

ITRC. 2012. *Incremental Sampling Methodology*: Interstate Technology Regulatory Council Washington, DC.

Luo, H., P. Dahlen, P.C. Johnson, T. Peargin, and T. Creamer. 2009. Spatial variability of soil-gas concentrations near and beneath a building overlying shallow petroleum hydrocarbon impacted soils. *Groundwater Monitoring & Remediation* 29, (1): 81–91.

MacDonald, G. A., A. T. Abbott, and F. L. Peterson. 1983. *Volcanoes in the Sea, The Geology of Hawaii*. 2nd ed. Honolulu: Univ. of Hawaii Press.

McAlary, T.A., Nicholson, P.J., Yik, L.K., Bertrand, D.M. and G. Thrupp. 2010. High Purge Volume Sampling - A New Paradigm for Subslab Soil Gas Monitoring: *Ground Water Monitoring and Remediation*. 30 (2): 73–85

Mink, J. F., and L. S. Lau. 1990. *Aquifer Identification and Classification for Oahu: Groundwater Protection Strategy for Hawaii*. Revised. Tech. Report No. 179. Honolulu: Univ. of Hawaii, Water Resources Research Center. February 1990.

NJDOH. 2011. *Isopropyl Alcohol Hazardous Substance Fact Sheet*: New Jersey Department of Health. April 2011.

Pitard, F.F. 1993. *Pierre Gy's sampling theory and sampling practice*. New York: CRC Press.

Pitard, F.F. 2005. *Sampling correctness – A comprehensive guideline*. In Proceedings of Sampling and Blending Conference, Sunshine Coast, Queensland, Australia, May 9–12, 2005.

Pitard, F.F. 2009. *Theoretical, practical and economic difficulties in sampling for trace constituents*. In Proceedings of the Fourth World Conference on Sampling and Blending, The Southern African Institute of Mining and Metallurgy, Cape Town, October 19–23, 2009.

Ramsey, C. A. and Hewitt, A.D. 2005. A methodology for assessing sample representativeness. *Environ. Forensics* 6: 71–75.

Schmidt, M.A. 2012. Innovative sampling methods for focusing the subslab soil-gas investigation. Paper presented at the annual meeting for *Air Quality Measurement Methods and Technology*, Durham, NC, April 24–26, 2012.

USDA. 1972. *Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii*: United States Department of Agriculture, Soil Conservation Service. Washington, DC. August 1972.

USGS. 1998. *Geohydrology of the Central Oahu, Hawaii*: U.S. Geological Survey, Water-Resources Investigations Report 97-4276.

USEPA. 1985. *Verification of PCB Spill Cleanup by Sampling and Analysis*: U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, DC. EPA-560/5-85-026. August 1985.

USEPA. 1986. *Field Manual for Grid Sampling of PCB Spill Sites to Verify Cleanups*: U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, DC. EPA-560/5-86-017. May 1986.

USEPA. 2002. *Guidance on Environmental Data Verification and Data Validation*: US Environmental Protection Agency, Office of Environmental Information. EPA/240/R-02/004. November 2002.

USEPA. 2004. *User's Guide for Subsurface Vapor Intrusion into Buildings*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

USEPA. 2012. *EPA's Vapor Intrusion Database: Evaluation and Characterization of Attenuation Factors for Chlorinated Volatile Organic Compounds and Residential Buildings*: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, DC. EPA 530-R-10-002.

USEPA. 2015a. *Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC. OSWER Publication 9200.2-154. June 2015

USEPA. 2015b. *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites*: U.S. Environmental Protection Agency, Office of Underground Storage Tanks, Washington, DC. EPA 510-R-15-001. June 2015.

USEPA. 2016. *Screening Levels for Chemical Contaminants*: U.S. Environmental Protection Agency, prepared by Oak Ridge National Laboratories. May 2016.

.

FIGURES

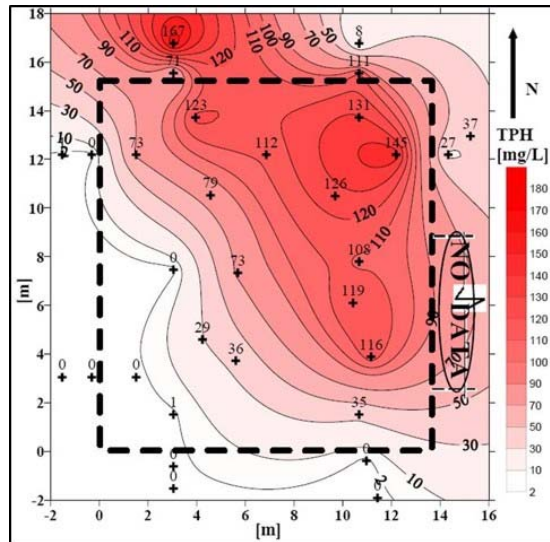


Figure 1-1. Example of vapor plume heterogeneity beneath a building slab (Luo et al. 2009).

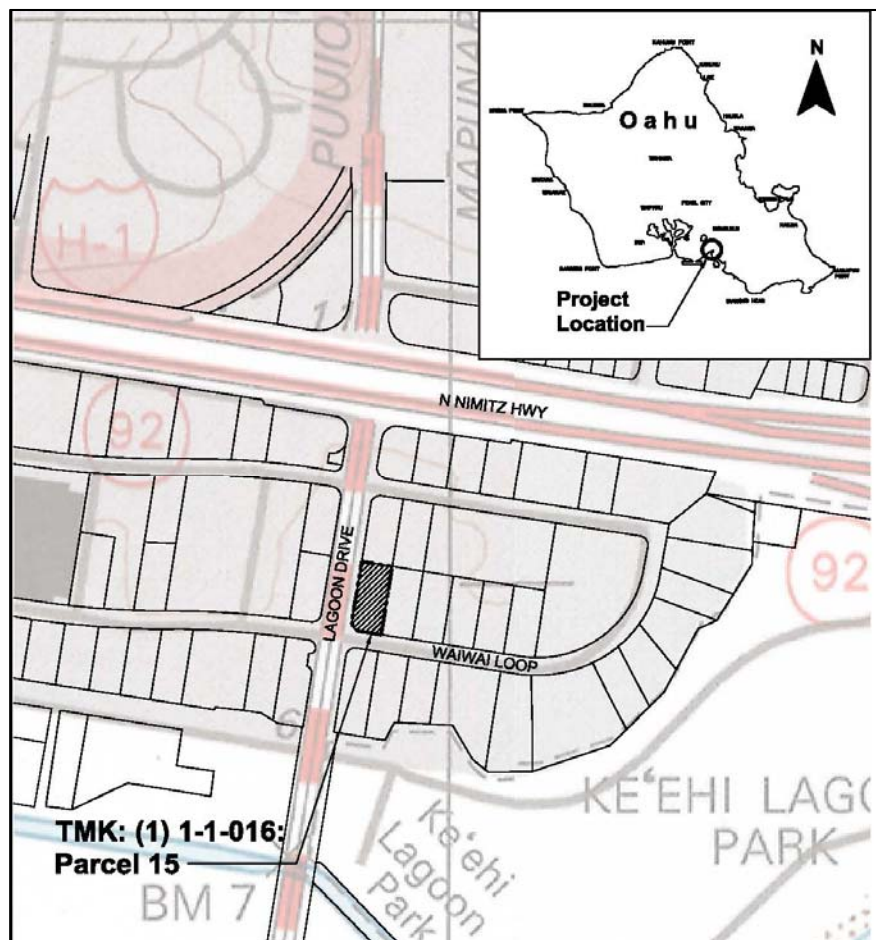


Figure 2-1. Site location at 515 Lagoon Drive in Honolulu, Hawaii (modified from AECOM 2013a).

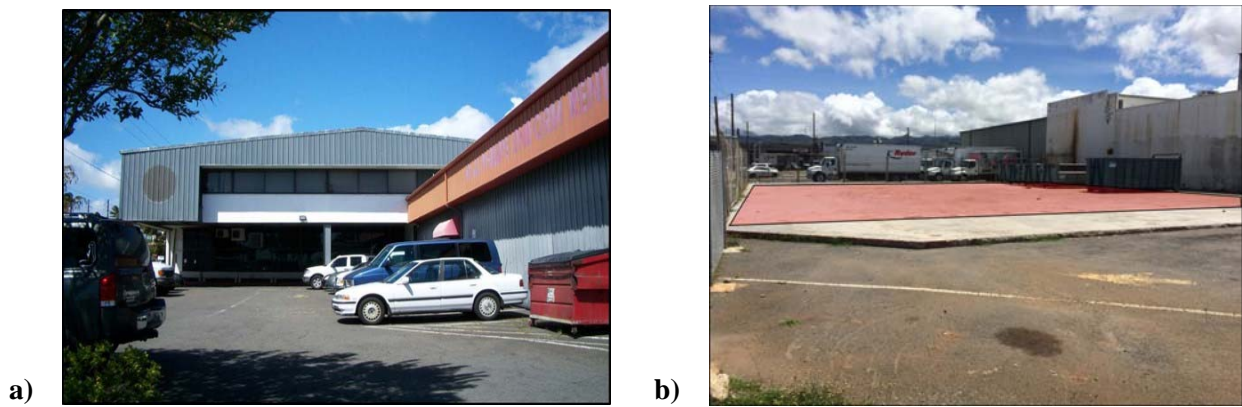


Figure 2-2. Dry cleaner operating at the site until 1997 (AECOM 2013a); a) photo of facility prior to closure (looking north), b) photo of facility in 2016 after removal of structure with only the original slab remaining (study area portion of slab highlighted in red).

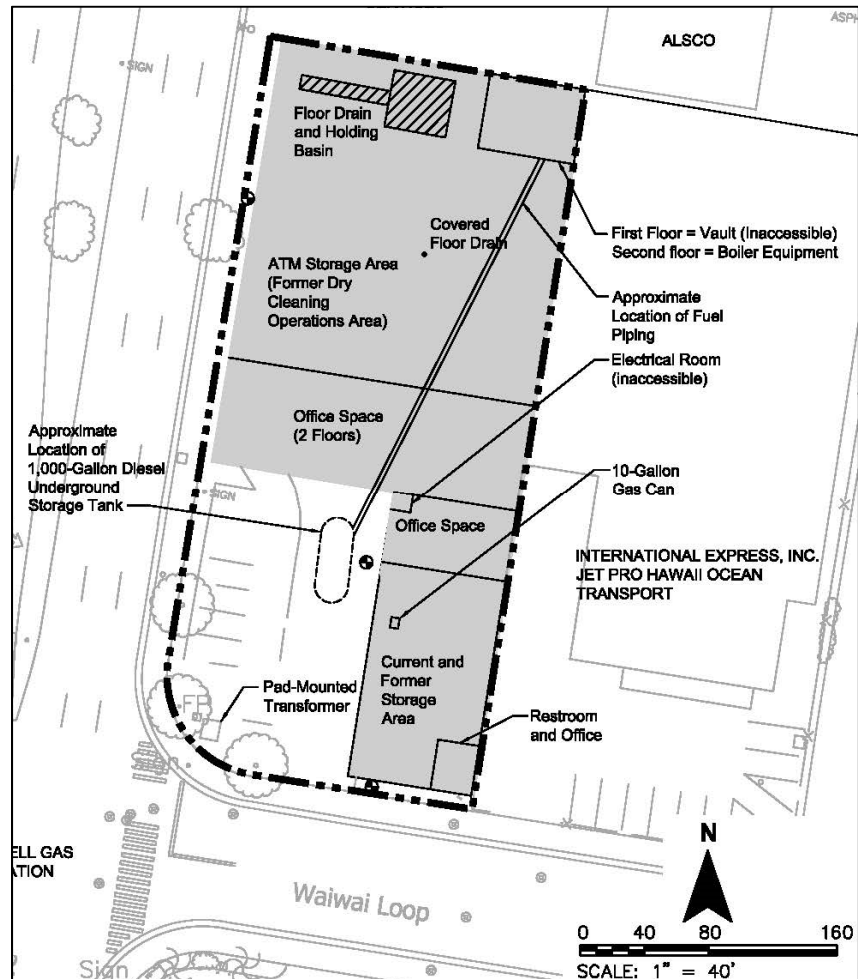


Figure 2-3. Original layout of former dry cleaning operations (modified from AECOM 2013a).

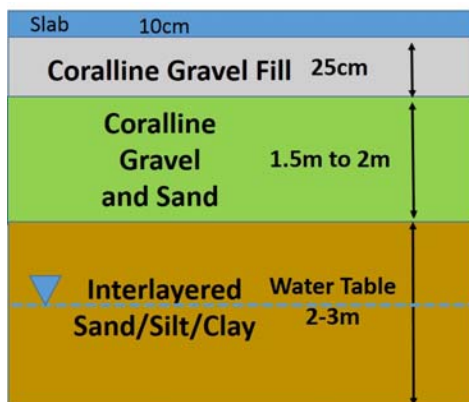


Figure 2-4. Site Stratigraphy.

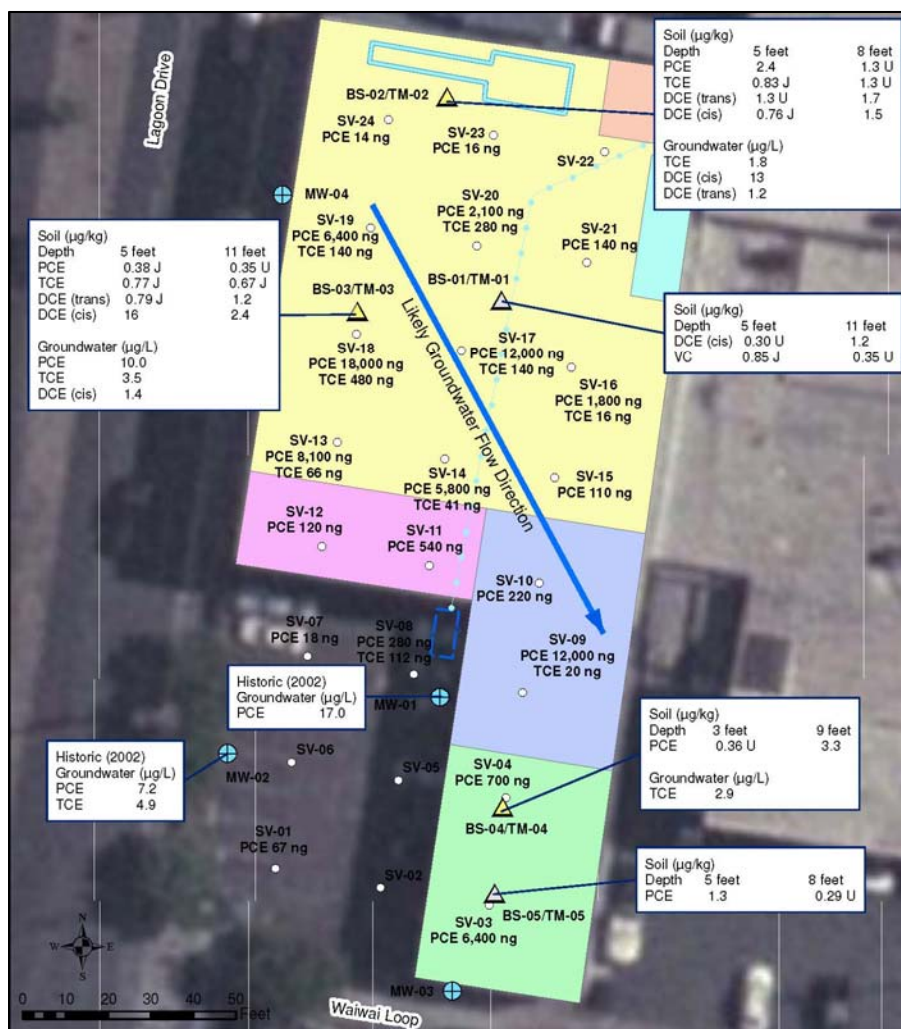


Figure 2-5. Summary of EST (2002b) soil vapor data, includes AECOM (2013) soil and groundwater data (modified from summary map presented in AECOM 2013).

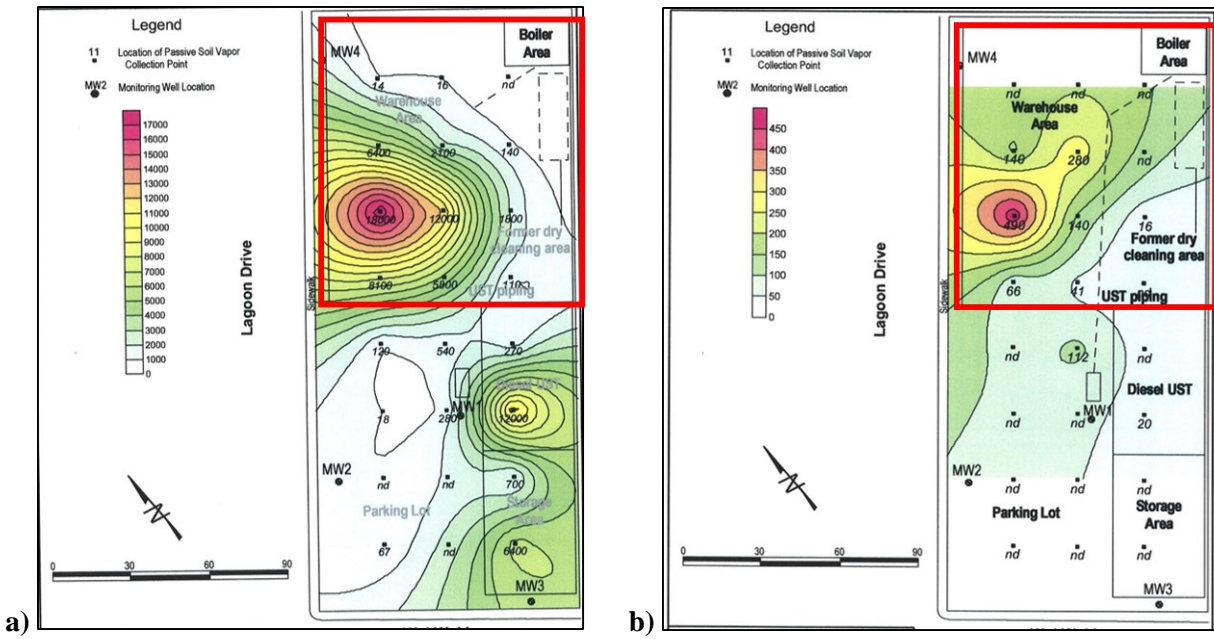


Figure 2-6. Isoconcentration map of 2002 passive soil vapor data (EST 2002b); a) PCE vapors; b) TCE vapors.

Figure 2-7 (reserved). Designation of DUs for 2016-2017 MIS investigation of subslab soil (CH2M 2017).

Figure 2-8 (reserved). Preparation of borehole DU MI samples by collection of regularly spaced, five-gram plugs from the entire core; plugs combined in methanol in the field or frozen for combination and extraction at the laboratory.

Figure 2-9 (reserved). Preparation of DU layer MI samples by collection of regularly spaced, five-gram plugs from individually targeted layers across all DU boreholes (placed in methanol in the field or frozen for combination and extraction at the laboratory).

Figure 2-10 (reserved). Summary of row and column MI data collected during the 2016-2016 site investigation (CH2M 2017; preliminary data).



Figure 2-11. Summary of 2016 active soil gas data (CH2M 2017; preliminary data).

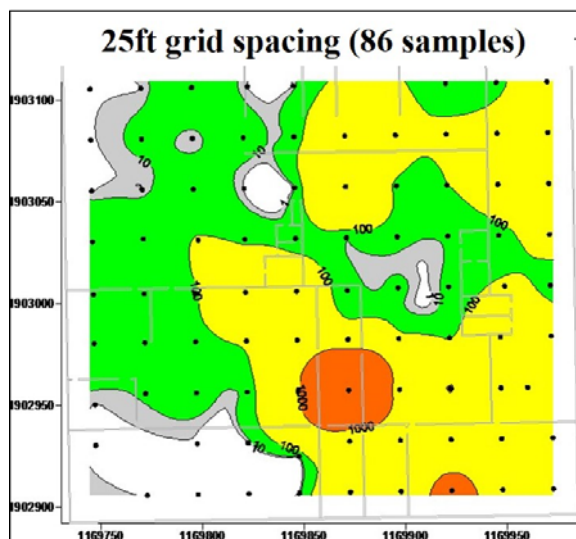


Figure 3-1. Example of subslab vapor plume heterogeneity beneath approximate 40,000 ft² industrial building slab (image provided by Chuck Schmidt).

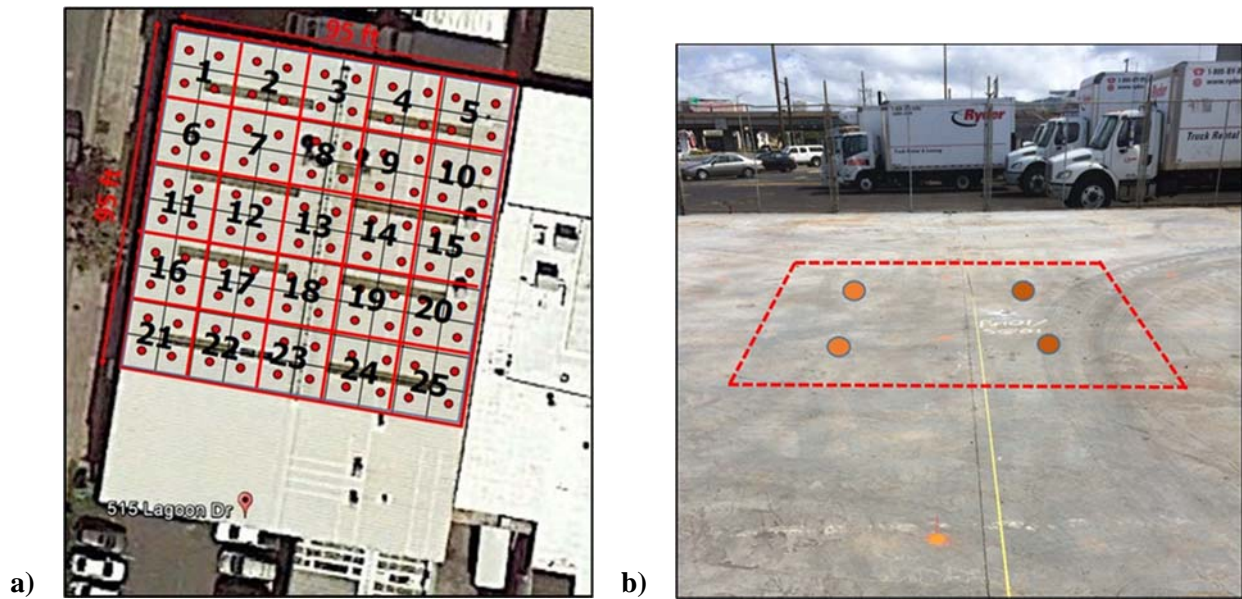


Figure 3-2. Subdivision of the targeted slab area into 25 grid cells for testing and identification of large-scale, vapor plume patterns beneath the slab; a) Grid cell areas, b) Default passive sampler installation design (cells 1-9, 11-12, 14-16, 18-23, 25).

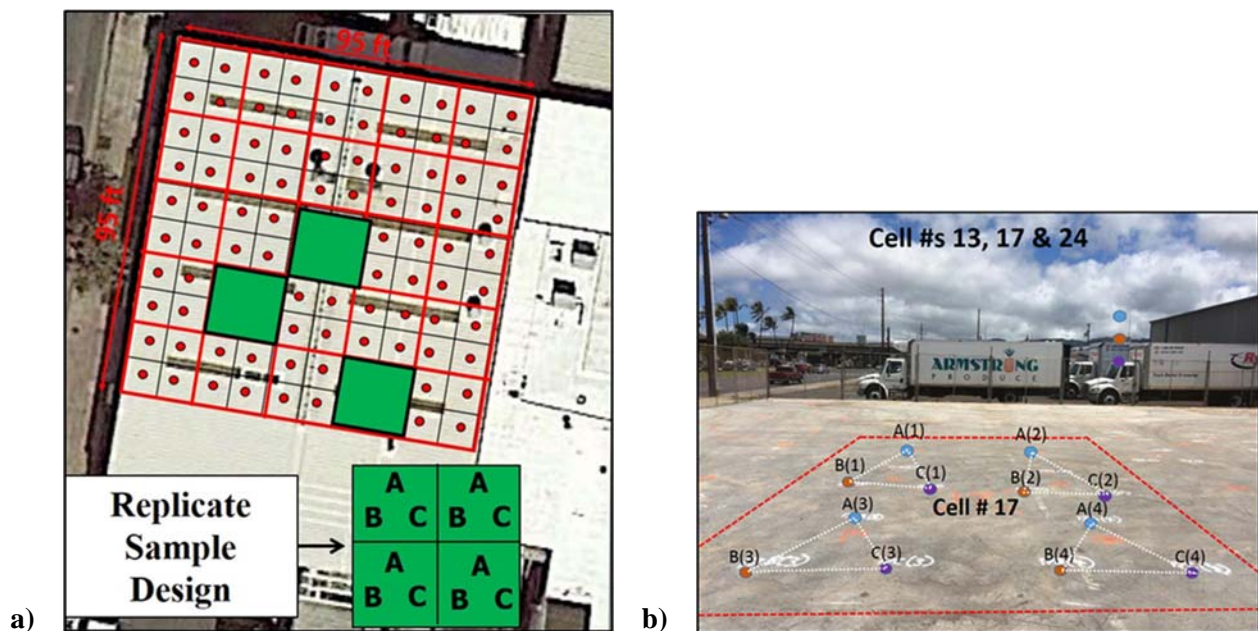


Figure 3-3. Triplicate design for passive samplers; a) Targeted grid cells (cells 13, 17 and 24); b) Replicate sampler sets A, B and C layout.

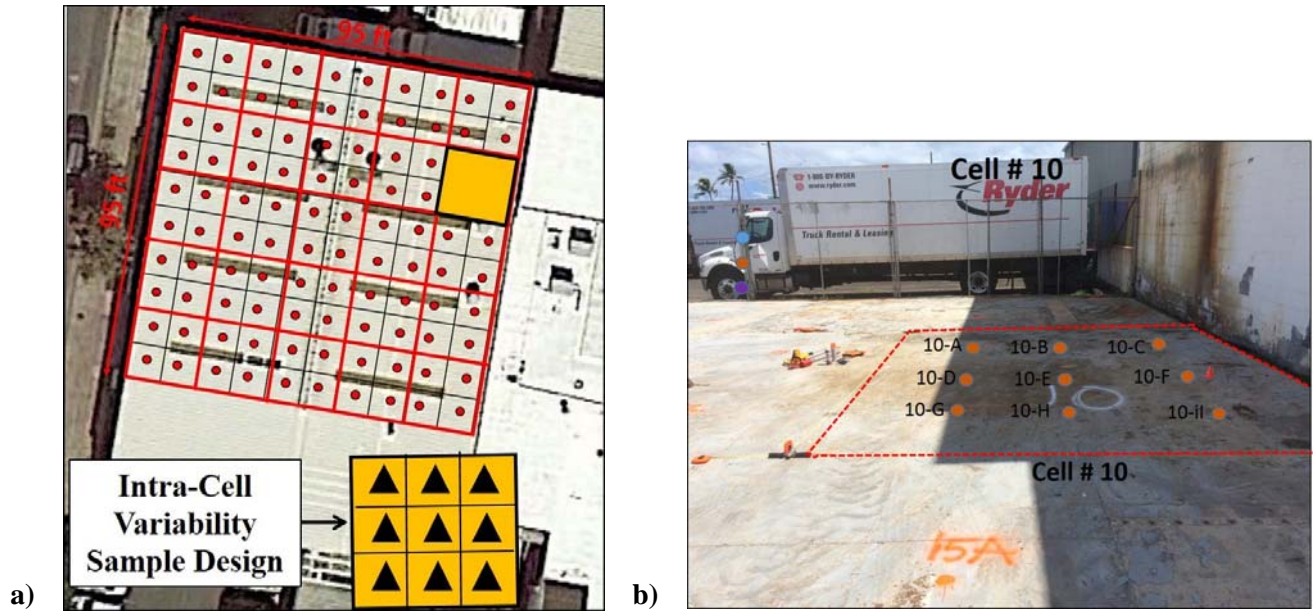


Figure 3-4. Sampler installation design for evaluation of small-scale, subslab vapor variability in Grid Cell 10.

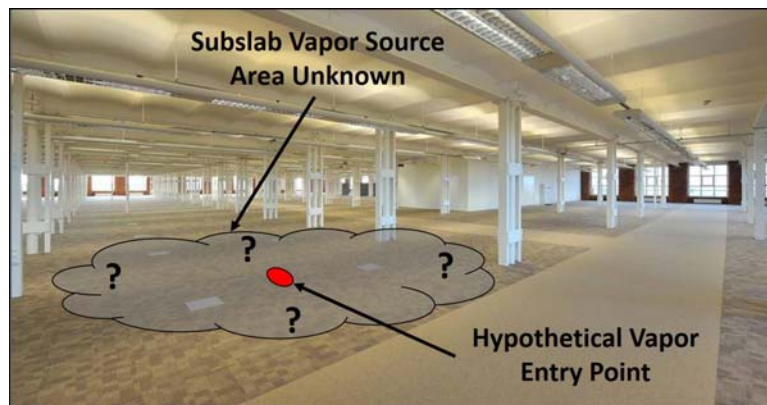


Figure 3-5. Hypothetical vapor entry point in a build slab to be used for the collection of Large Purge Volume (LVP) subslab vapor samples. The exact source area of the vapors is unknown and unimportant in terms of assessment of vapor intrusion risk.



Figure 4-1. Passive vapor sampler produced by Beacon Environmental.

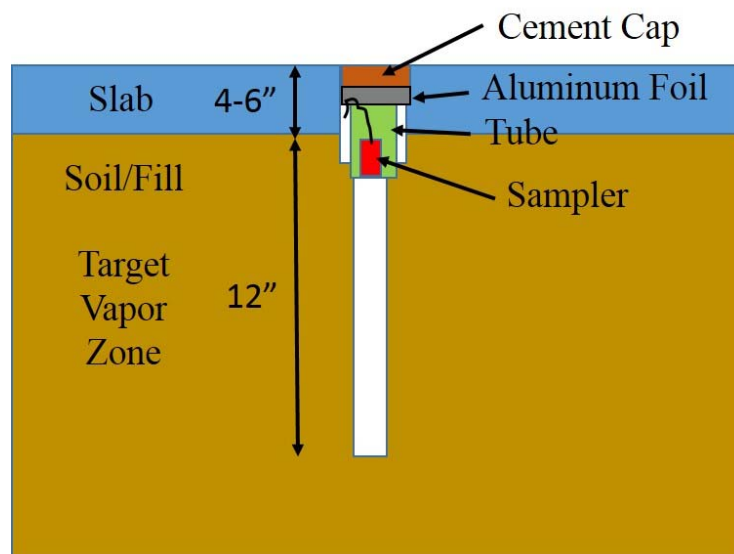


Figure 4-2. Passive sampler installation schematic.

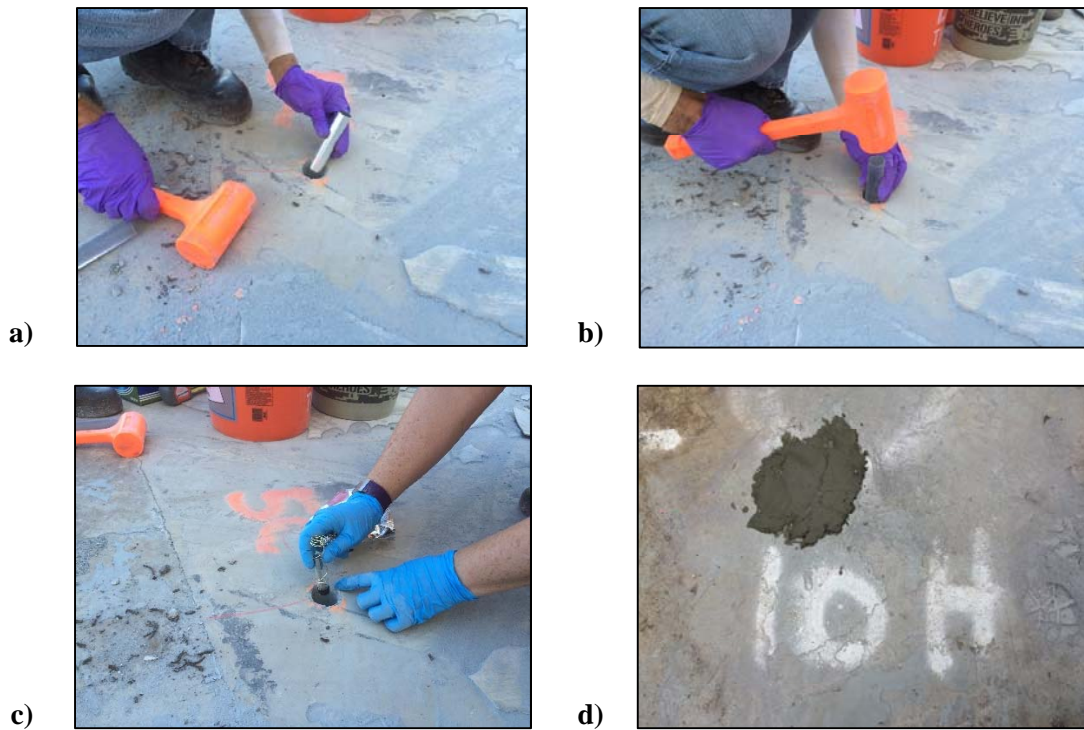


Figure 4-3. Passive sampler installation (see Figure 4-2): a) One-inch, aluminum tube inserted into 1 ½ inch boring through slab; b) Tube tamped into underling soil; c) Beacon passive sampler placed in tube; d) Sample point sealed with aluminum foil and concrete grout.

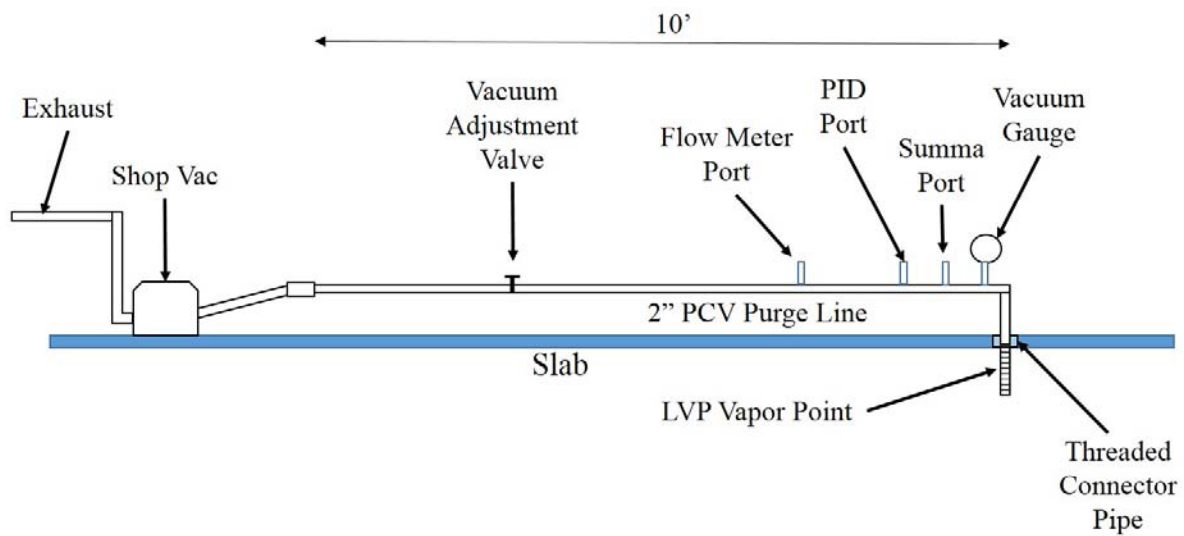


Figure 4-4. Simplified schematic of Large-Volume Purge sampling train.

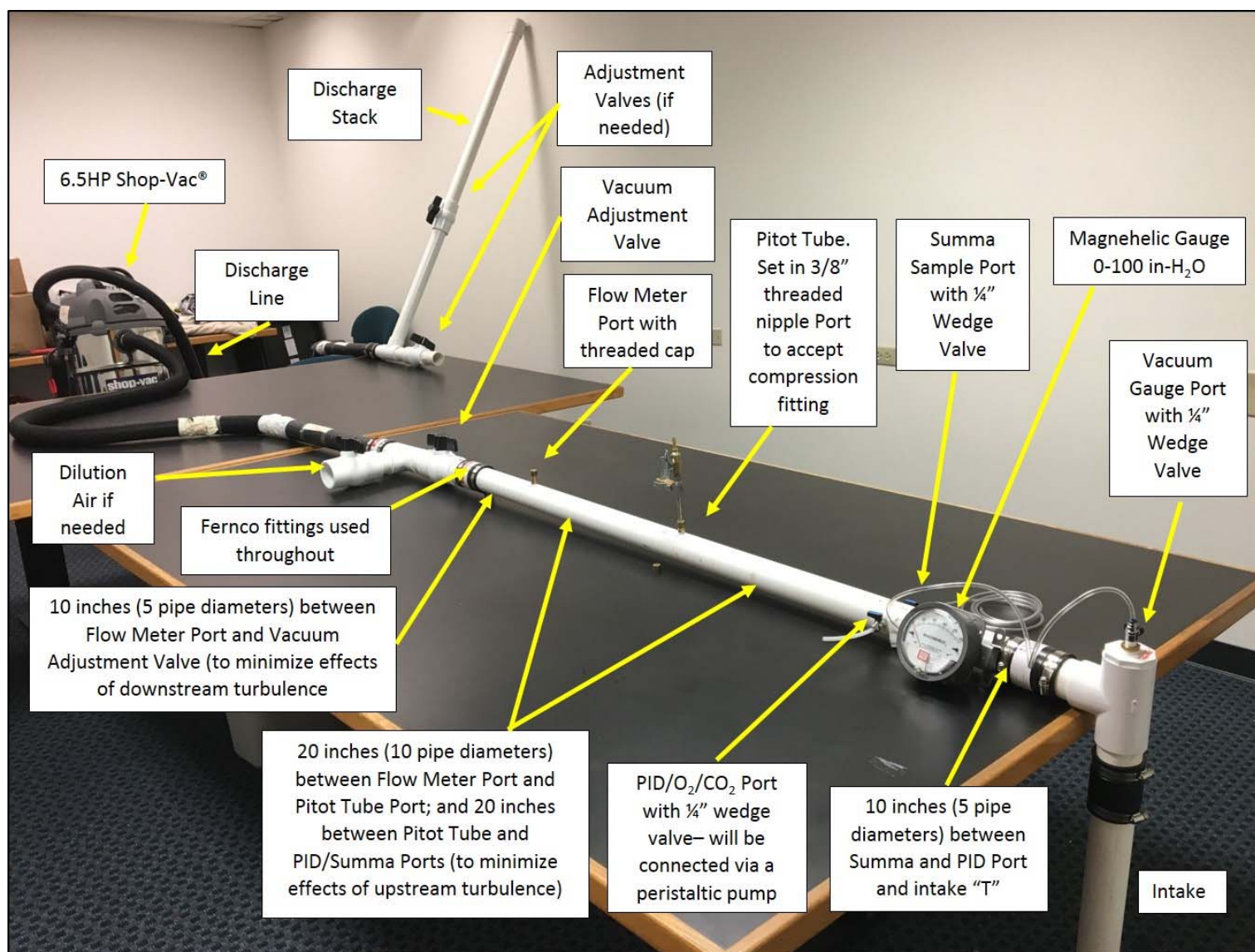


Figure 4-5a. Detailed design of LVP purge stream (profile view).

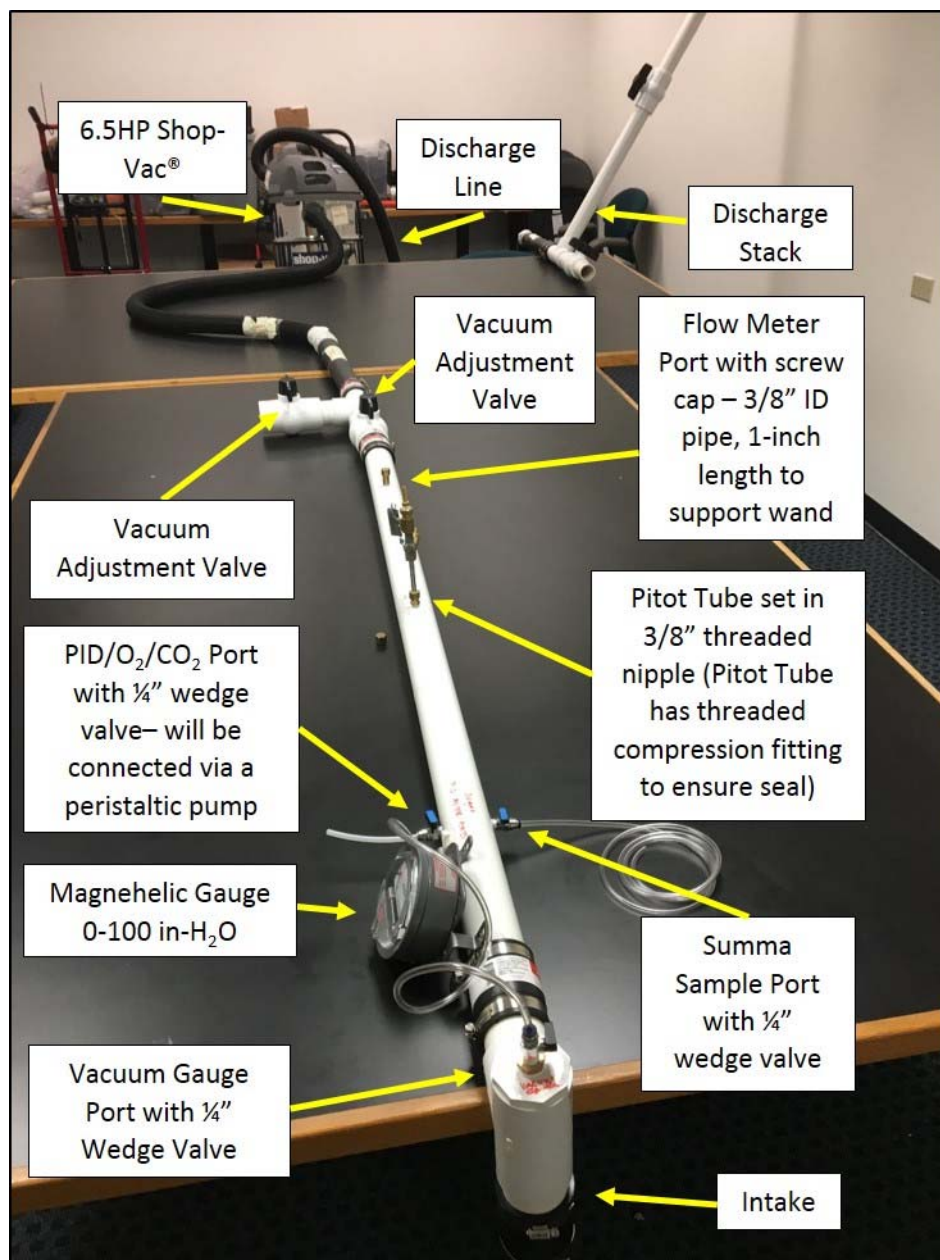


Figure 4-5b. Detailed design of LVP purge stream (plan view).

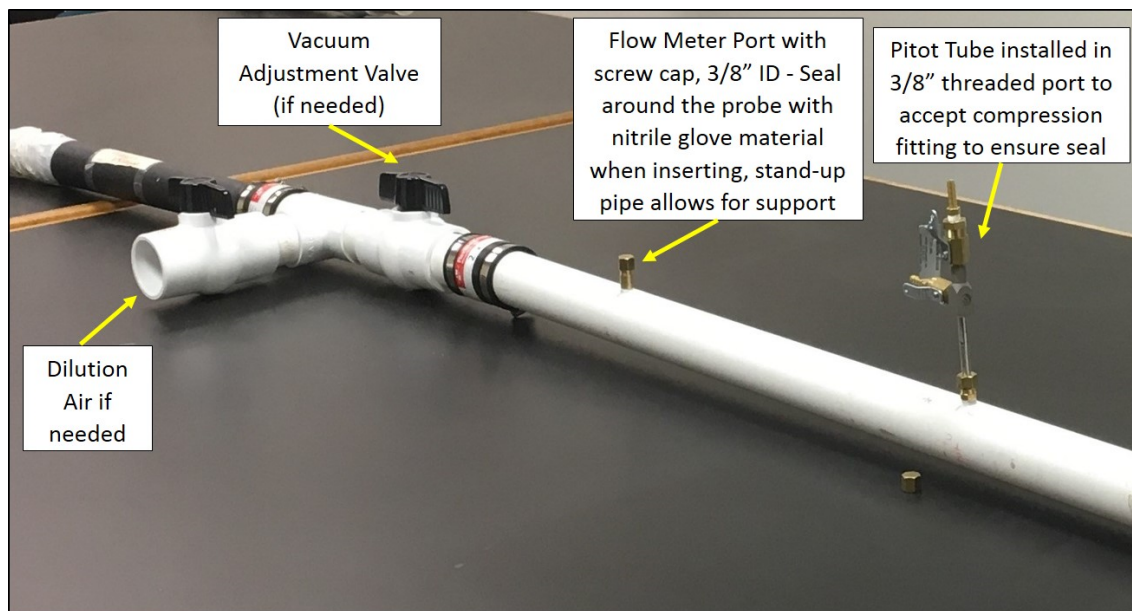


Figure 4-6. Close-up of LVP purge valves.



Figure 4-7. Latex, weather balloon used to check flow rate meters and evaluate purge times required to reach target, 7,000-liter purge volumes (target volume reached when balloon diameter = 2.4 m or 7.8 ft).

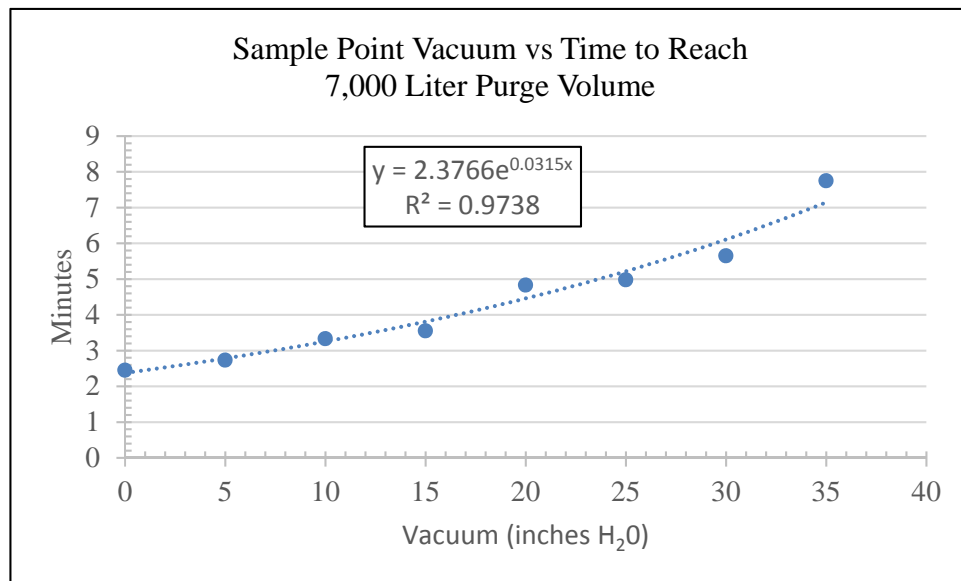


Figure 4-8. Data plot of well point vacuum versus time.

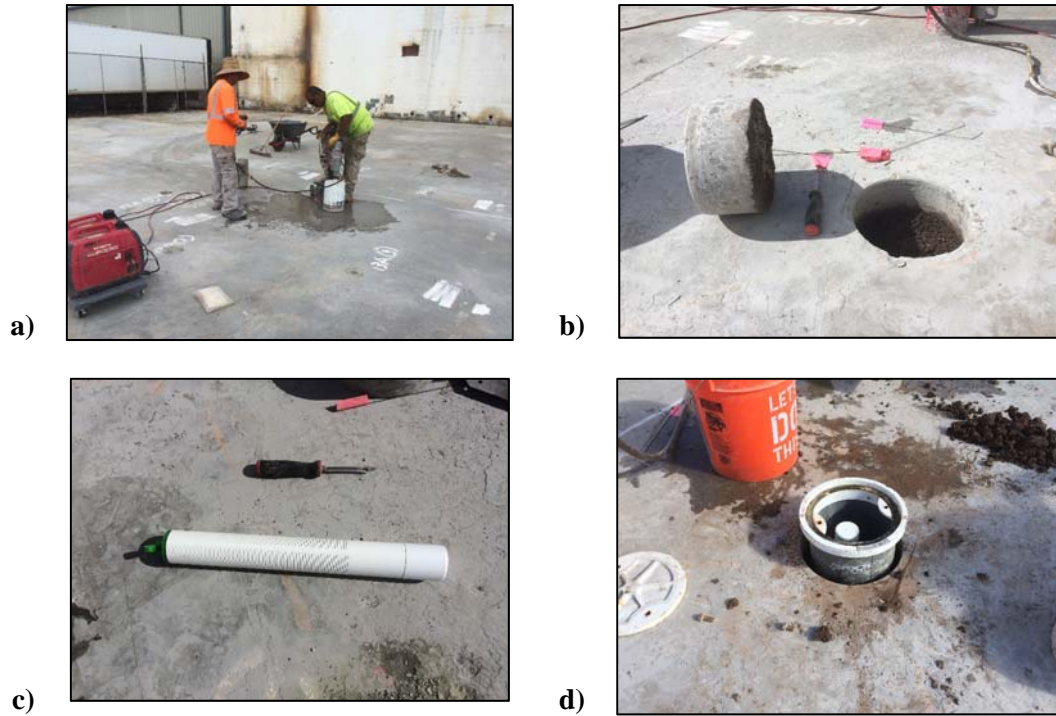


Figure 4-9. Installation of LVP vapor extraction point: a) Circular saw used to cut eight-inch hole in concrete for installation of vapor point and protective casing (latter not normally included); b) Completed hole; c) Two-inch PVC vapor point; d) Completed vapor point (interior sealed with cement grout).

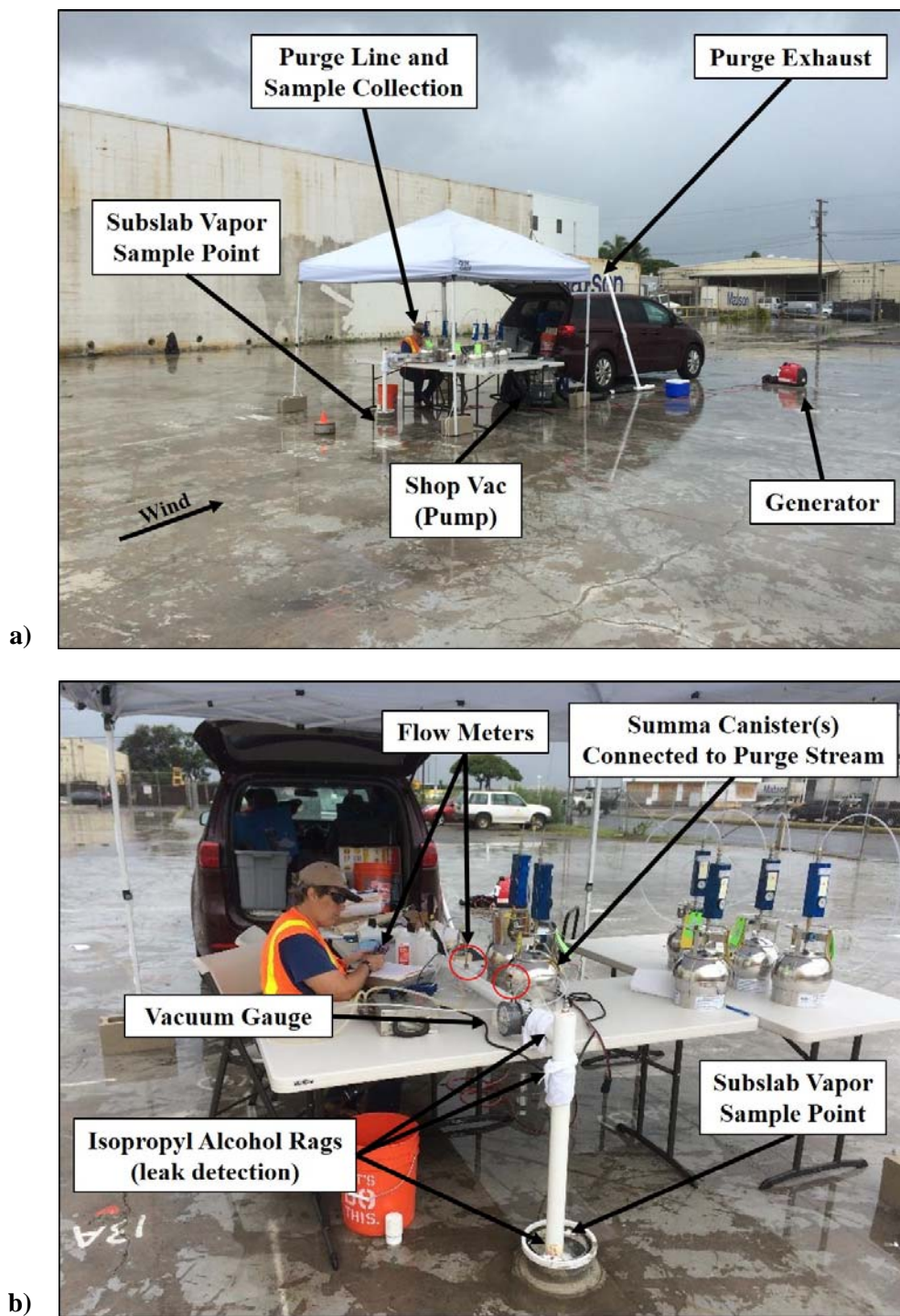


Figure 4-10. Completed field LVP sample collection set up: a) Overall system, b) Close up of system components.

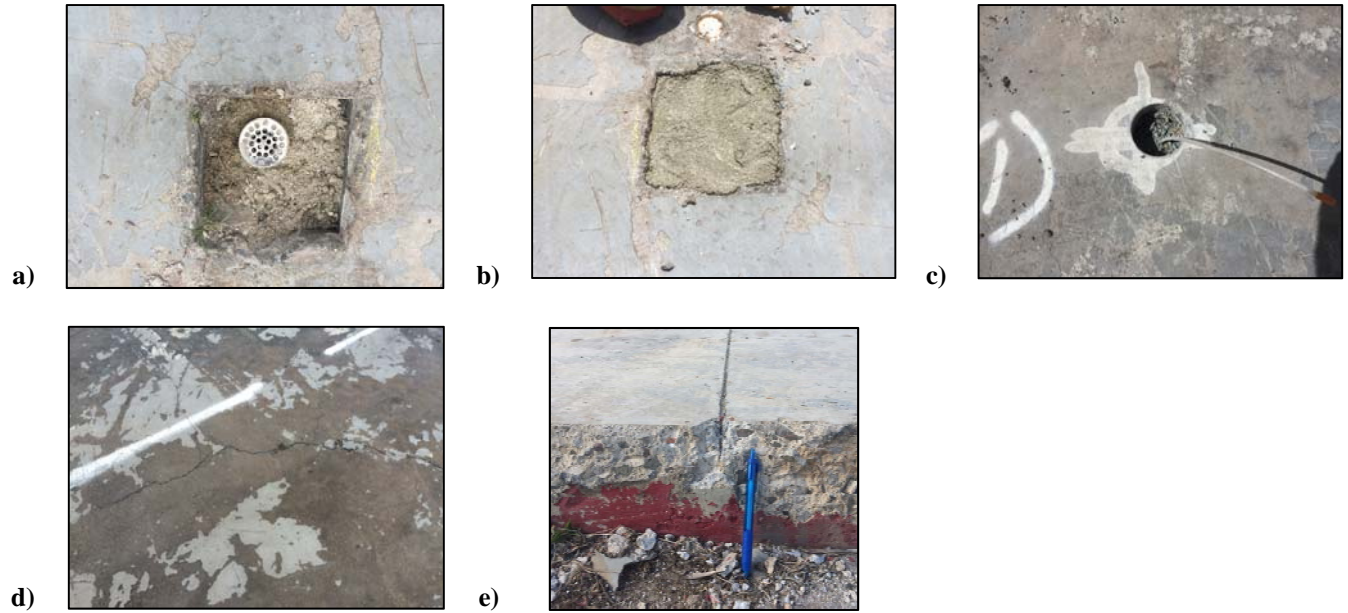


Figure 4-11. Sealing of slab drains and utility gaps in within immediate vicinity of vapor extraction point:
a) Floor drain (common source of leaks into subsurface soil); b) sealed drain; c) Soil vapor point in slab from previous investigations; d) Cracks in surface of pad; e) Side view of slab depicting lack of crack penetration through full slab thickness at expansion joints.



Figure 4-12. Weather balloon (vinyl) field test used to cross-check the purge volumes estimated from by flow rate meters; comparison of balloon volume to flow rate measurements and purge time indicated good correlation.

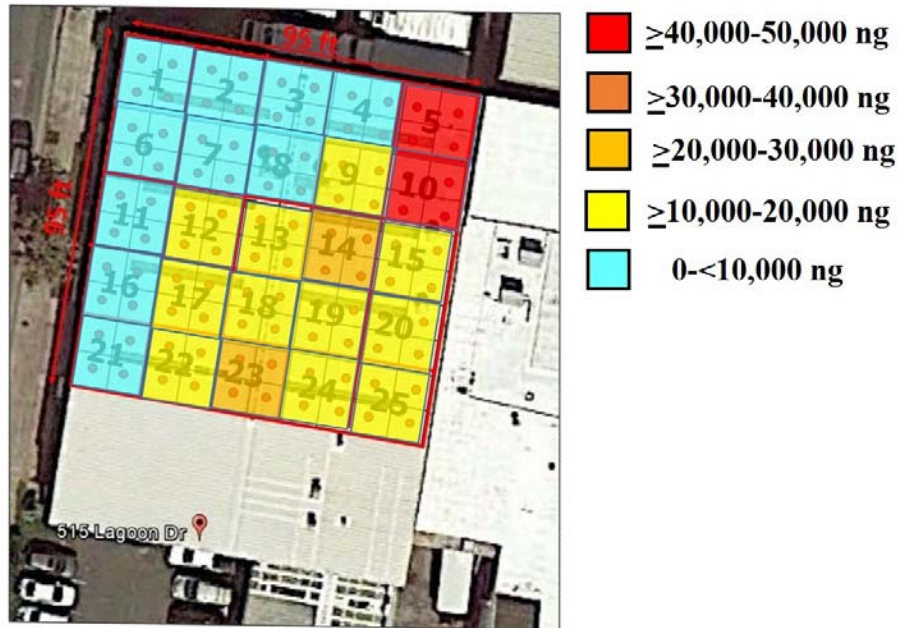


Figure 5-1. Summary of passive sampler data, based on assignment of reported PCE mass for individual grid cells.

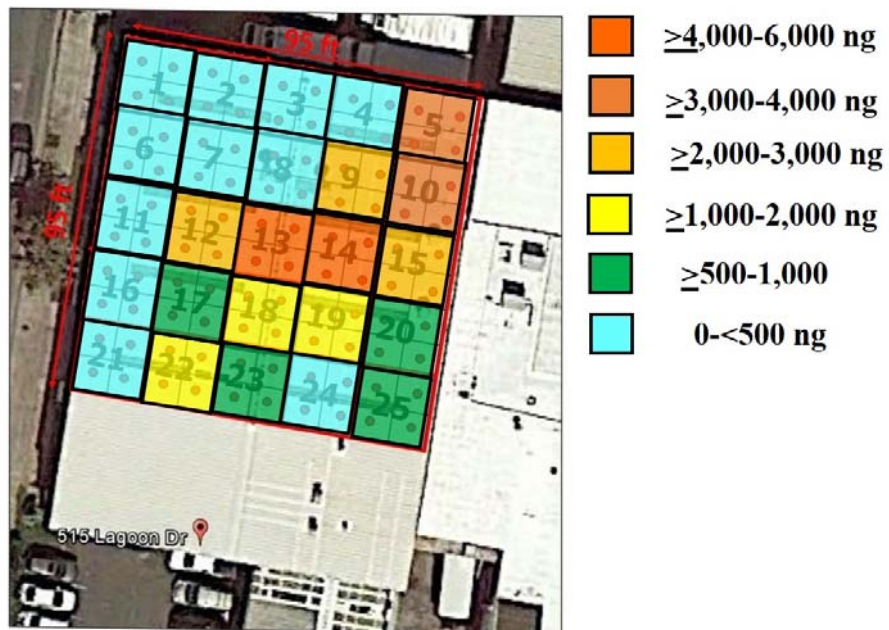


Figure 5-2. Summary of passive sampler data, based on assignment of reported TCE mass for individual grid cells (note different color scale).

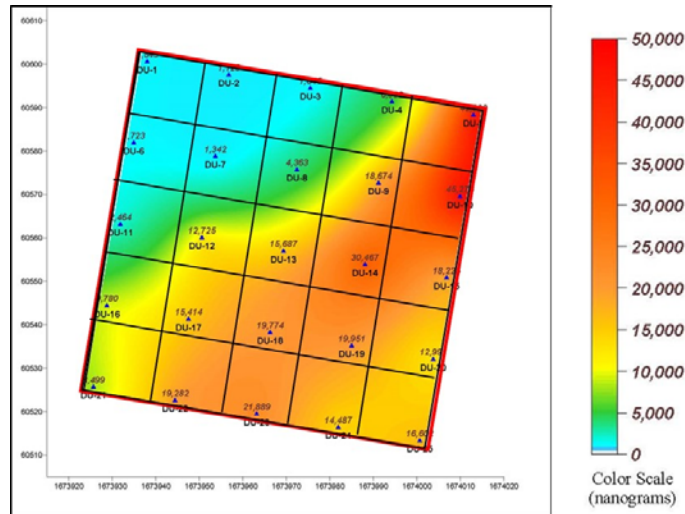


Figure 5-3. Alternative interpretation of the PCE passive sampler data by Beacon Environmental Services, generated by assigning the reported mass for each grid cell set to the center point of the grid cell and inputting the data into an isoconcentration mapping program (compare to Figure 5-1; grid cells superimposed on image). Resolution of program set to reduce emphasis on any single point and minimize the generation of seemingly isolated and potentially artificial hot spots and cold spots. Precision of variability predicted within individual cells is unknown.

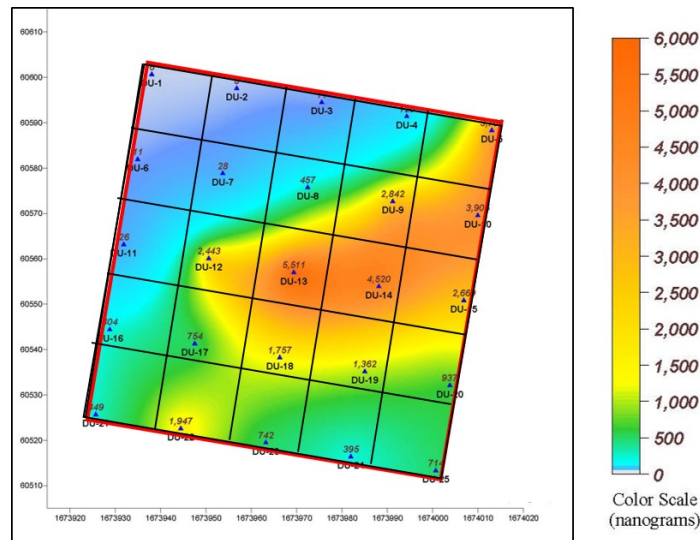


Figure 5-4. Alternative interpretation of the TCE passive sampler data by Beacon Environmental Services (compare to Figure 5-2; note change in color scale).

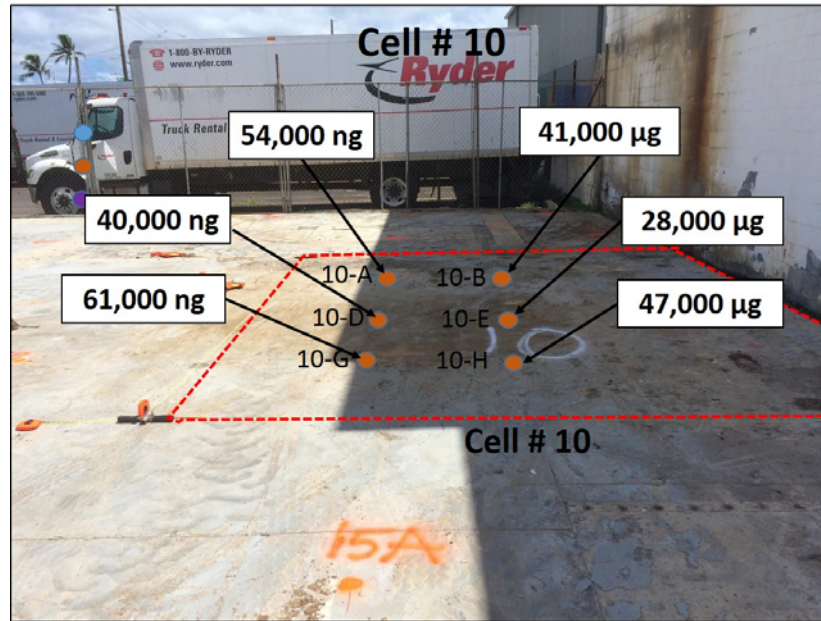


Figure 5-5. Variability of PCE in six passive samplers installed in Grid Cell 10 which were individually tested.

TABLES

Table 2-1. Summary of 2002 soil investigation ¹data (EST 2002a)

Sample ID	TPHg (mg/L)	TPHd (mg/L)	TPHrf (mg/L)	PCE (mg/L)	TCE (mg/L)	cis-1,2-DCE (mg/L)	trans-1,2-DCE (mg/L)
SS.B1.7	nd	350	nd	nd	nd	nd	nd
SS.B2.7	nd	64	nd	0.480	nd	nd	nd
SS.B3.7	nd	5.9	nd	nd	nd	nd	nd
SS.B4.7	nd	110	nd	nd	nd	nd	nd
SS.B5.7	nd	45	nd	nd	nd	nd	nd
SS.B6.7	nd	46	nd	nd	nd	nd	nd
SS.B7.8	nd	53	nd	0.490	nd	nd	nd
SS.B8.8	nd	30	nd	nd	0.099	nd	nd
SS.B9.8	nd	79	nd	0.180	0.230	nd	0.410
SS.B10.7	nd	95	nd	nd	nd	nd	nd
MDL	20	20	20	0.20-0.25	0.20-0.25	0.20-0.25	0.20-0.25
² HDOH EAL	500	500	2,500	4.2	0.21	0.83	8.3

Notes:

cis-1,2-DCE = cis-1,2-Dichloroethylene

trans-1,2-DCE = trans-1,2-Dichloroethylene

PCE = Tetrachloroethene

TCE = Trichloroethene

TPHd = Total petroleum hydrocarbons as diesel

TPHg = Total petroleum hydrocarbons as gasoline

TPHrf = Total petroleum hydrocarbons as residual fuel

mg/L = milligrams per liter

MDL = Method detection limit

nd = not detected above MDL

1. discrete soil samples.

2. Soil action level for commercial/industrial sites not located over a source of drinking water and >150m from a surface water body (HDOH 2016a); TPHg and TPHd action levels do not address potential vapor intrusion risks (soil vapor required).

Table 2-2. Summary of 2002 groundwater investigation data (EST 2002a)

Sample ID	TPHg (µg/L)	TPHd (µg/L)	TPHrf (µg/L)	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)
MW1	nd	nd	nd	0.017	nd	nd	nd
MW2	nd	nd	nd	0.0072	0.0049	nd	nd
MW3	nd	nd	nd	nd	nd	nd	nd
MW4	nd	nd	nd	nd	nd	nd	nd
MDL	0.60	0.60	1.0	0.001	0.001	0.001	0.001
¹ HDOH EAL	5,000	5,000	2,500	1,700	700	5,500	2,600

Notes:

cis-1,2-DCE = cis-1,2-Dichloroethylene

trans-1,2-DCE = trans-1,2-Dichloroethylene

PCE = Tetrachloroethene

TCE = Trichloroethene

TPHd = Total petroleum hydrocarbons as diesel

TPHg = Total petroleum hydrocarbons as gasoline

TPHrf = Total petroleum hydrocarbons as residual fuel

µg/L – micrograms per liter

MDL = Method detection limit

nd = not detected above MDL

1. Groundwater action level for commercial/industrial sites not located over a source of drinking water and >150m from a surface water body (HDOH 2016a); TPHg and TPHd action levels do not address potential vapor intrusion risks (soil vapor required).

Table 2-3. Summary of 2002 groundwater investigation data (EST 2002a)

Sample ID	TPHd (µg)	PCE (ng)	TCE (ng)
01	nd	67	nd
02	nd	nd	nd
03	nd	6,400	nd
04	nd	700	nd
05	nd	nd	nd
06	nd	nd	nd
07	nd	18	nd
08	nd	280	nd
09	nd	12,000	20
10	nd	270	nd
11	nd	540	12
12	nd	120	nd
13	nd	8,100	66
14	nd	5,800	41
15	nd	110	nd
16	nd	1,800	16
17	nd	12,000	140
18	nd	18,000	490
19	nd	6,100	140
20	400	2,100	280
21	nd	140	nd
22	nd	nd	nd
23	nd	16	nd
24	nd	14	nd
MDL	10 µg	5 ng	5 ng

Notes:

µg = micrograms

ng = nanograms

PCE = Tetrachloroethene

TCE = Trichloroethene

TPHd = Total petroleum hydrocarbons as diesel

MDL = Method detection limit

nd = not detected above MDL

Table 2-4. Summary of 2013 soil investigation ¹data (AECOM 2013b)

Sample ID	TPHg (mg/kg)	TPHd (mg/kg)	TPHrf (mg/kg)	PCE (mg/kg)	TCE (mg/kg)	cis-1,2-DCE (mg/kg)	trans-1,2-DCE (mg/kg)
BS-01 (5)	nd	26	150	0.0024	83	0.00076	nd
BS-01 (8)	nd	nd	nd	nd	nd	0.0015	0.0017
BS-02 (5)	nd	nd	nd	nd	nd	nd	nd
BS-02	nd	nd	nd	nd	nd	0.0012	
BS-03 (5)	nd	nd	nd	0.00038	0.00077	0.016	0.00079
BS-03	nd	nd	nd	nd	0.00067	0.0024	0.0012
BS-04 (3)	nd	nd	nd	nd	nd	nd	nd
BS-04 (9)	0.94	nd	24	0.0033	nd	nd	nd
BS-05 (5)	0.89	nd	nd	0.0013	nd	nd	nd
BS-05 (8)	nd	nd	nd	nd	nd	nd	nd
MDL	0.65-4.5	5.1 – 6.1	16-19	0.00029-0.0013	0.00028-0.0013	0.00028-0.0013	0.00028-0.0013
² HDOH EAL	500	500	2,500	4.2	0.21	0.83	8.3

Notes:

cis-1,2-DCE = cis-1,2-Dichloroethene

trans-1,2-DCE = trans-1,2-Dichloroethene

PCE = Tetrachloroethene

TCE = Trichloroethene

TPHd = Total petroleum hydrocarbons as diesel

TPHg = Total petroleum hydrocarbons as gasoline

TPHrf = Total petroleum hydrocarbons as residual fuel

mg/kg = milligrams per kilogram

MDL = method detection limit

nd = not detected above MDL

1. discrete soil samples.

2. Soil action level for commercial/industrial sites not located over a source of drinking water and >150m from a surface water body (HDOH 2016a); TPHg and TPHd action levels do not address potential vapor intrusion risks (soil vapor required).

Table 2-5. Summary of 2013 groundwater investigation data (AECOM 2013b)

Sample ID	TPHg (µg/L)	TPHd (µg/L)	TPHrf (µg/L)	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	trans-1,2-DCE (µg/L)
TM-02	-	550	350	nd	1.8	13	1.2
TM-03	-	280	250	10	3.5	nd	1.4
TM-04	-	330	260	nd	nd	nd	nd
MW-01	-	nd	nd	nd	nd	nd	nd
MW-02	-	nd	nd	nd	nd	nd	nd
MW-03	-	nd	nd	nd	nd	nd	nd
MW-04	-	nd	nd	nd	nd	nd	nd
MDL	-	120	240	1.0	1.0	1.0	1.0
¹ HDOH EAL	5,000	5,000	2,500	1,700	700	5,500	2,600

Notes:

DCE = Dichloroethylene PCE = Tetrachloroethene TCE = Trichloroethene

TPHd = Total petroleum hydrocarbons as diesel

TPHg = Total petroleum hydrocarbons as gasoline

TPHrf = Total petroleum hydrocarbons as residual fuel

µg/L = micrograms per liter

MDL = Method detection limit

nd = not detected above MDL

1. Groundwater action level for commercial/industrial sites not located over a source of drinking water and >150m from a surface water body (HDOH 2016a); TPHg and TPHd action levels do not address potential vapor intrusion risks (soil vapor required).

Table 2-6. Summary of 2017 Row and Column data for subslab soil (CH2M 2017; *reserved*, see also Figure 2-8)

Table 2-7. Summary of 2016 active soil vapor data (CH2M 2017; preliminary data, see also Figure 2-9).

Sample ID	PCE ($\mu\text{g}/\text{m}^3$)	TCE ($\mu\text{g}/\text{m}^3$)	Oxygen (%)	Carbon Dioxide (%)
SLAB001	1,710	19	19.7	0.0
SLAB002	45,000	1,620	18.8	0.1
SLAB003	186,000	2,090	18.9	1.4
SLAB004	9,560	39	16.7	0.4
SLAB005	108,000	346	16.8	2.6
¹ SG001	-	-	-	-
SG002	53,300	855	16.5	5.0
SG003	108,000	2,880	19.5	4.5
SG004	38,900	6,770	12.4	6.0
SG005	50,100	39	14.6	3.7
SG006	6,750	37	17.6	3.9

Notes:

PCE = tetrachloroethylene

TCE = trichloroethene

% = percent

$\mu\text{g}/\text{m}^3$ = micrograms per cubic meter

1. Vapor point could not be sampled due to water.

Table 4-1. Summary of samplers installed, retrieved and combined for testing in each grid cell

Grid Cell Number	Final Number of Samplers Installed and Tested	Number of Analyses	Notes
1	2	1	Samplers 1A, 1B not installed due to thickened slab.
2	2	1	Samplers 2A, 2B not installed due to thickened slab.
3	2	1	Samplers 3A, 3B not installed due to thickened slab.
4	2	1	Samplers 4A, 4B not installed due to thickened slab.
5	1	1	Samplers 5A, 5B, 5C not installed due to thickened slab.
6	3	1	Sampler 6D installed but could not be retrieved.
7	4	1	All samplers deployed and retrieved.
8	4	1	All samplers deployed and retrieved.
9	4	1	All samplers deployed and retrieved.
10	6	6	Samplers tested individually; samplers 10C, 10F, and 10I, not installed due to thickened slab.
11	4	1	All samplers deployed and retrieved.
12	4	1	All samplers deployed and retrieved.
13	12	3	Triplicates sets of samplers installed; all samplers deployed and retrieved.
14	2	1	Samplers 14A, 14B not installed due to thickened slab.
15	3	1	Sampler 15D not installed due to thickened slab.
16	3	1	Samplers 16C broke on retrieval and sorbent strips not recovered.
17	12	3	Triplicates sets of samplers installed; all samplers deployed and retrieved.
18	4	1	All samplers deployed and retrieved.
19	4	1	All samplers deployed and retrieved.
20	4	1	All samplers deployed and retrieved.
21	4	1	All samplers deployed and retrieved.
22	4	1	All samplers deployed and retrieved.
23	3	1	Sampler 23D broke on retrieval and sorbent strips not recovered.
24	12	3	Triplicates sets of samplers installed; all samplers deployed and retrieved.
25	4	1	All samplers deployed and retrieved.
Total:	109	36	

Table 4-2. Pilot test of vapor point vacuum versus purge rate based on time required to fill a weather balloon to 7,000 liters (used to check precision of flow meters)

¹Purge Vacuum (Inches H₂O)	Time (min)	Estimated Flow rate (m³/min)
35	7.75	903
30	5.65	1,239
25	4.98	1,406
20	4.83	1,449
15	3.55	1,972
10	3.33	2,102
5	2.73	2,564
0	2.45	2,857

Notes:

H₂O = water

m³/min = cubic meters per minute

min = minute(s)

1. As measured at vapor intake point.

Table 5-1. Unadjusted total mass of PCE and TCE reported for individual, grid cell sampler sets

Grid Cell	# of Carbon Strips in Sample	Raw Data					
		Sample A		Replicate B		Replicate C	
		PCE (ng)	TCE (ng)	PCE (ng)	TCE (ng)	PCE (ng)	TCE (ng)
1	2	3,085	13				
2	2	2,245	15				
3	2	3,290	21				
4	2	12,064	240				
5	1	42,923	3,703				
6	3	5,168	33				
7	4	5,366	111				
8	4	17,451	1,828				
9	4	74,696	11,367				
10A	1	54,417	4,950				
10B	1	41,162	3,535				
10D	1	39,575	2,522				
10E	1	28,131	1,564				
10G	1	61,194	6,631				
10H	1	47,177	4,229				
11	4	9,854	105				
12	4	50,902	9,771				
13	4	56,981	19,588	72,308	28,438	58,953	18,111
14	2	60,934	9,040				
15	3	54,674	8,007				
16	3	29,341	1,213				
17	4	53,698	2,560	77,288	3,982	53,983	2,502
18	4	79,095	7,029				
19	4	79,802	5,449				
20	4	51,964	3,748				
21	4	33,997	1,795				
22	4	77,128	7,787				
23	3	65,666	2,227				
24	4	55,004	1,870	68,664	2,092	50,171	781
25	4	66,407	2,858				

Notes:

PCE = Tetrachloroethene

TCE = Trichloroethene

ng = nanograms (equivalent of micrograms per cubic meter [$\mu\text{g}/\text{m}^3$])

Table 5-2. Total mass per grid cell sampler set adjusted with respect to the number of samplers included in each set (see Table 5-1)

Grid Cell	Adjusted Data (average mass per carbon strip)							
	Sample A		Percent Total (Total PCE+TCE)		Replicate B		Replicate C	
	PCE (ng)	TCE (ng)	PCE	TCE	PCE (ng)	TCE (ng)	PCE (ng)	TCE (ng)
1	1,543	6	100%	0.4%				
2	1,123	8	99%	0.7%				
3	1,645	11	99%	0.6%				
4	6,032	120	98%	2.0%				
5	42,923	3,703	92%	7.9%				
6	1,723	11	99%	0.6%				
7	1,342	28	98%	2.0%				
8	4,363	457	91%	9.5%				
9	18,674	2,842	87%	13%				
10A	54,417	4,950	92%	8.3%				
10B	41,162	3,535	92%	7.9%				
10D	39,575	2,522	94%	6.0%				
10E	28,131	1,564	95%	5.3%				
10G	61,194	6,631	90%	9.8%				
10H	47,177	4,229	92%	8.2%				
11	2,464	26	99%	1.1%				
12	12,725	2,443	84%	16%				
13	14,245	4,897	74%	26%	18,077	7,110	14,738	4,528
14	30,467	4,520	87%	13%				
15	18,225	2,669	87%	13%				
16	9,780	404	96%	4.0%				
17	13,425	640	95%	4.6%	19,322	996	13,496	625
18	19,774	1,757	92%	8.2%				
19	19,951	1,362	94%	6.4%				
20	12,991	937	93%	6.7%				
21	8,499	449	95%	5.0%				
22	19,282	1,947	91%	9.2%				
23	21,889	742	97%	3.3%				
24	13,751	467	97%	3.3%	17,166	523	12,543	195
25	16,602	714	96%	4.1%				
Average:	19,503	1,820	93%	6.9%				
STDEV:	16,695	1,852	5.5%	5.5%				
RSD:	86%	102%	5.9%	80%				

Notes:

PCE = Tetrachloroethene TCE = Trichloroethene ng = nanograms (equivalent of micrograms per cubic meter [$\mu\text{g}/\text{m}^3$])
RSD = Relative Standard Deviation STDEV= standard deviation

Table 5-3. Grid Cell 10 passive sampler data

Sample #	Sample Data	
	PCE (ng)	TCE (ng)
10A	54,417	4,950
10B	41,162	3,535
10D	39,575	2,522
10E	28,131	1,564
10G	61,194	6,631
10H	47,177	4,229
Average:	45,276	3,905
SDEV:	11,696	1,798
RSD:	26%	46%

Notes:

PCE = Tetrachloroethene

TCE = Trichloroethene

ng = nanograms (equivalent of micrograms per cubic meter [$\mu\text{g}/\text{m}^3$])**Table 5-4. Passive sampler replicate data**

Grid Cell	Sample A		Replicate B		Replicate C		Mean		RSD	
	PCE (ng)	TCE (ng)	PCE (ng)	TCE (ng)	PCE (ng)	TCE (ng)	PCE (ng)	TCE (ng)	PCE	TCE
13	14,245	4,897	18,077	7,110	14,738	4,528	15,687	5,511	11%	21%
17	13,425	640	19,322	996	13,496	625	15,414	754	18%	23%
24	13,751	467	17,166	523	12,543	195	14,487	395	14%	36%

Notes:ng = nanograms (equivalent of micrograms per cubic meter [$\mu\text{g}/\text{m}^3$])

PCE = Tetrachloroethene

RSD = Relative standard deviation

TCE = Trichloroethene

Table 5-5. Summary of LVP subslab vapor data for VOCs

Sample ID	PCE ($\mu\text{g}/\text{m}^3$)	TCE ($\mu\text{g}/\text{m}^3$)	cis-1,2-DCE ($\mu\text{g}/\text{m}^3$)	trans-1,2-DCE ($\mu\text{g}/\text{m}^3$)	2-Propanol (mg/m^3)
S-1	17,000	1,400	260	98	11 E
S-1 (dup)	19,000	1,400	300	110	12 E
S-2	36,000	1,600	350	160	48 E
S-3	50,000	2,200	nd (<32)	nd (<32)	330
S-4	51,000	1,800	340	nd (<32)	160 E
S-5	54,000	2,400	nd (<32)	nd (<32)	340
*AMBIENT	nd (<1.2)	nd (0.93)	nd (0.68)	nd (0.68)	0.39

Notes: $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter mg/m^3 = milligram per cubic meter

nd = not detected

cis-1,2-DCE = cis-1,2-Dichloroethene

trans-1,2-DCE = trans-1,2-Dichloroethene

*Background ambient air.

Table 5-6 Summary of LVP subslab vapor data for oxygen and carbon dioxide

Sample ID	Oxygen (%)	Carbon Dioxide (%)
S-1	19	0.92
S-1 (dup)	21	1.1
S-2	17	2.2
S-3	17	2.0
S-4	17	2.5
S-5	17	2.6
*AMBIENT	21	0.042

Notes:

% = percent

*Background ambient air.

Appendix A

EnviroServices & Training Center Site Investigation, 2002 (key sections)

PASSIVE SOIL VAPOR SURVEY REPORT

Al Phillips Facility
515 Lagoon Drive
Honolulu, Hawaii 96819
TMK 1-1-16:15

Prepared for:
American Linen
2771 Wai Wai Loop
Honolulu, Hawaii 96819-1965

Prepared by:
ENVIROSERVICES & TRAINING CENTER, LLC
2850 Pa'a Street, Suite 150
Honolulu, Hawaii 96819
tel: (808) 839-7222

Project No. 02-2012

September 13, 2002

TABLE OF CONTENTS

1.0	CERTIFICATIONS AND LIMITATIONS	1
2.0	EXECUTIVE SUMMARY	2
3.0	INTRODUCTION/PURPOSE	3
4.0	BACKGROUND.....	4
4.1	SITE DESCRIPTION.....	4
4.2	GEOLOGIC AND HYDROGEOLOGIC SETTING	4
4.2.1	Regional Geology	4
4.2.2	Site Geology.....	4
4.2.3	Regional Hydrogeology.....	5
4.2.4	Site Hydrogeology.....	5
4.3	OTHER INVESTIGATIVE ACTIVITIES	6
5.0	PASSIVE SOIL GAS SURVEY ACTIVITIES.....	7
5.1	BACKGROUND	7
5.2	SOIL GAS SURVEY ACTIVITIES.....	8
5.3	ANALYTICAL RESULTS	8
6.0	FINDINGS, CONCLUSIONS AND RECOMMENDATIONS	11
7.0	REFERENCES.....	12

Appendices

APPENDIX I:	FIGURES
APPENDIX II:	VAPORTEC™ PASSIVE SOIL VAPOR SURVEY DATA MAPS
APPENDIX III:	LABORATORY ANALYSIS AND CHAIN-OF-CUSTODY
APPENDIX IV:	PHOTOGRAPHIC DOCUMENTATION


1.0 CERTIFICATIONS AND LIMITATIONS

EnviroServices & Training Center, LLC (ETC) has completed this passive soil vapor survey for the project site. ETC's findings are based on research, site observations, government regulations, and laboratory data, which were gathered at the time and location of the study. Even with such extensive investigative efforts, we cannot dismiss the possibility that all chemically affected areas of the site have been discovered.

We make no guarantee or warranty; either expressed or implied, except that our services are consistent with good commercial or customary practices designed to conform to acceptable industry standards.

This report is exclusively for the use and benefit of American Linen and is not for the use or benefit of, nor may any other person or entity rely upon it. The contents of this report may not be quoted in whole or in part or distributed to any person or entity without the written consent of the undersigned.

Prepared By:




Scott Curran
Geologist

Date:

9/13/02

Reviewed By:



Damon Hamura
Environmental Engineer

Date:

9/13/02

2.0 EXECUTIVE SUMMARY

EnviroServices & Training Center, LLC (ETC) was contracted by American Linen to perform a passive soil vapor survey at the former Al Phillips facility on 515 Lagoon Drive, Honolulu, Hawaii. The objective of this study was to qualitatively identify the extent of diesel-range petroleum concentrations and halogenated volatile organic compounds (HVOCs) specifically tetrachloroethene (PCE) and trichloroethene (TCE). This report presents the results of the passive soil vapor survey activities at the above referenced site.

In July 2002, ETC conducted a passive soil vapor survey at the site using 24 VaporTec™ samplers to determine hotspots, or areas where contaminants are concentrated on the subject property. The analytical results were used to generate colorimetric maps for total petroleum hydrocarbons as diesel (TPH-D) and the HVOCs detected. The maps can be found in Appendix II of this report.

TPH-D was detected in sample module 20, located near the turn in the underground storage tank (UST) piping in the northeast end of the warehouse. The colorimetric map for TPH-D shows the area of concentration near the location of the UST piping.

In the analysis for HVOCs, the constituents PCE and TCE were detected above method detection limits. PCE concentrations ranged from none detectable concentration above the method detection limit (nd) in sample modules 02, 05, 06 and 22 to 18,000 nanograms (ng) in sample module 18. TCE concentrations ranged from nd in modules 01-08, 10, 12, 15, 21, 22, 23 and 24 to 480 ng in module 18. The colorimetric map of PCE indicates that PCE vapors extends across nearly the entire property with the highest concentrations located under the existing structures. Two distinct "Hot Spots" of soil vapor with elevated concentrations of PCE are shown.

Based on the results of this and the previous Phase II Environmental Site Assessment (ESA), ETC concludes that diesel contamination has been sufficiently delineated; however, the extent of PCE contamination of soil and groundwater in the warehouse and office areas has not been delineated. Therefore ETC recommends the installation of an additional ground water monitoring well and collection of a soil sample in the location of passive soil vapor module number 18. Moreover, ETC recommends that groundwater samples from this and the four existing wells be sampled and analyzed for HVOCs.

3.0 INTRODUCTION/PURPOSE

This report presents the results of ETC's findings during the passive soil vapor survey activities for the subject property located at 515 Lagoon Drive, Honolulu, Hawaii.

The purpose of this investigation was to assess the subsurface soil for vapor concentrations with respect to TPH-D and HVOCs associated with commercial dry cleaning activities performed in the past. Investigation activities were performed in general accordance with: 1) Risk-Based Corrective Action and Decision Making at Sites with Contaminated Soil and Groundwater, DOH, December 1995; and 2) Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan, HDOH, February 1996. Specifically, ETC completed the following tasks:

- Developed a strategy to place passive soil vapor modules (VaporTec™ modules) in a twenty five foot grid on the subject property;
- Contract American Leak Detection (ALD) to identify potential underground utility lines in the area of the proposed module installation;
- Installed 24 VaporTec™ modules at a depth of approximately 18 inches utilizing a hand-held rotary hammer drill;
- Removed VaporTec™ modules 14 days later and delivered the modules to Environmental Services Network – Pacific (ESN-P) for 5-day analysis of TPH-D and HVOCs including PCE and TCE;
- Backfilled borings with hydrated bentonite chips and Quikrete® concrete patch; and
- Prepared this report documenting the field activities and the results of the investigation including maps, analytical results, conclusions and recommendations.

4.0 BACKGROUND

4.1 SITE DESCRIPTION

The subject property (TMK 1-1-16:15) is located in Honolulu, Hawaii, on the island of Oahu (Figure 1). The site encompasses a total land area of approximately 22,300 square feet. A former dry cleaning/laundry warehouse facility is located on the property. Commercial and industrial facilities occupy neighboring properties in the general vicinity.

The elevation of the subject property is approximately 5 to 10 feet above msl. The site and surrounding area are relatively flat, with no discernible gradient.

Topographic map coverage of the site vicinity is provided by the United States Geological Survey, Island of Oahu, Hawaii 7.5 minute Pearl Harbor quadrangle, 1983. The nearest surface water to the site is Keehi Lagoon located approximately 0.5 miles south of the project site.

4.2 GEOLOGIC AND HYDROGEOLOGIC SETTING

4.2.1 Regional Geology

Oahu is formed by the erosional remnants of two shield volcanoes. These are the Waianae range to the west and the Koolau range to the east. The Waianae volcano is estimated to have formed 2.4 to 3.6 million years ago. It consists of a tholeiitic lava shield with a thick cap of transitional to alkalic rock. Rejuvenation-stage volcanics of undifferentiated age occur in Kolekole Pass and on the south flank of the Waianae shield. Dike orientations define northwest and southwest rift zones (Macdonald, et al., 1983).

The Koolau volcano is estimated to have formed 1.8 to 2.6 million years ago (Macdonald, et al., 1983). It consists of a tholeiitic lava shield and lacks an alkalic cap. It has well defined major dike complex trending northwest-southwest. A third, minor rift zone referred to as the Kaau rift trends southward from Kaau crater, near the upland crest of the Koolau Ridge. After a long dormant period and periods of deep erosion, the Koolau volcano developed abundant and scattered rejuvenation-stage vents, typically aligned on northeast-striking fissures (Macdonald, et al., 1983).

4.2.2 Site Geology

The soil at the site is mapped as Ewa silty clay loam which is moderately shallow with 0 to 2 percent slopes (EmA). This soil type consists of well-drained soils in basins and on alluvial fans. The EmA developed in the alluvium derived from basic igneous rock. Generally, the depth to coral limestone is approximately 20 to 50 inches. Runoff is very slow with an erosion hazard

of no more than slight. The annual rainfall amounts to 10 to 30 inches, which occurs mostly between November and April. The mean annual soil temperature is approximately 73° F. This land type is primarily used for sugarcane, truck crops, and pasture (USDA, 1972).

During the previous Limited Phase II ESA, performed by ETC, fill soil was observed and documented at the site. Fill soils on Oahu are derived from material dredged from the ocean, or hauled from nearby areas, garbage, and various other materials. Mixed fill land occurs mostly near Pearl Harbor and in Honolulu, adjacent to the ocean (USDA, 1972).

4.2.3 Regional Hydrogeology

The primary drinking water in the Hawaiian Islands is drawn from basal groundwater. Basal groundwater is formed by rainwater percolating down through soil and permeable volcanic rock. All of the island situated below sea level, except within rift zones of the volcanoes, is saturated with ocean salt water and thus forms a basal lens called the "Ghyben-Herzberg" lens. A zone of transition between the fresh groundwater and the ocean salt water occurs due to the constant movement of the interface as a result of tidal fluctuations, aquifer development and seasonal fluctuations in recharge and discharge (Macdonald, et al., 1983).

Downward percolation of rainwater may be stopped by impermeable layers such as dense lava flows, alluvial clay layers and volcanic ash. The groundwater then forms a perched or high level aquifer, which is not in contact with salt water. Recharge of the aquifer occurs in areas of high rainfall, which are the interior mountainous areas. The groundwater flows from the recharge areas to the areas of discharge along the shoreline. Frictional resistance to groundwater flow causes it to pile up within the island until it attains sufficient hydraulic head to overcome friction. Thus, basal groundwater tends to slope toward the shoreline.

4.2.4 Site Hydrogeology

The Moanalua Aquifer System underlies the site, and is part of the Honolulu Aquifer Sector on the island of Oahu. The aquifer is classified by Mink and Lau, 1990, with the upper aquifer identification number of 30104116 (23321) and a lower aquifer identification number of 30104121 (11113). The upper aquifer is unconfined and basal in nonvolcanic sedimentary lithology. The groundwater in this aquifer is described as having potential for use and containing groundwater with a moderate salinity (1,000 to 5,000 mg/l Cl⁻). The groundwater is neither a drinking water source nor ecologically important, and is described as replaceable with a high level of vulnerability to contamination (Mink and Lau, 1990). The lower aquifer is confined and basal in horizontally extensive lava compartments. This portion of the aquifer is described as a currently used drinking water source containing groundwater with a fresh salinity (<250 mg/l Cl⁻). It is also described as irreplaceable with a low vulnerability to contamination. The direction of groundwater flow is interpreted to be to the south, toward the Pacific Ocean.

Since the upper aquifer is not currently used as a drinking water resource, DOH Tier 1 Soil Action Levels (SALs) and DOH Tier 1 Action Levels for groundwater in an area where a drinking water source is not threatened (Tier 1 GALs) were applied to evaluate site impacts. The DOH Tier I SALs and GALs for non-threatened drinking water sources are generally less

stringent than the SALs and GALs established for threatened drinking water sources.

4.3 OTHER INVESTIGATIVE ACTIVITIES

Prior to passive soil vapor survey activities, ETC performed a Phase I Environmental Site Assessment (ESA) and Limited Phase II ESA for the project site, dated September 28, 2001 and April 25, 2002 respectively. The Phase I report identified one existing 2,000-gallon diesel underground storage tank that had not undergone tank tightness testing. The tank was over 20 years old with approximately 100 feet of underground piping running from the tank to an interior boiler room. Following document research of the facility outlined in the report, ETC also identified numerous leaking underground storage tank (LUST) facilities in the vicinity of the subject property. The possibility of offsite migration from these surrounding facilities could not be dismissed. In addition, the Phase I ESA reported previous dry cleaning operations conducted in the warehouse facility.

Based on such information, ETC performed a subsurface investigation to determine whether contamination from previous on site usage or from surrounding facilities may have impacted subsurface soil and/or groundwater within the subject property.

Ten soil borings were advance to varying depths not exceeding 16 feet below ground surface (bgs). Four of the ten borings were converted to groundwater monitoring wells. Analytical data from the soil samples collected during the investigation indicated that TPH-D was detected in each of the ten soil samples at depths of approximately 7-8 feet bgs. In addition, four of the soil samples contained detectable concentrations of HVOCs. All detectable concentrations were below their respective DOH Tier 1 SAL or EPA PRGs for industrial soil. Soil sample results are presented in Figure 2.

In addition, four groundwater samples were collected from the monitoring wells. TPH concentrations were not detected above method detection limits. However, two of the monitoring wells, MW1 and MW2, contained detectable concentrations of HVOCs. All detected concentrations were below their respective DOH GALs.

5.0 PASSIVE SOIL GAS SURVEY ACTIVITIES

ETC determined that the most efficient approach to delineate the extent of contamination would be to perform a passive soil vapor survey at the site to qualitatively define the general shape of the plume.

5.1 BACKGROUND

The VaporTec™ survey is based on the principle that volatile compounds have high vapor pressures and consequently partition from the liquid or dissolved phase into the gas or vapor phase. Therefore, results are reported in soil gas mass levels present in the vapor phase.

Movement of contaminants in the vapor phase in soil is a dynamic process, dependent on a number of variables including the geometry and characteristics of the soil, surface features, weather, and characteristics of the soil gas mixture (e.g., concentration gradients, density relative to vapor-saturated air, etc.). In addition, vapors are subject to a variety of attenuation factors during migration away from the contaminant source to the module. Thus, the mass levels reported from the module will often be less than the concentrations reported in soil and groundwater matrix data. In most instances, the soil gas masses reported on the modules compare favorably with concentrations reported in the soil and groundwater (e.g., where soil gas levels are reported at greater levels relative to other sampled locations on the site, matrix data should reveal the same pattern, and vice versa). However, due to a variety of factors, a perfect comparison between matrix data and soil vapor levels can rarely be achieved.

The source of soil vapor concentrations reported by this method cannot be directly correlated to contaminants adsorbed to the soil, contaminants dissolved in the groundwater, and/or the presence of free product contamination. The mass concentrations reported from each module may reflect any or all of these sources. Differentiation between contaminant sources can only be achieved with prior knowledge of the site history.

The VaporTec™ samplers consist of 40-milliliter glass vials and activated charcoal. Soil vapor sample collection is performed by removing the vial cap and exposing the charcoal to the soil gas of the subsurface environment at the base of a shallow borehole. Sample collection proceeds via free vapor diffusion through the opening of the uncapped sample container. Following a controlled period of time, the sampler is retrieved from the borehole, resealed, and submitted for analysis.

A QA/QC trip blank module was provided to document the presence of potential contaminants during module shipment, installation, retrieval, and storage. The trip blank module is identically manufactured and packaged as those modules placed in the subsurface. However, the trip blank remains unopened during all phases of the soil gas survey. Levels reported on the trip blank may indicate potential impact to modules other than the contaminant source of interest.

5.2 SOIL GAS SURVEY ACTIVITIES

In July 2002, ETC conducted a passive soil vapor survey at the site using 24 VaporTec™ samplers to determine hotspots, or areas where contaminants are concentrated. A total of 24 locations were selected by ETC within the property boundaries. Locations of the modules are shown on Figure 3, Appendix I and the colorimetric maps included in the VaporTec™ report in Appendix II. The modules were installed on July 16, 2002 in 1.5-inch diameter by 18-inch deep borings (advanced with a Bosch SDS Max hammer drill). All 24 modules were removed from the ground on July 30, 2002, sealed, and delivered to ESN-P. The borings were then filled with granular bentonite and completed to the surface with Quikrete® Concrete Patch.

5.3 ANALYTICAL RESULTS

Twenty-four (24) VaporTec™ modules were recovered from the former Al Phillips Facility on July 30, 2002. The modules were submitted for laboratory analyses of TPH-D by Method NWTPH - Dx and HVOCs by EPA method 8021B. Analytical results are included in Table 1.

Table 1: VaporTec™ Survey Analytical Results

Sample ID	TPH-D (µg)	Tetrachloroethylene(ng)	Trichloroethene (ng)
01	nd	67	nd
02	nd	nd	nd
03	nd	6,400	nd
04	nd	700	nd
05	nd	nd	nd
06	nd	nd	nd
07	nd	18	nd
08	nd	280	nd
09	nd	12,000	20
10	nd	270	nd
11	nd	540	12
12	nd	120	nd
13	nd	8,100	66
14	nd	5,800	41
15	nd	110	nd
16	nd	1,800	16
17	nd	12,000	140
18	nd	18,000	490
19	nd	6,100	140
20	400	2,100	280
21	nd	140	nd
22	nd	nd	nd
23	nd	16	nd
24	nd	14	nd
Blank	nd	nd	nd

Notes: ng = nanograms
µg = micrograms
nd = not detected above method detection limits

The analytical results were used to generate colorimetric maps for TPH-D and HVOCs. The maps can be found in Appendix II of this report.

TPH-D was detected in sample module 20, located near the turn in the UST piping in the northeast end of the warehouse. The colorimetric map of TPH-D shows the area of concentration around the location of the UST piping.

In the analysis for HVOCs, the constituents Tetrachloroethene (PCE) and Trichloroethene (TCE) were detected above method detection limits. PCE concentrations ranged from nd in sample modules 02, 05, 06 and 22 to 18,000 ng in sample module 18. TCE concentrations ranged from nd in sample modules 01-08, 10, 12, 15, 21, 22, 23 and 24 to 480 ng in sample module 18. The colorimetric map of PCE indicates that the PCE vapors extends across nearly

the entire property with the highest concentrations located under the existing structures. Two distinct "Hot Spots" of soil vapor with elevated concentrations of PCE are shown.

6.0 FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

ETC performed a passive soil vapor survey at the project site. The results of the investigation are as follows:

- Diesel range vapors were detected in one of the twenty four samples collected located in the garment cleaning portion of the facility.
- HVOCs were detected at the subject site as PCE and TCE vapors.
- PCE vapors were detected in nineteen of the twenty four samples collected.
- TCE vapors were detected in nine of the twenty four samples collected. Seven of which were located in the garment cleaning portion of the facility.
- TCE and PCE are solvents commonly associated with dry cleaning operations, which are known to have taken place in the past at the site.
- The chlorinated hydrocarbons, PCE and TCE, are dense non-aqueous phase liquids (DNAPLs) with solubilities of 150 mg/l at 25° Celsius and 1,100 mg/l at 25° Celsius in water, respectively. Because the densities of PCE and TCE are greater than water, the contaminants will migrate down through groundwater to the bottom of the aquifer. Typically as TCE and PCE migrate through the aquifer the liquids will begin to go into solution with groundwater generating a plume of dissolved product. Residual DNAPL in the vadose zone can partition into the air in the soil pores and fractures. The plume of vapors can spread for many meters from the contaminant source.
- TCE was detected in groundwater at a concentration of 0.0049 milligrams per liter (mg/l) in MW2 during the previous Phase II ESA investigation dated April 25, 2002.
- PCE was detected in groundwater samples collected from MW1 and MW2 at concentrations of 0.017 mg/l and 0.0072 mg/l, respectively, during the previous Phase II ESA investigation dated April 25, 2002.

Based on the results of this and the previous Phase II ESA, ETC concludes that diesel contamination has been sufficiently delineated; however, the extent of PCE contamination of soil and groundwater in the area of the warehouse and office has not been delineated.

ETC recommends the installation of an additional ground water monitoring well and collection of a soil sample in the location of passive soil vapor module number 18. Moreover, ETC recommends that groundwater samples from this and the four existing wells be sampled and analyzed for HVOCs.

7.0 REFERENCES

- EnviroServices & Training Center, LLC. "Phase II Environmental Site Assessment for the Al Phillips Facility," dated April 25, 2002.
- EnviroServices & Training Center, LLC. "Phase I Environmental Site Assessment for the Al Phillips Facility," dated October 5, 2001.
- Macdonald, G.A., A.T. Abbot, and F.L. Peterson. "Volcanoes and the Sea." University of Hawaii Press. 1983.
- Mink, John F. and Stephen L. Lau. "Aquifer Identification and Classification for Oahu: Groundwater Protection Strategy for Hawaii." February 1990.
- State of Hawaii Department of Health. Risk-Based Corrective Action and Decision-Making at Sites with Contaminated Soil and Groundwater. December 1995.
- State of Hawaii Department of Health. Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan. December 1996.
- State of Hawaii Department of Health. Technical Guidance Manual for Underground Storage Tank Closure and Release Response. 2nd Edition. March 2000.
- US Department of Agriculture Soil Conservation Service. "Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii." 1972.
- US Department of Interior Geological Survey. 1983. Honolulu Quadrangle, Island of Oahu, 7.5 Minute Series (Topographic Map).

APPENDIX I

FIGURES



Source:
U.S. Department of Geological Services
Honolulu Quadrangle
Island of Oahu, 7.5 Minute Series
1983



**EnviroServices &
Training
Center**

Site Location Map

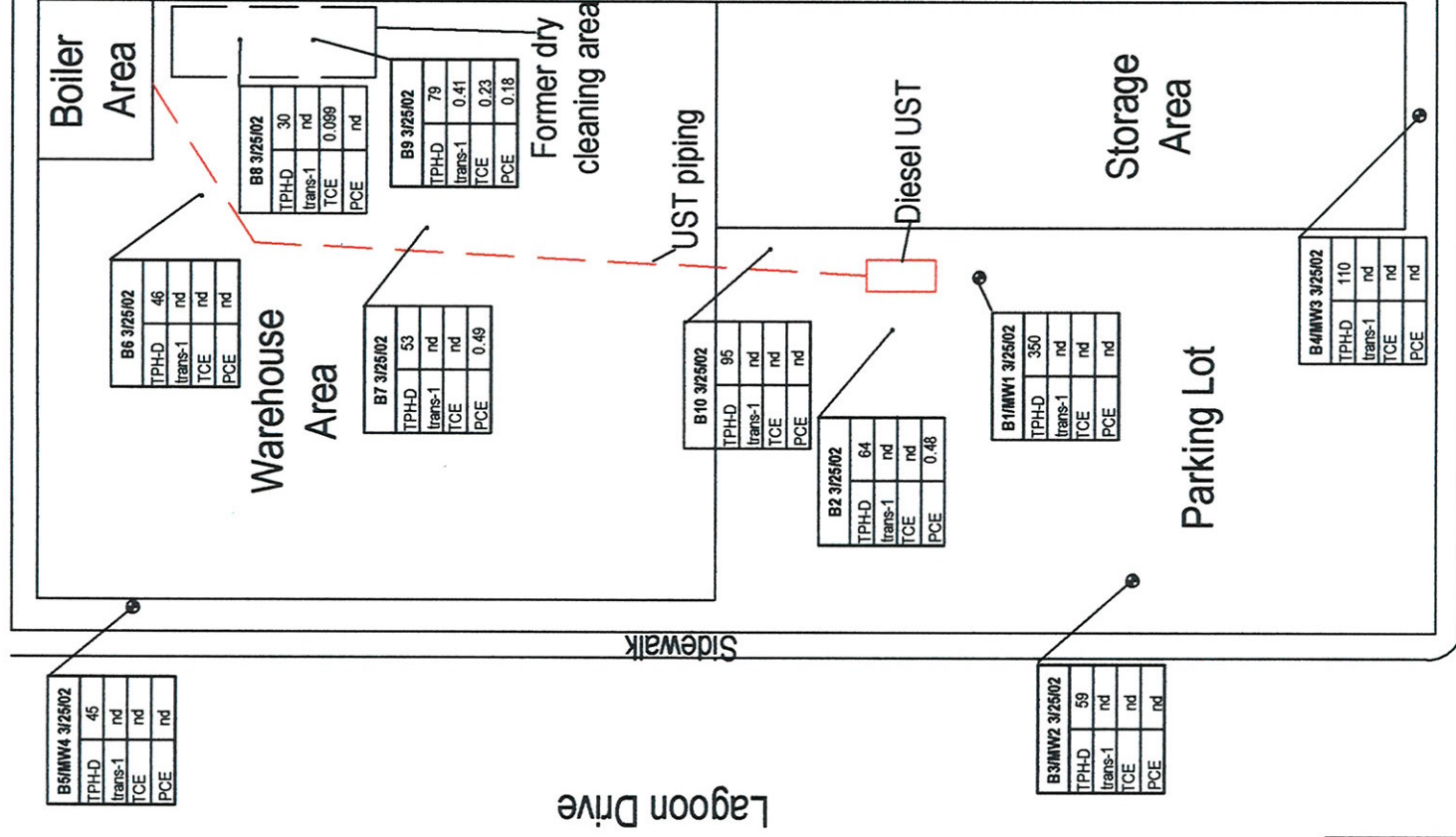
Former Al Phillips Facility

515 Lagoon Drive, Honolulu, HI

ETC Project #: 02-2012

September 13, 2002

Figure 1



Legend

B# Boring Location
 MW# Monitoring Well Location
 3/25/02 March 25, 2002 Date Soil Samples were Collected
 TPH-D Total Petroleum Hydrocarbons as Diesel
 trans-1 trans-1,2-dichloroethene
 TCE Trichloroethene
 PCE Tetrachloroethene
 All Concentrations are in mg/kg
 nd None detected above method detection limit



EnviroServices &
 Training
 Center LLC

Analytical Data Map for Previous Soil Investigation

515 Lagoon Drive, Honolulu, Hawaii

Client: American Linen

ETC Project No. 02-2012

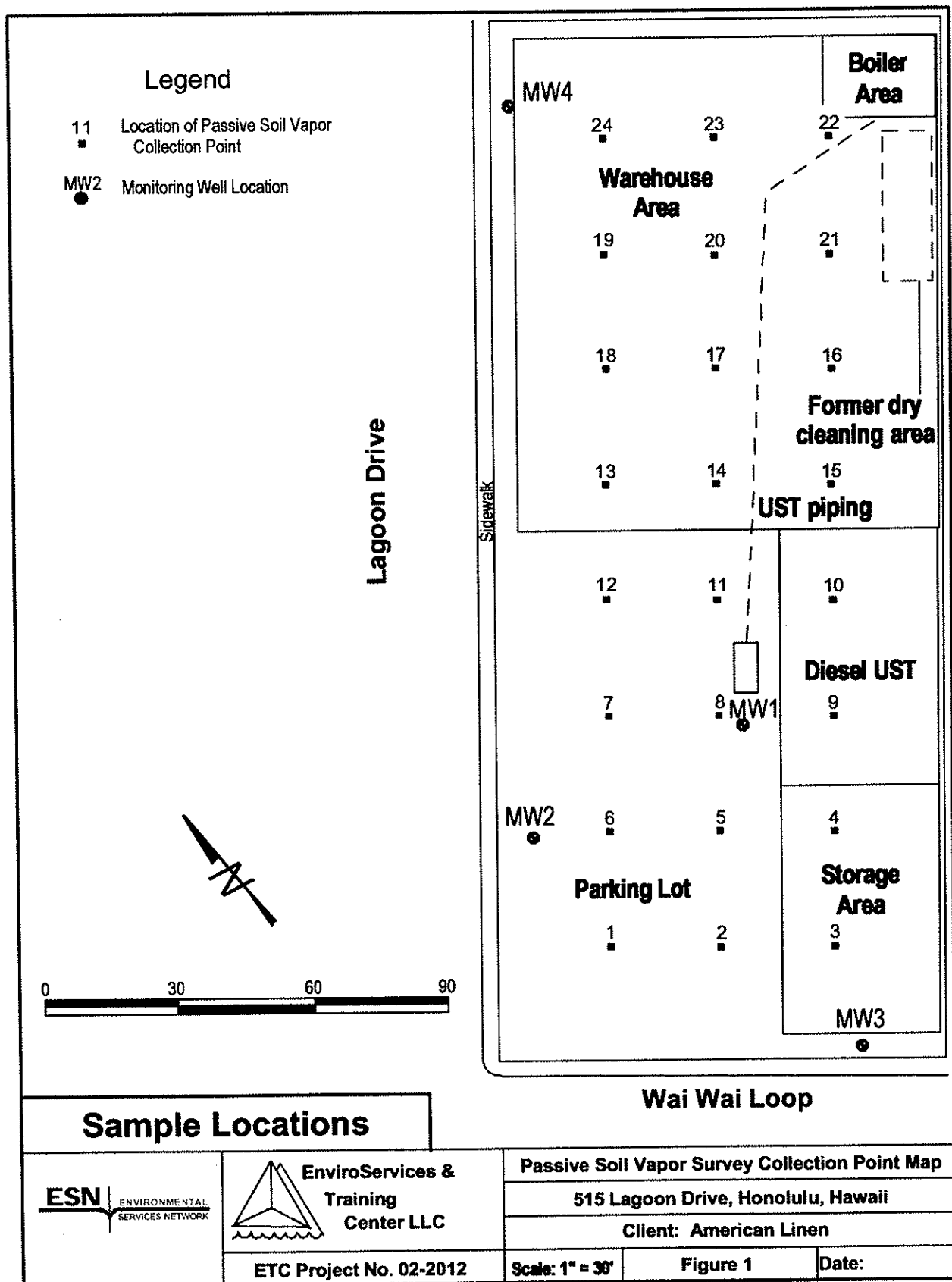
Scale: 1' = 30'

Figure 2

Date: 9/13/02

APPENDIX II

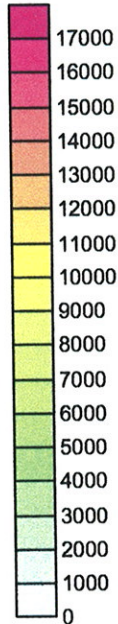
VaporTec[™] Passive Soil Vapor Survey Data Maps



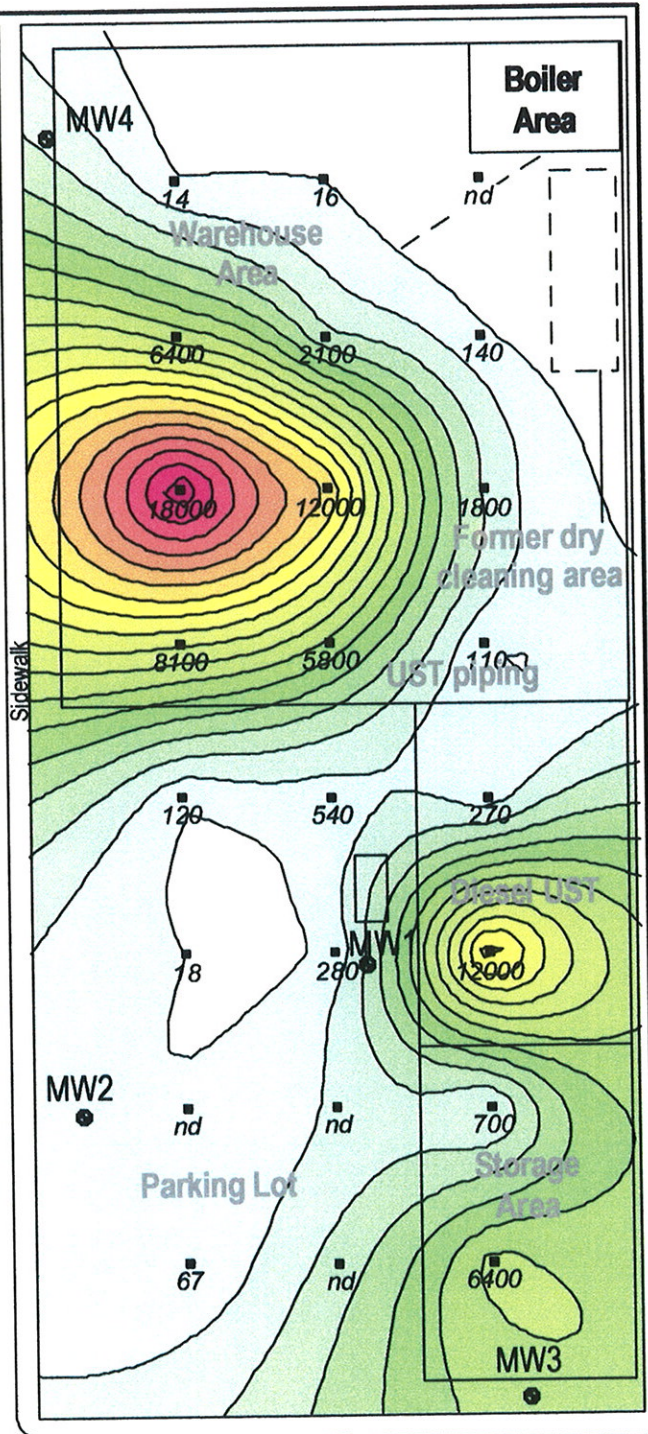
Legend

11 ■ Location of Passive Soil Vapor Collection Point

MW2 ● Monitoring Well Location



Lagoon Drive



Wai Wai Loop

PCE Distribution (ng)



EnviroServices &
Training
Center LLC

ETC Project No. 02-2012

Passive Soil Vapor Survey Collection Point Map

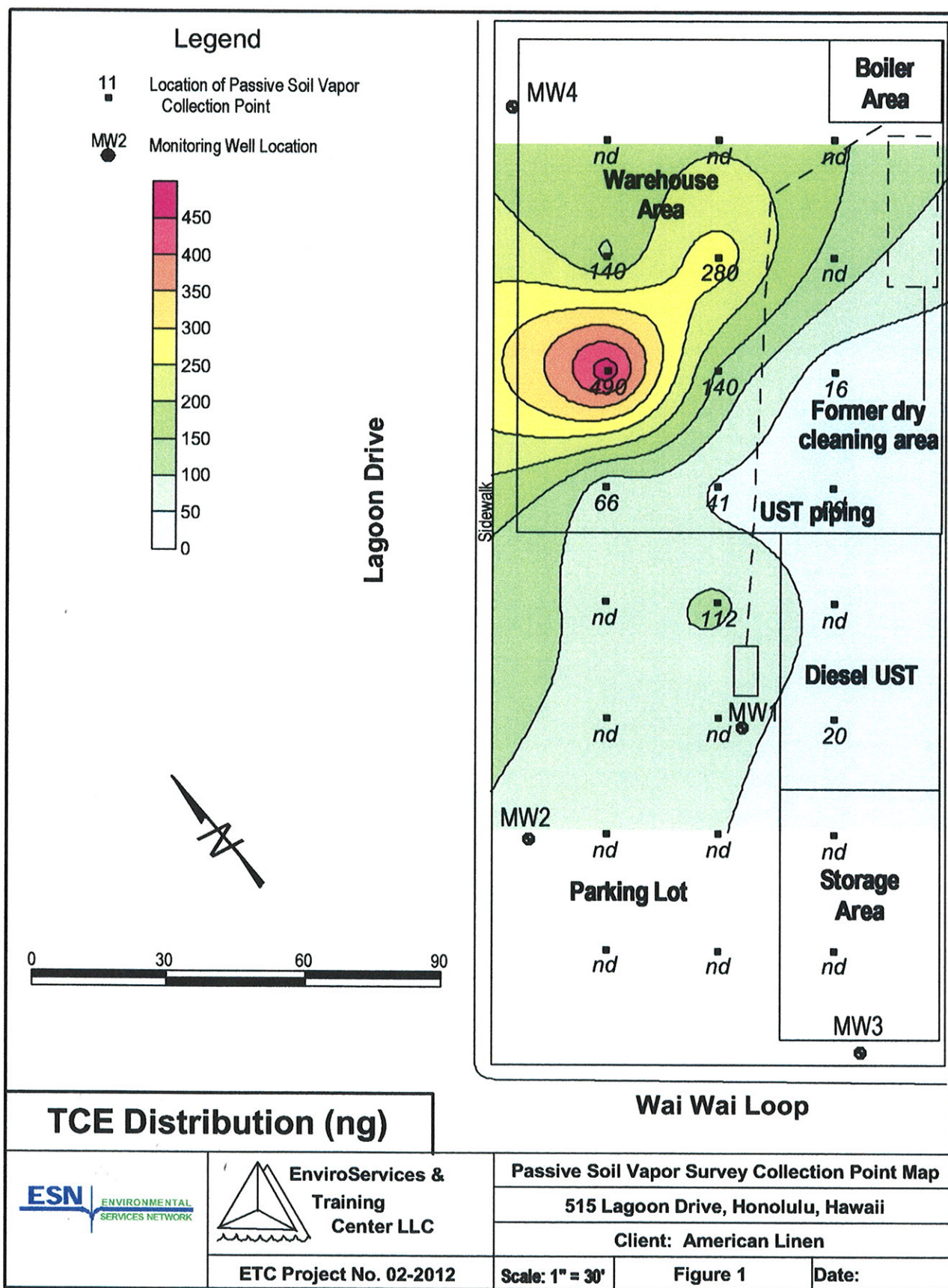
515 Lagoon Drive, Honolulu, Hawaii

Client: American Linen

Scale: 1" = 30'

Figure 1

Date:



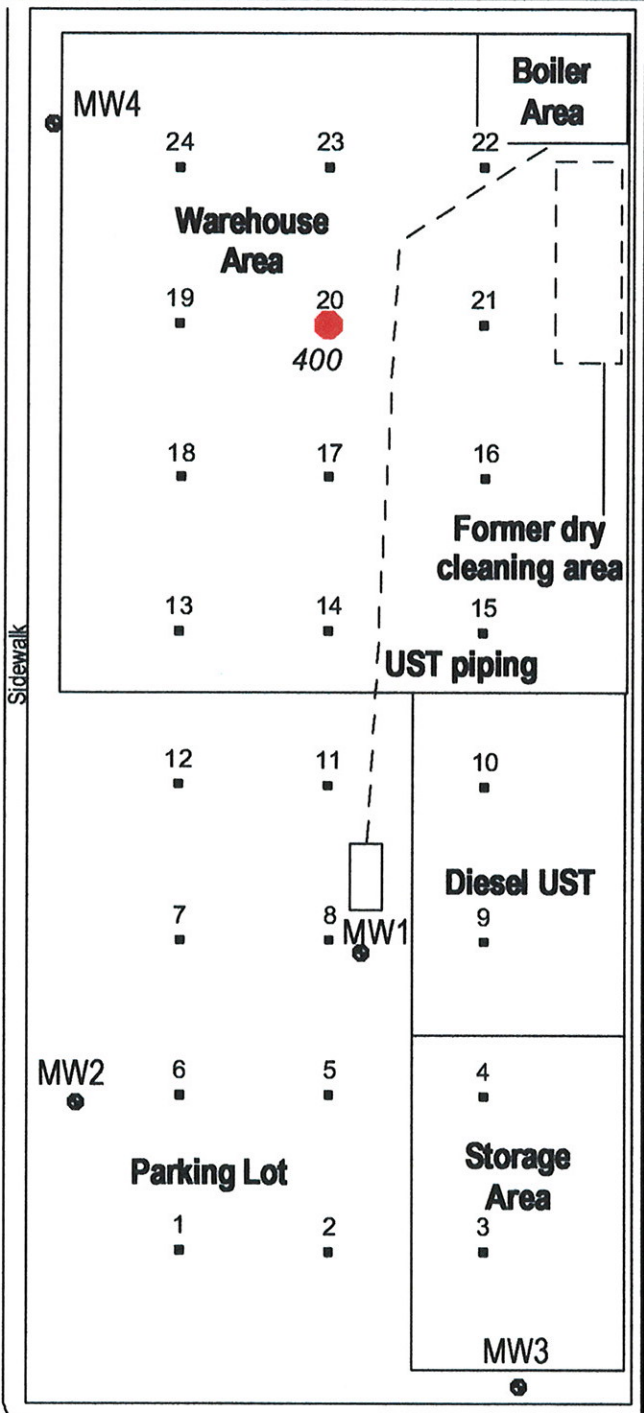
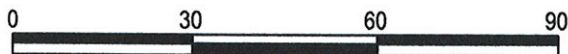
Legend

11 ■ Location of Passive Soil Vapor Collection Point

400 ● Diesel Contamination (ng)

MW2 ● Monitoring Well Location

Lagoon Drive



Diesel

Wai Wai Loop

Drawn by:



150 Capital Drive, Suite C
Golden, CO 80401-5454
Phone: 303-278-1911
FAX: 303-278-0104
E-Mail: Info@ESN-RM.com



**EnviroServices &
Training
Center LLC**

ETC Project No. 02-2012

Passive Soil Vapor Survey Collection Point Map

515 Lagoon Drive, Honolulu, Hawaii

Client: American Linen

Scale: 1" = 30'

Figure 1

Date:

APPENDIX III

LABORATORY ANALYSIS AND CHAIN-OF-CUSTODY

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

8021B, ng	MTH BLK		LCS	01	02	03	04	05
Matrix	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor
Date analyzed	Limits	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02
Chloromethane	25	nd		nd	nd	nd	nd	nd
Bromomethane	25	nd		nd	nd	nd	nd	nd
Vinyl chloride	25	nd		nd	nd	nd	nd	nd
Chloroethane	25	nd		nd	nd	nd	nd	nd
cis-1,2-Dichloroethene	25	nd		nd	nd	nd	nd	nd
1,1-Dichloroethene	25	nd		nd	nd	nd	nd	nd
Methylene Chloride	25	nd		nd	nd	nd	nd	nd
trans-1,2-Dichloroethene	25	nd		nd	nd	nd	nd	nd
1,1-Dichloroethane	25	nd		nd	nd	nd	nd	nd
Chloroform	5.0	nd		nd	nd	nd	nd	nd
1,1,1-Trichloroethane	5.0	nd		nd	nd	nd	nd	nd
Carbontetrachloride	5.0	nd		nd	nd	nd	nd	nd
1,2-Dichloroethane	25	nd		nd	nd	nd	nd	nd
Trichloroethene	5.0	nd	108%	nd	nd	nd	nd	nd
1,2-Dichloropropane	25	nd	124%	nd	nd	nd	nd	nd
Bromodichloromethane	25	nd		nd	nd	nd	nd	nd
cis-1,3-Dichloropropene	25	nd		nd	nd	nd	nd	nd
trans-1,3-Dichloropropene	25	nd		nd	nd	nd	nd	nd
Chlorobenzene	25	nd		nd	nd	nd	nd	nd
1,1,2-Trichloroethane	5.0	nd		nd	nd	nd	nd	nd
Tetrachloroethene	5.0	nd		67	nd	6,400	700	nd
Dibromochloromethane	25	nd		nd	nd	nd	nd	nd
Bromoform	25	nd		nd	nd	nd	nd	nd
1,1,2,2-Tetrachloroethane	25	nd		nd	nd	nd	nd	nd
1,1,1,2-Tetrachloroethane	25	nd		nd	nd	nd	nd	nd
Bromobenzene	25	nd		nd	nd	nd	nd	nd
1,2,3-Trichloropropane	25	nd		nd	nd	nd	nd	nd
Dibromomethane(*)	5.0	nd		nd	nd	nd	nd	nd
m-Dichlorobenzene	5.0	nd		nd	nd	nd	nd	nd
p-Dichlorobenzene	5.0	nd		nd	nd	nd	nd	nd
o-Dichlorobenzene	5.0	nd		nd	nd	nd	nd	nd
Benzene	5.0	nd	112%	nd	nd	nd	nd	nd
Toluene	5.0	nd	103%	nd	nd	nd	nd	nd
Ethylbenzene	5.0	nd		nd	nd	nd	nd	nd
Xylenes	5.0	nd		nd	nd	nd	nd	nd
*-instrument detection limit								
Surrogate recoveries:								
Bromochloromethane		77%	91%	117%	115%	111%	111%	114%
1,4-Dichlorobutane		83%	86%	98%	97%	95%	99%	98%
Bromochloropropane		90%	94%	105%	105%	101%	100%	100%
Trifluorotoluene		78%	80%	95%	93%	101%	101%	104%
Bromofluorobenzene		85%	86%	97%	86%	97%	96%	96%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits

na - not analyzed

C - coelution with sample peaks

M - matrix interference

J - estimated value

Acceptable Recovery limits: 65% TO 135%

Acceptable RPD limit: 35%

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

8021B, ng		06	07	08	09	10	11	12
Matrix	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor
Date analyzed	Limits	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02
Chloromethane	25	nd	nd	nd	nd	nd	nd	nd
Bromomethane	25	nd	nd	nd	nd	nd	nd	nd
Vinyl chloride	25	nd	nd	nd	nd	nd	nd	nd
Chloroethane	25	nd	nd	nd	nd	nd	nd	nd
cis-1,2-Dichloroethene	25	nd	nd	nd	nd	nd	nd	nd
1,1-Dichloroethene	25	nd	nd	nd	nd	nd	nd	nd
Methylene Chloride	25	nd	nd	nd	nd	nd	nd	nd
trans-1,2-Dichloroethene	25	nd	nd	nd	nd	nd	nd	nd
1,1-Dichloroethane	25	nd	nd	nd	nd	nd	nd	nd
Chloroform	5.0	nd	nd	nd	nd	nd	nd	nd
1,1,1-Trichloroethane	5.0	nd	nd	nd	nd	nd	nd	nd
Carbontetrachloride	5.0	nd	nd	nd	nd	nd	nd	nd
1,2-Dichloroethane	25	nd	nd	nd	nd	nd	nd	nd
Trichloroethene	5.0	nd	nd	nd	20	nd	12	nd
1,2-Dichloropropane	25	nd	nd	nd	nd	nd	nd	nd
Bromodichloromethane	25	nd	nd	nd	nd	nd	nd	nd
cis-1,3-Dichloropropene	25	nd	nd	nd	nd	nd	nd	nd
trans-1,3-Dichloropropene	25	nd	nd	nd	nd	nd	nd	nd
Chlorobenzene	25	nd	nd	nd	nd	nd	nd	nd
1,1,2-Trichloroethane	5.0	nd	nd	nd	nd	nd	nd	nd
Tetrachloroethene	5.0	nd	18	280	12,000	270	540	120
Dibromochloromethane	25	nd	nd	nd	nd	nd	nd	nd
Bromoform	25	nd	nd	nd	nd	nd	nd	nd
1,1,2,2-Tetrachloroethane	25	nd	nd	nd	nd	nd	nd	nd
1,1,1,2-Tetrachloroethane	25	nd	nd	nd	nd	nd	nd	nd
Bromobenzene	25	nd	nd	nd	nd	nd	nd	nd
1,2,3-Trichloropropane	25	nd	nd	nd	nd	nd	nd	nd
Dibromomethane(*)	5.0	nd	nd	nd	nd	nd	nd	nd
m-Dichlorobenzene	5.0	nd	nd	nd	nd	nd	nd	nd
p-Dichlorobenzene	5.0	nd	nd	nd	nd	nd	nd	nd
o-Dichlorobenzene	5.0	nd	nd	nd	nd	nd	nd	nd
Benzene	5.0	nd	nd	nd	nd	nd	nd	nd
Toluene	5.0	nd	nd	nd	nd	nd	nd	nd
Ethylbenzene	5.0	nd	nd	nd	nd	nd	nd	nd
Xylenes	5.0	nd	nd	nd	nd	nd	nd	nd
*-instrument detection limit								
Surrogate recoveries:								
Bromochloromethane		114%	113%	113%	111%	110%	112%	104%
1,4-Dichlorobutane		99%	98%	101%	95%	94%	96%	92%
Bromochloropropane		104%	103%	98%	100%	103%	101%	99%
Trifluorotoluene		102%	100%	102%	97%	102%	106%	103%
Bromofluorobenzene		93%	95%	97%	94%	97%	100%	98%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits
na - not analyzed
C - coelution with sample peaks
M - matrix interference
J - estimated value
Acceptable Recovery limits: 65% TO 135%
Acceptable RPD limit: 35%

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

8021B, ng		13	14	15	16	17	18	19
Matrix	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor
Date analyzed	Limits	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02
Chloromethane	25	nd	nd	nd	nd	nd	nd	nd
Bromomethane	25	nd	nd	nd	nd	nd	nd	nd
Vinyl chloride	25	nd	nd	nd	nd	nd	nd	nd
Chloroethane	25	nd	nd	nd	nd	nd	nd	nd
cis-1,2-Dichloroethene	25	nd	nd	nd	nd	nd	nd	nd
1,1-Dichloroethene	25	nd	nd	nd	nd	nd	nd	nd
Methylene Chloride	25	nd	nd	nd	nd	nd	nd	nd
trans-1,2-Dichloroethene	25	nd	nd	nd	nd	nd	nd	nd
1,1-Dichloroethane	25	nd	nd	nd	nd	nd	nd	nd
Chloroform	5.0	nd	nd	nd	nd	nd	nd	nd
1,1,1-Trichloroethane	5.0	nd	nd	nd	nd	nd	nd	nd
Carbontetrachloride	5.0	nd	nd	nd	nd	nd	nd	nd
1,2-Dichloroethane	25	nd	nd	nd	nd	nd	nd	nd
Trichloroethene	5.0	66	41	nd	16	140	490	140
1,2-Dichloropropane	25	nd	nd	nd	nd	nd	nd	nd
Bromodichloromethane	25	nd	nd	nd	nd	nd	nd	nd
cis-1,3-Dichloropropene	25	nd	nd	nd	nd	nd	nd	nd
trans-1,3-Dichloropropene	25	nd	nd	nd	nd	nd	nd	nd
Chlorobenzene	25	nd	nd	nd	nd	nd	nd	nd
1,1,2-Trichloroethane	5.0	nd	nd	nd	nd	nd	nd	nd
Tetrachloroethene	5.0	8,100	5,800	110	1,800	12,000	18,000	6,400
Dibromochloromethane	25	nd	nd	nd	nd	nd	nd	nd
Bromoform	25	nd	nd	nd	nd	nd	nd	nd
1,1,2,2-Tetrachloroethane	25	nd	nd	nd	nd	nd	nd	nd
1,1,1,2-Tetrachloroethane	25	nd	nd	nd	nd	nd	nd	nd
Bromobenzene	25	nd	nd	nd	nd	nd	nd	nd
1,2,3-Trichloropropane	25	nd	nd	nd	nd	nd	nd	nd
Dibromomethane(*)	5.0	nd	nd	nd	nd	nd	nd	nd
m-Dichlorobenzene	5.0	nd	nd	nd	nd	nd	nd	nd
p-Dichlorobenzene	5.0	nd	nd	nd	nd	nd	nd	nd
o-Dichlorobenzene	5.0	nd	nd	nd	nd	nd	nd	nd
Benzene	5.0	nd	nd	nd	nd	nd	nd	nd
Toluene	5.0	nd	nd	nd	nd	nd	nd	nd
Ethylbenzene	5.0	nd	nd	nd	nd	nd	nd	nd
Xylenes	5.0	nd	nd	nd	nd	nd	nd	nd

*-instrument detection limit

Surrogate recoveries:

Bromochloromethane	108%	109%	109%	104%	103%	105%	99%
1,4-Dichlorobutane	97%	98%	98%	94%	92%	95%	98%
Bromochloropropane	105%	104%	107%	100%	100%	103%	104%
Trifluorotoluene	104%	103%	102%	101%	99%	98%	97%
Bromofluorobenzene	101%	99%	100%	98%	100%	96%	97%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits

na - not analyzed

C - coelution with sample peaks

M - matrix interference

J - estimated value

Acceptable Recovery limits: 65% TO 135%

Acceptable RPD limit: 35%

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

8021B, ng		20	21	22	23	24
Matrix	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor
Date analyzed	Limits	08/09/02	08/09/02	08/09/02	08/09/02	08/09/02
Chloromethane	25	nd	nd	nd	nd	nd
Bromomethane	25	nd	nd	nd	nd	nd
Vinyl chloride	25	nd	nd	nd	nd	nd
Chloroethane	25	nd	nd	nd	nd	nd
cis-1,2-Dichloroethene	25	nd	nd	nd	nd	nd
1,1-Dichloroethene	25	nd	nd	nd	nd	nd
Methylene Chloride	25	nd	nd	nd	nd	nd
trans-1,2-Dichloroethene	25	nd	nd	nd	nd	nd
1,1-Dichloroethane	25	nd	nd	nd	nd	nd
Chloroform	5.0	nd	nd	nd	nd	nd
1,1,1-Trichloroethane	5.0	nd	nd	nd	nd	nd
Carbontetrachloride	5.0	nd	nd	nd	nd	nd
1,2-Dichloroethane	25	nd	nd	nd	nd	nd
Trichloroethene	5.0	280	nd	nd	nd	nd
1,2-Dichloropropane	25	nd	nd	nd	nd	nd
Bromodichloromethane	25	nd	nd	nd	nd	nd
cis-1,3-Dichloropropene	25	nd	nd	nd	nd	nd
trans-1,3-Dichloropropene	25	nd	nd	nd	nd	nd
Chlorobenzene	25	nd	nd	nd	nd	nd
1,1,2-Trichloroethane	5.0	nd	nd	nd	nd	nd
Tetrachloroethene	5.0	2,100	140	nd	16	14
Dibromochloromethane	25	nd	nd	nd	nd	nd
Bromoform	25	nd	nd	nd	nd	nd
1,1,2,2-Tetrachloroethane	25	nd	nd	nd	nd	nd
1,1,1,2-Tetrachloroethane	25	nd	nd	nd	nd	nd
Bromobenzene	25	nd	nd	nd	nd	nd
1,2,3-Trichloropropane	25	nd	nd	nd	nd	nd
Dibromomethane(*)	5.0	nd	nd	nd	nd	nd
m-Dichlorobenzene	5.0	nd	nd	nd	nd	nd
p-Dichlorobenzene	5.0	nd	nd	nd	nd	nd
o-Dichlorobenzene	5.0	nd	nd	nd	nd	nd
Benzene	5.0	nd	nd	nd	nd	nd
Toluene	5.0	nd	nd	nd	nd	nd
Ethylbenzene	5.0	nd	nd	nd	nd	nd
Xylenes	5.0	nd	nd	nd	nd	nd

*-instrument detection limit

Surrogate recoveries:

Bromochloromethane	107%	97%	98%	103%	100%
1,4-Dichlorobutane	98%	91%	94%	96%	95%
Bromochloropropane	109%	97%	96%	106%	103%
Trifluorotoluene	90%	97%	97%	100%	99%
Bromofluorobenzene	91%	96%	97%	100%	100%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits

na - not analyzed

C - coelution with sample peaks

M - matrix interference

J - estimated value

Acceptable Recovery limits: 65% TO 135%

Acceptable RPD limit: 35%

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

NWTPH-Dx, ug	MTH BLK	01	02	03	04	05
Matrix	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor
Date extracted	Reporting	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02
Date analyzed	Limits	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02
Diesel/Fuel oil	10	nd	nd	nd	nd	nd

Surrogate recoveries:

Fluorobiphenyl	93%	108%	78%	68%	78%	74%
o-Terphenyl	104%	124%	91%	86%	90%	92%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits

na - not analyzed

C - coelution with sample peaks

M - matrix interference

J - estimated value

Acceptable Recovery limits: 65% TO 135%

Acceptable RPD limit: 35%

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

NWTPH-Dx, ug		06	07	08	09	10	11
Matrix	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor
Date extracted	Reporting	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02
Date analyzed	Limits	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02
Diesel/Fuel oil	10	nd	nd	nd	nd	nd	nd

Surrogate recoveries:

Fluorobiphenyl	102%	92%	126%	65%	117%	82%
o-Terphenyl	111%	101%	125%	69%	119%	96%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits

na - not analyzed

C - coelution with sample peaks

M - matrix interference

J - estimated value

Acceptable Recovery limits: 65% TO 135%

Acceptable RPD limit: 35%

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

NWTPH-Dx, ug		12	13	14	15	16	17
Matrix	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor
Date extracted	Reporting	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02
Date analyzed	Limits	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02
Diesel/Fuel oil	10	nd	nd	nd	nd	nd	nd
Surrogate recoveries:							
Fluorobiphenyl		111%	93%	81%	112%	84%	90%
o-Terphenyl		114%	98%	95%	114%	96%	96%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits

na - not analyzed

C - coelution with sample peaks

M - matrix interference

J - estimated value

Acceptable Recovery limits: 65% TO 135%

Acceptable RPD limit: 35%

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

NWTPH-Dx, ug		18	19	20	21	22	23
Matrix	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor	Soil vapor
Date extracted	Reporting	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02
Date analyzed	Limits	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02	08/12/02
Diesel/Fuel oil	10	nd	nd	400	nd	nd	nd
Surrogate recoveries:							
Fluorobiphenyl		98%	89%	114%	114%	97%	111%
o-Terphenyl		105%	100%	111%	116%	106%	116%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits

na - not analyzed

C - coelution with sample peaks

M - matrix interference

J - estimated value

Acceptable Recovery limits: 65% TO 135%

Acceptable RPD limit: 35%

ESN SEATTLE CHEMISTRY LABORATORY
(425) 957-9872, fax (425) 957-9904

ESN Job Number: S20805-2
Client: ESN PACIFIC
Client Job Name: ETC
Client Job Number: D207300384

Analytical Results

NWTPH-Dx, ug		24
Matrix	Soil vapor	Soil vapor
Date extracted	Reporting	08/12/02
Date analyzed	Limits	08/12/02
Diesel/Fuel oil		
	10	nd

Surrogate recoveries:

Fluorobiphenyl	94%
o-Terphenyl	103%

Data Qualifiers and Analytical Comments

nd - not detected at listed reporting limits

na - not analyzed

C - coelution with sample peaks

M - matrix interference

J - estimated value

Acceptable Recovery limits: 65% TO 135%

Acceptable RPD limit: 35%

S20805-2

TURNAROUND TIME: 5-DAY

CHAIN-OF-CUSTODY RECORD

CLIENT: ESN Pacific
 ADDRESS: 1818 Kahaia St. Honolulu HI 96819
 PHONE: 808-847-0067 FAX: 808-847-0917
 CLIENT PROJECT #: _____ PROJECT MANAGER: C. Poma

DATE: 7-31-02 PAGE 1 OF 2
 ESN PROJECT #: D207300384
 LOCATION: ETC-SIS Lagoon Dr.
 COLLECTOR: _____ DATE OF COLLECTION: 7-30

Sample Number	Depth	Time	Sample Type	Container Type	ANALYSES										FIELD NOTES	Total Number Of Containers	Laboratory Note Number
					8021B HVOC	8021B BTEX	8021B MMBE	8015 GASOLINE	8015 DIESEL	418-1 TPH	8082 PCB	8100 PAH	TOTAL LEAD	TOTAL CADMIUM	TOTAL CHROMIUM		
01		805	SV	VUP	X			X									
02		815			X			X									
03		1205			X			X									
04		1155			X			X									
05		825			X			X									
06		835			X			X									
07		845			X			X									
08		855			X			X									
09		1145			X			X									
10		1135			X			X									
11		915			X			X									
12		905			X			X									
13		930			X			X									
14		940			X			X									
15		1125			X			X									
16		1115			X			X									
17		1000			X			X									
18		950			X			X									

RELINQUISHED BY (Signature) Kam DATE/TIME 7-31 1230 RECEIVED BY (Signature) 1/11/02 8/5/2 DATE/TIME 1300
 RELINQUISHED BY (Signature) _____ DATE/TIME _____ RECEIVED BY (Signature) _____ DATE/TIME _____

SAMPLE DISPOSAL INSTRUCTIONS

☐ ESN DISPOSAL @ \$200 each ☐ Return ☐ Pickup

SAMPLE RECEIPT

TOTAL NUMBER OF CONTAINERS 18 (24)
 CHAIN OF CUSTODY SEALS Y/N/NA NA
 SEALS INTACT? Y/N/NA NA
 RECEIVED GOOD COND./COLD _____
 NOTES: _____

LABORATORY NOTES:

ng on
wire

Map of location
HUGO to
ESN Rocky Mtn.
w/ results

S-DAY

620505-2

CLIENT: ESIU Pac.Fic
ADDRESS: 1818 Kahai St. Honolulu 111 96819
PHONE: 808-847-0067 FAX: 808-847-0917
CLIENT PROJECT #: _____ PROJECT MANAGER: C. Poma

DATE: 7-31-02 PAGE 2 OF 2
ESN PROJECT #: D207300384
LOCATION: ETC-SIS Lagoon Dr.
COLLECTOR: _____ DATE OF COLLECTION: 7-30

[illegible]

RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED BY (Signature)	DATE/TIME
KAWCUT	7-31 1:30	V. Williams	8/5/2 1:30
RELINQUISHED BY (Signature)	DATE/TIME	RECEIVED BY (Signature)	DATE/TIME

SAMPLE DISPOSAL INSTRUCTIONS

☐ ESN DISPOSAL @ \$2.00 each ☐ Return ☐ Pickup

SAMPLE RECEIPT

TOTAL NUMBER OF CONTAINERS

CHAIN OF CUSTODY SEALS Y/N/NA

SEALS INTACT? Y/N/NA

RECEIVED GOOD COND./COLD

NOTES:

LABORATORY NOTES:

ng on
~~columns~~
wife

APPENDIX IV

PHOTOGRAPHIC DOCUMENTATION



Photograph 1: View of passive soil vapor boring advancement.



Photograph 2 : View of passive soil vapor module being installed.



**EnviroServices &
Training
Center**

Photographic Documentation

Former Al Phillips Facility

515 Lagoon Drive, Honolulu, Hawaii

ETC Project # 02-2012

Client: American Linen

September 13, 2002

Appendix B

AECOM Phase II Environmental Site Assessment, 2013 (key sections)



**REVISION 0
PHASE II ENVIRONMENTAL SITE
ASSESSMENT
515 LAGOON DRIVE
TMK NUMBER: (1) 1-1-016:015
HONOLULU, OAHU, HAWAII**

Prepared for:

Honolulu Authority for Rapid Transportation
1099 Alakea Street, 17th Floor
Honolulu, Hawaii, 96813

June 2013

**REVISION 0
PHASE II ENVIRONMENTAL SITE
ASSESSMENT
515 LAGOON DRIVE
TMK NUMBER: (1) 1-1-016:015
HONOLULU, O‘AHU, HAWAI‘I**

Prepared for:

Honolulu Authority for Rapid Transportation
1099 Alakea Street, 17th Floor
Honolulu, Hawai‘i 96813

Prepared by:

AECOM Technical Services, Inc.
1001 Bishop Street, Suite 1600
Honolulu, Hawai‘i 96813

June 2013

CONTENTS

Acronyms and Abbreviations	v
Certification of Environmental Professional	vii
1.0 INTRODUCTION	1-1
1.1 Statement of Objective	1-1
1.2 Scope of Services	1-1
1.3 Limitations and Exceptions	1-2
1.4 Special Terms and Conditions	1-2
1.5 User Reliance	1-3
2.0 BACKGROUND	2-1
2.1 Site Description and Features	2-1
2.2 Physical Setting	2-1
2.2.1 Physiography and Geology	2-1
2.2.2 Groundwater	2-1
2.2.3 Summary of Physical Settings	2-2
2.3 Site History and Land Use	2-2
2.4 Adjacent Property Land Use	2-2
2.5 Summary of Previous Assessments	2-3
2.5.1 Phase I ESA	2-3
2.5.2 Limited Phase II ESA	2-4
2.5.3 Passive Soil Vapor Survey	2-5
3.0 WORK PERFORMED AND RATIONALE	3-1
3.1 Scope of Assessment	3-1
3.2 Exploration, Sampling, and Test Screening Methods	3-1
3.2.1 Geophysical Survey	3-1
3.2.2 Subsurface Soil Sampling	3-2
3.2.3 Groundwater Sampling Program	3-2
3.2.4 Field Quality Control	3-3
3.2.5 Laboratory Analysis	3-3
3.3 Deviations from the Scope	3-4
4.0 SUMMARY OF SAMPLING RESULTS	4-1
4.1 Sampling Summary	4-1
4.2 Regulatory Criteria	4-1
4.3 Subsurface Soil	4-1
4.4 Groundwater	4-2
5.0 INTERPRETATION AND CONCLUSIONS	5-1
5.1 Recognized Environmental Conditions/Potential Release Area	5-1
5.2 Absence, Presence, Degree, and Extent of Target Analytes	5-1
5.2.1 Petroleum Release	5-1
5.2.2 HVOC Release	5-1
5.2.3 Petroleum Release Fate and Transport	5-2
5.2.4 HVOC Release Fate and Transport	5-2
5.3 Data Gaps	5-2
5.4 Conceptual Model For the Site	5-3
5.4.1 Conceptual Site Model for Petroleum Release	5-3
5.4.2 Conceptual Site Model for HVOC Release	5-3
5.4.3 Conceptual Site Model for UST	5-3
5.5 Conclusions/Objectives Met	5-3

6.0	RECOMMENDATIONS	6-1
7.0	REFERENCES	7-1

TABLES

1	Monitoring Well Construction A-Details
2	Summary of Analytical A-Samples
3	Summary of Subsurface Soil Sample A-Results
4	Summary of Groundwater Sample A-Results
5	Physical/Chemical Properties of PCE, TCE, DCE, and A-VC

FIGURES

1	Site Location A-Map
2	Site Layout A-Map
3	Detected Target Analytes in A-Soil
4	Detected Target Analytes in A-Groundwater
5	Current and Historic HVOC A-Detections

APPENDIXES

A	Photo Log
B	Field Logs
C	Data Quality Assessment and Laboratory Reports

ACRONYMS AND ABBREVIATIONS

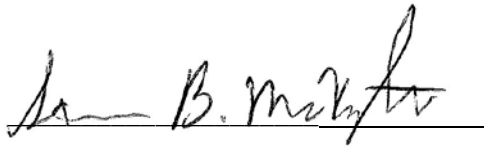
µg/kg	microgram per kilogram
µg/L	microgram per liter
%	percent
AECOM	AECOM Technical Services, Inc.
ALSCO	American Linen/Young Laundry and Dry Cleaning
AST	aboveground storage tank
ASTM	ASTM International
ATM	automated teller machine
bgs	below ground surface
DCE	dichloroethylene
DOH	Department of Health, State of Hawai'i
DPT	direct-push technology
DRO	diesel range organics
EPA	Environmental Protection Agency, United States
ESA	Environmental Site Assessment
ft	feet or foot
ft ²	square feet
GAL	groundwater action level
GRO	gasoline range organics
HART	Honolulu Authority for Rapid Transportation
HVOC	halogenated volatile organic compounds
IDW	investigation-derived waste
LUST	leaking underground storage tank
mg/kg	microgram per kilogram
mg/L Cl ⁻	milligrams of chloride per liter of water
msl	mean sea level
NRC	National Response Center
PAH	polynuclear aromatic hydrocarbon
PCE	tetrachloroethylene
PID	photoionization detector
QC	quality control
RCRA	Resource Conservation and Recovery Act
REC	recognized environmental condition
RRO	residual range organics
SAL	soil action level
SHWB	Solid and Hazardous Waste Branch, Hawaii
TCE	trichloroethylene
TMK	Tax Map Key
TPH	total petroleum hydrocarbons
U.S.	United States
UST	underground storage tank
VC	vinyl chloride
VOC	volatile organic compound

Certification of Environmental Professional signing below:

I declare that, to the best of my professional knowledge and belief, I meet the definition of Environmental Professional as defined in Section 312.10 of 40 Code of Federal Regulations 312. I have the specific qualifications based on education, training, and experience to assess a property of the nature, history, and setting of the subject property. I have performed a Phase II environmental site assessment at 515 Lagoon Drive (Tax Map Key number [1] 1-1-016: Parcel 015), Honolulu, O'ahu, Hawai'i in conformance with the scope and limitations of ASTM International Practice E 1903-11.

No guarantee or warranty, either expressed or implied, is made, except that the services performed are consistent with good commercial or customary practices designed to conform with acceptable industry standards. The findings are based upon site observations, government regulations, and laboratory data, which were gathered at the time and location of the study. Even with such extensive investigative efforts, we cannot dismiss the possibility that parts of the site may be chemically affected.

This report is exclusively for the use and benefit of Honolulu Authority for Rapid Transportation (HART) and is not for the use or benefit of, nor may it be relied upon by, any other person or entity. The contents of this report may not be quoted in whole or in part or distributed to any person or entity without the written consent of the undersigned.

A handwritten signature in black ink, appearing to read "Steve McKnight", is written over a horizontal line.

Steve McKnight, PG
Geologist
AECOM Environment
1001 Bishop Street, Suite 1600
Honolulu, HI 96813

1.0 INTRODUCTION

This Phase II Environmental Site Assessment (ESA) report has been prepared for the property located at 515 Lagoon Drive (Tax Map Key [TMK] number [1] 1-1-016: Parcel 015), Honolulu, O'ahu, Hawai'i (the "subject property"). The location of this property is illustrated on Figure 1. This report summarizes data obtained during the Phase II ESA completed in March 2013. The Phase II investigation was performed in conformance with the scope of services described below, limitations of ASTM International (ASTM) Practice E 1903-11, and is subject to the Limitations and Restrictions defined herein.

This Phase II ESA was prepared at the request of, and for the benefit of, the Honolulu Authority for Rapid Transportation (HART), and may not be relied on by other parties except as described in the section on Limitations and Restrictions. The HART is the "User" of this report, as that term is defined in ASTM E1903-11. In this report, the term User includes any legal counsel to HART or other representative of the User.

1.1 STATEMENT OF OBJECTIVE

A Phase II ESA was performed for the objectives described below to further investigate the recognized environmental conditions (REC) described in the previous Phase I ESA (AECOM 2012), the results of previous Phase II ESA (EnviroServices 2002a), and the results of the previous passive soil gas survey (EnviroServices 2002b). The details of the previous investigations are provided in Section 2.5 and the objectives for this Phase II ESA are as follows:

- Assess the releases of hazardous substances (referred to as target analytes for the assessment, which include total petroleum hydrocarbons [TPH], polynuclear aromatic hydrocarbons [PAH], Resource Conservation and Recovery Act [RCRA] metals, and halogenated volatile organics [HVOCs]) that were stored on site and detected in samples from previous investigations to the soil and groundwater beneath the subject property. To the extent applicable, this assessment is for the purposes including landowner liability protections (i.e., innocent landowner, bona fide prospective purchaser, and contiguous property owner).
- Evaluate the condition of the existing groundwater wells and determine if they are in good condition for continued use or they should be abandoned.
- Locate the 1,000-gallon underground storage tank (UST), which was stated to exist at the center of the property.
- Provide information relevant to identifying, defining and evaluating property conditions associated with target analytes that may pose risk to human health or the environment, or risk of bodily injury to persons on the property and thereby give rise to potential liability in tort.
- Provide information relevant to evaluating and allocating business environmental risk in transactional and contractual contexts, including transferring, financing, and insuring properties, and due diligence relating thereto.

1.2 SCOPE OF SERVICES

The standard professional practices that AECOM Technical Services, Inc. (AECOM) conducted for the Phase II ESA in connection with the subject property included the following:

- Geophysical survey to clear utilities and evaluate the location of the 1,000-gallon UST at the site.
- Collection of discrete subsurface soil samples from soil borings advanced using direct-push technology (DPT). These borings are located around the hotspots for HVOCs and TPH-

diesel range organics (DRO) observed in previous investigations and around a floor drain feature existing onsite.

- Collection of grab groundwater samples from temporary wells installed within the DPT borings.
- Collection of groundwater samples from existing monitoring wells at the site.
- Abandonment of the temporary wells after grab groundwater sampling.
- Management of investigation-derived waste (IDW) consisting of soil cuttings and purge water.

1.3 LIMITATIONS AND EXCEPTIONS

This report describes the results of AECOM's Phase II ESA to identify the presence of contamination-related liabilities materially affecting the subject property. In the conduct of this assessment, AECOM assessed the presence of such problems within the limits of the established scope of work as described in its proposal.

The findings and opinions expressed in this report are subject to certain conditions and assumptions, which are noted in the report. Any party reviewing the findings of the report must carefully review and consider all such conditions and assumptions.

This report and all field data and notes were gathered and/or prepared by AECOM in accordance with the agreed-upon scope of work and generally accepted engineering and scientific practice in effect at the time of AECOM's assessment of the subject property. The statements, findings, and opinions contained in this report are only intended to give approximations of the environmental conditions at the subject property.

As specified in the ASTM standard (referred to below as "this practice"), it is incumbent that the client and any other parties who review and rely on this report understand the following inherent conditions surrounding any Phase II ESA:

- **Not Exhaustive:** A single round of sampling and chemical testing may not always provide data sufficient to meet the chosen objectives. If not, this practice contemplates additional sampling in an iterative sequence that concludes when the available data is sufficient. This practice also acknowledges, however, that the User may instead elect either to redefine the objectives to that they can be met with the data available, or to terminate the investigative process, without meeting the stated objectives. The Phase II ESA report must disclose any respect in which available data are insufficient to meet objectives.
- **Incomplete Characterization:** This practice does not require full site characterization in every instance, but maybe used to carry out an investigation sufficient for that purpose if desired to meet the User's objectives.
- **Comparison with Subsequent Inquiry:** ESAs must be evaluated based on the reasonableness of judgments made at the time and under the circumstances in which they were made. Subsequent ESAs should not be considered valid standards to judge the appropriateness of any prior assessment based on hindsight, new information, use of developing technology or analytical techniques, or other factors.

1.4 SPECIAL TERMS AND CONDITIONS

There were no special terms and conditions between the User and AECOM.

1.5 USER RELIANCE

This report is intended for use only as the complete document. It is based on the Scope of Services, and is subject to the Limitations and Exceptions and other restrictions, defined herein. This report was prepared pursuant to an agreement between HART and AECOM and is for the exclusive use of HART and its legal counsel. No other person or organization is entitled to rely on any part of it without first obtaining AECOM's written consent and provided any such party signs an AECOM-generated Reliance Letter. HART or its legal counsel may release or authorize the release of all or part(s) of this report to third parties. However, if any third party uses or relies on this report without the express written permission of AECOM, such third party agrees that it shall have no legal recourse against AECOM or its parent or subsidiaries, and shall indemnify and defend them from and against all claims arising out of or in conjunction with such use or reliance.

The passage of time may result in changes in technology, economic conditions, site variations, or regulatory provisions that would render the report inaccurate. Reliance on this report after the date of issuance as an accurate representation of current site conditions shall be at the User's sole risk.

2.0 BACKGROUND

2.1 SITE DESCRIPTION AND FEATURES

The subject property consists of approximately 22,307 square feet (ft²) of land located 515 Lagoon Drive, Honolulu, O'ahu, Hawai'i. The property lies on the east side of Lagoon Drive between the two intersections where Waiwai Loop intersects Lagoon Drive. The areas surrounding the property primarily consist of light industrial and commercial properties. The subject property's general location is shown on Figure 1. The site is composed of an approximately 17,759-ft² warehouse, and associated parking and landscaped areas. The northern portion of the warehouse is approximately 24 feet (ft) high and consists of a large open area as well as two stories of office space. The southern portion of the building consists of office and storage spaces. Figure 2 shows the layout of essential features of the subject property. The site is currently used by an automated teller machine (ATM) service facility and was formerly a dry cleaning facility. According to HART, the planned long-term use for the subject property is demolition and redevelopment for Honolulu Rail Transit Project.

The subject parcel is further described as located in Division 1 (island of O'ahu), Zone 1, Section 1, Plat 015 and Parcel number 015. According to the Hawai'i State Land Use Commission, the State Land Use designation is "Urban."

2.2 PHYSICAL SETTING

The subject property is located on the southern side of the island of O'ahu and is approximately 3.1 miles northwest of downtown Honolulu. The subject property lies at an approximate elevation of 10 ft above mean sea level (msl). Surface runoff is expected to flow to the south and southeast. Observed conditions of the subject property during AECOM's site reconnaissance (AECOM 2012) correspond with information presented in the topographic map.

2.2.1 Physiography and Geology

The island of O'ahu consists of two main shield volcanoes, the Wai'anae and Ko'olau, bridged in the middle by the Central O'ahu Plain. The subject property is located near the southern coastline of the island of O'ahu within the Pearl Harbor Plain physiographic region, which includes Ke'ehi Lagoon. Alluvium from the Ko'olau Mountains may cover the reef limestone and noncalcareous marine sediments. The general area is characterized by a large area with low relief (MacDonald et al. 1983). Much of the land in this area is fill consisting of materials dredged to create Honolulu Harbor as well as material from inland sources (USDA SCS 1972).

Soil at the subject property is identified as Ewa silty clay loam (EDR 2012). This well-drained soil has moderate infiltration rates. Ewa soils are found on alluvial fans and terraces at elevations ranging from sea level to 150 ft. The slope in the area ranges from 0 to 12 percent (%). The soils formed from alluvium that eroded from the adjacent uplands and consists of material weathered from basic volcanic rocks (USDA NRCS 2012). The subsoil also consists of silty clay loam. The substratum is bedrock.

2.2.2 Groundwater

According to Mink and Lau (1992), the aquifer system near the subject property belongs to the Moanalua aquifer system within the Honolulu aquifer sector. The system is characterized as an unconfined basal aquifer of the sedimentary type overlaying a confined basal aquifer occurring in horizontally extensive lavas. The upper aquifer has a moderate salinity (1,000 to 5,000 milligrams of chloride per liter of water [mg/L Cl⁻]) and is not considered a drinking or ecologically significant source of water. It has a high vulnerability to contamination. The lower aquifer has fresh water (less than 250 mg/L Cl⁻) and a low vulnerability to contamination.

The subject property is located below of the State of Hawai'i Department of Health (DOH) Underground Injection Control line. Therefore, the underlying aquifer is not considered a potential source for drinking water.

The depth of unconfined water table is approximately 8 ft below ground surface (bgs) based upon groundwater measurements collected during the Phase II ESA. The groundwater is expected to flow in a southeasterly direction toward the Pacific Ocean coastline and Ke'ehi Lagoon. The groundwater direction is deduced from the long-term release response report (LFR 2000) for the neighboring Chevron property at 2604 Waiwai Loop. However, the gradient and flow direction of groundwater below the subject property may be affected by zones of higher or lower permeability or recharge, and therefore, may deviate from the expected trend.

The closest surface water to the subject property is Ke'ehi Lagoon, located southeast and approximately 0.3 mile from the subject property. The National Wetlands Inventory by the United States (U.S.) Fish and Wildlife Service classifies Ke'ehi Lagoon as an estuarine, subtidal, and unconsolidated bottom system. Other surface water features near the subject property include a drainage canal, located approximately 0.2 mile south of the subject property, and Moanalua Stream, located approximately 0.5 mile northeast of the subject property.

Based on Federal Emergency Management Agency *Flood Insurance Rate Map Community Panel Number 15003C0334G*, dated January 19, 2011, the subject property is located in Zone D, areas in which flood hazards are undetermined, but possible (FEMA 2011). The subject property is not in a special flood hazard area subject to inundation by 1% chance floods. No base flood elevations or depths are shown within this zone.

2.2.3 Summary of Physical Settings

The subject property covers approximately 22,307 ft² and lies at an elevation of approximately 10 ft above msl. The subject parcel is located near the southern coastline of the Island of O'ahu within the Pearl Harbor Plain physiographic region. The groundwater below the subject parcel is not considered a potential source for drinking water. The groundwater flow is expected to flow in a southeasterly direction toward the Pacific Ocean and Ke'ehi Lagoon. No wetlands or surface water bodies were observed on the subject parcel.

2.3 SITE HISTORY AND LAND USE

The subject property was developed in the late 1970s. The area surrounding the subject property began to become more commercialized in the late 1950s and early 1960s. Lagoon Drive and Waiwai Loop appeared to be constructed in the 1950s.

The subject property was used as a dry cleaning facility from as early as 1977 based on historical ownership records. The use of the property as a dry cleaning facility ended in 1997 based on files reviewed at the DOH Solid and Hazardous Waste Branch (SHWB).

The City and County of Honolulu Department of Planning and Permitting building permit database indicated that the earliest known use of the subject property was likely as a car rental facility. Information from the Honolulu Fire Department files revealed that a building was constructed on the property in 1978 and was used for laundry and related activities. According to the DOH SHWB files, a diesel-containing UST was installed near the center of the property in 1979. Inspection reports from 1989 and 1999 indicated that large volumes of tetrachloroethylene (PCE) were generated and stored at the facility. Improper storage, as well as PCE odors and leaking drums were observed during the 1999 inspection. The exact location of where the leaking drums were being stored could not be determined. Based on the 1999 inspection, the facility was issued several violations, and in 2000, a consent agreement was signed and the owner paid a \$21,000 penalty related to the mismanagement of PCE waste.

2.4 ADJACENT PROPERTY LAND USE

The subject property is bordered to the north by Ryder Truck Rental; to the northeast by ALSCO (American Linen/Young Laundry and Dry Cleaning); to the east by International Express, Inc., Jet Pro Hawaii, and Ocean Transport; to the south by Lagoon Chevron; to the southwest by Lagoon

Drive followed by a Shell Gas Station; and to the west by Lagoon Drive followed by a vacant warehouse. Evidence of RECs observed on the adjacent properties include the presence USTs and use of petroleum products at the Lagoon Chevron and Shell Gas Station.

Several properties in the vicinity were determined to represent potential RECs based on database listings, documented releases, and distance and direction relative to the subject property. These properties are shown on Figure 1 and described below.

ALSCO represents a potential REC due to current engineering controls and restricted site usage. The facility is located 150 ft from and in an upgradient direction relative to the subject property. Airport Shell, located 135 ft from the subject property and in a crossgradient direction relative to it, represents a potential REC due to an ongoing leaking UST (LUST) clean up. Lagoon Chevron, located on an adjacent property across Waiwai Loop, represents a potential REC due to current operation of three 10,000-gallon USTs.

2.5 SUMMARY OF PREVIOUS ASSESSMENTS

2.5.1 Phase I ESA

A Phase I ESA was conducted by EnviroServices for the subject property on September 28, 2001 for ALSCO; however, the ESA report was not made available to AECOM. AECOM performed an independent Phase I ESA (AECOM 2012) for HART that presented the following recognized environmental conditions for the site:

- While the subject property has been used for dry cleaning, large quantities of PCE were improperly stored on the site and leaking drums were observed during a regulatory agency site inspection in 1999. The exact location of these drums is not known. This represents a REC due to the potential for releases of PCE and related contaminants to have impacted the surface and subsurface at the subject property.
- A 1,000-gallon diesel UST, although no longer in use, is present at the subject property. This represents a REC due to the potential for past releases of diesel fuel to have impacted the surface and subsurface at the subject property.
- A floor drain and sump was observed during the site reconnaissance. PCE was used during operations at the facility and may have been released into the floor drain and sump. This represents a REC because of the potential for unauthorized releases to have impacted the subject property.
- The offsite adjacent property Airport Shell constitutes a REC for the subject property. According to regulatory agency file documents, Airport Shell, located crossgradient and across Lagoon Drive from the subject property, has ongoing groundwater monitoring as a result of a LUST case and additional investigation at the site has been requested by the DOH. Based on the current status of the LUST case, groundwater contamination from Airport Shell has the potential to impact soil or groundwater at the subject property.
- The offsite adjacent property Lagoon Chevron constitutes a REC for the subject property. The facility has two historical RECs regarding a 1988 release of approximately 1,073 gallons of gasoline and a 1998 used oil LUST case. The site has been used as a gasoline station for over 30 years and there are three 10,000-gallon gasoline USTs currently in use.
- ALSCO, located crossgradient and approximately 150 ft from the subject property, constitutes an offsite REC for the subject property. The site was labeled a dry cleaner in fire insurance maps reviewed between 1973 and 1993. Based on reviewed DOH files, soil and groundwater at the southern and western property boundaries are impacted by petroleum hydrocarbons and chlorinated solvents. Furthermore, unlined sumps exist on the eastern side of the property. No investigations to determine any impact of free-phase petroleum hydrocarbons on offsite properties appear to have been conducted based on available DOH records. Therefore, without sampling to determine whether contaminants have migrated off

site, the potential still exists for contaminants released at the ALSCO property to have impacted the subsurface of the subject property.

The Phase I ESA by AECOM recommended the following:

- A Phase II ESA should be conducted to evaluate the potential impact of diesel fuel, PCE, and related contaminants that were stored on site to the soil and groundwater beneath the subject property.
- The condition of the existing groundwater monitoring wells should be assessed and included in the Phase II investigation, if appropriate. If the wells are no longer usable, they should be abandoned according to state and local regulations.
- The 1,000-gallon diesel UST should be removed or abandoned in place according to state regulations.

2.5.2 Limited Phase II ESA

A limited Phase II ESA was previously conducted for the subject property (EnviroServices 2002a) and AECOM was provided with only the executive summary and figures for the document. The previous limited Phase II ESA conducted field screening of surface and subsurface soils, installation of four monitoring wells, and laboratory analyses of soil and groundwater samples for the presence of petroleum hydrocarbons and HVOCs. The location of the boreholes was not available to AECOM and the existing groundwater wells at the site are shown on Figure 2.

In the first phase of the limited Phase II ESA, 10 soil borings were advanced to a maximum depth of 16 ft bgs using DPT and 4 of the borings were converted into 1-inch diameter monitoring wells. The borings were selected in targeted areas throughout the site in an effort to investigate possible subsurface contamination from offsite sources and current onsite concerns. A total of 10 soil samples and four groundwater samples were collected for chemical analysis.

Analytical data from the soil samples indicated that TPH-DRO was detected in each of the 10 soil samples at depths of approximately 7-8 ft bgs. In addition, 4 of the soil samples contained detectable concentrations of HVOCs. All detectable concentrations were below their respective DOH Tier 1 soil action levels (SALs) or the U.S. Environmental Protection Agency (EPA) Preliminary Remediation Goals (Region 9) for industrial soil. All four of the groundwater samples contained petroleum hydrocarbon concentrations below method detection limits. However, two of the monitoring wells contained detectable concentrations of HVOCs. PCE was detected in MW-01 and MW-02 at concentrations of 17 micrograms per liter ($\mu\text{g/L}$) and 7.2 $\mu\text{g/L}$, respectively during the limited Phase II ESA. Trichloroethylene (TCE) was detected in MW-02 at a concentration of 4.9 $\mu\text{g/L}$. All detectable concentrations were below their respective DOH Tier 1 groundwater action levels (GALs).

Based on laboratory data and investigation activities, the previous limited Phase II ESA concluded that low concentrations (less than DOH Tier 1 SALs) of TPH-DRO exist in the subsurface soil near the soil water interface. However, no discernible pattern of contamination could be determined with respect to the existing UST system and associated piping; and the source of the TPH-DRO could not be determined. The first phase of the limited Phase II ESA recommended that a passive soil gas survey be performed to determine the location of elevated TPH-DRO in the subsurface and did not rule out additional investigation pending the soil gas survey.

Since groundwater samples were below GALs, the previous limited Phase II did not suspect significant migration of petroleum hydrocarbons via groundwater. The report recommended resampling of the four wells in 6 months to account for seasonal groundwater fluctuations. The report further concluded that HVOCs have impacted subsurface soil near the former dry cleaning operations area. HVOCs were also detected in subsurface soil located in areas south of the dry cleaning area. Additionally, underlying groundwater contained detectable concentrations of HVOCs from assumed downgradient monitoring wells, suggesting that the source of the HVOCs was on site.

The report stated that specific HVOCs detected at the site are commonly associated with solvents used during dry cleaning operations, which were known to have been performed in the past. The report recommended that the passive soil gas survey for petroleum hydrocarbons should also include investigation for select HVOCs.

2.5.3 Passive Soil Vapor Survey

A passive soil vapor survey (EnviroServices 2002b) was conducted at the site based upon the recommendation of the limited Phase II ESA. The objective of the study was to qualitatively identify the extent of TPH-DRO concentrations and HVOCs (specifically PCE and TCE) at the site.

A total of 24 VaporTec samplers were installed at approximately 18 inches bgs in a systematic square grid fashion with spacing of approximately 30 ft between points across the site. The samplers were left in place for a 2-week period in which soil vapor passively adsorbed to the sampling media.

TPH-DRO was detected in 1 of 24 samples (sample module SV-20), located near the turn in the UST piping in the northeast end of the warehouse. PCE vapors were detected in 19 of 24 samples with two separate hotspots being observed. The highest detections were 18,000 nanograms at sampling module SV-18 and 12,000 nanograms at a hotspot located on sampling module SV-9. TCE vapors were detected in 9 of 24 samples collected, 7 of which were located in the garment cleaning portion of the facility. The highest TCE was detected at 480 nanograms at SV-18 (where highest level of PCE was also detected). The concentrations detected in the soil vapor samples cannot be directly correlated to contaminants adsorbed to the soil, contaminants dissolved in the groundwater, and/or the presence of free product contamination. The mass concentrations reported from each module may reflect any or all of these sources.

Based upon the results of the passive soil vapor survey and the previous limited Phase II ESA, the report concluded that the TPH-DRO contamination was sufficiently delineated; however, the extent of PCE contamination of soil and groundwater in the area of the warehouse and the office was not delineated. The report recommended installation of an additional groundwater monitoring well at SV-18 and collection of soil and groundwater samples from this location. The report also recommended another round of sampling of the existing four groundwater wells at the site for HVOCs.

3.0 WORK PERFORMED AND RATIONALE

3.1 SCOPE OF ASSESSMENT

This investigation was conducted using assessment methods outlined in the ASTM 1903-11 and DOH Technical Guidance Manual (DOH 2009). The investigation was completed to assess the potential impact of TPH-gasoline range organics (GRO), TPH-DRO, PCE, and other dry cleaning and petroleum related contaminants from onsite and offsite sources to subsurface soil and groundwater at the subject property. Site activity photographs are shown on the photo log in Appendix A.

The following tasks were completed in the project scope of work:

- Located public utility lines at the site using Hawaii One-Call "Call Before You Dig" primary locating services.
- Conducted a geophysical clearance to identify and locate subsurface anomalies on the subject property and to mark the potential location of the diesel UST.
- Advanced five investigative boreholes around hotspots for HVOCs and TPH-DRO identified in previous investigations and around a floor drain feature. Converted all of these boreholes into temporary monitoring wells.
- Collected soil samples from the DPT liner and field screen the sample for volatile organic compound (VOC) concentrations utilizing a photoionization detector (PID). A total of two primary soil samples were collected from each borehole (one soil sample collected judgmentally from the vadose zone based upon staining or PID measurements, and one soil sample collected from the capillary fringe).
- Completed a groundwater monitoring program for the newly installed and existing monitoring wells at the subject property. The program included collecting grab-groundwater samples from the temporary wells and low-flow groundwater samples from the existing groundwater wells, and gaging the groundwater levels in existing monitoring wells.
- Analyzed soil and groundwater samples in a laboratory for VOCs, TPH-GRO, PAHs, TPH-DRO/ residual range organics (RRO), and RCRA metals.
- Abandoned the temporary wells after grab groundwater sampling.
- Managed IDW consisting of soil cuttings and purge water.

3.2 EXPLORATION, SAMPLING, AND TEST SCREENING METHODS

3.2.1 Geophysical Survey

Pural Water Specialty Co. Inc. was subcontracted to perform a geophysical survey of the subject property on March 5, 2013 to locate underground utilities or other features that might impede subsurface investigations. The geophysical investigation was also carried to determine the location and depth of any UST that may be buried within the boundaries of the subject property.

A radio detection RD-4000 electromagnetic locator and ground penetrating radar (NogginPlus 250) were used to delineate subsurface features. The survey was conducted along transects over rectangular areas extending 10 ft south and 10 ft north of each proposed soil boring location. Spray paint was used to mark the clearance area corners for each boring location. Geophysical measurements were also conducted along transects spaced 5 to 10 ft apart to survey for the presence of abandoned USTs.

Several linear anomalies were identified and marked prior to intrusive activities. Although some of these anomalies were subsequently identified as the joint between concrete blocks, the proposed boring locations were slightly relocated to anomaly-free areas. No USTs or fuel lines were identified during the investigation.

3.2.2 Subsurface Soil Sampling

Subsurface soil samples were collected at the subject property on March 6, 2013. GeoTek Hawaii utilized concrete coring and DPT to collect representative samples. A total of five soil borings were advanced at the subject property using a concrete corer (top 6 inches) and a GeoProbe 6620DT to a depth of approximately 15 ft bgs for the collection of subsurface soil. However, subsurface conditions at BS-01 contributed to advance the soil boring to a depth of 18 ft bgs. All subsurface soils were described and logged on standard boring logs. Completed boring logs are presented in Appendix B. A 2.25-inch split-spoon with a 2-inch disposable acetate soil core sampler was used to collect soil samples in shallow soil above groundwater (4-5 ft bgs) and at the capillary fringe (10-11 ft bgs) from each boring. Samples analyzed for VOCs, TPH-GRO, and percent moisture were collected directly from the core with a 5-gram disposable polyethylene Terra Core sampler. Samples for analysis of the remaining target analytes were collected using a disposable scoop. Soil samples were placed in laboratory-certified 4-ounce wide-mouth clear glass jars (two jars per location), 2-ounce wide-mouth clear glass jars (one jar per location), 40-milliliter pre-tare glass vials with 5 milliliter deionized water (four samples per location), 40-milliliter pre-tare glass vials with 5 milliliters of methanol (two samples per location), and 40-milliliter polyethylene vials (two samples per location). Sample containers were labeled, sealed, placed in resealable plastic bags, and preserved on ice prior to transporting to the laboratory for analysis. All non-disposable sampling equipment was properly decontaminated between soil boring locations. A total of 10 samples, excluding field quality control (QC) samples, were submitted for analysis of VOCs, TPH-GRO, PAHs, TPH-DRO/RRO, RCRA metals, and percent moisture. All soil IDW generated during drilling operations was properly contained in U.S. Department of Transportation-approved 55-gallon drums.

3.2.3 Groundwater Sampling Program

3.2.3.1 MONITORING WELL INSTALLATION AND CONSTRUCTION

This investigation included the installation of five temporary groundwater monitoring wells (TM-01 through TM-05) to assess current groundwater conditions at the subject property. Well construction details are summarized in Table 1. The temporary wells were 1.5-inch diameter pre-packed wells. Well construction details are presented in Appendix B.

The total depths of the wells, except TM-01, are approximately 15 ft bgs. Groundwater was encountered in boreholes TM-02 through TM-05 at 8–9 ft below top of concrete slab. Groundwater was not encountered in borehole TM-01. Each well was constructed with 5 ft of 0.020-inch slotted screen set approximately 5 ft below the observed water table to provide sufficient coverage for anticipated fluctuations in water table elevation. For TM-01, a total of 10 ft of screened interval was set between 8 ft and 18 ft below top of concrete slab. Blank well casing was installed from the top of the screened interval to approximately 1 inch below the top of concrete slab. The annular materials were comprised of prepack sand.

3.2.3.2 GROUNDWATER SAMPLING

Temporary and existing groundwater monitoring wells were sampled during March 7 and 8, 2013. Prior to purging each well, head-space was screened for VOC vapors immediately after opening the well using a miniRAE 3000 PID calibrated to 100 parts per million isobutylene. No VOCs were detected in the head-space of any of the nine monitoring wells. Each well was purged prior to collecting groundwater samples for laboratory analysis. Purging was completed using low-flow sampling methodology with a submersible stainless-steel bladder pump at a rate of 300 milliliters per minute. The following field parameters were measured at regular intervals during purging: total dissolved solids, pH, specific conductance, dissolved oxygen, temperature, oxidation-reduction potential, turbidity, salinity, and depth to water. All parameters, except for depth to water, were measured using a YSI multi-parameter meter. Depth to water was measured from the top of casing with an interface probe. Field parameters were recorded on monitoring well sampling logs (Appendix B). All non-disposable sampling equipment was properly decontaminated between groundwater sampling locations. Groundwater removed during purging was handled as IDW. Groundwater samples were collected in laboratory certified 1-liter amber glass bottles (three bottles

per well) and 40-milliliter clear glass vials preserved with hydrochloric acid (four vials per well). A 0.45-micrometer in-line filter was then attached to the outflow of the sampling tube and a sample for analysis of dissolved metals sample was collected in a 250-milliliter polyethylene bottle preserved with 5 milliliters of nitric acid. Sample containers were labeled, sealed, placed in resealable plastic bags, and preserved on ice prior to transporting to the laboratory for analysis. A total of seven samples, excluding field QC samples, were submitted for the analysis of VOCs, TPH-GRO, PAHs, TPH-DRO/RRO, and dissolved metals.

3.2.3.3 GROUNDWATER GAGING AND GROUNDWATER DIRECTION

The water levels in the permanent wells at the subject property were gaged within a 7-minute time period to obtain data for groundwater flow direction calculations. The well caps were opened and pressure equilibrated with atmospheric conditions for 15 minutes before gaging the wells. The water depths in feet below top of well casing on March 8, 2013 were as follows:

- MW-01 = 8.01 ft (9:06 a.m.)
- MW-02 = 7.70 ft (9:08 a.m.)
- MW-03 = 7.30 ft (9:20 a.m.)
- MW-04 = 8.20 ft (9:03 a.m.)

The water table calculations require the survey measurements for top of casing elevations, which were not available to AECOM at the time of writing this report. The groundwater gradient is relatively flat in this area and the detailed survey elevations for top of casing are required to determine precise groundwater flow direction. MW-01 and MW-02 are at relatively the same elevation, whereas MW-03 and MW-04 are at relatively higher elevation because they were installed on sloped driveways. Just comparing water table depths at MW-01 and MW-02 it appears that the flow is from MW-02 towards MW-01 in eastern direction towards the property.

The groundwater direction has been recorded for the Lagoon Chevron Service Station (2603 Waiwai Loop) across the street south from subject property (LFR 2000). The groundwater was observed to flow in a southeastern direction. The same direction appears likely to hold for the subject property.

3.2.3.4 ABANDONMENT OF TEMPORARY GROUNDWATER WELLS

The five temporary groundwater wells were abandoned by pulling out the pre-packed wells from the borehole. The borehole was filled with bentonite chips and the upper 1 foot of the surface was completed with Quickrete finish.

3.2.4 Field Quality Control

Field QC samples were collected throughout the sampling effort to monitor sampling procedures and identify potential outside sources of contamination. The field QC samples consisted of equipment rinsates, trip blanks, and duplicates. Field QC samples and data quality assessment are discussed in Appendix C.

3.2.5 Laboratory Analysis

Samples collected for analysis were recorded in the field bounded logbook and chain-of-custody forms. Samples were handled, stored, transported to TestAmerica Honolulu, and shipped to the analytical laboratory (TestAmerica Seattle) via overnight air carrier with the appropriate soil permit information. Analytical summary tables are presented in Section 4.0 accompanying the discussion of the investigation results. Copies of the laboratory analytical reports are presented in Appendix C.

3.3 DEVIATIONS FROM THE SCOPE

The following deviations are noted from the original scope:

- Grab groundwater was not collected from installed temporary well TM-01 because the well TM-01 did not yield significant water even though it was left open for a 24 hour period. The lithology in this well comprised of tight clay that had very low hydraulic conductivity. Only soil samples were collected from this well.
- Grab groundwater was not collected from installed temporary well TM-05 because it did not yield significant water during the sampling event. Samples from TM-04 and MW-03 were considered sufficient for providing spatial coverage for the area. Only soil samples were collected from the borehole BS-05/TM-05.
- Complete coverage of the parking area was not available for locating USTs because a couple of stalls near the reported location of the UST were occupied by parked vehicles. Only the area beneath the cars was inaccessible.

4.0 SUMMARY OF SAMPLING RESULTS

This section summarizes the results of the field activities conducted at the subject property, including subsurface soil sampling and groundwater sampling as described in Section 3.0. Based on historical usage and activities at the site, as well as site reconnaissance, samples were analyzed for site-specific target analytes. The reported concentration ranges and spatial distribution of analytes in soil and groundwater are presented in Sections 4.3 and 4.4.

4.1 SAMPLING SUMMARY

A total of 10 subsurface soil and seven groundwater samples were collected. Table 2 presents a summary of all samples analyzed at the subject property, per matrix and analytical method.

4.2 REGULATORY CRITERIA

Based on groundwater classification criteria, site groundwater is not a suitable source of potable drinking water. Therefore, the following project screening criteria were identified from the DOH Tier 1 EALs (DOH 2011):

- The lowest values for each target analyte reported in Table B-2: Soil Action Levels (surface water >150 meters and groundwater is not a current or potential drinking water source).
- The lowest values for each target analyte in Table D-1d: Groundwater Action Levels (surface water >150 meters and groundwater is not a current or potential drinking water source).

4.3 SUBSURFACE SOIL

This section describes the results of the soil sampling analyses conducted at the subject property. Analytical results for the subsurface soil are summarized in Table 3 and detected results are shown on Figure 3. Complete analytical results and laboratory reports are presented in Appendix C.

A total of five VOC compounds comprising PCE and PCE degradation daughter products (i.e., PCE, TCE, cis-1,2-dichloroethylene [DCE], trans-1,2-DCE, and vinyl chloride [VC]) were detected in subsurface soil. All detected VOC concentrations were below their respective project screening criteria.

A total of 13 PAH compounds (anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)-fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene) were detected in subsurface soil at the site. The PAH detections were limited to boreholes BS-03 and BS-05. All detected PAH concentrations were at least an order of magnitude below their respective project screening criteria.

Petroleum hydrocarbons (TPH-GRO, -DRO, and -RRO) were detected in subsurface soil samples at BS-01, BS-04, and BS-05. Borehole BS-01 located in the Former Dry Cleaning Operations Area reported the highest concentrations of TPH-DRO and -RRO. However, TPH-GRO detections and the maximum concentration were found in boreholes located in the Former and Current Storage Area. TPH-GRO was not detected in samples collected from the Former Dry Cleaning Operations Area. All detected TPH concentrations were below their respective project screening criteria.

A total of six RCRA metals (arsenic, barium, cadmium, chromium, lead, and mercury) were detected in subsurface soil. RCRA metals were reported in all sampling locations at the subject property. The majority of maximum concentrations were found in samples from borehole BS-01 in the Former Dry Cleaning Operations Area. All detected RCRA metals concentrations were below their respective project screening criteria.

4.4 GROUNDWATER

This section describes the results of the groundwater sampling analyses conducted at the subject property. Analytical results for the groundwater are summarized in Table 4 and detected results are shown on Figure 4. Complete analytical results and laboratory reports are presented in Appendix C.

A total of five VOC compounds comprising PCE and PCE degradation daughter products (i.e., PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC) were detected in the temporary monitoring wells TM-02, TM-03, and TM-04. All detected VOC concentrations were below their respective project screening criteria. No VOCs were detected in samples collected from the existing groundwater monitoring wells.

A total of seven PAH compounds were detected in samples collected from temporary groundwater wells TM-02, TM-03, and TM-04. All detected concentrations were below their respective screening criteria. No PAHs were detected in samples collected from the existing groundwater monitoring wells.

Petroleum hydrocarbons (TPH-DRO and -RRO), were detected at concentrations below the screening criteria at temporary groundwater sampling locations TM-02, TM-03, and TM-04. TPH-GRO was not detected in groundwater samples at the subject property. No TPH compounds were detected in samples collected from the existing groundwater monitoring wells.

Barium was the only RCRA metal detected in groundwater samples at the site. Barium was reported in all sampling locations except MW-01. The detected concentrations were all below the project screening criteria.

5.0 INTERPRETATION AND CONCLUSIONS

This section provides an interpretation of the findings of the Phase II ESA in relation to the potential release area, presence and extent of *target analytes* in environmental media at the site, refinement of the conceptual site model, and potential data gaps.

5.1 RECOGNIZED ENVIRONMENTAL CONDITIONS/POTENTIAL RELEASE AREA

This Phase II ESA, in conjunction with the results of the 2002 Phase II ESA, confirms that petroleum hydrocarbons and HVOCs were released to the subsurface soil and groundwater at the site. The contaminants have persisted at the site for over 16 years since the closure of dry cleaning operations at the site, as evidenced by the detection of the target analytes found during the previous Phase II in 2002 (EnviroServices 2002a,b) and also during this round of investigation. The following sections describe the released contamination in terms of the nature and extent of contamination, conceptual site model, potential transport concerns, and potential data gaps.

5.2 ABSENCE, PRESENCE, DEGREE, AND EXTENT OF TARGET ANALYTES

Petroleum and HVOC contamination was detected in site soil and groundwater confirming that petroleum and HVOC releases occurred at the site in the past. All target analytes are below the DOH screening criteria for a site on a non-drinking water aquifer and surface water source being >150 meters from the site. The concentrations of petroleum hydrocarbons and HVOCs detected at site soil and groundwater are relatively low.

Currently available data from the site does not indicate a significant concern from migration of contamination from offsite properties to the subject property. The limited releases of HVOC and petroleum appear to be site related. This is deduced from the fact that monitoring wells MW-01 through MW-04 did not detect HVOC or petroleum related contamination above the DOH screening levels. However, insufficient data is presently available in the northern and eastern boundary of the property to rule out possible migration of contamination from neighboring properties. Also, the groundwater direction may vary at the site based upon tidal fluctuations.

5.2.1 Petroleum Release

The petroleum release appears to be a very small release as evidenced from the absence of free product or light non-aqueous phase liquid in the capillary fringe of groundwater. Dissolved TPH and PAH concentrations are well below DOH screening levels. The primary release is around BS-01 and a secondary release area around BS-05 (Figure 3 and Figure 4).

5.2.2 HVOC Release

The current and historic (EnviroServices 2002a,b) detected results for HVOCs are summarized on Figure 5.

The primary HVOC release source appears to be around BS-03/TM-03 and previous passive gas sampling location at module SV-18. The HVOC contamination appears to be more widespread around the site than the petroleum releases as evidenced by detected HVOC contamination in multiple soil, soil gas, and groundwater sampling locations.

The concentration of HVOCs detected so far in soil are quite low (<5 micrograms per kilogram [µg/kg] for PCE). The concentration in groundwater is relatively low but significant (10 µg/L of PCE and 16 µg/L of DCE in TM-03 and 13 µg/L of DCE in TM-02). Previous investigations have detected HVOCs in groundwater wells MW-01 (17.0 µg/L of PCE) and MW-02 (7.2 µg/L of PCE and 4.2 µg/L of TCE). These wells (MW-01 and MW-02) did not have any HVOC detects during the current investigation and it could either indicate fluctuations in groundwater flow direction or migration of the plume downgradient from the site. The previous passive soil vapor investigation detected widespread HVOC soil vapor issues at 1.8 ft bgs (Figure 5).

PCE daughter products (TCE, DCE, and VC) were detected in the warehouse/ATM storage area, indicating that biodegradation through dechlorination processes is actively occurring at the site.

5.2.3 Petroleum Release Fate and Transport

No free petroleum product was detected below the site in soil or groundwater samples. The detected concentrations for TPH and PAHs in soil and groundwater are all below the site screening criteria. There is no apparent significant threat of migration of the contamination. The concentration in soil is minimal and does not pose a leaching hazard in the clayey stratigraphy present beneath the site. The dissolved concentrations are below the screening level and migration is not an apparent concern. The low concentrations in soil and groundwater indicate that the vapor intrusion concern from the former petroleum release is negligible.

The limited contamination related to petroleum releases at the site will naturally biodegrade over time.

5.2.4 HVOC Release Fate and Transport

Dry cleaning activities have stopped at the site, therefore the only continuing source at the site for the contamination is the initial HVOC spilled or released into subsurface soil and groundwater. The released contamination has been observed in soil, groundwater, and soil gas at the site.

The physical properties of the HVOCs at the site are presented in Table 5. Both PCE and TCE are significantly denser than water and also less viscous than water. This implies that any releases to the subsurface soil would cause the PCE and TCE to percolate downwards through both soil and the groundwater table. If the release volume was minimal, the majority of the contamination would be adsorbed to the vadose zone soil and shallow groundwater. If a higher volume of PCE solvent was released, then the contamination would percolate through the water table and contamination would increase with depth until it encountered impervious stratigraphic layers/aquitards such as the shallow clay layer below the site. Based on the low concentrations that have been detected in soil and groundwater, it appears that a limited volume of PCE/TCE was released into the subsurface.

HVOCs (see Henry's Law Constants in Table 5) will readily partition to the soil vapor phase. The previous soil gas results found HVOC vapor to be widespread beneath the building's concrete slab. The soil vapor results were acquired using temporary vapor probes which measure the mass of HVOC adsorbed in the probe but do not provide an accurate estimate of actual soil vapor concentration. The potential for vapor intrusion at this site or the adjacent properties is unknown. The risk to future construction workers excavating below the slab is also unknown.

The concentration of HVOCs present at the site could decrease over time due to biodegradation of PCE, TCE, and DCE. VC was detected in a soil sample at BS-01 at a low concentration, which could indicate that dehalococoides bacteria may be naturally present at the site to cause biodegradation of DCE to VC.

HVOC groundwater contamination could potentially migrate off site and impact downgradient properties, though the onsite concentrations are all below the site screening criteria.

5.3 DATA GAPS

Data gaps related to contamination at the site include the following:

- The 1,000-gallon UST could not be located. The geophysical survey around the previously noted location of the UST did not show any anomalies that indicated a buried UST.
- Vapor intrusion may be a concern at the site for present and future use of the property. Previous results collected using passive vapor probes beneath the concrete slab indicated

the presence of HVOC vapors but did not provide direct soil gas concentrations. The potential for offsite migration of HVOC soil vapors to adjacent properties is also unknown.

- The groundwater flow direction could not be determined during the March 2013 Phase II ESA because surveyed top of casing elevations for the wells were not available.
- Potential migration of groundwater contamination along the eastern edge of the site remains unknown. There are no wells along the eastern edge of the property, which is the expected direction of groundwater flow.
- The potential for contaminant migration onto the site from adjacent upgradient sites is unknown.

5.4 CONCEPTUAL MODEL FOR THE SITE

Based upon the results of the current and previous investigations, the following refinement to the conceptual site model is described.

5.4.1 Conceptual Site Model for Petroleum Release

The petroleum release appears to be of minimal impact at the site. No free product or light non-aqueous phase liquid was detected at the capillary fringe at the site and there is no free product in any of the monitoring wells at the site. The dissolved TPH and PAHs detected in site groundwater samples are all well below the applicable DOH screening levels and do not appear to present a significant risk.

5.4.2 Conceptual Site Model for HVOC Release

The data indicates small release(s) of HVOCs to the subsurface soil at the warehouse and the storage areas at the site. Soil and groundwater concentrations are all well below the applicable DOH screening levels. It is unlikely that significant contamination is present in deeper groundwater based upon the soil and groundwater concentrations observed so far. The potential for vapor intrusion and vapor migration risks, however, is unknown.

5.4.3 Conceptual Site Model for UST

The UST or its associated piping could not be located through geophysical survey during the Phase II ESA. It is possible that the UST and associated piping were removed. Boring BS-01 was advanced in the vicinity of where the underground piping between the UST and the boiler existed. The utility survey at the location did not show any underground piping. The borehole had a different geology (fat clays throughout the borehole) to 18 ft bgs. Though unlikely, it is possible that the UST was missed during the survey because part of the parking lot was occupied by vehicles (Figure 4 for geophysical survey coverage for locating UST).

5.5 CONCLUSIONS/OBJECTIVES MET

The objectives of the investigation were substantially met. The Phase II confirms the presence of target analytes in soil, groundwater, and soil gas. The data points towards relatively low contamination in subsurface soil. There is potentially significant contamination from HVOCs in the vapor phase, and there is potential concern for offsite issues with groundwater and offsite and onsite concerns for vapor intrusion.

The UST that was reported to be present was not located during this investigation. It may or may not be present at the site. In the absence of confirmation, it should be assumed that the UST is present and needs to be abandoned.

The existing groundwater monitoring wells were found to be in good condition. They should be left in place until all planned future investigations at the site are completed. They will eventually have to be abandoned.

6.0 RECOMMENDATIONS

The presence of target analytes has been confirmed for the subject property with data collected during this and previous Phase II ESAs, but the full extent of contamination and related risk are unknown. The extent of further assessment is a function of the degree of confidence required and the degree of uncertainty acceptable in relation to the objectives of the assessment. The user should evaluate legal, business, and environmental risks in light of the data presented in this report and in consultation with the legal and business advisors.

The following recommendations are made based on the obtained data and the remaining data gaps:

1. Confirm, by further review of records and geophysical survey, that the UST and associated piping has been removed.
2. Sample subslab soil vapor to determine whether intrusion to indoor air (onsite and offsite) is a significant concern. If the area will be paved in future; then engineering controls, such as vapor barriers, maybe implemented to control any potential vapor intrusion issues. Implementation of proper engineering controls may result in no further soil vapor sampling being necessary for the site.
3. Acquire the monitoring well top-of-casing elevations to confirm the groundwater flow direction across the site and to determine whether offsite contaminant migration is a significant concern.

7.0 REFERENCES

- AECOM Technical Services, Inc. (AECOM). 2012. *Phase I Environmental Site Assessment 2676 WaiWai Loop, TMK Number (1) 1-1-016:005, Honolulu, O'ahu, Hawai'i*. Prepared for Honolulu Authority for Rapid Transportation. Honolulu. April.
- ASTM International (ASTM). 2001. *Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process*. E1903-97. West Conshohocken, PA.
- LFR Levine Fricke (LFR). 2000. *Underground Storage Tank Removal and Long-Term Release Response Report, Lagoon Chevron Service Station, 2604 Waiwai Loop, Honolulu Hawaii*. DOH Facility No. 9-101221, Release No. 980241, Chevron Facility No. 95570. LFR 6513.02 Honolulu, March.
- Department of Health, State of Hawaii (DOH). 2009. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*. Interim Final. Honolulu: Office of Hazard Evaluation and Emergency Response. 21 June.
- . 2011. *Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater*. Hawai'i Edition. Office of Hazard Evaluation and Emergency Response. Revised March 2012. Fall.
- Environmental Data Resources (EDR). 2012. Historic topographic maps obtained from EDR dated 1928, 1954, 1959, 1968, 1970, 1983, and 1999.
- EnviroServices. 2002a. *Limited Phase II Environmental Site Assessment, Al Phillips Facility, 515 Lagoon Drive, Honolulu, Hawaii. TMK 1-1-16:15*. Honolulu, April.
- . 2002b. *Passive Soil Vapor Survey Report, Al Phillips Facility, 515 Lagoon Drive, Honolulu, Hawaii, TMK 1-1-16:15*. Honolulu, September.
- Federal Emergency Management Agency. 2011. *Flood Insurance Rate Map, Panel number: 15003C0353G*. January 19.
- MacDonald, G. A., A. T. Abbott, and F. L. Peterson. 1983. *Volcanoes in the Sea, The Geology of Hawaii*. 2nd ed. Honolulu: Univ. of Hawaii Press.
- Mink, J. F., and L. S. Lau. 1990. *Aquifer Identification and Classification for Oahu: Groundwater Protection Strategy for Hawaii*. Revised. Tech. Report No. 179. Honolulu: Univ. of Hawaii, Water Resources Research Center. February.
- United States Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). *Official Soil Series Descriptions*. Accessed [02/10/2012].

TABLES

Table 1: Monitoring Well Construction Details

Well	Installation Date	Abandonment Date	Diameter (inches)	Screen Interval (ft below tocs)	Total Depth (ft below tocs)	Depth to Water (ft below tocs)
TM-01	3/6/2013	3/7/2013	1.5	8-18	18	—
TM-02	3/6/2013	3/7/2013	1.5	10-15	15	9.14
TM-03	3/6/2013	3/7/2013	1.5	10-15	15	8.63
TM-04	3/6/2013	3/7/2013	1.5	10-15	15	8.60
TM-05	3/6/2013	3/7/2013	1.5	10-15	15	8.30

— dry well, no reading/measurement

ft foot or feet

tocs top of concrete slab

Table 2: Summary of Analytical Samples

Analytical Group	Analytical Method ^a	Quantity Analyzed				
		Primary	Field Duplicate	MS/MSD Pairs	Equipment Blank	Trip Blank ^b
Subsurface Soil						
VOCs	8260B	10	1	1	—	1
TPH-GRO	8015B	10	1	1	—	1
PAHs	8310	10	1	1	—	N/R
TPH-DRO/RRO	8015B	10	1	1	—	N/R
Metals ^c	6010B	10	1	1	—	N/R
Mercury	7471A	10	1	1	—	N/R
Groundwater						
VOCs	8260B	7	1	1	1	2
TPH-GRO	8015B	7	1	1	1	2
PAHs	8310	7	1	1	1	N/R
TPH-DRO/RRO	8015B	7	1	1	1	N/R
Metals (dissolved) ^c	6010B	7	1	1	1	N/R
Mercury	7470A	7	1	1	1	N/R

— Not collected

DRO diesel range organics

GRO gasoline range organics

MS matrix spike

MSD matrix spike duplicate

N/R not required

PAH polyaromatic hydrocarbon

RRO residual range organics

TPH total petroleum hydrocarbons

VOC volatile organic compound

^a Method Source: EPA SW-846.^b One per analysis per cooler containing samples for VOC and/or GRO analysis.^c RCRA metals include the following: As, Ba, Cd, Cr, Pb, Se, Ag.

Table 3: Summary of Subsurface Soil Sample Results

Analyte	Method ^a	Screening Level ^b	Location	BS-01		BS-01		BS-02		BS-02		BS-03		BS-03		BS-04		BS-04		BS-04 (FD)		BS-05		BS-05	
			Depth (ft bgs)	5		8		5		11		5		11		3		9		9		5		8	
			Units	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
VOCs																									
cis-1,2-Dichloroethene	8260B	310	µg/kg	0.76	J	1.5		0.30	U	1.2		16		2.4		0.36	U	0.32	U	0.30	U	0.28	U	0.29	U
trans-1,2-Dichloroethene	8260B	2,700	µg/kg	1.3	U	1.7		0.30	U	0.35	U	0.79	J	1.2		0.36	U	0.32	U	0.30	U	0.28	U	0.29	U
Trichloroethene	8260B	260	µg/kg	0.83	J	1.3	U	0.30	U	0.35	U	0.77	J	0.67	J	0.36	U	0.32	U	0.30	U	0.28	U	0.29	U
Tetrachloroethene	8260B	88	µg/kg	2.4		1.3	U	0.30	U	0.35	U	0.38	J	0.35	U	0.36	U	3.3		3.0		1.3		0.29	U
Vinyl chloride	8260B	720	µg/kg	1.3	U	5.1		0.85	J	0.35	U	0.35	U	0.35	U	0.36	U	0.32	U	0.30	U	0.28	U	0.29	U
PAHs																									
Anthracene	8310	4,300	µg/kg	1.66	U	0.175	U	0.167	U	0.390	U	7.07	J	0.347	U	0.371	U	0.356	U	0.361	U	0.366	U	0.144	U
Benzo[a]anthracene	8310	1,500	µg/kg	1.52	U	0.161	U	0.153	U	0.357	U	12.6	J	0.318	U	0.340	U	0.327	U	0.331	U	5.45	J	0.132	U
Benzo[a]pyrene	8310	150	µg/kg	11.7	U	1.24	U	1.18	U	2.76	U	33.9		2.46	U	2.63	U	2.52	U	2.56	U	14.6	J	1.02	U
Benzo[b]fluoranthene	8310	1,500	µg/kg	2.76	U	0.292	U	0.278	U	0.650	U	32.1		0.578	U	0.618	U	0.594	U	0.602	U	14.6	J	0.241	U
Benzo[g,h,i]perylene	8310	27,000	µg/kg	3.31	U	0.351	U	0.333	U	0.780	U	25.2		0.694	U	0.742	U	0.713	U	0.723	U	12.4	J	0.289	U
Benzo[k]fluoranthene	8310	15,000	µg/kg	2.76	U	0.292	U	0.278	U	0.650	U	12.4	J	0.578	U	0.618	U	0.594	U	0.602	U	2.15	J	0.241	U
Chrysene	8310	10,000	µg/kg	4.14	U	0.438	U	0.417	U	0.975	U	34.8		0.867	U	0.927	U	0.891	U	0.903	U	11.1	J	0.361	U
Dibenzo(a,h)anthracene	8310	150	µg/kg	2.90	U	0.307	U	0.292	U	0.682	U	5.44	J	0.607	U	0.649	U	0.624	U	0.632	U	0.640	U	0.253	U
Fluoranthene	8310	87000	µg/kg	13.4	U	1.42	U	1.35	U	3.15	U	41.3		2.80	U	3.00	U	2.88	U	2.92	U	10.1	J	1.17	U
Indeno[1,2,3-cd]pyrene	8310	1500	µg/kg	3.73	U	0.394	U	0.375	U	0.877	U	42.0		0.781	U	0.835	U	0.802	U	0.813	U	0.823	U	0.325	U
Naphthalene	8310	4500	µg/kg	13.8	U	1.46	U	1.39	U	3.25	U	22.4	J	2.89	U	3.09	U	2.97	U	3.01	U	3.05	U	1.20	U
Phenanthrene	8310	69000	µg/kg	9.52	U	1.01	U	0.958	U	2.24	U	39.9		1.99	U	2.13	U	2.05	U	2.08	U	2.10	U	0.831	U
Pyrene	8310	44000	µg/kg	11.70	U	1.24	U	1.18	U	2.76	U	26.9	J	2.46	U	2.63	U	2.52	U	2.56	U	4.22	J	1.02	U
TPH																									
GRO (C6-C12)	8015B	100	mg/kg	4.5	U	0.80	U	0.66	U	0.65	U	0.76	U	0.74	U	0.77	U	0.94	J	1.1	J	0.89	J	0.69	U
DRO (>C12-C24)	8015B	500	mg/kg	26	J	5.9	U	5.0	U	6.1	U	5.8	U	5.9	U	5.3	U	5.6	U	4.9	U	5.1	U	5.1	U
RRO (>C24-C32)	8015B	500	mg/kg	150		19	U	16	U	19	U	18	U	19	U	17	U	18	U	16	U	24	J	16	U
Metals																									
Arsenic	6010B	24	mg/kg	2.6	J	0.58	J	0.34	U	6.1		2.2	J	1.6	J	0.34	U	4.1		1.1	J	0.35	U	2.0	J
Barium	6010B	1,000	mg/kg	390		240		60		150		430		130		86		75		57		85		58	
Cadmium	6010B	14	mg/kg	3.7		3.2		1.4		2.3		4.2		1.8		1.5		0.85	J	0.72	J	1.6		0.39	J
Chromium (total)	6010B	1,100	mg/kg	210		170		76		120		210		100		89		47		25		87		16	
Lead	6010B	200	mg/kg	56		11		6.4		3.0		23		1.3	J	7.7		0.19	U	0.25	J	14		0.13	U
Mercury	7471A	4.7	mg/kg	0.58		0.046		0.0090	J	0.30		0.073		0.041		0.021		0.016	J	0.0061	J	0.031		0.0051	U

µg/kg

microgram per kilogram

bgs

below ground surface

DRO

diesel range organics

FD

field duplicate

ft

foot or feet

GRO

gasoline range organics

J

estimated value

mg/kg

milligram per kilogram

PAH

polyaromatic hydrocarbon

Qual

qualifier

RRO

residual range organics

TPH

total petroleum hydrocarbons

U

not detected above instrument detection level

^a

Methods are EPA SW-846.

^b

Screening levels are the DOH Fall 2011 EALs, Table B-2.

Table 4: Summary of Groundwater Sample Results

Analyte	Method ^a	Screening Level ^b	Location	TM-02		TM-03		TM-04		MW-01		MW-02		MW-03		MW-03 (FD)		MW-04	
			Depth (ft bgs)	11		9.6		12		13		13.5		13.5		13.5		13	
			Units	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
VOCs																			
cis-1,2-Dichloroethene	8260B	1,100	µg/L	13		1.4		1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
trans-1,2-Dichloroethene	8260B	2,600	µg/L	1.2		1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Naphthalene	8260B	210	µg/L	1.2		1.0	U	2.9		1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Trichloroethene	8260B	610	µg/L	1.8		3.5		1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Tetrachloroethene	8260B	180	µg/L	1.0	U	10.0		1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
PAHs																			
Anthracene	8310	22	µg/L	0.101		0.135		0.00952		0.00962	U	0.00952	U	0.00990	U	0.0100	U	0.00952	U
Benzo[a]anthracene	8310	4.7	µg/L	0.0312	J	0.0462	J	0.0346	J	0.0192	U	0.0190	U	0.0198	U	0.0200	U	0.0190	U
Benzo[a]pyrene	8310	0.81	µg/L	0.00777		0.0433	J	0.0375	J	0.00769	U	0.00762	U	0.00792	U	0.00800	U	0.00762	U
Chrysene	8310	1	µg/L	0.0384	J	0.0584	J	0.0422	J	0.00769	U	0.00762	U	0.00792	U	0.00800	U	0.00762	U
Fluoranthene	8310	130	µg/L	0.950		1.11		0.489		0.00962	U	0.00952	U	0.00990	U	0.0100	U	0.00952	U
Phenanthrene	8310	300	µg/L	0.774		0.725		0.00476	U	0.00481	U	0.00476	U	0.00495	U	0.00500	U	0.00476	U
Pyrene	8310	68	µg/L	0.653		0.820		0.485		0.0163	U	0.0162	U	0.0168	U	0.0170	U	0.0162	U
TPH																			
DRO (>C12-C24)	8015B	2.5	mg/L	0.35		0.25		0.26		0.12	U	0.12	U	0.12	U	0.13	U	0.12	U
RRO (>C24-C32)	8015B	2.5	mg/L	0.55		0.28		0.33		0.24	U	0.24	U	0.25	U	0.25	U	0.24	U
Metals																			
Barium	6010B	1	mg/L	0.29		0.13		0.30		0.010	U	0.097		0.083		0.083		0.060	

µg/L

bgs

DRO

FD

ft

J

mg/L

Qual

RRO

TPH

U

microgram per liter

below ground surface

diesel range organics

field duplicate

foot or feet

estimated value

milligram per liter

qualifier

residual range organics

total petroleum hydrocarbons

not detected above instrument detection level

^a Methods are EPA SW-846.

^b Screening levels are the DOH Fall 2011 EALs, Table D-1d.

Table 5: Physical/Chemical Properties of PCE, TCE, DCE, and VC

Analyte	Density (g/cm ³)	Henry's Law Constants (unitless)	Organic Carbon Partition Coefficient K _{oc} (cm ³ /g)	Pure Component Water Solubility (mg/L)	Dynamic Viscosity (centipoise)	Diffusivity in Air D _a (cm ² /s)	Diffusivity in Water D _w (cm ² /s)
PCE	1.625	0.753	155	200	0.89	0.0720	0.0000082
TCE	1.462	0.421	166	1,470	0.57	0.0790	0.0000091
cis-DCE	1.280	0.167	35.5	3,500	0.47	0.0736	0.0000113
VC	0.911	1.1	18.6	8,800	0.18	0.106	0.0000123

Note: All parameters except dynamic viscosity are for a reference temperature of 25°C. Dynamic viscosity is for a reference temperature of 20°C.

°C degree Celsius
cm³/g cubic centimeter per gram
cm²/s square centimeter per second
DCE dichloroethylene
g/cm³ gram per cubic centimeter
K_{oc} organic-carbon partition coefficient
mg/L milligram per liter
PCE tetrachloroethylene
TCE trichloroethylene
VC vinyl chloride

FIGURES

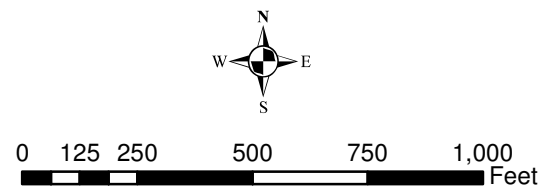
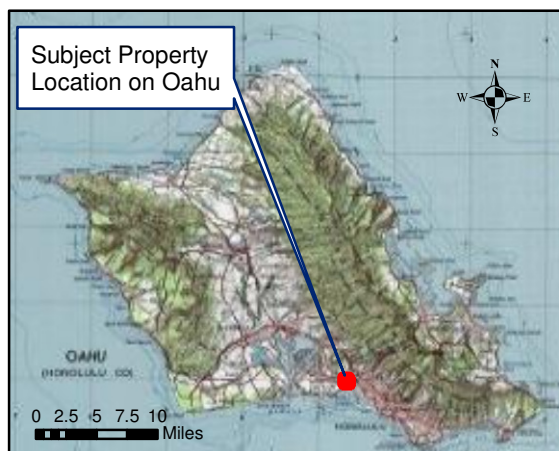


Figure 1
Site Location Map
Phase II ESA
515 Lagoon Drive, Parcel 15
Honolulu, Oahu, Hawaii



Legend	
	1st Floor Vault and 2nd Floor Boiler Equipment
	Former Dry Cleaning Area
	Former Storage Area / Courier Storage Area
	Former Warehouse Area
	Office Space 1st and 2nd Floor
	Overhang and 2nd Floor Offices
	Previous documented location of UST
	Previous Documented Location of UST Pipe
	Existing Groundwater Well
	Current Phase II ESA Soil Sampling and Grab - Groundwater Sampling Location
	Current Phase II ESA Soil Sampling Location
	Previous Phase II ESA Soil Vapor Sampling Location

Notes

1. All locations and dimensions shown on the map are approximate and not based on certified survey information.

Figure 2
Site Layout Map
Phase II ESA
515 Lagoon Drive, Parcel 15
Honolulu, Oahu, Hawaii

Lagoon Drive

Analyte	Screening Level	Location	BS-03	BS-03
		Depth (ft bgs)	5	11
		Units	Result	Result
VOCs				
cis-1,2-Dichloroethene	310	µg/kg	16	2.4
trans-1,2-Dichloroethene	2700	µg/kg	0.79 J	1.2
Trichloroethene	260	µg/kg	0.77 J	0.67 J
Tetrachloroethene	88	µg/kg	0.38 J	0.35 U
PAHs				
Anthracene	4300	µg/kg	7.07 J	0.347 U
Benzo[a]anthracene	1500	µg/kg	12.6 J	0.318 U
Benzo[a]pyrene	150	µg/kg	33.9	2.46 U
Benzo[b]fluoranthene	1500	µg/kg	32.1	0.578 U
Benzo[g,h,i]perylene	27000	µg/kg	25.2	0.694 U
Benzo[k]fluoranthene	15000	µg/kg	12.4 J	0.578 U
Chrysene	10000	µg/kg	34.8	0.867 U
Dibenz(a,h)anthracene	150	µg/kg	5.44 J	0.607 U
Fluoranthene	87000	µg/kg	41.3	2.80 U
Indeno[1,2,3-cd]pyrene	1500	µg/kg	42.0	0.781 U
Naphthalene	4500	µg/kg	22.4 J	2.89 U
Phenanthrene	69000	µg/kg	39.9	1.99 U
Pyrene	44000	µg/kg	26.9 J	2.46 U
Metals				
Arsenic	24	mg/Kg	2.2 J	1.6 J
Barium	1000	mg/Kg	430	130
Cadmium	14	mg/Kg	4.2	1.8
Chromium (total)	1100	mg/Kg	210	100
Lead	200	mg/Kg	23	1.3 J
Mercury	4.7	mg/Kg	0.073	0.041

Analyte	Screening Level	Location	BS-05	BS-05
		Depth (ft bgs)	5	8
		Units	Result	Result
VOCs				
Tetrachloroethene	88	µg/kg	1.3	0.29 U
PAHs				
Benzo[a]anthracene	1500	µg/kg	5.45 J	0.132 U
Benzo[a]pyrene	150	µg/kg	14.6 J	1.02 U
Benzo[b]fluoranthene	1500	µg/kg	14.6 J	0.241 U
Benzo[g,h,i]perylene	27000	µg/kg	12.4 J	0.289 U
Benzo[k]fluoranthene	15000	µg/kg	2.15 J	0.241 U
Chrysene	10000	µg/kg	11.1 J	0.361 U
Fluoranthene	87000	µg/kg	10.1 J	1.17 U
Pyrene	44000	µg/kg	4.22 J	1.02 U
TPH				
GRO (C6-C12)	100	mg/Kg	0.89 J	0.69 U
RRO (>C24-C32)	500	mg/Kg	24 J	16 U
Metals				
Arsenic	24	mg/Kg	0.35 U	2.0 J
Barium	1000	mg/Kg	85	58
Cadmium	14	mg/Kg	1.6	0.39 J
Chromium (total)	1100	mg/Kg	87	16
Lead	200	mg/Kg	14	0.13 U
Mercury	4.7	mg/Kg	0.031	0.0051 U

MW-02

MW-03

MW-01

BS-03/TM-03

BS-02/TM-02

BS-01/TM-01

BS-04/TM-04

BS-05/TM-05

Waiwai Loop

Analyte	Screening Level	Location	BS-02	BS-02
		Depth (ft bgs)	5	11
		Units	Result	Result
VOCs				
cis-1,2-Dichloroethene	310	µg/kg	0.30 U	1.2
Vinyl chloride	720	µg/kg	0.85 J	0.35 U
Metals				
Arsenic	24	mg/Kg	0.34 U	6.1
Barium	1000	mg/Kg	60	150
Cadmium	14	mg/Kg	1.4	2.3
Chromium (total)	1100	mg/Kg	76	120
Lead	200	mg/Kg	6.4	3.0
Mercury	4.7	mg/Kg	0.0090 J	0.30

Analyte	Screening Level	Location	BS-01	BS-01
		Depth (ft bgs)	5	8
		Units	Result	Result
VOCs				
cis-1,2-Dichloroethene	310	µg/kg	0.76 J	1.5
trans-1,2-Dichloroethene	2700	µg/kg	1.3 U	1.7
Trichloroethene	260	µg/kg	0.83 J	1.3 U
Tetrachloroethene	88	µg/kg	2.4	1.3 U
Vinyl chloride	720	µg/kg	1.3 U	5.1
DRO (>C12-C24)	500	mg/Kg	26 J	5.9 U
RRO (>C24-C32)	500	mg/Kg	150	19 U
Metals				
Arsenic	24	mg/Kg	2.6 J	0.58 J
Barium	1000	mg/Kg	390	240
Cadmium	14	mg/Kg	3.7	3.2
Chromium (total)	1100	mg/Kg	210	170
Lead	200	mg/Kg	56	11
Mercury	4.7	mg/Kg	0.58	0.046

Analyte	Screening Level	Location	BS-04	BS-04	BS-04 (FD)
		Depth (ft bgs)	3	9	9
		Units	Result	Result	Result
VOCs					
Tetrachloroethene	88	µg/kg	0.36 U	3.3	3.0
TPH					
GRO (C6-C12)	100	mg/Kg	0.77 U	0.94 J	1.1 J
Metals					
Arsenic	24	mg/Kg	0.34 U	4.1	1.1 J
Barium	1000	mg/Kg	86	75	57
Cadmium	14	mg/Kg	1.5	0.85 J	0.72 J
Chromium (total)	1100	mg/Kg	89	47	25
Lead	200	mg/Kg	7.7	0.19 U	0.25 J
Mercury	4.7	mg/Kg	0.021	0.016 J	0.0061 J

Legend

- 1st Floor Vault and 2nd Floor Boiler Equipment
- Former Dry Cleaning Area
- Former Storage Area / Courier Storage Area
- Former Warehouse Area
- Office Space 1st and 2nd Floor
- Overhang and 2nd Floor Offices
- Previous Documented Location of UST
- Previous Documented Location of UST Pipe
- Existing Floor Drain
- Existing Groundwater Well
- Current Phase II ESA Soil Sampling and Grab - Groundwater Sampling Location
- Current Phase II ESA Soil Sampling Location

Notes

- All locations and dimensions shown on the map are approximate and not based on certified survey information.
- Shaded cells highlight target analytes that were detected at the location.
- Screening levels are based on DOH Fall 2011 EALs, Table B-2.
- Acronyms:
µg/kg microgram per kilogram
DRO diesel range organics
ft bgs feet below ground surface
GRO gasoline range organics
mg/kg microgram per kilogram
PAH polyaromatic hydrocarbon
RRO residual range organics
VOC volatile organic compound
U nondetect
J estimated



0 10 20 30 40 50 Feet

Figure 3
Detected Target Analytes in Soil
Phase II ESA
515 Lagoon Drive, Parcel 15
Honolulu, Oahu, Hawaii

Path: \\ushm11p003\data\Projects\US\G\Civil\Oahu\60225194-HRTP\400 Design\423 Environmental\02 Phase II\01 Airport Segment\01 Parcel 15\02 GIS\Figure4 Detects Groundwater.mxd



Legend

- 1st Floor Vault and 2nd Floor Boiler Equipment
- Former Dry Cleaning Area
- Former Storage Area / Courier Storage Area
- Former Warehouse Area
- Office Space 1st and 2nd Floor
- Overhang and 2nd Floor Offices
- Previous Documented Location of UST
- Previous Documented Location of UST Pipe
- Existing Floor Drain
- Existing Groundwater Well
- Current Phase II ESA Soil Sampling and Grab - Groundwater Sampling Location
- Current Phase II ESA Soil Sampling and Grab - Groundwater Sampling Location - No groundwater sample collected
- Geophysical Survey Area - Complete Coverage
- Geophysical Survey Area - Partial Coverage

Notes

- All locations and dimensions shown on the map are approximate and not based on certified survey information.
- Shaded cells highlight target analytes that were detected at the location.
- Screening levels are based on DOH Fall 2011 EALs, Table D-1d.
- Abbreviations:
µg/L microgram per liter
DRO diesel range organics
ft bgs feet below ground surface
GRO gasoline range organics
mg/kg microgram per kilogram
PAH polyaromatic hydrocarbon
RRO residual range organics
VOC volatile organic compound
U nondetect
J estimated

Figure 4
Detected Target Analytes in Groundwater
and Geophysical Survey Coverage for Locating UST
Phase II ESA
515 Lagoon Drive, Parcel 15
Honolulu, Oahu, Hawaii

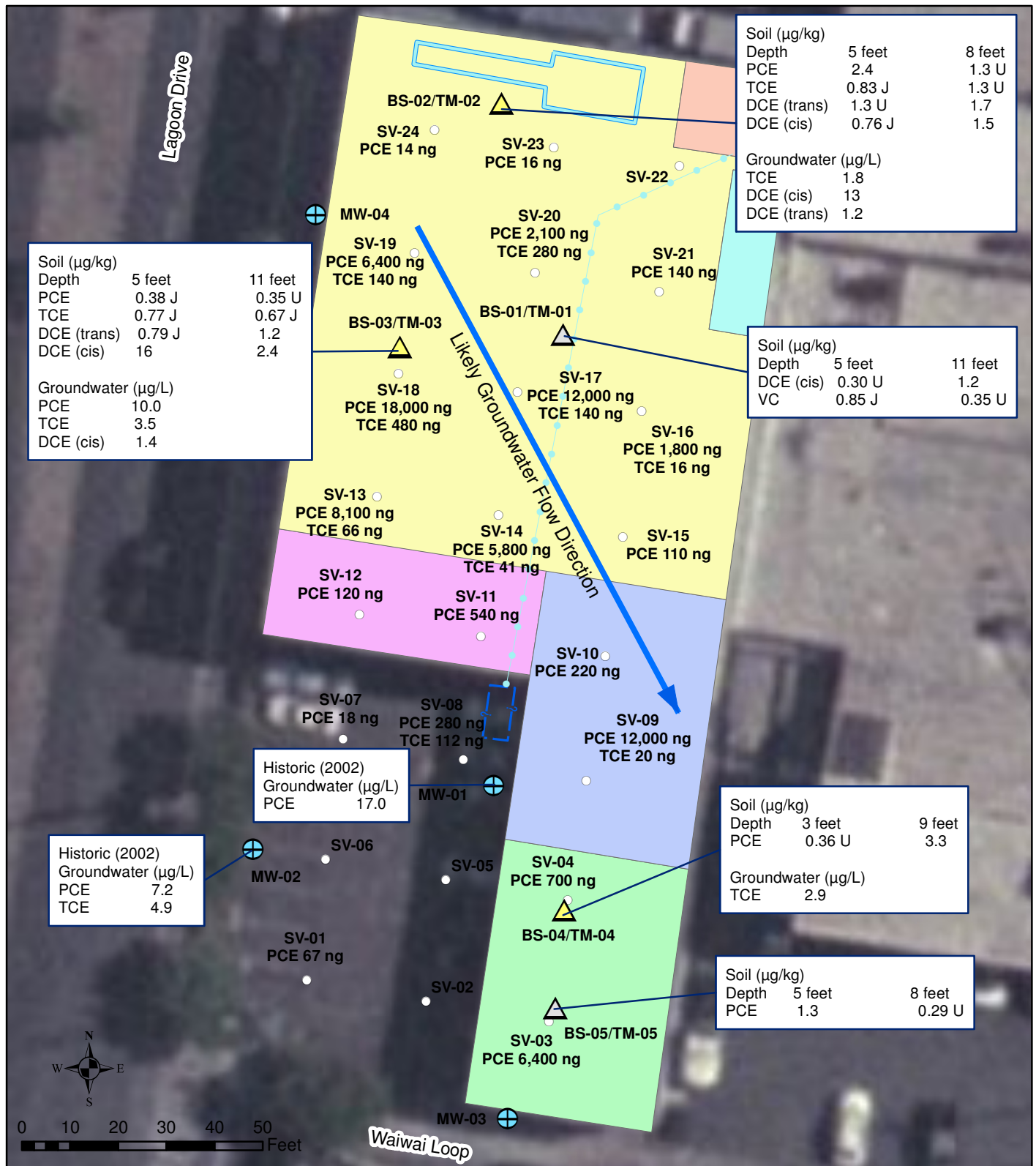


Figure 5
Current and Historic HVOC Detections, Phase II
ESA, 515 Lagoon Drive, Parcel 15, Oahu, Hawaii

Appendix C

**CH2M Soil Vapor Study
2016 (key sections, *pending*)**

Appendix D

Beacon Passive Soil Gas Survey – Analytical Report, 2016 (key sections)

(Includes field deployment protocol, raw data summary, composite data summary,
and PCE/TCE Isopleth Maps)

Tetra Tech
737 Bishop Street, Suite 2340
Honolulu, HI 96813
Attn: Mr. Eric Jensen

Passive Soil Gas Survey – Analytical Report
Date: October 11, 2016

Beacon Project No. 3446

Project Reference:	Vapor Plume Heterogeneity Study, Hawaii
Samplers Installed:	August 18, 2016
Samplers Retrieved:	August 26, 2016
Samples Received:	August 29, 2016
Analyses Completed:	September 7, 2016
Laboratory Data Issued:	September 9, 2016

EPA Method 8260C

All samples were successfully analyzed using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) instrumentation to target a custom compound list following EPA Method 8260C. Laboratory results are reported in nanograms (ng) of specific compound per sample.

Laboratory QA/QC procedures included internal standards, surrogates, and blanks based on EPA Method 8260C. Analyses and reporting were in accordance with BEACON's Quality Assurance Project Plan.

Reporting limits

The reporting limit (RL) is 10 nanograms (ng) for vinyl chloride, 1,1-dichloroethene, trans-1,2-dichloroethene, cis-1,2-dichloroethene, and trichloroethene; and 25 ng for the remaining individual compounds. **Tables 1 and 2** provide survey results in nanograms and compound name. For the five (5) compounds listed above with an RL of 10 ng, measurements below the limit of quantitation (10 ng) but above the limit of detection (5 ng) are flagged with a "J." The RLs represent a baseline above which results exceed laboratory-determined limits of precision and accuracy. Any field sample measurements above the upper calibration standard are estimated; however, these values are reported without qualifiers because all reported measurements are relative to each other and are appropriate to meet the survey objectives of locating source areas and vapor intrusion pathways and defining the lateral extent of contamination.

Calibration Verification

The continuing calibration verification (CCV) values for the calibration check compounds were all within $\pm 20\%$ of the true values as defined by the initial five-point calibration and met the requirements specified in Beacon Environmental's Quality Assurance Project Plan.

Method Blanks/Trip Blanks

Laboratory method blanks are run with each sample batch to identify contamination present in the laboratory. If contamination is detected on a method blank, measurements of identical compounds in that sample batch are flagged in the laboratory report. The laboratory method blanks analyzed in connection with the present samples revealed no contamination.

The trip blank is a sampler prepared, transported, and analyzed with other samples but intentionally not exposed. Any target compounds identified on the trip blanks are reported in the laboratory data. The analyses of the trip blanks (labeled Trip-1 and Trip-2) reported none of the targeted compounds.

Passive Soil-Gas Survey Notes

When sample locations are covered with or near the edge of an artificial surface (*e.g.*, asphalt or concrete), the concentrations of compounds in soil gas are often significantly higher than the concentrations would be if the surfacing were not present. Thus, a reading taken below or near an impermeable surface is much higher than it would be in the absence of such a cap. Therefore, the sample location conditions should be evaluated when comparing results between locations.

Survey findings are exclusive to this project and when the spatial relationships are compared with results of other BEACON Surveys it is necessary to incorporate survey and site information from both investigations (*e.g.*, depth to sources, soil types, porosity, soil moisture, presence of impervious surfacing, sample collection times). BEACON recommends the guidelines stated in **Attachment 1** to establish a relationship between reported soil-gas measurements and actual subsurface contaminant concentrations, which will indicate those measurements representing significant subsurface contamination.

Project Details

Samplers were deployed on August 18, 2016, and were retrieved on August 26, 2016. **Attachment 2** describes standard field procedures. Individual deployment and retrieval times will be found in the Chain of Custody Form (**Attachment 3**).

One-hundred nine (109) field samples, and two (2) trip blanks were received by BEACON on August 29, 2016. Adsorbent cartridges from the passive samplers were thermally desorbed, then analyzed using gas chromatography/mass spectrometry (GC/MS) equipment, in accordance with EPA Method 8260C, as described in **Attachment 4**. BEACON's laboratory analyzed each sample for the targeted compounds; analyses were completed on September 7, 2016. Following a laboratory review, results were provided on September 9, 2016.

The reported values in **Table 1** are the summations of the composite samples (when requested) based on the Chain of Custody. The analytical procedure was to desorb each single sample from a composite group within a decision unit (DU) onto a focusing trap, which was then desorbed into the GC/MS. The results from that analysis are shown on **Table 1**. The data reported on **Table 2** and on the maps provides the average of the composite measurements based on the number of samples included in a composite and then the average of the composites, if more than one composite was collected within that DU. For example, if three samples were composited (as with DU-6), then the reported result in **Table 1** for that composite sample was divided by three and provided in **Table 2**. For DU-10 that had individual analyses of six samples, the average measurement of those six samples is reported in **Table 2**. For DU-13, the average of the three composite samples within that DU is reported in **Table 2**. **Attachment 5** provides the composite sample groupings and the number of composites for each DU.

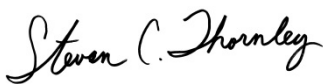
Sample locations are shown on **Figure 1**. The following table lists frequency of detections based on the number of field samples analyzed, the reporting limit, and the maximum value for each mapped compound, based on results in **Table 2**. The table also includes the transformation and interpolation method for the compound distribution maps provided.

Figure No.	2	3	4
Compound	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene
Frequency	25	25	18
Reporting Limit (nanograms)	10	25	10
Max Value (nanograms)	45,276	5,511	865
Transformation Method	Log	Log	Log
Interpolation Method	Kriging	Kriging	Kriging

Attachments:

- 1- Applying Results From Passive Soil-Gas Surveys
- 2- Field Procedures
- 3- Chain-of-Custody Form
- 4- Laboratory Procedures
- 5- Composite Samples Table

ALL DATA MEET REQUIREMENTS AS SPECIFIED IN THE BEACON ENVIRONMENTAL SERVICES, INC. QUALITY ASSURANCE PROJECT PLAN AND THE RESULTS RELATE ONLY TO THE SAMPLES REPORTED. BEACON ENVIRONMENTAL SERVICES IS ACCREDITED TO ISO/IEC 17025:2005, AND THE WORK PERFORMED WAS IN ACCORDANCE WITH ISO/IEC 17025:2005 REQUIREMENTS WITH THE EXCEPTION THAT SAMPLES WERE ANALYZED WITHIN A 24-HOUR TUNE WINDOW. THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF THE LABORATORY. RELEASE OF THE DATA CONTAINED IN THIS DATA PACKAGE HAS BEEN AUTHORIZED BY THE LABORATORY DIRECTOR OR HIS SIGNEE, AS VERIFIED BY THE FOLLOWING SIGNATURES:



Steven C. Thornley
Laboratory Director



Patti J. Riggs
Quality Manager

Table 1

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	LB160902c	Trip-1	Trip-2	DU-1	DU-2	DU-3
Project Number:		3446	3446	3446	3446	3446
Lab File ID:	C16090203	C16090205	C16090206	C16090207	C16090208	C16090209
Received Date:		8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016
Analysis Time:	11:00	11:44	12:06	12:42	13:17	13:52
Matrix:				Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	<10	<10	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	<25	<25	<25	<25	<25	<25
1,1-Dichloroethene	<10	<10	<10	<10	<10	<10
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	<10	<10	<10	<10	<10
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	<10	<10	<10	<10	<10	<10
Chloroform	<25	<25	<25	<25	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	<10	<10	<10	13	15	21
1,4-Dioxane	<25	<25	<25	32	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	<25	<25	<25	3,085	2,245	3,290
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 1

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	DU-4	5C	DU-6	DU-7	DU-8	DU-9
Project Number:	3446	3446	3446	3446	3446	3446
Lab File ID:	C16090210	C16090211	C16090212	C16090213	C16090214	C16090215
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016
Analysis Time:	14:28	14:50	15:47	17:06	18:25	19:44
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng

COMPOUNDS

Vinyl Chloride	<10	<10	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	26	<25	<25	31	59	56
1,1-Dichloroethene	<10	7 J	<10	<10	<10	26
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	49	<10	<10	22	246
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	<10	19	<10	<10	74	115
Chloroform	<25	<25	<25	<25	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	240	3,703	33	111	1,828	11,367
1,4-Dioxane	<25	<25	45	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	12,064	42,923	5,168	5,366	17,451	74,696
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 1

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	10A	10B	10D	10E	10G	10H
Project Number:	3446	3446	3446	3446	3446	3446
Lab File ID:	C16090216	C16090217	C16090218	C16090219	C16090220	C16090221
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016
Analysis Time:	20:06	20:28	20:50	21:11	21:34	21:56
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng

COMPOUNDS

Vinyl Chloride	7 J	<10	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	<25	<25	<25	<25	<25	<25
1,1-Dichloroethene	16	7 J	5 J	<10	19	12
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	197	334	96	24	185	118
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	55	112	29	9 J	55	27
Chloroform	<25	<25	<25	<25	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	4,950	3,535	2,522	1,564	6,631	4,229
1,4-Dioxane	<25	<25	<25	60	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	54,417	41,162	39,575	28,131	61,194	47,177
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 1

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	DU-11	DU-12	DU-13A	DU-13B	DU-13C	DU-14
Project Number:	3446	3446	3446	3446	3446	3446
Lab File ID:	C16090222	C16090223	C16090224	C16090225	C16090226	C16090227
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/2/2016	9/3/2016	9/3/2016	9/3/2016	9/3/2016	9/3/2016
Analysis Time:	23:14	0:33	1:53	3:12	4:31	5:06
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng

COMPOUNDS

Vinyl Chloride	<10	8 J	7 J	21	7 J	9 J
Trichlorofluoromethane (Freon 11)	59	<25	34	60	65	<25
1,1-Dichloroethene	<10	34	38	43	31	29
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	188	213	825	287	837
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	<10	590	1,066	7,064	2,245	594
Chloroform	<25	<25	<25	35	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	105	9,771	19,588	28,438	18,111	9,040
1,4-Dioxane	<25	<25	<25	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	9,854	50,902	56,981	72,308	58,953	60,934
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 1

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	DU-15	DU-16	LB160906c	DU-17A	DU-17B	DU-17C
Project Number:	3446	3446		3446	3446	3446
Lab File ID:	C16090228	C16090229	C16090603	C16090605	C16090606	C16090607
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/3/2016	9/3/2016	9/6/2016	9/6/2016	9/6/2016	9/6/2016
Analysis Time:	6:04	7:01	10:38	12:20	13:38	14:58
Matrix:	Soil Gas	Soil Gas		Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng

COMPOUNDS

Vinyl Chloride	46	<10	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	71	52	<25	43	91	90
1,1-Dichloroethene	17	<10	<10	<10	15	<10
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	668	<10	<10	<10	<10	<10
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	346	8 J	<10	9 J	14	8 J
Chloroform	<25	<25	<25	<25	<25	<25
1,2-Dichloroethane	175	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	8,007	1,213	<10	2,560	3,982	2,502
1,4-Dioxane	<25	<25	<25	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	54,674	29,341	<25	53,698	77,288	53,983
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 1

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	DU-18	DU-19	DU-20	DU-21	DU-22	DU-23
Project Number:	3446	3446	3446	3446	3446	3446
Lab File ID:	C16090608	C16090609	C16090610	C16090611	C16090612	C16090613
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/6/2016	9/6/2016	9/6/2016	9/6/2016	9/6/2016	9/6/2016
Analysis Time:	16:17	17:38	18:58	20:17	21:36	22:34
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng

COMPOUNDS

Vinyl Chloride	<10	<10	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	43	38	124	29	36	121
1,1-Dichloroethene	21	19	7 J	9 J	21	7 J
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	29	5 J	138	10	51	<10
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	225	9 J	198	88	557	6 J
Chloroform	45	<25	<25	<25	32	32
1,2-Dichloroethane	<25	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	7,029	5,449	3,748	1,795	7,787	2,227
1,4-Dioxane	<25	<25	<25	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	79,095	79,802	51,964	33,997	77,128	65,666
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 1

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	DU-24A	DU-24B	DU-25	DU-24C
Project Number:	3446	3446	3446	3446
Lab File ID:	C16090614	C16090615	C16090617	C16090618
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/6/2016	9/7/2016	9/7/2016	9/7/2016
Analysis Time:	23:53	1:12	3:39	9:43
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng

COMPOUNDS

Vinyl Chloride	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	58	48	214	91
1,1-Dichloroethene	11	9 J	13	6 J
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	<10	11	<10
1,1-Dichloroethane	<25	<25	<25	<25
cis-1,2-Dichloroethene	6 J	<10	20	<10
Chloroform	<25	<25	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25
Trichloroethene	1,870	2,092	2,858	781
1,4-Dioxane	<25	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25
Tetrachloroethene	55,004	68,664	66,407	50,171
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 2

Average Measurements in each Decision Unit

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	LB160902c	Trip-1	Trip-2	DU-1	DU-2	DU-3
Project Number:		3446	3446	3446	3446	3446
Lab File ID:	C16090203	C16090205	C16090206	C16090207	C16090208	C16090209
Received Date:		42611.61736	42611.61736	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016
Analysis Time:	11:00	11:44	12:06	12:42	13:17	13:52
Matrix:				Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	<10	<10	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	<25	<25	<25	<25	<25	<25
1,1-Dichloroethene	<10	<10	<10	<10	<10	<10
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	<10	<10	<10	<10	<10
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	<10	<10	<10	<10	<10	<10
Chloroform	<25	<25	<25	<25	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	<10	<10	<10	6	8	11
1,4-Dioxane	<25	<25	<25	16	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	<25	<25	<25	1,543	1,123	1,645
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 2

Average Measurements in each Decision Unit

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	DU-4	DU-5	DU-6	DU-7	DU-8	DU-9
Project Number:	3446	3446	3446	3446	3446	3446
Lab File ID:	C16090210	C16090211	C16090212	C16090213	C16090214	C16090215
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016	9/2/2016
Analysis Time:	14:28	14:50	15:47	17:06	18:25	19:44
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	<10	<10	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	13	<25	<25	8	15	14
1,1-Dichloroethene	<10	7	<10	<10	<10	7
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	49	<10	<10	5	62
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	<10	19	<10	<10	18	29
Chloroform	<25	<25	<25	<25	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	120	3,703	11	28	457	2,842
1,4-Dioxane	<25	<25	15	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	6,032	42,923	1,723	1,342	4,363	18,674
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 2

Average Measurements in each Decision Unit

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	DU-10	DU-11	DU-12	DU-13	DU-14	DU-15
Project Number:	3446	3446	3446	3446	3446	3446
Lab File ID:	C16090216	C16090222	C16090223	C16090224	C16090227	C16090228
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/2/2016	9/2/2016	9/3/2016	9/3/2016	9/3/2016	9/3/2016
Analysis Time:	20:06	23:14	0:33	1:53	5:06	6:04
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	1	<10	2	3	5	15
Trichlorofluoromethane (Freon 11)	<25	15	<25	13	<25	24
1,1-Dichloroethene	10	<10	8	9	15	6
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	159	<10	47	110	419	223
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	48	<10	147	865	297	115
Chloroform	<25	<25	<25	3	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25	<25	58
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	3,905	26	2,443	5,511	4,520	2,669
1,4-Dioxane	10	<25	<25	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	45,276	2,464	12,725	15,687	30,467	18,225
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 2

Average Measurements in each Decision Unit

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

Client Sample ID:	DU-16	DU-17	DU-18	DU-19	DU-20	DU-21
Project Number:	3446	3446	3446	3446	3446	3446
Lab File ID:	C16090229	C16090605	C16090608	C16090609	C16090610	C16090611
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/3/2016	9/6/2016	9/6/2016	9/6/2016	9/6/2016	9/6/2016
Analysis Time:	7:01	12:20	16:17	17:38	18:58	20:17
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	<10	<10	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	17	19	11	10	31	7
1,1-Dichloroethene	<10	1	5	5	2	2
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	<10	7	1	35	3
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	3	3	56	2	50	22
Chloroform	<25	<25	11	<25	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25	<25	<25
Trichloroethene	404	754	1,757	1,362	937	449
1,4-Dioxane	<25	<25	<25	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25	<25	<25
Tetrachloroethene	9,780	15,414	19,774	19,951	12,991	8,499
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25	<25	<25

Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.

Table 2

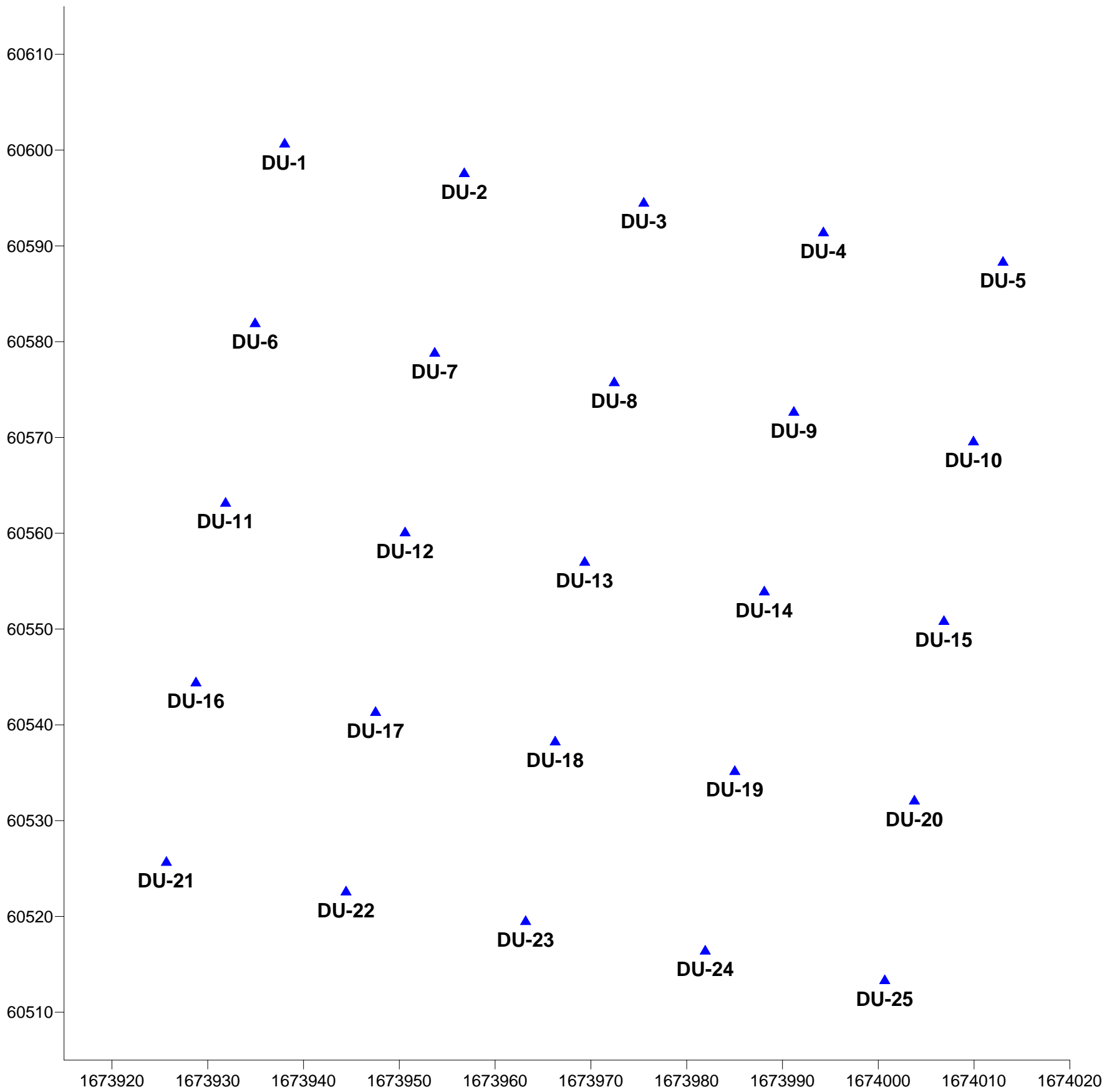
Average Measurements in each Decision Unit

Beacon Environmental Services, Inc.
2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA

Analysis by EPA Method 8260C

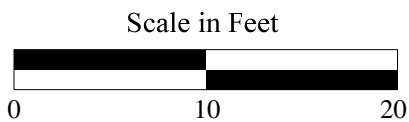
Client Sample ID:	DU-22	DU-23	DU-24	DU-25
Project Number:	3446	3446	3446	3446
Lab File ID:	C16090612	C16090613	C16090614	C16090617
Received Date:	8/29/2016	8/29/2016	8/29/2016	8/29/2016
Analysis Date:	9/6/2016	9/6/2016	9/6/2016	9/7/2016
Analysis Time:	21:36	22:34	23:53	3:39
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng
COMPOUNDS				
Vinyl Chloride	<10	<10	<10	<10
Trichlorofluoromethane (Freon 11)	9	40	16	54
1,1-Dichloroethene	5	2	2	3
1,1,2-Trichlorotrifluoroethane (Fr.113)	<25	<25	<25	<25
trans-1,2-Dichloroethene	13	<10	<10	3
1,1-Dichloroethane	<25	<25	<25	<25
cis-1,2-Dichloroethene	139	2	1	5
Chloroform	8	11	<25	<25
1,2-Dichloroethane	<25	<25	<25	<25
1,1,1-Trichloroethane	<25	<25	<25	<25
Carbon Tetrachloride	<25	<25	<25	<25
Trichloroethene	1,947	742	395	714
1,4-Dioxane	<25	<25	<25	<25
1,1,2-Trichloroethane	<25	<25	<25	<25
1,2-Dibromoethane (EDB)	<25	<25	<25	<25
Tetrachloroethene	19,282	21,889	14,487	16,602
1,1,1,2-Tetrachloroethane	<25	<25	<25	<25
Chlorobenzene	<25	<25	<25	<25
1,1,2,2-Tetrachloroethane	<25	<25	<25	<25

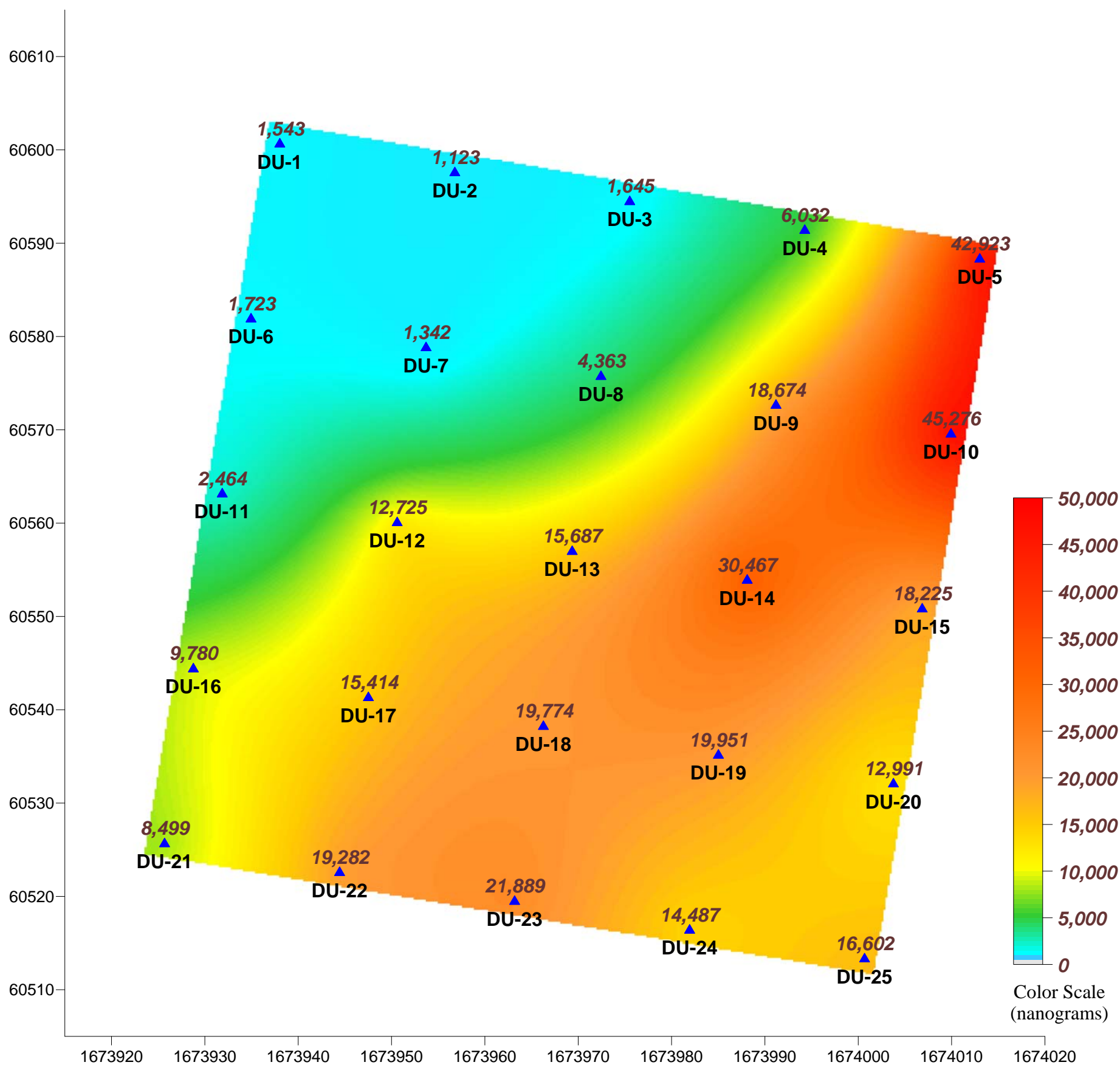
Results in nanograms (ng). J = Values below limit of quantitation (LOQ) but above limit of detection (LOD). B = Detected in method blank.



LEGEND

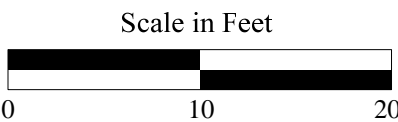
▲ DECISION UNIT: PASSIVE SOIL-GAS SAMPLES

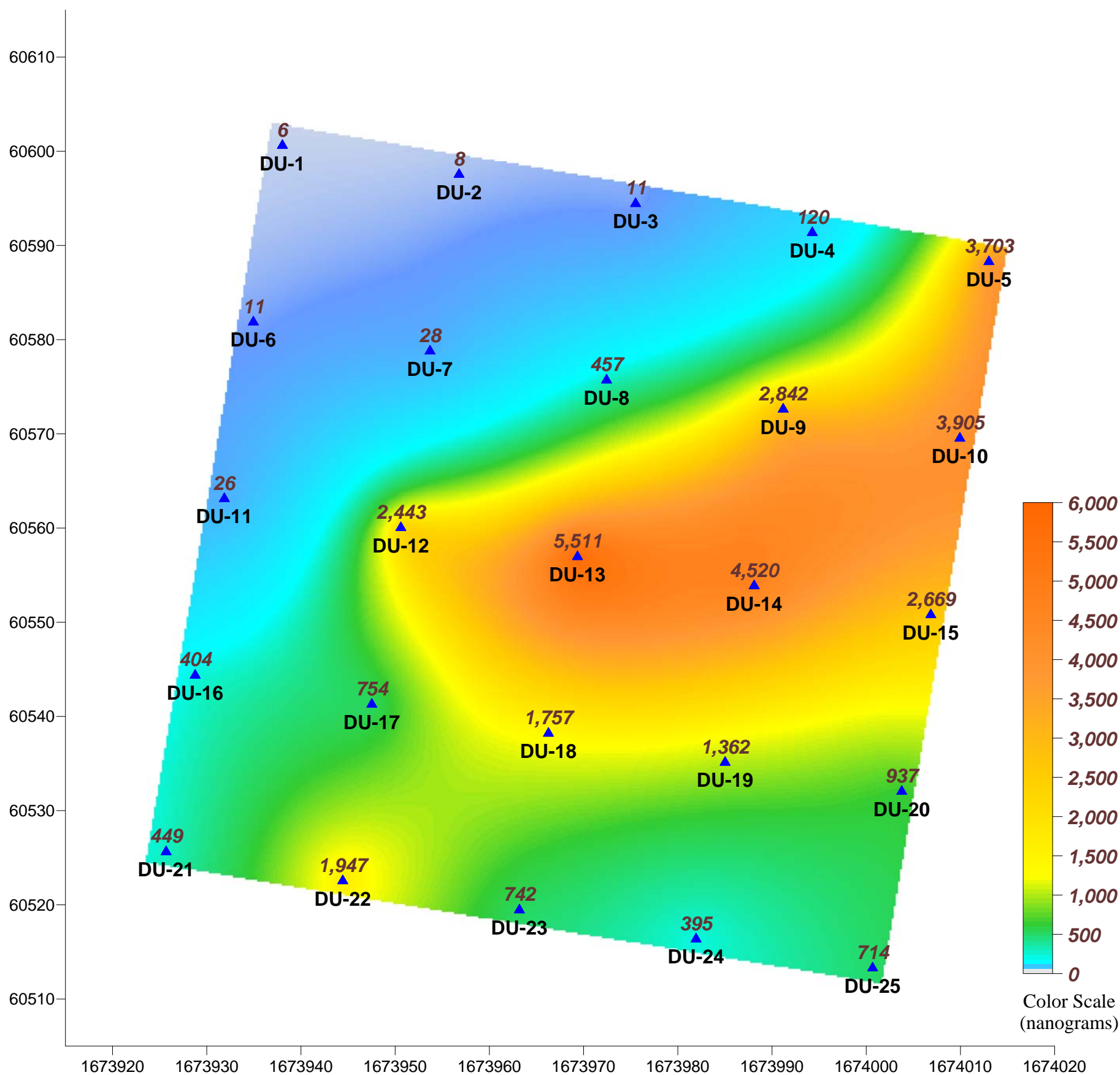




LEGEND

- 1,000 NANOGRAMS/SAMPLER
- ▲ DECISION UNIT: PASSIVE SOIL-GAS SAMPLES



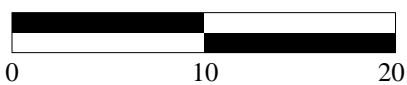


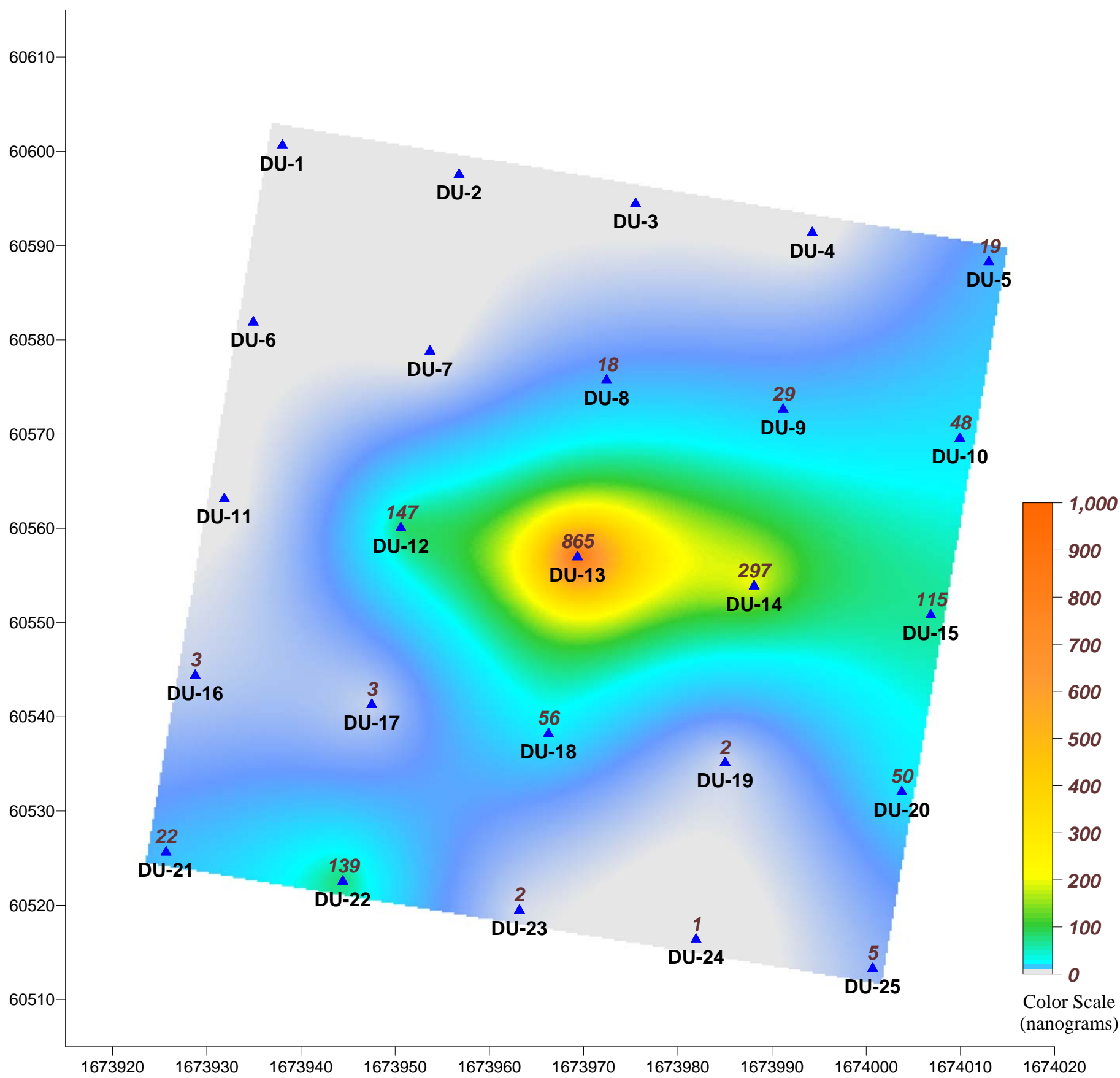
LEGEND

1,000 NANOGRAMS/SAMPLER

▲ DECISION UNIT: PASSIVE SOIL-GAS SAMPLES

Scale in Feet



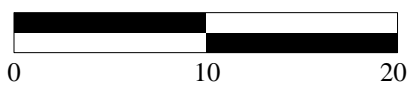


LEGEND

1,000 NANOGRAMS/SAMPLER

▲ DECISION UNIT: PASSIVE SOIL-GAS SAMPLES

Scale in Feet



Attachments

Attachment 1

APPLYING RESULTS FROM PASSIVE SOIL-GAS SURVEYS

The utility of soil-gas surveys is directly proportional to their accuracy in reflecting and representing changes in the subsurface concentrations of source compounds. Passive soil-gas survey results are the mass collected from the vapor-phase emanating from the source(s). The vapor-phase is merely a fractional trace of the source(s) and, as a matter of convenience, the units used in reporting detection values from passive soil-gas surveys are smaller than those employed for source-compound concentrations.

Passive soil gas data are reported in mass of compounds identified per sample location (e.g., nanograms (ng) or micrograms (µg) per sampler). Results from a passive soil gas survey typically are then used to guide where follow-on intrusive samples should be collected to obtain corresponding concentrations of the contaminants in soil, soil gas, and/or groundwater, as well as eliminate those areas where intrusive samples are not required. It is not practical to report passive soil gas data as concentration because the sampler's uptake rates of the compounds are often greater than the replenishment rates of the compounds around the sampler, which results in low bias measurements, and the replenishment rates will be dependent on several factors that include, at a minimum, soil gas concentrations, soil porosity and permeability, and soil moisture level.

Whatever the relative concentrations of source and associated soil gas, best results are realized when the ratio of soil-gas measurements to actual subsurface concentrations remains as close to constant as the real world permits. It is the reliability and consistency of this ratio, not the particular units of mass (e.g., nanograms) that determine usefulness. Thus, BEACON emphasizes the necessity of conducting — at minimum — follow-on intrusive sampling in areas that show relatively high soil-gas measurements to obtain corresponding concentrations of soil and groundwater contaminants. These correspondent values furnish the basis for approximating a relationship. For extrapolating passive soil gas results to vapor intrusion evaluations, we recommend a minimum of three passive soil gas locations be converted to a shallow vapor well then sampled using an active soil gas method. Once a relationship is established, it can be used in conjunction with the remaining soil-gas measurements to estimate subsurface contaminant concentrations across the survey field. (See www.beacon-usa.com/passivesoilgas.html, Publication 1: *Mass to Concentration Tie-In for PSG Surveys* and Publication 4: *Groundwater and PSG Correlation*.) It is important to keep in mind, however, that specific conditions at individual sample points, including soil porosity and permeability, depth to contamination, and perched ground water, can have an impact on soil-gas measurements at those locations.

When passive soil-gas surveys are utilized as described above, the data provide information that can yield substantial savings in drilling costs and in time. They furnish, among other things, a checklist of compounds expected at each survey location and help to determine how and where drilling budgets can most effectively be spent. Passive soil-gas surveys can also be used as a remediation or general site monitoring tool that can be implemented on a quarterly, semi-annual or annual basis.

Attachment 2

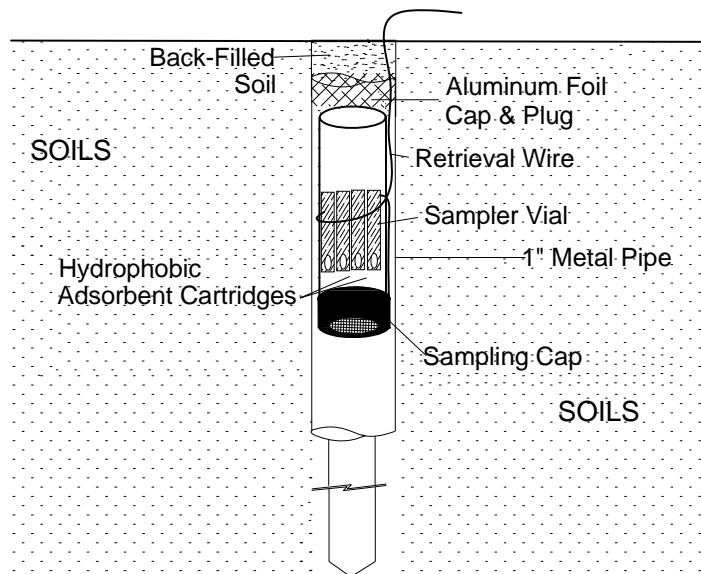
FIELD PROCEDURES FOR PASSIVE SOIL-GAS SURVEYS

The following field procedures are routinely used during a BEACON Passive Soil-Gas Survey. Modifications can be and are incorporated from time to time in response to individual project requirements. In all instances, BEACON adheres to EPA-approved Quality Assurance and Quality Control practices.

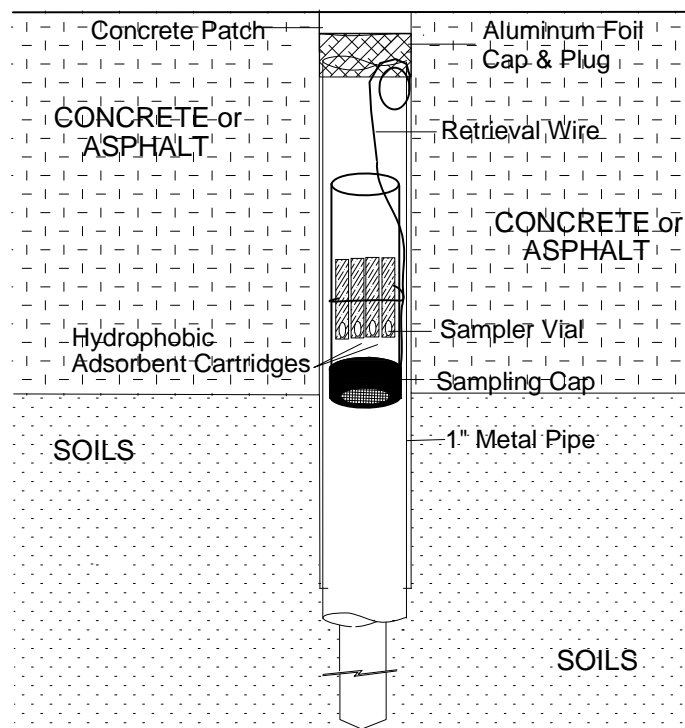
- A. Field personnel carry a BESURE Sample Collection Kit™ and support equipment to the site and deploy the passive samplers in a prearranged survey pattern. A passive sampler consists of a borosilicate glass vial containing hydrophobic adsorbent cartridges with a length of wire attached to the vial for retrieval. Although samplers require only one person for emplacement and retrieval, the specific number of field personnel required depends upon the scope and schedule of the project. Each Sampler emplacement generally takes less than two minutes.
- B. At each survey point a field technician clears vegetation as needed and, using a hammer drill with a 1"- to 1½"-diameter bit, creates a hole 12 to 14 inches deep. [Note: For locations covered with asphalt, concrete, or gravel surfacing, the field technician drills a 1"- to 1½"-diameter hole through the surfacing to the soils beneath]. The technician then, using a hammer drill with a ½" diameter bit, creates a hole three-feet deep. The hole is then sleeved with a 1"-diameter metal sleeve.
- C. The technician then removes the solid plastic cap from a sampler and replaces it with a Sampling Cap (a plastic cap with a hole covered by screen meshing). The technician inserts the sampler, with the Sampling Cap end facing down, into the hole (**see attached figure**). The sampler is then covered with an aluminum foil plug and soils for uncapped locations or, for capped locations, an aluminum foil plug and a concrete patch. The sampler's location, time and date of emplacement, and other relevant information are recorded on the Field Deployment Form.
- D. One or more trip blanks are included as part of the quality-control procedures.
- E. Once all the samplers have been deployed, field personnel schedule sampler recovery and depart, taking all other equipment and materials with them.
- F. Field personnel retrieve the samplers at the end of the exposure period. At each location, a field technician withdraws the sampler from its hole, removes the retrieval wire, and wipes the outside of the vial clean using gauze cloth; following removal of the Sampling Cap, the threads of the vial are also cleaned. A solid plastic cap is screwed onto the vial and the sample location number is written on the label. The technician then records sample-point location, date, time, etc. on the Field Deployment Form.
- G. Sampling holes are refilled with soil, sand, or other suitable material. If samplers have been installed through asphalt or concrete, the hole is filled to grade with a plug of cold patch or cement.
- H. Following retrieval, field personnel ship or transport the passive samplers to BEACON's laboratory.

BEACON'S PASSIVE SOIL-GAS SAMPLER

DEPLOYMENT THROUGH SOILS



DEPLOYMENT THROUGH AN ASPHALT/CONCRETE CAP



Attachment 3
Chain of Custody Form

**CHAIN-OF-CUSTODY
PASSIVE SOIL-GAS SAMPLES**

2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA
P: 1-410-838-8780 | F: 1-410-838-8740

Project Information				Client Information	
Beacon Project No.:	3446	Company Name:	Tetra Tech, Inc.	Client PO No.:	
Site Name:	Former Al Phillips Cleaners	Office Location:	Honolulu		
Site Location:	Honolulu, HI	Samples Submitted By:	Eric Jensen	Expedited Turnaround Time	
Analytical Method:	U.S. EPA Method 8260C	Contact Phone No.:	808.441.4784	<input type="checkbox"/> Rush (Specify): ____ days	
Target Compounds: Dry Cleaner Compounds					
Field Sample ID	Date Emplaced	Date Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)
1A	X			concrete	> 12" concrete, no sampler edge of pad
1B	X			concrete	assume > 12" edge of pad
1C	0847	0903		concrete	8" PID = 0.0 (1.5")
1D	0905	901		concrete	86.5"
2A	X			concrete	> 12" no sampler assume > 12" pad edge
2B	X			concrete	" " " "
2C	0920	0838		concrete	PID = 102.8 (0.5")
2D	0926	0837		concrete	PID = 0.0 (1.5")
3A	X			concrete	assume > 12" pad edge
3B	X			concrete	assume > 12" pad edge
3C	0932	0847		concrete	PID = 141.2 (1.5")
3D	0934	0849		concrete	PID = 115.4 (0.5")
Special Notes/Instructions: (0.5") P = P10+					

Shipment of Field Kit to Laboratory — Custody Seal #			Intact? <input checked="" type="checkbox"/> N	
4607445				
Relinquished by:	Date/Time	Courier	Received by:	Date/Time
EM Benson	08/26/2016 1500	4500 FedEx	Steven J. Hordley	8.29.16 / 1449



CHAIN-OF-CUSTODY PASSIVE SOIL-GAS SAMPLES

2203A Commerce Road, Suite 1
Forest Hill, MD 21050 USA
P: 1-410-838-8780 | F: 1-410-838-8740

Project Information				Client Information		
Beacon Project No.:		Company Name:		Tetra Tech, Inc.		Client PO No.:
Site Name:		Office Location:		Honolulu		
Site Location:		Samples Submitted By:		Eric Jensen		Expedited Turnaround Time
Analytical Method:		U.S. EPA Method 8260C		Contact Phone No.:		<input type="checkbox"/> Rush (Specify): _____ days
Target Compounds: Dry Cleaner Compounds						
Field Sample ID		Date Emplaced	Date Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)
		Time Emplaced	Time Retrieved			
4A		X	08-26-2016	concrete X	—	ASSUME > 12" pad edge
4B		X	—	concrete X	—	" " " "
4C	✓	0939	0852	concrete 3.5"	—	PID=47.0 (P)
4D	✓	0945	0856	concrete 4"	—	PID=28.1 (P)
5A		X	—	concrete X	—	X ASSUME > 12" pad edge
5B		X	—	concrete X	—	X " " > 18" concrete
5C	✓	0948	0857	concrete 5"	—	PID=23.2 (P)
5D	✓	X	—	concrete	—	concrete 15" - ASSUME edge/area 54.1" = PID
6A	✓	1447	0909	concrete	~ 4"	
6B	✓	1448	0924	concrete	~ 4"	
6C	✓	1449	0911	concrete	~ 4"	
6D	X	1441	XX NO X X	concrete	~ 4"	NO SAMPLES
7A	✓	1449	0940	concrete	3-4"	
7B	✓	1450	0933	concrete	3-4"	
7C	✓	1436	0938	concrete	3-4"	
7D	✓	1435	0936	concrete	3-4"	
Special Notes/Instructions:						

CHAIN-OF-CUSTODY PASSIVE SOIL-GAS SAMPLES

Project Information				Client Information		
Beacon Project No.:	Company Name:	Tetra Tech, Inc.		Client PO No.:		
Site Name:	Office Location:	Honolulu		Expedited Turnaround Time		
Site Location:	Samples Submitted By:	Eric Jensen		<input type="checkbox"/> Rush (Specify): ____ days		
Analytical Method:	Contact Phone No.:	808.441.4784				
Target Compounds:	Dry Cleaner Compounds					
Field Sample ID	Date Emplaced	Date Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)	
	Time Emplaced	Time Retrieved				
8A ✓	1450	0948	4 3/4"	concrete		
8B ✓	1451	0950	4 1/2"	concrete		
8C ✓	1447	0952	5 1/2"	concrete		
8D ✓	1448	0953	5"	concrete		
9A ✓	1450	0959	6 1/8"	concrete		
9B ✓	1453	1000	9"	concrete		
9C ✓	1452	1001	5 1/2"	concrete		
9D ✓	1453	1003	5"	concrete		
10A ✓	1004	1015		concrete	PID = 25.6	
10B ✓	1003	1016		concrete	—	
10C ✗	X	—		concrete	PID = 1.8 NO sample package	
10D ✓	1024	1018		concrete	PID = 8.0	
10E ✓	1013	1020		concrete	PID = 6.0	
10F ✗	— X	—		concrete	PID = 5.1	
10G ✓	1015	1022		concrete	PID = 5.4	
10H ✓	1020	1021		concrete	PID = 15.4	
10I ✗	X X	X X	X X	concrete	PID = 9.7	
Special Notes/Instructions:						

CHAIN-OF-CUSTODY PASSIVE SOIL-GAS SAMPLES

Project Information				Client Information		
Beacon Project No.:	Former AI Phillips Cleaners	Company Name:	Tetra Tech, Inc.	Client PO No.:		
Site Name:	Honolulu, HI	Office Location:	Honolulu	Expedited Turnaround Time		
Site Location:	U.S. EPA Method 8260C	Samples Submitted By:	Eric Jensen	<input type="checkbox"/> Rush (Specify): _____ days		
Analytical Method:	Dry Cleaner Compounds	Contact Phone No.:	808.441.4784			
Field Sample ID	Date Emplaced	Date Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)	
11A ✓	08-18-2016 1420	08-26-2016 1128		concrete	3"	
11B ✓	1427	1130		concrete	3"	
11C ✓	1419	1135		concrete	3"	
11D ✓	1417	1140		concrete	4"	
12A ✓	1401	1127		concrete	3 1/4"	
12B ✓	1357	1129		concrete	3 1/2"	
12C ✓	1359	1126		concrete	3 1/2"	
12D ✓	1405	1124		concrete	3 3/4"	
13-A1 ✓	1353	1049		concrete		
13-B1 ✓	1345	1103		concrete		
13-C1 ✓	1346	1109		concrete	4	
13-A2 ✓	1415	1047		concrete	5	
13-B2 ✓	1345	1101		concrete	6	
13-C2 ✓	1348	1108		concrete	3.5	
13-A3 ✓	1410	1050		concrete	3	
13-B3 ✓	1425	1104		concrete	noil, filled w/ gravel	
13-C3 ✓	1344	1111		concrete	3	
Special Notes/Instructions:						

Bag #2 Du-16

CHAIN-OF-CUSTODY PASSIVE SOIL-GAS SAMPLES

Project Information				Client Information		
Beacon Project No.:		Company Name:		Tetra Tech, Inc.		Client PO No.:
Site Name:		Office Location:		Honolulu		
Site Location:		Samples Submitted By:		Eric Jensen		Expedited Turnaround Time
Analytical Method:		Contact Phone No.:		808.441.4784		<input type="checkbox"/> Rush (Specify): ___ days
Target Compounds: Dry Cleaner Compounds						
Field Sample ID	Date Emplaced	Date Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)	
13-A4 ✓	1347	1053		concrete 4		
13-B4 ✓	1341	1105		concrete 4		
13-C4 ✓	1359	1114 *		concrete 4	* BROKEN JAR - (1) FILTER LOST	
14A ✓	X	X	X	concrete	PID = 14.1	
14B ✓	X	X	X	concrete	PID = 19.2	
14C ✓	1342	1036		concrete 5.5		
14D ✓	1345	1031		concrete 5	PID =	
15A ✓	1039	1026		concrete 2.5"	PID = 14.1	
15B ✓	1038	1025		concrete 4.4"	PID = 19.2	
15C ✓	1046	1029		concrete 5"	PID = 35.3 gravel injured beneath pad	
15D ✓	X			concrete >10"	PID = 38.3 NO SAMPLE	
16A ✓	1329	1116		concrete 6		
16B ✓	1330	1117		concrete 3.75		
16C ✓	1303	1119 *		concrete 3.75	* JAR BROKE & used sparger	
16D ✓	1305	1121		concrete 3.25		
Special Notes/Instructions:						

346 #2

CHAIN-OF-CUSTODY

PASSIVE SOIL-GAS SAMPLES

Project Information				Client Information		
Beacon Project No.:	Former Al Phillips Cleaners		Company Name:	Tetra Tech, Inc.		
Site Name:	Honolulu, HI		Office Location:	Honolulu		
Site Location:	U.S. EPA Method 8260C		Samples Submitted By:	Eric Jensen		
Analytical Method:	Dry Cleaner Compounds		Contact Phone No.:	808.441.4784		
Target Compounds:	Date Placed		Date Retrieved	Expedited Turnaround Time		
Field Sample ID	Time Placed	Time Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)	
17-A1 ✓	1350	1040		concrete	3.5	
17-B1 ✓	1327	1054		concrete	8	
17-C1 ✓	1328	1101		concrete	4.75	concrete. forerunner depth of 1 1/2, but 1/2 to soil
17-A2 ✓	1338	1042		concrete	3.5	
17-B2 ✓	1327	1052		concrete	4.5	
17-C2 ✓	1324	1059		concrete	4.0	
17-A3 ✓	1331	1044		concrete	3.5	
17-B3 ✓	1412	1057		concrete	2.5	gravel sand when in 1 1/2 inch hole in ground
17-C3 ✓	1308	1103		concrete	3	
17-A4 ✓	1402	1046		concrete	3	
17-B4 ✓	1309	1055		concrete	4	
17-C4 ✓	1314	1105		concrete	4.5	
18A ✓	1318	1025		concrete	4.5	
18B ✓	1336	1030	1031	concrete	4	
18C ✓	1314	1033		concrete	3	
18D ✓	1322	1036		concrete	3.5	
Special Notes/Instructions:						

CHAIN-OF-CUSTODY PASSIVE SOIL-GAS SAMPLES

Project Information				Client Information		
Beacon Project No.:	Company Name:		Tetra Tech, Inc.		Client PO No.:	
Site Name:	Office Location:		Honolulu			
Site Location:	Samples Submitted By:		Eric Jensen		Expedited Turnaround Time	
Analytical Method:	Contact Phone No.:		808.441.4784		<input type="checkbox"/> Rush (Specify): _____ days	
Target Compounds:						
Dry Cleaner Compounds						
Field Sample ID	Date Emplaced	Date Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)	
					Time Emplaced	Time Retrieved
19A ✓	1330	1012		concrete	4.5	
19B ✓	1331	1014		concrete	4.0	
19C ✓	1440	1026		concrete	2.5	bad hole. Hard bottom - not sample
19D ✓	1340	1018		concrete	3.75	
20A ✓	1048	1005		concrete	5"	PID=8.4 gravel in area beneath cover
20B ✓	1041	1007		concrete	5"	PID=2.6
20C ✓	1050	1009		concrete	4"	PID=0.9
20D ✓	1052	1011		concrete	4"	PID=16
21A ✓	1254	0845		concrete	3"	PID=0.0
21B ✓	1302	0850		concrete	3 1/4"	PID=0.0
21C ✓	1304	0855		concrete	5 1/2"	PID=0.0
21D ✓	1306	0900		concrete	4"	—
22A ✓	1227	1109		concrete	4 1/2"	PID=0.0
22B ✓	1224	1111		concrete	4 1/2"	PID=0.0
22C ✓	1238	1113		concrete	3.5"	PID=6.6
22D ✓	1236	1115		concrete	3.5"	—
Special Notes/Instructions:						

CHAIN-OF-CUSTODY PASSIVE SOIL-GAS SAMPLES

Project Information				Client Information		
Beacon Project No.:	Company Name:	Tetra Tech, Inc.	Client PO No.:			
Site Name:	Office Location:	Honolulu				
Site Location:	Samples Submitted By:	Eric Jensen			Expedited Turnaround Time	
Analytical Method:	Contact Phone No.:	808.441.4784			<input type="checkbox"/> Rush (Specify): _____ days	
Target Compounds:						
Dry Cleaner Compounds						
Field Sample ID	Date Emplaced	Date Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)	
	Time Emplaced	Time Retrieved				
23A ✓	1205	0902 *		concrete	PID=0.0 * BROKEN JAR - used spare	
23B ✓	1233	0905	4"	concrete	PID=2.7	
23C ✓	1208	0907	4.5"	concrete		
23D ✓	1206	0911 *	3"	concrete	PID=3.1 * BROKEN JAR - used spare	
24-A1 ✓	1218	0914	3"		PID=0.0	
24-B1 ✓	1401	0926			PID=4.1	
24-C1 ✓	1202	0942		4.5"	PID=14.0	
24-A2 ✓	1404	0919		4.5"		
24-B2 ✓	1140	0930		4.1"	PID=43.0	
24-C2 ✓	1135	0945		4"	PID=42.0	
24-A3 ✓	1157	0921		4.5" 3.0"	PID=1.5	
24-B3 ✓	1158	0932		4.5"	PID=0.0	
24-C3 ✓	1155	0947		4.5"	PID=14.8	
Special Notes/Instructions:						

CHAIN-OF-CUSTODY PASSIVE SOIL-GAS SAMPLES

Project Information				Client Information		
Beacon Project No.:		Company Name:		Tetra Tech, Inc.		Client PO No.:
Site Name:		Office Location:		Honolulu		
Site Location:		Samples Submitted By:		Eric Jensen		Expedited Turnaround Time
Analytical Method:		Contact Phone No.:		808.441.4784		<input type="checkbox"/> Rush (Specify): _____ days
Target Compounds: Dry Cleaner Compounds						
Field Sample ID		Date Placed	Date Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)
		Time Placed	Time Retrieved			
24-A4	✓	1140	0925		4"	near in bottom of hole
24-B4	✓	1144	0939		4" 4.5"	PID = 0.3 (note drilling nearby)
24-C4	✓	1131	0950		4"	PID = 0.1
25A	✓	1124	0953		3"	PID = 0.0
25B	✓	1102	0956		3"	PID = 0.0
25C	✓	1121	0959		4"	PID = 0.0
25D	✓	1117	1002		4"	PID = 0.3
Special Notes/Instructions:						

CHAIN-OF-CUSTODY

PASSIVE SOIL-GAS SAMPLES

Project Information				Client Information		
Beacon Project No.:		Former Al Phillips Cleaners		Company Name:		Tetra Tech, Inc.
Site Name:		Honolulu, HI		Office Location:		Honolulu
Site Location:		U.S. EPA Method 8260C		Samples Submitted By:		Eric Jensen
Analytical Method:		Dry Cleaner Compounds		Contact Phone No.:		808.441.4784
Target Compounds:		Date Retrieved		Date Retrieved		Expedited Turnaround Time
		08-18-2016		XXXXXX		<input type="checkbox"/> Rush (Specify): ____ days
Field Sample ID		Time Retrieved		Time Retrieved		
Trip 1	1700	✓	XXXXXXXXXX	0800	XXXXXXXXXX	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)
Trip 2	1705	✓	XXXXXXXXXX	0800	XXXXXXXXXX	XXXXXX BAG #1
						XXXXXX BAG #2
Special Notes/Instructions:						

Attachment 4

LABORATORY PROCEDURES FOR PASSIVE SOIL-GAS SAMPLES

Following are laboratory procedures used with BEACON Passive Soil-Gas Surveys, a screening technology for expedited site investigation. After exposure, adsorbent cartridges from the passive samplers are analyzed using U.S. EPA Method 8260C as a guidance document, a capillary gas chromatographic/mass spectrometric method, modified to accommodate high temperature thermal desorption of the adsorbent cartridges and to meet the objectives of reporting semi-quantitative data. This procedure is summarized as follows:

- A. The adsorbent cartridges are loaded with internal standards and surrogates prior to loading the autosampler with the cartridges. The loaded cartridges are purged in a helium flow. Then the cartridges are thermally desorbed in a helium flow onto a focusing trap. Any analytes in the helium stream are adsorbed onto a focusing trap.
- B. Following trap focusing, the trap is thermally desorbed onto a Rxi-624Sil MS 20m, 0.18 mm ID, 1.00 micron film thickness capillary column.
- C. The GC/MS is scanned between 35 and 300 Atomic Mass Units (AMU) at 3.12 scans per second.
- D. BFB tuning criteria and the initial five-point calibration procedures are those stated in method SW846-8260C. System performance and calibration check criteria are met prior to analysis of samples. A laboratory method blank is analyzed after the daily standard to determine that the system is contaminant-free.
- E. The instrumentation used for these analyses includes:
 - Agilent 7890-5975c Gas Chromatograph/Mass Spectrometer;
 - Markes Unity2 thermal desorber;
 - Markes Ultra2 autosampler; and
 - Markes Mass Flow Controller Modules.

Attachment 5

Composite Samples Table

Sample ID	Decision Unit (DU)	# of samples in composite
1C	1	2
1D	1	
2C	2	2
2D	2	
3C	3	2
3D	3	
4C	4	2
4D	4	
5C	5	1
6A	6	3
6B	6	
6C	6	
7A	7	4
7B	7	
7C	7	
7D	7	
8A	8	4
8B	8	
8C	8	
8D	8	
9A	9	4
9B	9	
9C	9	
9D	9	
10A	10	1
10B	10	1
10D	10	1
10E	10	1
10G	10	1
10H	10	1
11A	11	4
11B	11	
11C	11	
11D	11	
12A	12	4
12B	12	
12C	12	
12D	12	
13-A1	13A	4
13-A2	13A	
13-A3	13A	
13-A4	13A	
13-B1	13B	4
13-B2	13B	
13-B3	13B	
13-B4	13B	

Sample ID	Decision Unit (DU)	# of samples in composite
13-C1	13C	4
13-C2	13C	
13-C3	13C	
13-C4	13C	
14C	14	2
14D	14	
15A	15	3
15B	15	
15C	15	
16A	16	3
16B	16	
16C	16	
17-A1	17A	4
17-A2	17A	
17-A3	17A	
17-A4	17A	
17-B1	17B	4
17-B2	17B	
17-B3	17B	
17-B4	17B	
17-C1	17C	4
17-C2	17C	
17-C3	17C	
17-C4	17C	
18A	18	4
18B	18	
18C	18	
18D	18	
19A	19	4
19B	19	
19C	19	
19D	19	
20A	20	4
20B	20	
20C	20	
20D	20	
21A	21	4
21B	21	
21C	21	
21D	21	
22A	22	4
22B	22	
22C	2	
22D	22	
23A	23	3
23B	23	
23C	23	

Sample ID	Decision Unit (DU)	# of samples in composite
24-A1	24A	4
24-A2	24A	
24-A3	24A	
24-A4	24A	
24-B1	24B	4
24-B2	24B	
24-B3	24B	
24-B4	24B	
24-C1	24C	4
24-C2	24C	
24-C3	24C	
24-C4	24C	
25A	25	4
25B	25	
25C	25	
25D	25	

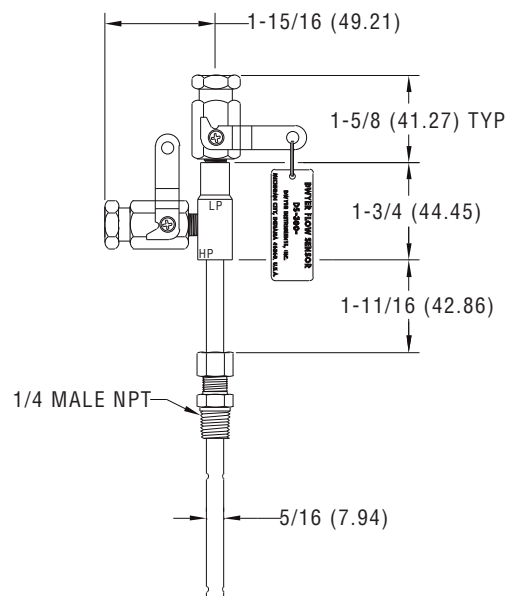
Appendix E

Dwyer Pitot Tube Manufacturer Specification Sheet



Series DS-300 Flow Sensors

Installation and Operating Instructions Flow Calculations



Series DS-300 Flow Sensors are averaging pitot tubes that provide accurate, convenient flow rate sensing. When purchased with a Dwyer Capsuhelic® for liquid flow or Magnehelic® for air flow, differential pressure gage of appropriate range, the result is a flow-indicating system delivered off the shelf at an economical price. Series DS-300 Flow Sensors are designed to be inserted in the pipeline through a compression fitting and are furnished with instrument shut-off valves on both pressure connections. Valves are fitted with 1/8" female NPT connections. Accessories include adapters with 1/4" SAE 45° flared ends compatible with hoses supplied with the Model A-471 Portable Capsuhelic® kit. Standard valves are rated at 200°F (93.3°C). Where valves are not required, they can be omitted at reduced cost. Series DS-300 Flow Sensors are available for pipe sizes from 1" to 10".

INSPECTION

Inspect sensor upon receipt of shipment to be certain it is as ordered and not damaged. If damaged, contact carrier.

INSTALLATION

General - The sensing ports of the flow sensor must be correctly positioned for measurement accuracy. The instrument connections on the sensor indicate correct positioning. The side connection is for total or high pressure and should be pointed upstream. The top connection is for static or low pressure.

Location - The sensor should be installed in the flowing line with as much straight run of pipe upstream as possible. A rule of thumb is to allow 10 - 15 pipe diameters upstream and 5 downstream. The table below lists recommended up and down piping.

PRESSURE AND TEMPERATURE

Maximum: 200 psig (13.78 bar) at 200°F (93.3°C).

Upstream and Downstream Dimensions in Terms of Internal Diameter of Pipe *			
Upstream Condition	Minimum Diameter of Straight Pipe		
	Upstream		Downstream
	In-Plane	Out of Plane	
One Elbow or Tee	7	9	5
Two 90° Bends in Same Plane	8	12	5
Two 90° Bends in Different Plane	18	24	5
Reducers or Expanders	8	8	5
All Valves**	24	24	5

* Values shown are recommended spacing, in terms of internal diameter for normal industrial metering requirements. For laboratory or high accuracy work, add 25% to values.

** Includes gate, globe, plug and other throttling valves that are only partially opened. If valve is to be fully open, use values for pipe size change. **CONTROL VALVES SHOULD BE LOCATED AFTER THE FLOW SENSOR.**

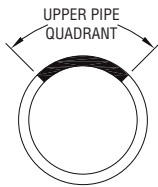
POSITION

Be certain there is sufficient clearance between the mounting position and other pipes, walls, structures, etc, so that the sensor can be inserted through the mounting unit once the mounting unit has been installed onto the pipe.

Flow sensors should be positioned to keep air out of the instrument connecting lines on liquid flows and condensate out of the lines on gas flows. The easiest way to assure this is to install the sensor into the pipe so that air will bleed into, or condensate will drain back to, the pipe.

For Air or Gas Flow

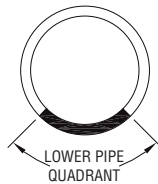
Install in upper quadrant of pipe



Condensate drains back to pipe

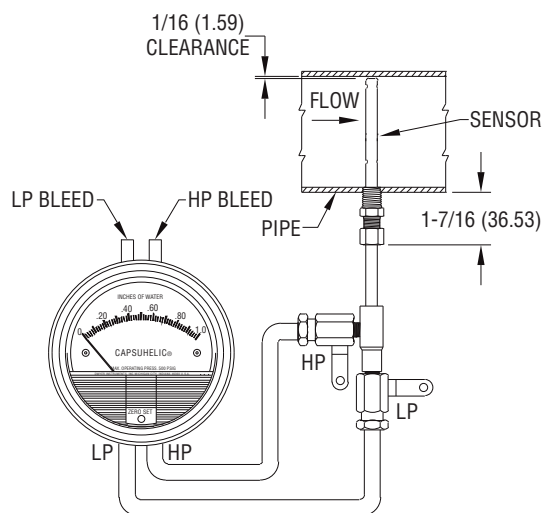
For Liquid or Steam Flow

Install in lower quadrant of pipe



Air bleeds back to pipe

Water Flow



INSTALLATION

1. When using an A-160 thred-o-let, weld it to the pipe wall. If replacing a DS-200 unit, an A-161 bushing (1/4" x 3/8") will be needed.
2. Drill through center of the thred-o-let into the pipe with a drill that is slightly larger than the flow sensor diameter.
3. Install the packing gland using proper pipe sealant. If the packing gland is disassembled, note that the tapered end of the ferrule goes into the fitting body.
4. Insert sensor until it bottoms against opposite wall of the pipe, then withdraw 1/16" to allow for thermal expansion.
5. Tighten packing gland nut finger tight. Then tighten nut with a wrench an additional 1-1/4 turns. Be sure to hold the sensor body with a second wrench to prevent the sensor from turning.

INSTRUMENT CONNECTION

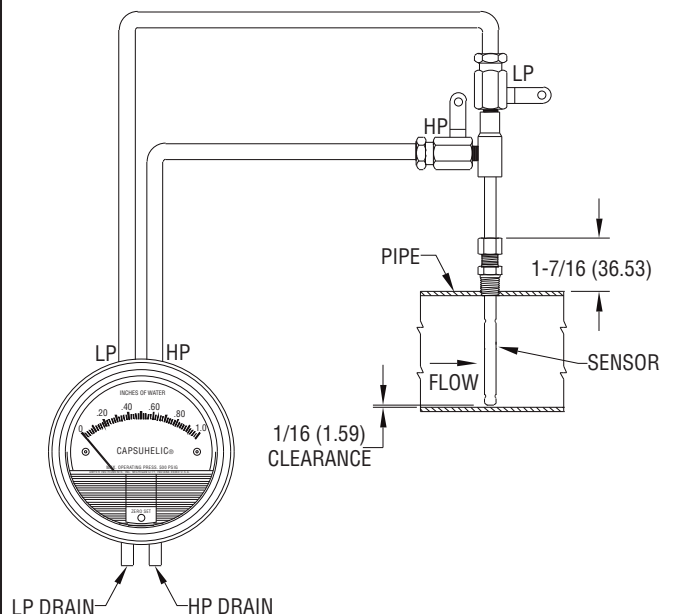
Connect the slide pressure tap to the high pressure port of the Magnehelic® (air only) or Capsuhelic® gage or transmitting instrument and the top connection to the low pressure port.

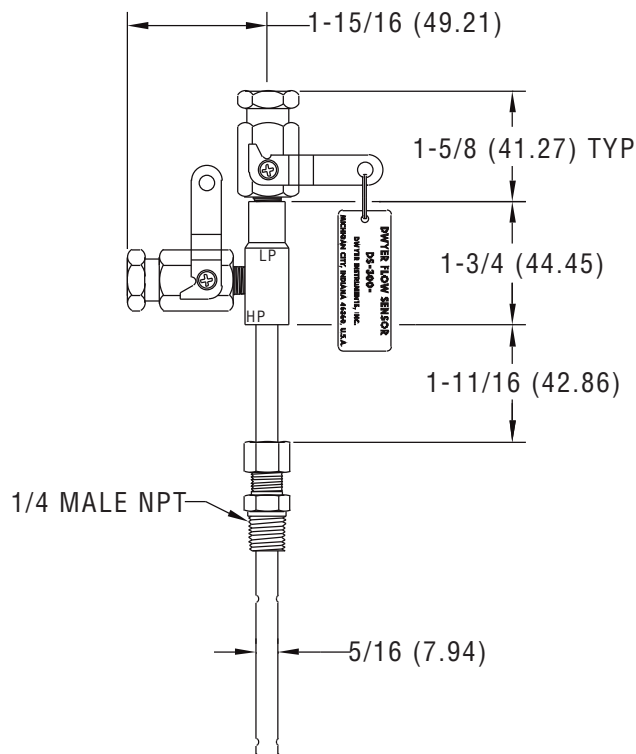
See the connection schematics below.

Bleed air from instrument piping on liquid flows. Drain any condensate from the instrument piping on air and gas flows.

Open valves to instrument to place flow meter into service. For permanent installations, a 3-valve manifold is recommended to allow the gage to be zero checked without interrupting the flow. The Dwyer A-471 Portable Test Kit includes such a device.

Air or Gas Flow





Flow Calculations and Charts

The following information contains tables and equations for determining the differential pressure developed by the DS-300 Flow Sensor for various flow rates of water, steam, air or other gases in different pipe sizes.

This information can be used to prepare conversion charts to translate the differential pressure readings being sensed into the equivalent flow rate. When direct readout of flow is required, use this information to calculate the full flow differential pressure in order to specify the exact range of Dwyer Magnehelic® or Capsuhelic® gage required. Special ranges and calculations are available for these gages at minimal extra cost. See bulletins A-30 and F-41 for additional information on Magnehelic® and Capsuhelic® gages and DS-300 flow sensors.

For additional useful information on making flow calculations, the following service is recommended: Crane Valve Co. Technical Paper No. 410 "Flow of Fluids Through Valves, Fittings and Pipe." It is available from Crane Valve Company, www.cranvalve.com.

Using the appropriate differential pressure equation from Page 4 of this bulletin, calculate the differential pressure generated by the sensor under normal operating conditions of the system. Check the chart below to determine if this value is within the recommended operating range for the sensor. Note that the data in this chart is limited to standard conditions of air at 60°F (15.6°C) and 14.7 psia static line pressure or water at 70°F (21.1°C). To determine recommended operating ranges of other gases, liquids an/or operating conditions, consult factory.

Note: the column on the right side of the chart which defines velocity ranges to avoid. Continuous operation within these ranges can result in damage to the flow sensor caused by excess vibration.

Pipe Size (Schedule 40)	Flow Coefficient "K"	Operating Ranges Air @ 60°F & 14.7 psia (D/P in. W.C.)	Operating Ranges Water @ 70°F (D/P in. W.C.)	Velocity Ranges Not Recommended (Feet per Second)
1	0.52	1.10 to 186	4.00 to 675	146 to 220
1-1/4	0.58	1.15 to 157	4.18 to 568	113 to 170
1-1/2	0.58	0.38 to 115	1.36 to 417	96 to 144
2	0.64	0.75 to 75	2.72 to 271	71 to 108
2-1/2	0.62	1.72 to 53	6.22 to 193	56 to 85
3	0.67	0.39 to 35	1.43 to 127	42 to 64
4	0.67	0.28 to 34	1.02 to 123	28 to 43
6	0.71	0.64 to 11	2.31 to 40	15 to 23
8	0.67	0.10 to 10	0.37 to 37	9.5 to 15
10	0.70	0.17 to 22	0.60 to 79	6.4 to 10

FLOW EQUATIONS

1. Any Liquid

$$Q \text{ (GPM)} = 5.668 \times K \times D^2 \times \sqrt{\Delta P / S_f}$$

2. Steam or Any Gas

$$Q \text{ (lb/Hr)} = 359.1 \times K \times D^2 \times \sqrt{p \times \Delta P}$$

3. Any Gas

$$Q \text{ (SCFM)} = 128.8 \times K \times D^2 \times \sqrt{\frac{P \times \Delta P}{(T + 460) \times S_s}}$$

DIFFERENTIAL PRESSURE EQUATIONS

1. Any Liquid

$$\Delta P \text{ (in. WC)} = \frac{Q^2 \times S_f}{K^2 \times D^4 \times 32.14}$$

2. Steam or Any Gas

$$\Delta P \text{ (in. WC)} = \frac{Q^2}{K^2 \times D^4 \times p \times 128,900}$$

3. Any Gas

$$\Delta P \text{ (in. WC)} = \frac{Q^2 \times S_s \times (T + 460)}{K^2 \times D^4 \times P \times 16,590}$$

Technical Notations

The following notations apply:

ΔP = Differential pressure expressed in inches of water column

Q = Flow expressed in GPM, SCFM, or PPH as shown in equation

K = Flow coefficient— See values tabulated on Pg. 3.

D = Inside diameter of line size expressed in inches.

$$\text{For square or rectangular ducts, use: } D = \sqrt{\frac{4 \times \text{Height} \times \text{Width}}{\pi}}$$

P = Static Line pressure (psia)

T = Temperature in degrees Fahrenheit (plus 460 = °Rankine)

p = Density of medium in pounds per square foot

S_f = Sp Gr at flowing conditions

S_s = Sp Gr at 60°F (15.6°C)

SCFM TO ACFM EQUATION

$$\text{SCFM} = \text{ACFM} \times \left(\frac{14.7 + \text{PSIG}}{14.7} \right) \left(\frac{520^*}{460 + ^\circ\text{F}} \right)$$

$$\text{ACFM} = \text{SCFM} \times \left(\frac{14.7}{14.7 + \text{PSIG}} \right) \left(\frac{460 + ^\circ\text{F}}{520} \right)$$

$$\frac{\text{POUNDS PER CUBIC FOOT}}{\text{STD.}} = \frac{\text{POUNDS PER CUBIC FOOT}}{\text{ACT.}} \times \left(\frac{14.7}{14.7 + \text{PSIG}} \right) \left(\frac{460 + ^\circ\text{F}}{520^*} \right)$$

$$\frac{\text{POUNDS PER CUBIC FOOT}}{\text{ACT.}} = \frac{\text{POUNDS PER CUBIC FOOT}}{\text{STD.}} \times \left(\frac{14.7 + \text{PSIG}}{14.7} \right) \left(\frac{520^*}{460 + ^\circ\text{F}} \right)$$

1 Cubic foot of air = 0.076 pounds per cubic foot at 60° F (15.6°C) and 14.7 psia.

* (520° = 460 + 60°) Std. Temp. Rankine

Appendix F

Pitot Tube Flow Calculation Spreadsheet

Worksheet Password: "LVP"

3. Any Gas

$$Q \text{ (SCFM)} = 128.8 \times K \times D^2 \times \sqrt{\frac{P \times \Delta P}{(T + 460) \times S_s}}$$

The following notations apply:

ΔP = Differential pressure expressed in inches of water column

Q = Flow expressed in GPM, SCFM, or PPH as shown in equation

K = Flow coefficient— See values tabulated on Pg. 3.

D = Inside diameter of line size expressed in inches.

$$\text{For square or rectangular ducts, use: } D = \sqrt{\frac{4 \times \text{Height} \times \text{W}}{\pi}}$$

P = Static Line pressure (psia)

T = Temperature in degrees Fahrenheit (plus 460 = °Rankine)

p = Density of medium in pounds per square foot

S_r = Sp Gr at flowing conditions

S_s = Sp Gr at 60°F (15.6°C)

	<u>Input</u>	
ΔP =	0.129	inches water column
D =	2.067	diameter of pipe (inches), 8" Sch 80 PVC is 7.625"
K =	0.67	from Table on Page 3

Calculate Static Line Pressure (P) in

psia

Blower inlet pressure =	-42	inches water column (gauge-- use negative number for vacuum)
Blower inlet pressure =	-1.52	psig
Atmospheric Pressure =	14.7	psia for sea level
Static Line Pressure =	13.18	psia
Blower Discharge Temperature =	100	deg F
S_s =	1	for air

	<u>Calculations</u>	
Q =	20.32	cfm
V =	871.9	ft/min

Appendix G

Large Volume Purge Sample - Field Data Sheets

Time	FLOW TSI Meter CFM	Pitot Tube Delta P	Pitot Tube - Calculated Flow CFM	Vacuum (- "H ₂ O)	PID (PPM)	O ₂ (%)	CO ₂	Notes
1130	20.28	0.111		40				START V
1131	24.11	0.108	20.57	40				-30" Hg
1132	23.67	0.106		40				-30" Hg
1133	23.53	0.107		40				
1134	23.37	0.106		40				
1135	23.30	0.107		40				
1136	23.42	0.102		40				
1137	23.28	0.107		40				
1138	23.34	0.107		40				
1139	23.32	0.106	20.38	40				
1140	23.36	0.107		40				
1141	23.27	0.106		40				
1142	23.25	0.105		40				
1143	23.15	0.105		40				
1144	23.20	0.106		40				
1145	23.17	0.105		40				
1146	23.18	0.106		40				
1147	23.13	0.105	20.29	40				
1148								
1149								
1150								
1151								
1152								
1153								
1154								
1155								
1156								
1157								
1158								
1159								
1160								
1161								
1162								
1163								
1164								
1165								
1166								
1167								
1168								
1169								
1170								
1171								
1172								
1173								
1174								
1175								
1176								
1177								
1178								
1179								
1180								
1181								
1182								
1183								
1184								
1185								
1186								
1187								
1188								
1189								
1190								
1191								
1192								
1193								
1194								
1195								
1196								
1197								
1198								
1199								
1200								

11:47 start

[illegible]

start 12:00

SAMPLE ID:

PAGE: / OF

DATE _____

02-20

9102-

[illegible]

Start 12:13

Time	FLOW TSI Meter CFM	Pilot Tube Delta P	Pilot Tube - Calculated Flow CFM	Velocity - H ₂ O	PID (PPM)	O2 (%)	CO2	Notes
0	5.30	0.047		40				START V ENO V
:30	21.10	0.081		40				30" Hg 23.5" Hg
1:00	20.69	0.079	17.71	41				
1:30	20.43	0.080		41				CAPILLARY ID: N0848
2:00	20.30	0.077		41				CONROLLER: 00805
2:30	20.06	0.077		41				
3:00	19.86	0.078		42				TIME: 1213-1224
3:30	19.94	0.075		42				
4:00	19.75	0.074		42				
4:30	19.63	0.071		42				
5:00	20.12	0.071		42				
5:30	19.88	0.079		42				water in air. gauge tube
6:00	20.10	0.067		42				
6:30	64.37	0.078	16.20	42				CFM increase very short
7:00	19.78	0.071	16.68	41				
7:30	19.93	0.073		42				
8:00	19.82	0.070		41				
8:30	20.82	0.074		41				
9:00	19.70	0.070		41				
9:30	33.01	0.070		42				
10:00	20.05	0.070		42				
10:30	19.88	0.077		42				
11:00	20.63	0.074		42				
11:30	20.23	0.072		41				
12:00	19.93	0.066	16.08					

start 12:20:00

Time	FLOW TSI Meter CFM	Pitot Tube Delta P	Pitot Tube - Calculated Flow CFM	Vacuum - "H ₂ O	PID (PPM)	O ₂ (%)	CO ₂	Notes
00	19.06	0.057		40				START V LEND V
:30	19.54	0.067		42				30" Hg 17" Hg
1:00	19.21	0.065	16.00	42				
1:30	19.21	0.066		41				
2:00	19.46	0.057		42				
2:30	19.37	0.060		41				vacuum gauge a little jumping
3:00	21.73	0.062		43				n 36-48 18
3:30	18.87	0.064		41				
4:00	19.61	0.069		40				
4:30	21.56	0.068		42				canister ID: 641299
5:00	18.56	0.061		40				Flow controller: 00208
5:30	18.66	0.052		41				
6:00	18.60	0.066		41				TIME: 1229-1242
6:30	42.16	0.063	15.71	36				
7:00	18.47	0.056	14.81	40				
7:30	18.24	0.060		40				
8:00	17.96	0.062		40				
8:30	19.15	0.050		40				
9:00	18.15	0.065		39				
9:30	18.23	0.060		40				
10:00	19.34	0.067		40				
10:30	18.62	0.058		38				
11:00	18.61	0.061		40				
11:30	18.76	0.071		41				
12:00	18.53	0.049		40				
12:30	21.12	0.058		41				
13:00	18.39	0.068	16.34	41				

Appendix H

**Summa Sample Laboratory Reports, 2016 - Eurofins
Air Toxics, Inc.**

9/28/2016

Mr. Eric Jensen
Tetra Tech
737 Bishop Street
Suite 2340
Honolulu HI 96813

Project Name: LAGOON DRIVE

Project #: 10351902611

Workorder #: 1609423A

Dear Mr. Eric Jensen

The following report includes the data for the above referenced project for sample(s) received on 9/16/2016 at Air Toxics Ltd.

The data and associated QC analyzed by Modified TO-15 are compliant with the project requirements or laboratory criteria with the exception of the deviations noted in the attached case narrative.

Thank you for choosing Eurofins Air Toxics Inc. for your air analysis needs. Eurofins Air Toxics Inc. is committed to providing accurate data of the highest quality. Please feel free the Project Manager: Brian Whittaker at 916-985-1000 if you have any questions regarding the data in this report.

Regards,



Brian Whittaker
Project Manager

WORK ORDER #: 1609423A

Work Order Summary

CLIENT: Mr. Eric Jensen
Tetra Tech
737 Bishop Street
Suite 2340
Honolulu, HI 96813

BILL TO: Accounts Payable
Tetra Tech
3746 Mt. Diablo Blvd.
Suite 300
Lafayette, CA 94549

PHONE: 808-441-6600

P.O. #

FAX: 808-836-1689

PROJECT # 10351902611 LAGOON DRIVE

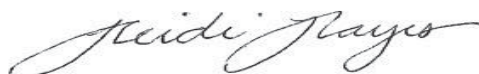
DATE RECEIVED: 09/16/2016

CONTACT: Brian Whittaker

DATE COMPLETED: 09/28/2016

<u>FRACTION #</u>	<u>NAME</u>	<u>TEST</u>	<u>RECEIPT VAC./PRES.</u>	<u>FINAL PRESSURE</u>
01A	S-1 [Box #1]	Modified TO-15	12 "Hg	4.8 psi
02A	S-1 (DUP) [Box #1]	Modified TO-15	10.6 "Hg	4.9 psi
03A	S-2 [Box #1]	Modified TO-15	17.6 "Hg	4.9 psi
04A	S-3 [Box #1]	Modified TO-15	18 "Hg	5.1 psi
05A	S-4 [Box #2]	Modified TO-15	21.2 "Hg	5 psi
06A	S-5 [Box #2]	Modified TO-15	15.9 "Hg	4.8 psi
07A	AMBIENT [Box #2]	Modified TO-15	6.7 "Hg	5 psi
08A	Lab Blank	Modified TO-15	NA	NA
08B	Lab Blank	Modified TO-15	NA	NA
08C	Lab Blank	Modified TO-15	NA	NA
09A	CCV	Modified TO-15	NA	NA
09B	CCV	Modified TO-15	NA	NA
09C	CCV	Modified TO-15	NA	NA
10A	LCS	Modified TO-15	NA	NA
10AA	LCSD	Modified TO-15	NA	NA
10B	LCS	Modified TO-15	NA	NA
10BB	LCSD	Modified TO-15	NA	NA
10C	LCS	Modified TO-15	NA	NA
10CC	LCSD	Modified TO-15	NA	NA

CERTIFIED BY:



Technical Director

DATE: 09/28/16

Certification numbers: AZ Licensure AZ0775, NJ NELAP - CA016, NY NELAP - 11291,
TX NELAP - T104704434-15-9, UT NELAP CA0093332015-6, VA NELAP - 8113, WA NELAP - C935
Name of Accreditation Body: NELAP/ORELAP (Oregon Environmental Laboratory Accreditation Program)
Accreditation number: CA300005, Effective date: 10/18/2015, Expiration date: 10/17/2016.

Eurofins Air Toxics Inc., certifies that the test results contained in this report meet all requirements of the NELAC standards

This report shall not be reproduced, except in full, without the written approval of Eurofins Air Toxics, Inc.

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630

(916) 985-1000 . (800) 985-5955 . FAX (916) 985-1020

LABORATORY NARRATIVE
Modified TO-15
Tetra Tech
Workorder# 1609423A

Seven 6 Liter Summa Canister (100% Certified) samples were received on September 16, 2016. The laboratory performed analysis via modified EPA Method TO-15 using GC/MS in the full scan mode.

This workorder was independently validated prior to submittal using 'USEPA National Functional Guidelines' as generally applied to the analysis of volatile organic compounds in air. A rules-based, logic driven, independent validation engine was employed to assess completeness, evaluate pass/fail of relevant project quality control requirements and verification of all quantified amounts.

Method modifications taken to run these samples are summarized in the table below. Specific project requirements may over-ride the EATL modifications.

<i>Requirement</i>	<i>TO-15</i>	<i>ATL Modifications</i>
Initial Calibration	$\leq 30\%$ RSD with 2 compounds allowed out to $< 40\%$ RSD	$\leq 30\%$ RSD with 4 compounds allowed out to $< 40\%$ RSD
Blank and standards	Zero Air	UHP Nitrogen provides a higher purity gas matrix than zero air

Receiving Notes

The Chain of Custody (COC) information for samples S-3 [Box #1] and AMBIENT [Box #2] did not match the information on the canister with regard to canister identification. The client was notified of the discrepancy and the information on the canister was used to process and report the samples.

The Chain of Custody (COC) information for samples S-1 [Box #1], S-1 (DUP) [Box #1], S-2 [Box #1], S-3 [Box #1], S-4 [Box #2], S-5 [Box #2] and AMBIENT [Box #2] did not match the entries on the sample tags with regard to sample identification. Therefore the information on the COC was used to process and report the samples.

Analytical Notes

All Quality Control Limit exceedances and affected sample results are noted by flags. Each flag is defined at the bottom of this Case Narrative and on each Sample Result Summary page. Target compound non-detects in the samples that are associated with high bias in QC analyses have not been flagged.

A single point calibration for TPH referenced to Gasoline was performed for each daily analytical batch. Recovery is reported as 100% in the associated results for each CCV.

Samples S-1 [Box #1], S-1 (DUP) [Box #1], S-2 [Box #1], S-3 [Box #1], S-4 [Box #2] and S-5 [Box #2] were transferred from Low Level analysis to full scan TO-15 due to high levels of target compounds.

Dilution was performed on samples S-1 [Box #1], S-1 (DUP) [Box #1], S-2 [Box #1], S-3 [Box #1],

S-4 [Box #2] and S-5 [Box #2] due to the presence of high level target species.

Definition of Data Qualifying Flags

Eight qualifiers may have been used on the data analysis sheets and indicates as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction not performed).

J - Estimated value.

E - Exceeds instrument calibration range.

S - Saturated peak.

Q - Exceeds quality control limits.

U - Compound analyzed for but not detected above the reporting limit, LOD, or MDL value. See data page for project specific U-flag definition.

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

N - The identification is based on presumptive evidence.

File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified

b-File was quantified by a second column and detector

r1-File was requantified for the purpose of reissue

Summary of Detected Compounds

EPA METHOD TO-15 GC/MS FULL SCAN

Client Sample ID: S-1 [Box #1]

Lab ID#: 1609423A-01A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
2-Propanol	44	4600 E	110	11000 E
trans-1,2-Dichloroethene	11	25	44	98
cis-1,2-Dichloroethene	11	65	44	260
Trichloroethene	11	250	59	1400
Tetrachloroethene	11	2600	75	17000

Client Sample ID: S-1 (DUP) [Box #1]

Lab ID#: 1609423A-02A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
2-Propanol	41	5000 E	100	12000 E
trans-1,2-Dichloroethene	10	28	41	110
cis-1,2-Dichloroethene	10	77	41	300
Trichloroethene	10	270	55	1400
Tetrachloroethene	10	2800	70	19000

Client Sample ID: S-2 [Box #1]

Lab ID#: 1609423A-03A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
2-Propanol	130	20000 E	320	48000 E
trans-1,2-Dichloroethene	32	39	130	160
cis-1,2-Dichloroethene	32	88	130	350
Trichloroethene	32	300	170	1600
Tetrachloroethene	32	5400	220	36000

Client Sample ID: S-3 [Box #1]

Lab ID#: 1609423A-04A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
2-Propanol	670	130000	1600	330000
Trichloroethene	170	410	900	2200

Summary of Detected Compounds EPA METHOD TO-15 GC/MS

Client Sample ID: S-3 [Box #1]

Lab ID#: 1609423A-04A

Tetrachloroethene	170	7400	1100	50000
-------------------	-----	------	------	-------

Client Sample ID: S-4 [Box #2]

Lab ID#: 1609423A-05A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
2-Propanol	230	67000 E	560	160000 E
cis-1,2-Dichloroethene	57	86	220	340
Trichloroethene	57	340	310	1800
Tetrachloroethene	57	7500	390	51000

Client Sample ID: S-5 [Box #2]

Lab ID#: 1609423A-06A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Acetone	560	750	1300	1800
2-Propanol	560	140000	1400	340000
Trichloroethene	140	440	760	2400
Tetrachloroethene	140	7900	960	54000

Client Sample ID: AMBIENT [Box #2]

Lab ID#: 1609423A-07A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	0.17	0.65	0.86	3.2
Freon 11	0.17	0.76	0.97	4.2
Ethanol	0.86	10	1.6	19
Freon 113	0.17	0.17	1.3	1.3
Acetone	0.86	14	2.0	33
2-Propanol	0.86	160 E	2.1	390 E
2-Butanone (Methyl Ethyl Ketone)	0.86	1.2	2.6	3.5
Chloroform	0.17	0.20	0.84	0.95
Benzene	0.17	0.21	0.55	0.68
Heptane	0.17	0.17	0.71	0.71

Summary of Detected Compounds
MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

Client Sample ID: AMBIENT [Box #2]

Lab ID#: 1609423A-07A

Toluene	0.17	0.87	0.65	3.3
m,p-Xylene	0.17	0.20	0.75	0.87



Air Toxics

Client Sample ID: S-1 [Box #1]

Lab ID#: 1609423A-01A

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092722	Date of Collection:	9/14/16 11:41:00 AM
Dil. Factor:	22.1	Date of Analysis:	9/28/16 12:32 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	11	Not Detected	55	Not Detected
Freon 114	11	Not Detected	77	Not Detected
Chloromethane	110	Not Detected	230	Not Detected
Vinyl Chloride	11	Not Detected	28	Not Detected
1,3-Butadiene	11	Not Detected	24	Not Detected
Bromomethane	110	Not Detected	430	Not Detected
Chloroethane	44	Not Detected	120	Not Detected
Freon 11	11	Not Detected	62	Not Detected
Ethanol	44	Not Detected	83	Not Detected
Freon 113	11	Not Detected	85	Not Detected
1,1-Dichloroethene	11	Not Detected	44	Not Detected
Acetone	110	Not Detected	260	Not Detected
2-Propanol	44	4600 E	110	11000 E
Carbon Disulfide	44	Not Detected	140	Not Detected
3-Chloropropene	44	Not Detected	140	Not Detected
Methylene Chloride	110	Not Detected	380	Not Detected
Methyl tert-butyl ether	44	Not Detected	160	Not Detected
trans-1,2-Dichloroethene	11	25	44	98
Hexane	11	Not Detected	39	Not Detected
1,1-Dichloroethane	11	Not Detected	45	Not Detected
2-Butanone (Methyl Ethyl Ketone)	44	Not Detected	130	Not Detected
cis-1,2-Dichloroethene	11	65	44	260
Tetrahydrofuran	11	Not Detected	32	Not Detected
Chloroform	11	Not Detected	54	Not Detected
1,1,1-Trichloroethane	11	Not Detected	60	Not Detected
Cyclohexane	11	Not Detected	38	Not Detected
Carbon Tetrachloride	11	Not Detected	70	Not Detected
2,2,4-Trimethylpentane	11	Not Detected	52	Not Detected
Benzene	11	Not Detected	35	Not Detected
1,2-Dichloroethane	11	Not Detected	45	Not Detected
Heptane	11	Not Detected	45	Not Detected
Trichloroethene	11	250	59	1400
1,2-Dichloropropane	11	Not Detected	51	Not Detected
1,4-Dioxane	44	Not Detected	160	Not Detected
Bromodichloromethane	11	Not Detected	74	Not Detected
cis-1,3-Dichloropropene	11	Not Detected	50	Not Detected
4-Methyl-2-pentanone	11	Not Detected	45	Not Detected
Toluene	11	Not Detected	42	Not Detected
trans-1,3-Dichloropropene	11	Not Detected	50	Not Detected
1,1,2-Trichloroethane	11	Not Detected	60	Not Detected
Tetrachloroethene	11	2600	75	17000
2-Hexanone	44	Not Detected	180	Not Detected



Air Toxics

Client Sample ID: S-1 [Box #1]

Lab ID#: 1609423A-01A

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092722	Date of Collection:	9/14/16 11:41:00 AM
Dil. Factor:	22.1	Date of Analysis:	9/28/16 12:32 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	11	Not Detected	94	Not Detected
1,2-Dibromoethane (EDB)	11	Not Detected	85	Not Detected
Chlorobenzene	11	Not Detected	51	Not Detected
Ethyl Benzene	11	Not Detected	48	Not Detected
m,p-Xylene	11	Not Detected	48	Not Detected
o-Xylene	11	Not Detected	48	Not Detected
Styrene	11	Not Detected	47	Not Detected
Bromoform	11	Not Detected	110	Not Detected
Cumene	11	Not Detected	54	Not Detected
1,1,2,2-Tetrachloroethane	11	Not Detected	76	Not Detected
Propylbenzene	11	Not Detected	54	Not Detected
4-Ethyltoluene	11	Not Detected	54	Not Detected
1,3,5-Trimethylbenzene	11	Not Detected	54	Not Detected
1,2,4-Trimethylbenzene	11	Not Detected	54	Not Detected
1,3-Dichlorobenzene	11	Not Detected	66	Not Detected
1,4-Dichlorobenzene	11	Not Detected	66	Not Detected
alpha-Chlorotoluene	11	Not Detected	57	Not Detected
1,2-Dichlorobenzene	11	Not Detected	66	Not Detected
1,2,4-Trichlorobenzene	44	Not Detected	330	Not Detected
Hexachlorobutadiene	44	Not Detected	470	Not Detected
TPH ref. to Gasoline (MW=100)	1100	Not Detected	4500	Not Detected

E = Exceeds instrument calibration range.

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
Toluene-d8	100	70-130
1,2-Dichloroethane-d4	94	70-130
4-Bromofluorobenzene	110	70-130



Air Toxics

Client Sample ID: S-1 (DUP) [Box #1]

Lab ID#: 1609423A-02A

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092723	Date of Collection:	9/14/16 11:41:00 AM
Dil. Factor:	20.6	Date of Analysis:	9/28/16 12:57 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	10	Not Detected	51	Not Detected
Freon 114	10	Not Detected	72	Not Detected
Chloromethane	100	Not Detected	210	Not Detected
Vinyl Chloride	10	Not Detected	26	Not Detected
1,3-Butadiene	10	Not Detected	23	Not Detected
Bromomethane	100	Not Detected	400	Not Detected
Chloroethane	41	Not Detected	110	Not Detected
Freon 11	10	Not Detected	58	Not Detected
Ethanol	41	Not Detected	78	Not Detected
Freon 113	10	Not Detected	79	Not Detected
1,1-Dichloroethene	10	Not Detected	41	Not Detected
Acetone	100	Not Detected	240	Not Detected
2-Propanol	41	5000 E	100	12000 E
Carbon Disulfide	41	Not Detected	130	Not Detected
3-Chloropropene	41	Not Detected	130	Not Detected
Methylene Chloride	100	Not Detected	360	Not Detected
Methyl tert-butyl ether	41	Not Detected	150	Not Detected
trans-1,2-Dichloroethene	10	28	41	110
Hexane	10	Not Detected	36	Not Detected
1,1-Dichloroethane	10	Not Detected	42	Not Detected
2-Butanone (Methyl Ethyl Ketone)	41	Not Detected	120	Not Detected
cis-1,2-Dichloroethene	10	77	41	300
Tetrahydrofuran	10	Not Detected	30	Not Detected
Chloroform	10	Not Detected	50	Not Detected
1,1,1-Trichloroethane	10	Not Detected	56	Not Detected
Cyclohexane	10	Not Detected	35	Not Detected
Carbon Tetrachloride	10	Not Detected	65	Not Detected
2,2,4-Trimethylpentane	10	Not Detected	48	Not Detected
Benzene	10	Not Detected	33	Not Detected
1,2-Dichloroethane	10	Not Detected	42	Not Detected
Heptane	10	Not Detected	42	Not Detected
Trichloroethene	10	270	55	1400
1,2-Dichloropropane	10	Not Detected	48	Not Detected
1,4-Dioxane	41	Not Detected	150	Not Detected
Bromodichloromethane	10	Not Detected	69	Not Detected
cis-1,3-Dichloropropene	10	Not Detected	47	Not Detected
4-Methyl-2-pentanone	10	Not Detected	42	Not Detected
Toluene	10	Not Detected	39	Not Detected
trans-1,3-Dichloropropene	10	Not Detected	47	Not Detected
1,1,2-Trichloroethane	10	Not Detected	56	Not Detected
Tetrachloroethene	10	2800	70	19000
2-Hexanone	41	Not Detected	170	Not Detected



Air Toxics

Client Sample ID: S-1 (DUP) [Box #1]

Lab ID#: 1609423A-02A

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092723	Date of Collection: 9/14/16 11:41:00 AM
Dil. Factor:	20.6	Date of Analysis: 9/28/16 12:57 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	10	Not Detected	88	Not Detected
1,2-Dibromoethane (EDB)	10	Not Detected	79	Not Detected
Chlorobenzene	10	Not Detected	47	Not Detected
Ethyl Benzene	10	Not Detected	45	Not Detected
m,p-Xylene	10	Not Detected	45	Not Detected
o-Xylene	10	Not Detected	45	Not Detected
Styrene	10	Not Detected	44	Not Detected
Bromoform	10	Not Detected	110	Not Detected
Cumene	10	Not Detected	51	Not Detected
1,1,2,2-Tetrachloroethane	10	Not Detected	71	Not Detected
Propylbenzene	10	Not Detected	51	Not Detected
4-Ethyltoluene	10	Not Detected	51	Not Detected
1,3,5-Trimethylbenzene	10	Not Detected	51	Not Detected
1,2,4-Trimethylbenzene	10	Not Detected	51	Not Detected
1,3-Dichlorobenzene	10	Not Detected	62	Not Detected
1,4-Dichlorobenzene	10	Not Detected	62	Not Detected
alpha-Chlorotoluene	10	Not Detected	53	Not Detected
1,2-Dichlorobenzene	10	Not Detected	62	Not Detected
1,2,4-Trichlorobenzene	41	Not Detected	300	Not Detected
Hexachlorobutadiene	41	Not Detected	440	Not Detected
TPH ref. to Gasoline (MW=100)	1000	Not Detected	4200	Not Detected

E = Exceeds instrument calibration range.

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
Toluene-d8	98	70-130
1,2-Dichloroethane-d4	98	70-130
4-Bromofluorobenzene	107	70-130



Air Toxics

Client Sample ID: S-2 [Box #1]

Lab ID#: 1609423A-03A

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092724	Date of Collection:	9/14/16 11:58:00 AM
Dil. Factor:	64.5	Date of Analysis:	9/28/16 01:22 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	32	Not Detected	160	Not Detected
Freon 114	32	Not Detected	220	Not Detected
Chloromethane	320	Not Detected	660	Not Detected
Vinyl Chloride	32	Not Detected	82	Not Detected
1,3-Butadiene	32	Not Detected	71	Not Detected
Bromomethane	320	Not Detected	1200	Not Detected
Chloroethane	130	Not Detected	340	Not Detected
Freon 11	32	Not Detected	180	Not Detected
Ethanol	130	Not Detected	240	Not Detected
Freon 113	32	Not Detected	250	Not Detected
1,1-Dichloroethene	32	Not Detected	130	Not Detected
Acetone	320	Not Detected	770	Not Detected
2-Propanol	130	20000 E	320	48000 E
Carbon Disulfide	130	Not Detected	400	Not Detected
3-Chloropropene	130	Not Detected	400	Not Detected
Methylene Chloride	320	Not Detected	1100	Not Detected
Methyl tert-butyl ether	130	Not Detected	460	Not Detected
trans-1,2-Dichloroethene	32	39	130	160
Hexane	32	Not Detected	110	Not Detected
1,1-Dichloroethane	32	Not Detected	130	Not Detected
2-Butanone (Methyl Ethyl Ketone)	130	Not Detected	380	Not Detected
cis-1,2-Dichloroethene	32	88	130	350
Tetrahydrofuran	32	Not Detected	95	Not Detected
Chloroform	32	Not Detected	160	Not Detected
1,1,1-Trichloroethane	32	Not Detected	180	Not Detected
Cyclohexane	32	Not Detected	110	Not Detected
Carbon Tetrachloride	32	Not Detected	200	Not Detected
2,2,4-Trimethylpentane	32	Not Detected	150	Not Detected
Benzene	32	Not Detected	100	Not Detected
1,2-Dichloroethane	32	Not Detected	130	Not Detected
Heptane	32	Not Detected	130	Not Detected
Trichloroethene	32	300	170	1600
1,2-Dichloropropane	32	Not Detected	150	Not Detected
1,4-Dioxane	130	Not Detected	460	Not Detected
Bromodichloromethane	32	Not Detected	220	Not Detected
cis-1,3-Dichloropropene	32	Not Detected	150	Not Detected
4-Methyl-2-pentanone	32	Not Detected	130	Not Detected
Toluene	32	Not Detected	120	Not Detected
trans-1,3-Dichloropropene	32	Not Detected	150	Not Detected
1,1,2-Trichloroethane	32	Not Detected	180	Not Detected
Tetrachloroethene	32	5400	220	36000
2-Hexanone	130	Not Detected	530	Not Detected



Air Toxics

Client Sample ID: S-2 [Box #1]

Lab ID#: 1609423A-03A

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092724	Date of Collection:	9/14/16 11:58:00 AM
Dil. Factor:	64.5	Date of Analysis:	9/28/16 01:22 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	32	Not Detected	270	Not Detected
1,2-Dibromoethane (EDB)	32	Not Detected	250	Not Detected
Chlorobenzene	32	Not Detected	150	Not Detected
Ethyl Benzene	32	Not Detected	140	Not Detected
m,p-Xylene	32	Not Detected	140	Not Detected
o-Xylene	32	Not Detected	140	Not Detected
Styrene	32	Not Detected	140	Not Detected
Bromoform	32	Not Detected	330	Not Detected
Cumene	32	Not Detected	160	Not Detected
1,1,2,2-Tetrachloroethane	32	Not Detected	220	Not Detected
Propylbenzene	32	Not Detected	160	Not Detected
4-Ethyltoluene	32	Not Detected	160	Not Detected
1,3,5-Trimethylbenzene	32	Not Detected	160	Not Detected
1,2,4-Trimethylbenzene	32	Not Detected	160	Not Detected
1,3-Dichlorobenzene	32	Not Detected	190	Not Detected
1,4-Dichlorobenzene	32	Not Detected	190	Not Detected
alpha-Chlorotoluene	32	Not Detected	170	Not Detected
1,2-Dichlorobenzene	32	Not Detected	190	Not Detected
1,2,4-Trichlorobenzene	130	Not Detected	960	Not Detected
Hexachlorobutadiene	130	Not Detected	1400	Not Detected
TPH ref. to Gasoline (MW=100)	3200	Not Detected	13000	Not Detected

E = Exceeds instrument calibration range.

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
Toluene-d8	99	70-130
1,2-Dichloroethane-d4	101	70-130
4-Bromofluorobenzene	106	70-130



Air Toxics

Client Sample ID: S-3 [Box #1]

Lab ID#: 1609423A-04A

EPA METHOD TO-15 GC/MS

File Name:	j092715	Date of Collection:	9/14/16 12:11:00 PM
Dil. Factor:	33.7	Date of Analysis:	9/27/16 09:07 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	170	Not Detected	830	Not Detected
Freon 114	170	Not Detected	1200	Not Detected
Chloromethane	670	Not Detected	1400	Not Detected
Vinyl Chloride	170	Not Detected	430	Not Detected
1,3-Butadiene	170	Not Detected	370	Not Detected
Bromomethane	670	Not Detected	2600	Not Detected
Chloroethane	670	Not Detected	1800	Not Detected
Freon 11	170	Not Detected	950	Not Detected
Ethanol	670	Not Detected	1300	Not Detected
Freon 113	170	Not Detected	1300	Not Detected
1,1-Dichloroethene	170	Not Detected	670	Not Detected
Acetone	670	Not Detected	1600	Not Detected
2-Propanol	670	130000	1600	330000
Carbon Disulfide	670	Not Detected	2100	Not Detected
3-Chloropropene	670	Not Detected	2100	Not Detected
Methylene Chloride	670	Not Detected	2300	Not Detected
Methyl tert-butyl ether	170	Not Detected	610	Not Detected
trans-1,2-Dichloroethene	170	Not Detected	670	Not Detected
Hexane	170	Not Detected	590	Not Detected
1,1-Dichloroethane	170	Not Detected	680	Not Detected
2-Butanone (Methyl Ethyl Ketone)	670	Not Detected	2000	Not Detected
cis-1,2-Dichloroethene	170	Not Detected	670	Not Detected
Tetrahydrofuran	170	Not Detected	500	Not Detected
Chloroform	170	Not Detected	820	Not Detected
1,1,1-Trichloroethane	170	Not Detected	920	Not Detected
Cyclohexane	170	Not Detected	580	Not Detected
Carbon Tetrachloride	170	Not Detected	1100	Not Detected
2,2,4-Trimethylpentane	170	Not Detected	790	Not Detected
Benzene	170	Not Detected	540	Not Detected
1,2-Dichloroethane	170	Not Detected	680	Not Detected
Heptane	170	Not Detected	690	Not Detected
Trichloroethene	170	410	900	2200
1,2-Dichloropropane	170	Not Detected	780	Not Detected
1,4-Dioxane	670	Not Detected	2400	Not Detected
Bromodichloromethane	170	Not Detected	1100	Not Detected
cis-1,3-Dichloropropene	170	Not Detected	760	Not Detected
4-Methyl-2-pentanone	170	Not Detected	690	Not Detected
Toluene	170	Not Detected	630	Not Detected
trans-1,3-Dichloropropene	170	Not Detected	760	Not Detected
1,1,2-Trichloroethane	170	Not Detected	920	Not Detected
Tetrachloroethene	170	7400	1100	50000
2-Hexanone	670	Not Detected	2800	Not Detected



Air Toxics

Client Sample ID: S-3 [Box #1]

Lab ID#: 1609423A-04A

EPA METHOD TO-15 GC/MS

File Name:	j092715	Date of Collection:	9/14/16 12:11:00 PM
Dil. Factor:	33.7	Date of Analysis:	9/27/16 09:07 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	170	Not Detected	1400	Not Detected
1,2-Dibromoethane (EDB)	170	Not Detected	1300	Not Detected
Chlorobenzene	170	Not Detected	780	Not Detected
Ethyl Benzene	170	Not Detected	730	Not Detected
m,p-Xylene	170	Not Detected	730	Not Detected
o-Xylene	170	Not Detected	730	Not Detected
Styrene	170	Not Detected	720	Not Detected
Bromoform	170	Not Detected	1700	Not Detected
Cumene	170	Not Detected	830	Not Detected
1,1,2,2-Tetrachloroethane	170	Not Detected	1200	Not Detected
Propylbenzene	170	Not Detected	830	Not Detected
4-Ethyltoluene	170	Not Detected	830	Not Detected
1,3,5-Trimethylbenzene	170	Not Detected	830	Not Detected
1,2,4-Trimethylbenzene	170	Not Detected	830	Not Detected
1,3-Dichlorobenzene	170	Not Detected	1000	Not Detected
1,4-Dichlorobenzene	170	Not Detected	1000	Not Detected
alpha-Chlorotoluene	170	Not Detected	870	Not Detected
1,2-Dichlorobenzene	170	Not Detected	1000	Not Detected
1,2,4-Trichlorobenzene	670	Not Detected	5000	Not Detected
Hexachlorobutadiene	670	Not Detected	7200	Not Detected
TPH ref. to Gasoline (MW=100)	6700	Not Detected	28000	Not Detected

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	100	70-130
Toluene-d8	103	70-130
4-Bromofluorobenzene	98	70-130



Air Toxics

Client Sample ID: S-4 [Box #2]

Lab ID#: 1609423A-05A

EPA METHOD TO-15 GC/MS

File Name:	j092716	Date of Collection: 9/14/16 12:24:00 PM
Dil. Factor:	11.4	Date of Analysis: 9/27/16 09:31 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	57	Not Detected	280	Not Detected
Freon 114	57	Not Detected	400	Not Detected
Chloromethane	230	Not Detected	470	Not Detected
Vinyl Chloride	57	Not Detected	140	Not Detected
1,3-Butadiene	57	Not Detected	130	Not Detected
Bromomethane	230	Not Detected	880	Not Detected
Chloroethane	230	Not Detected	600	Not Detected
Freon 11	57	Not Detected	320	Not Detected
Ethanol	230	Not Detected	430	Not Detected
Freon 113	57	Not Detected	440	Not Detected
1,1-Dichloroethene	57	Not Detected	230	Not Detected
Acetone	230	Not Detected	540	Not Detected
2-Propanol	230	67000 E	560	160000 E
Carbon Disulfide	230	Not Detected	710	Not Detected
3-Chloropropene	230	Not Detected	710	Not Detected
Methylene Chloride	230	Not Detected	790	Not Detected
Methyl tert-butyl ether	57	Not Detected	200	Not Detected
trans-1,2-Dichloroethene	57	Not Detected	220	Not Detected
Hexane	57	Not Detected	200	Not Detected
1,1-Dichloroethane	57	Not Detected	230	Not Detected
2-Butanone (Methyl Ethyl Ketone)	230	Not Detected	670	Not Detected
cis-1,2-Dichloroethene	57	86	220	340
Tetrahydrofuran	57	Not Detected	170	Not Detected
Chloroform	57	Not Detected	280	Not Detected
1,1,1-Trichloroethane	57	Not Detected	310	Not Detected
Cyclohexane	57	Not Detected	200	Not Detected
Carbon Tetrachloride	57	Not Detected	360	Not Detected
2,2,4-Trimethylpentane	57	Not Detected	270	Not Detected
Benzene	57	Not Detected	180	Not Detected
1,2-Dichloroethane	57	Not Detected	230	Not Detected
Heptane	57	Not Detected	230	Not Detected
Trichloroethene	57	340	310	1800
1,2-Dichloropropane	57	Not Detected	260	Not Detected
1,4-Dioxane	230	Not Detected	820	Not Detected
Bromodichloromethane	57	Not Detected	380	Not Detected
cis-1,3-Dichloropropene	57	Not Detected	260	Not Detected
4-Methyl-2-pentanone	57	Not Detected	230	Not Detected
Toluene	57	Not Detected	210	Not Detected
trans-1,3-Dichloropropene	57	Not Detected	260	Not Detected
1,1,2-Trichloroethane	57	Not Detected	310	Not Detected
Tetrachloroethene	57	7500	390	51000
2-Hexanone	230	Not Detected	930	Not Detected



Air Toxics

Client Sample ID: S-4 [Box #2]

Lab ID#: 1609423A-05A

EPA METHOD TO-15 GC/MS

File Name:	j092716	Date of Collection:	9/14/16 12:24:00 PM
Dil. Factor:	11.4	Date of Analysis:	9/27/16 09:31 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	57	Not Detected	480	Not Detected
1,2-Dibromoethane (EDB)	57	Not Detected	440	Not Detected
Chlorobenzene	57	Not Detected	260	Not Detected
Ethyl Benzene	57	Not Detected	250	Not Detected
m,p-Xylene	57	Not Detected	250	Not Detected
o-Xylene	57	Not Detected	250	Not Detected
Styrene	57	Not Detected	240	Not Detected
Bromoform	57	Not Detected	590	Not Detected
Cumene	57	Not Detected	280	Not Detected
1,1,2,2-Tetrachloroethane	57	Not Detected	390	Not Detected
Propylbenzene	57	Not Detected	280	Not Detected
4-Ethyltoluene	57	Not Detected	280	Not Detected
1,3,5-Trimethylbenzene	57	Not Detected	280	Not Detected
1,2,4-Trimethylbenzene	57	Not Detected	280	Not Detected
1,3-Dichlorobenzene	57	Not Detected	340	Not Detected
1,4-Dichlorobenzene	57	Not Detected	340	Not Detected
alpha-Chlorotoluene	57	Not Detected	300	Not Detected
1,2-Dichlorobenzene	57	Not Detected	340	Not Detected
1,2,4-Trichlorobenzene	230	Not Detected	1700	Not Detected
Hexachlorobutadiene	230	Not Detected	2400	Not Detected
TPH ref. to Gasoline (MW=100)	2300	Not Detected	9300	Not Detected

E = Exceeds instrument calibration range.

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	102	70-130
Toluene-d8	102	70-130
4-Bromofluorobenzene	92	70-130



Air Toxics

Client Sample ID: S-5 [Box #2]

Lab ID#: 1609423A-06A

EPA METHOD TO-15 GC/MS

File Name:	j092717	Date of Collection:	9/14/16 12:42:00 PM
Dil. Factor:	28.2	Date of Analysis:	9/27/16 10:22 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	140	Not Detected	700	Not Detected
Freon 114	140	Not Detected	980	Not Detected
Chloromethane	560	Not Detected	1200	Not Detected
Vinyl Chloride	140	Not Detected	360	Not Detected
1,3-Butadiene	140	Not Detected	310	Not Detected
Bromomethane	560	Not Detected	2200	Not Detected
Chloroethane	560	Not Detected	1500	Not Detected
Freon 11	140	Not Detected	790	Not Detected
Ethanol	560	Not Detected	1100	Not Detected
Freon 113	140	Not Detected	1100	Not Detected
1,1-Dichloroethene	140	Not Detected	560	Not Detected
Acetone	560	750	1300	1800
2-Propanol	560	140000	1400	340000
Carbon Disulfide	560	Not Detected	1800	Not Detected
3-Chloropropene	560	Not Detected	1800	Not Detected
Methylene Chloride	560	Not Detected	2000	Not Detected
Methyl tert-butyl ether	140	Not Detected	510	Not Detected
trans-1,2-Dichloroethene	140	Not Detected	560	Not Detected
Hexane	140	Not Detected	500	Not Detected
1,1-Dichloroethane	140	Not Detected	570	Not Detected
2-Butanone (Methyl Ethyl Ketone)	560	Not Detected	1700	Not Detected
cis-1,2-Dichloroethene	140	Not Detected	560	Not Detected
Tetrahydrofuran	140	Not Detected	420	Not Detected
Chloroform	140	Not Detected	690	Not Detected
1,1,1-Trichloroethane	140	Not Detected	770	Not Detected
Cyclohexane	140	Not Detected	480	Not Detected
Carbon Tetrachloride	140	Not Detected	890	Not Detected
2,2,4-Trimethylpentane	140	Not Detected	660	Not Detected
Benzene	140	Not Detected	450	Not Detected
1,2-Dichloroethane	140	Not Detected	570	Not Detected
Heptane	140	Not Detected	580	Not Detected
Trichloroethene	140	440	760	2400
1,2-Dichloropropane	140	Not Detected	650	Not Detected
1,4-Dioxane	560	Not Detected	2000	Not Detected
Bromodichloromethane	140	Not Detected	940	Not Detected
cis-1,3-Dichloropropene	140	Not Detected	640	Not Detected
4-Methyl-2-pentanone	140	Not Detected	580	Not Detected
Toluene	140	Not Detected	530	Not Detected
trans-1,3-Dichloropropene	140	Not Detected	640	Not Detected
1,1,2-Trichloroethane	140	Not Detected	770	Not Detected
Tetrachloroethene	140	7900	960	54000
2-Hexanone	560	Not Detected	2300	Not Detected

Client Sample ID: S-5 [Box #2]

Lab ID#: 1609423A-06A

EPA METHOD TO-15 GC/MS

File Name:	j092717	Date of Collection:	9/14/16 12:42:00 PM
Dil. Factor:	28.2	Date of Analysis:	9/27/16 10:22 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	140	Not Detected	1200	Not Detected
1,2-Dibromoethane (EDB)	140	Not Detected	1100	Not Detected
Chlorobenzene	140	Not Detected	650	Not Detected
Ethyl Benzene	140	Not Detected	610	Not Detected
m,p-Xylene	140	Not Detected	610	Not Detected
o-Xylene	140	Not Detected	610	Not Detected
Styrene	140	Not Detected	600	Not Detected
Bromoform	140	Not Detected	1400	Not Detected
Cumene	140	Not Detected	690	Not Detected
1,1,2,2-Tetrachloroethane	140	Not Detected	970	Not Detected
Propylbenzene	140	Not Detected	690	Not Detected
4-Ethyltoluene	140	Not Detected	690	Not Detected
1,3,5-Trimethylbenzene	140	Not Detected	690	Not Detected
1,2,4-Trimethylbenzene	140	Not Detected	690	Not Detected
1,3-Dichlorobenzene	140	Not Detected	850	Not Detected
1,4-Dichlorobenzene	140	Not Detected	850	Not Detected
alpha-Chlorotoluene	140	Not Detected	730	Not Detected
1,2-Dichlorobenzene	140	Not Detected	850	Not Detected
1,2,4-Trichlorobenzene	560	Not Detected	4200	Not Detected
Hexachlorobutadiene	560	Not Detected	6000	Not Detected
TPH ref. to Gasoline (MW=100)	5600	Not Detected	23000	Not Detected

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	101	70-130
Toluene-d8	102	70-130
4-Bromofluorobenzene	93	70-130



Air Toxics

Client Sample ID: AMBIENT [Box #2]

Lab ID#: 1609423A-07A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	20092409	Date of Collection: 9/14/16 12:35:00 PM
Dil. Factor:	1.73	Date of Analysis: 9/24/16 01:49 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	0.17	0.65	0.86	3.2
Freon 114	0.17	Not Detected	1.2	Not Detected
Chloromethane	0.86	Not Detected	1.8	Not Detected
Vinyl Chloride	0.17	Not Detected	0.44	Not Detected
1,3-Butadiene	0.17	Not Detected	0.38	Not Detected
Bromomethane	0.86	Not Detected	3.4	Not Detected
Chloroethane	0.86	Not Detected	2.3	Not Detected
Freon 11	0.17	0.76	0.97	4.2
Ethanol	0.86	10	1.6	19
Freon 113	0.17	0.17	1.3	1.3
1,1-Dichloroethene	0.17	Not Detected	0.68	Not Detected
Acetone	0.86	14	2.0	33
2-Propanol	0.86	160 E	2.1	390 E
Carbon Disulfide	0.86	Not Detected	2.7	Not Detected
3-Chloropropene	0.86	Not Detected	2.7	Not Detected
Methylene Chloride	0.35	Not Detected	1.2	Not Detected
Methyl tert-butyl ether	0.17	Not Detected	0.62	Not Detected
trans-1,2-Dichloroethene	0.17	Not Detected	0.68	Not Detected
Hexane	0.17	Not Detected	0.61	Not Detected
1,1-Dichloroethane	0.17	Not Detected	0.70	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.86	1.2	2.6	3.5
cis-1,2-Dichloroethene	0.17	Not Detected	0.68	Not Detected
Tetrahydrofuran	0.86	Not Detected	2.6	Not Detected
Chloroform	0.17	0.20	0.84	0.95
1,1,1-Trichloroethane	0.17	Not Detected	0.94	Not Detected
Cyclohexane	0.17	Not Detected	0.60	Not Detected
Carbon Tetrachloride	0.17	Not Detected	1.1	Not Detected
2,2,4-Trimethylpentane	0.86	Not Detected	4.0	Not Detected
Benzene	0.17	0.21	0.55	0.68
1,2-Dichloroethane	0.17	Not Detected	0.70	Not Detected
Heptane	0.17	0.17	0.71	0.71
Trichloroethene	0.17	Not Detected	0.93	Not Detected
1,2-Dichloropropane	0.17	Not Detected	0.80	Not Detected
1,4-Dioxane	0.17	Not Detected	0.62	Not Detected
Bromodichloromethane	0.17	Not Detected	1.2	Not Detected
cis-1,3-Dichloropropene	0.17	Not Detected	0.78	Not Detected
4-Methyl-2-pentanone	0.17	Not Detected	0.71	Not Detected
Toluene	0.17	0.87	0.65	3.3
trans-1,3-Dichloropropene	0.17	Not Detected	0.78	Not Detected
1,1,2-Trichloroethane	0.17	Not Detected	0.94	Not Detected
Tetrachloroethene	0.17	Not Detected	1.2	Not Detected
2-Hexanone	0.86	Not Detected	3.5	Not Detected



Air Toxics

Client Sample ID: AMBIENT [Box #2]

Lab ID#: 1609423A-07A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	20092409	Date of Collection: 9/14/16 12:35:00 PM
Dil. Factor:	1.73	Date of Analysis: 9/24/16 01:49 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	0.17	Not Detected	1.5	Not Detected
1,2-Dibromoethane (EDB)	0.17	Not Detected	1.3	Not Detected
Chlorobenzene	0.17	Not Detected	0.80	Not Detected
Ethyl Benzene	0.17	Not Detected	0.75	Not Detected
m,p-Xylene	0.17	0.20	0.75	0.87
o-Xylene	0.17	Not Detected	0.75	Not Detected
Styrene	0.17	Not Detected	0.74	Not Detected
Bromoform	0.17	Not Detected	1.8	Not Detected
Cumene	0.17	Not Detected	0.85	Not Detected
1,1,2,2-Tetrachloroethane	0.17	Not Detected	1.2	Not Detected
Propylbenzene	0.17	Not Detected	0.85	Not Detected
4-Ethyltoluene	0.17	Not Detected	0.85	Not Detected
1,3,5-Trimethylbenzene	0.17	Not Detected	0.85	Not Detected
1,2,4-Trimethylbenzene	0.17	Not Detected	0.85	Not Detected
1,3-Dichlorobenzene	0.17	Not Detected	1.0	Not Detected
1,4-Dichlorobenzene	0.17	Not Detected	1.0	Not Detected
alpha-Chlorotoluene	0.17	Not Detected	0.90	Not Detected
1,2-Dichlorobenzene	0.17	Not Detected	1.0	Not Detected
1,2,4-Trichlorobenzene	0.86	Not Detected	6.4	Not Detected
Hexachlorobutadiene	0.86	Not Detected	9.2	Not Detected
TPH ref. to Gasoline (MW=100)	17	Not Detected	71	Not Detected

E = Exceeds instrument calibration range.

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	123	70-130
Toluene-d8	91	70-130
4-Bromofluorobenzene	97	70-130



Air Toxics

Client Sample ID: Lab Blank

Lab ID#: 1609423A-08A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	20092406	Date of Collection:	NA	
Dil. Factor:	1.00	Date of Analysis:	9/24/16 11:04 AM	
Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	0.10	Not Detected	0.49	Not Detected
Freon 114	0.10	Not Detected	0.70	Not Detected
Chloromethane	0.50	Not Detected	1.0	Not Detected
Vinyl Chloride	0.10	Not Detected	0.26	Not Detected
1,3-Butadiene	0.10	Not Detected	0.22	Not Detected
Bromomethane	0.50	Not Detected	1.9	Not Detected
Chloroethane	0.50	Not Detected	1.3	Not Detected
Freon 11	0.10	Not Detected	0.56	Not Detected
Ethanol	0.50	Not Detected	0.94	Not Detected
Freon 113	0.10	Not Detected	0.77	Not Detected
1,1-Dichloroethene	0.10	Not Detected	0.40	Not Detected
Acetone	0.50	Not Detected	1.2	Not Detected
2-Propanol	0.50	Not Detected	1.2	Not Detected
Carbon Disulfide	0.50	Not Detected	1.6	Not Detected
3-Chloropropene	0.50	Not Detected	1.6	Not Detected
Methylene Chloride	0.20	Not Detected	0.69	Not Detected
Methyl tert-butyl ether	0.10	Not Detected	0.36	Not Detected
trans-1,2-Dichloroethene	0.10	Not Detected	0.40	Not Detected
Hexane	0.10	Not Detected	0.35	Not Detected
1,1-Dichloroethane	0.10	Not Detected	0.40	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.50	Not Detected	1.5	Not Detected
cis-1,2-Dichloroethene	0.10	Not Detected	0.40	Not Detected
Tetrahydrofuran	0.50	Not Detected	1.5	Not Detected
Chloroform	0.10	Not Detected	0.49	Not Detected
1,1,1-Trichloroethane	0.10	Not Detected	0.54	Not Detected
Cyclohexane	0.10	Not Detected	0.34	Not Detected
Carbon Tetrachloride	0.10	Not Detected	0.63	Not Detected
2,2,4-Trimethylpentane	0.50	Not Detected	2.3	Not Detected
Benzene	0.10	Not Detected	0.32	Not Detected
1,2-Dichloroethane	0.10	Not Detected	0.40	Not Detected
Heptane	0.10	Not Detected	0.41	Not Detected
Trichloroethene	0.10	Not Detected	0.54	Not Detected
1,2-Dichloropropane	0.10	Not Detected	0.46	Not Detected
1,4-Dioxane	0.10	Not Detected	0.36	Not Detected
Bromodichloromethane	0.10	Not Detected	0.67	Not Detected
cis-1,3-Dichloropropene	0.10	Not Detected	0.45	Not Detected
4-Methyl-2-pentanone	0.10	Not Detected	0.41	Not Detected
Toluene	0.10	Not Detected	0.38	Not Detected
trans-1,3-Dichloropropene	0.10	Not Detected	0.45	Not Detected
1,1,2-Trichloroethane	0.10	Not Detected	0.54	Not Detected
Tetrachloroethene	0.10	Not Detected	0.68	Not Detected
2-Hexanone	0.50	Not Detected	2.0	Not Detected



Air Toxics

Client Sample ID: Lab Blank

Lab ID#: 1609423A-08A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	20092406	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/24/16 11:04 AM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	0.10	Not Detected	0.85	Not Detected
1,2-Dibromoethane (EDB)	0.10	Not Detected	0.77	Not Detected
Chlorobenzene	0.10	Not Detected	0.46	Not Detected
Ethyl Benzene	0.10	Not Detected	0.43	Not Detected
m,p-Xylene	0.10	Not Detected	0.43	Not Detected
o-Xylene	0.10	Not Detected	0.43	Not Detected
Styrene	0.10	Not Detected	0.42	Not Detected
Bromoform	0.10	Not Detected	1.0	Not Detected
Cumene	0.10	Not Detected	0.49	Not Detected
1,1,2,2-Tetrachloroethane	0.10	Not Detected	0.69	Not Detected
Propylbenzene	0.10	Not Detected	0.49	Not Detected
4-Ethyltoluene	0.10	Not Detected	0.49	Not Detected
1,3,5-Trimethylbenzene	0.10	Not Detected	0.49	Not Detected
1,2,4-Trimethylbenzene	0.10	Not Detected	0.49	Not Detected
1,3-Dichlorobenzene	0.10	Not Detected	0.60	Not Detected
1,4-Dichlorobenzene	0.10	Not Detected	0.60	Not Detected
alpha-Chlorotoluene	0.10	Not Detected	0.52	Not Detected
1,2-Dichlorobenzene	0.10	Not Detected	0.60	Not Detected
1,2,4-Trichlorobenzene	0.50	Not Detected	3.7	Not Detected
Hexachlorobutadiene	0.50	Not Detected	5.3	Not Detected
TPH ref. to Gasoline (MW=100)	10	Not Detected	41	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	117	70-130
Toluene-d8	96	70-130
4-Bromofluorobenzene	89	70-130



Air Toxics

Client Sample ID: Lab Blank

Lab ID#: 1609423A-08B

EPA METHOD TO-15 GC/MS

File Name: j092705

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/27/16 12:18 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	5.0	Not Detected	25	Not Detected
Freon 114	5.0	Not Detected	35	Not Detected
Chloromethane	20	Not Detected	41	Not Detected
Vinyl Chloride	5.0	Not Detected	13	Not Detected
1,3-Butadiene	5.0	Not Detected	11	Not Detected
Bromomethane	20	Not Detected	78	Not Detected
Chloroethane	20	Not Detected	53	Not Detected
Freon 11	5.0	Not Detected	28	Not Detected
Ethanol	20	Not Detected	38	Not Detected
Freon 113	5.0	Not Detected	38	Not Detected
1,1-Dichloroethene	5.0	Not Detected	20	Not Detected
Acetone	20	Not Detected	48	Not Detected
2-Propanol	20	Not Detected	49	Not Detected
Carbon Disulfide	20	Not Detected	62	Not Detected
3-Chloropropene	20	Not Detected	63	Not Detected
Methylene Chloride	20	Not Detected	69	Not Detected
Methyl tert-butyl ether	5.0	Not Detected	18	Not Detected
trans-1,2-Dichloroethene	5.0	Not Detected	20	Not Detected
Hexane	5.0	Not Detected	18	Not Detected
1,1-Dichloroethane	5.0	Not Detected	20	Not Detected
2-Butanone (Methyl Ethyl Ketone)	20	Not Detected	59	Not Detected
cis-1,2-Dichloroethene	5.0	Not Detected	20	Not Detected
Tetrahydrofuran	5.0	Not Detected	15	Not Detected
Chloroform	5.0	Not Detected	24	Not Detected
1,1,1-Trichloroethane	5.0	Not Detected	27	Not Detected
Cyclohexane	5.0	Not Detected	17	Not Detected
Carbon Tetrachloride	5.0	Not Detected	31	Not Detected
2,2,4-Trimethylpentane	5.0	Not Detected	23	Not Detected
Benzene	5.0	Not Detected	16	Not Detected
1,2-Dichloroethane	5.0	Not Detected	20	Not Detected
Heptane	5.0	Not Detected	20	Not Detected
Trichloroethene	5.0	Not Detected	27	Not Detected
1,2-Dichloropropane	5.0	Not Detected	23	Not Detected
1,4-Dioxane	20	Not Detected	72	Not Detected
Bromodichloromethane	5.0	Not Detected	34	Not Detected
cis-1,3-Dichloropropene	5.0	Not Detected	23	Not Detected
4-Methyl-2-pentanone	5.0	Not Detected	20	Not Detected
Toluene	5.0	Not Detected	19	Not Detected
trans-1,3-Dichloropropene	5.0	Not Detected	23	Not Detected
1,1,2-Trichloroethane	5.0	Not Detected	27	Not Detected
Tetrachloroethene	5.0	Not Detected	34	Not Detected
2-Hexanone	20	Not Detected	82	Not Detected

Client Sample ID: Lab Blank

Lab ID#: 1609423A-08B

EPA METHOD TO-15 GC/MS

File Name:	j092705	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/27/16 12:18 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	5.0	Not Detected	42	Not Detected
1,2-Dibromoethane (EDB)	5.0	Not Detected	38	Not Detected
Chlorobenzene	5.0	Not Detected	23	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected
Styrene	5.0	Not Detected	21	Not Detected
Bromoform	5.0	Not Detected	52	Not Detected
Cumene	5.0	Not Detected	24	Not Detected
1,1,2,2-Tetrachloroethane	5.0	Not Detected	34	Not Detected
Propylbenzene	5.0	Not Detected	24	Not Detected
4-Ethyltoluene	5.0	Not Detected	24	Not Detected
1,3,5-Trimethylbenzene	5.0	Not Detected	24	Not Detected
1,2,4-Trimethylbenzene	5.0	Not Detected	24	Not Detected
1,3-Dichlorobenzene	5.0	Not Detected	30	Not Detected
1,4-Dichlorobenzene	5.0	Not Detected	30	Not Detected
alpha-Chlorotoluene	5.0	Not Detected	26	Not Detected
1,2-Dichlorobenzene	5.0	Not Detected	30	Not Detected
1,2,4-Trichlorobenzene	20	Not Detected	150	Not Detected
Hexachlorobutadiene	20	Not Detected	210	Not Detected
TPH ref. to Gasoline (MW=100)	200	Not Detected	820	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	101	70-130
Toluene-d8	102	70-130
4-Bromofluorobenzene	99	70-130



Air Toxics

Client Sample ID: Lab Blank

Lab ID#: 1609423A-08C

EPA METHOD TO-15 GC/MS FULL SCAN

File Name: a092710

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/27/16 04:44 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Freon 12	0.50	Not Detected	2.5	Not Detected
Freon 114	0.50	Not Detected	3.5	Not Detected
Chloromethane	5.0	Not Detected	10	Not Detected
Vinyl Chloride	0.50	Not Detected	1.3	Not Detected
1,3-Butadiene	0.50	Not Detected	1.1	Not Detected
Bromomethane	5.0	Not Detected	19	Not Detected
Chloroethane	2.0	Not Detected	5.3	Not Detected
Freon 11	0.50	Not Detected	2.8	Not Detected
Ethanol	2.0	Not Detected	3.8	Not Detected
Freon 113	0.50	Not Detected	3.8	Not Detected
1,1-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Acetone	5.0	Not Detected	12	Not Detected
2-Propanol	2.0	Not Detected	4.9	Not Detected
Carbon Disulfide	2.0	Not Detected	6.2	Not Detected
3-Chloropropene	2.0	Not Detected	6.3	Not Detected
Methylene Chloride	5.0	Not Detected	17	Not Detected
Methyl tert-butyl ether	2.0	Not Detected	7.2	Not Detected
trans-1,2-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Hexane	0.50	Not Detected	1.8	Not Detected
1,1-Dichloroethane	0.50	Not Detected	2.0	Not Detected
2-Butanone (Methyl Ethyl Ketone)	2.0	Not Detected	5.9	Not Detected
cis-1,2-Dichloroethene	0.50	Not Detected	2.0	Not Detected
Tetrahydrofuran	0.50	Not Detected	1.5	Not Detected
Chloroform	0.50	Not Detected	2.4	Not Detected
1,1,1-Trichloroethane	0.50	Not Detected	2.7	Not Detected
Cyclohexane	0.50	Not Detected	1.7	Not Detected
Carbon Tetrachloride	0.50	Not Detected	3.1	Not Detected
2,2,4-Trimethylpentane	0.50	Not Detected	2.3	Not Detected
Benzene	0.50	Not Detected	1.6	Not Detected
1,2-Dichloroethane	0.50	Not Detected	2.0	Not Detected
Heptane	0.50	Not Detected	2.0	Not Detected
Trichloroethene	0.50	Not Detected	2.7	Not Detected
1,2-Dichloropropane	0.50	Not Detected	2.3	Not Detected
1,4-Dioxane	2.0	Not Detected	7.2	Not Detected
Bromodichloromethane	0.50	Not Detected	3.4	Not Detected
cis-1,3-Dichloropropene	0.50	Not Detected	2.3	Not Detected
4-Methyl-2-pentanone	0.50	Not Detected	2.0	Not Detected
Toluene	0.50	Not Detected	1.9	Not Detected
trans-1,3-Dichloropropene	0.50	Not Detected	2.3	Not Detected
1,1,2-Trichloroethane	0.50	Not Detected	2.7	Not Detected
Tetrachloroethene	0.50	Not Detected	3.4	Not Detected
2-Hexanone	2.0	Not Detected	8.2	Not Detected

Client Sample ID: Lab Blank

Lab ID#: 1609423A-08C

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092710	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/27/16 04:44 PM

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Dibromochloromethane	0.50	Not Detected	4.2	Not Detected
1,2-Dibromoethane (EDB)	0.50	Not Detected	3.8	Not Detected
Chlorobenzene	0.50	Not Detected	2.3	Not Detected
Ethyl Benzene	0.50	Not Detected	2.2	Not Detected
m,p-Xylene	0.50	Not Detected	2.2	Not Detected
o-Xylene	0.50	Not Detected	2.2	Not Detected
Styrene	0.50	Not Detected	2.1	Not Detected
Bromoform	0.50	Not Detected	5.2	Not Detected
Cumene	0.50	Not Detected	2.4	Not Detected
1,1,2,2-Tetrachloroethane	0.50	Not Detected	3.4	Not Detected
Propylbenzene	0.50	Not Detected	2.4	Not Detected
4-Ethyltoluene	0.50	Not Detected	2.4	Not Detected
1,3,5-Trimethylbenzene	0.50	Not Detected	2.4	Not Detected
1,2,4-Trimethylbenzene	0.50	Not Detected	2.4	Not Detected
1,3-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
1,4-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
alpha-Chlorotoluene	0.50	Not Detected	2.6	Not Detected
1,2-Dichlorobenzene	0.50	Not Detected	3.0	Not Detected
1,2,4-Trichlorobenzene	2.0	Not Detected	15	Not Detected
Hexachlorobutadiene	2.0	Not Detected	21	Not Detected
TPH ref. to Gasoline (MW=100)	50	Not Detected	200	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130
1,2-Dichloroethane-d4	95	70-130
4-Bromofluorobenzene	107	70-130



Air Toxics

Client Sample ID: CCV

Lab ID#: 1609423A-09A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	20092402	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/24/16 08:28 AM

Compound	%Recovery
Freon 12	110
Freon 114	97
Chloromethane	103
Vinyl Chloride	100
1,3-Butadiene	100
Bromomethane	117
Chloroethane	100
Freon 11	101
Ethanol	98
Freon 113	91
1,1-Dichloroethene	91
Acetone	95
2-Propanol	93
Carbon Disulfide	104
3-Chloropropene	100
Methylene Chloride	94
Methyl tert-butyl ether	96
trans-1,2-Dichloroethene	97
Hexane	99
1,1-Dichloroethane	103
2-Butanone (Methyl Ethyl Ketone)	101
cis-1,2-Dichloroethene	98
Tetrahydrofuran	103
Chloroform	104
1,1,1-Trichloroethane	102
Cyclohexane	98
Carbon Tetrachloride	105
2,2,4-Trimethylpentane	102
Benzene	109
1,2-Dichloroethane	120
Heptane	119
Trichloroethene	105
1,2-Dichloropropane	110
1,4-Dioxane	105
Bromodichloromethane	121
cis-1,3-Dichloropropene	112
4-Methyl-2-pentanone	122
Toluene	109
trans-1,3-Dichloropropene	117
1,1,2-Trichloroethane	108
Tetrachloroethene	101
2-Hexanone	113



Air Toxics

Client Sample ID: CCV

Lab ID#: 1609423A-09A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	20092402	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/24/16 08:28 AM

Compound	%Recovery
Dibromochloromethane	124
1,2-Dibromoethane (EDB)	112
Chlorobenzene	107
Ethyl Benzene	110
m,p-Xylene	108
o-Xylene	109
Styrene	115
Bromoform	127
Cumene	117
1,1,2,2-Tetrachloroethane	122
Propylbenzene	110
4-Ethyltoluene	100
1,3,5-Trimethylbenzene	111
1,2,4-Trimethylbenzene	106
1,3-Dichlorobenzene	101
1,4-Dichlorobenzene	96
alpha-Chlorotoluene	120
1,2-Dichlorobenzene	103
1,2,4-Trichlorobenzene	84
Hexachlorobutadiene	83
TPH ref. to Gasoline (MW=100)	100

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	107	70-130
Toluene-d8	106	70-130
4-Bromofluorobenzene	101	70-130



Air Toxics

Client Sample ID: CCV

Lab ID#: 1609423A-09B

EPA METHOD TO-15 GC/MS

File Name:	j092702	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/27/16 10:49 AM

Compound	%Recovery
Freon 12	103
Freon 114	96
Chloromethane	98
Vinyl Chloride	103
1,3-Butadiene	104
Bromomethane	98
Chloroethane	102
Freon 11	118
Ethanol	113
Freon 113	112
1,1-Dichloroethene	119
Acetone	123
2-Propanol	109
Carbon Disulfide	100
3-Chloropropene	100
Methylene Chloride	126
Methyl tert-butyl ether	104
trans-1,2-Dichloroethene	100
Hexane	110
1,1-Dichloroethane	109
2-Butanone (Methyl Ethyl Ketone)	96
cis-1,2-Dichloroethene	116
Tetrahydrofuran	96
Chloroform	106
1,1,1-Trichloroethane	105
Cyclohexane	111
Carbon Tetrachloride	107
2,2,4-Trimethylpentane	108
Benzene	103
1,2-Dichloroethane	98
Heptane	95
Trichloroethene	109
1,2-Dichloropropane	97
1,4-Dioxane	102
Bromodichloromethane	100
cis-1,3-Dichloropropene	99
4-Methyl-2-pentanone	101
Toluene	100
trans-1,3-Dichloropropene	103
1,1,2-Trichloroethane	98
Tetrachloroethene	100
2-Hexanone	101



Air Toxics

Client Sample ID: CCV

Lab ID#: 1609423A-09B

EPA METHOD TO-15 GC/MS

File Name:	j092702	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/27/16 10:49 AM

Compound	%Recovery
----------	-----------

Dibromochloromethane	98
1,2-Dibromoethane (EDB)	99
Chlorobenzene	101
Ethyl Benzene	100
m,p-Xylene	102
o-Xylene	102
Styrene	101
Bromoform	103
Cumene	100
1,1,1,2-Tetrachloroethane	100
Propylbenzene	100
4-Ethyltoluene	100
1,3,5-Trimethylbenzene	100
1,2,4-Trimethylbenzene	99
1,3-Dichlorobenzene	98
1,4-Dichlorobenzene	98
alpha-Chlorotoluene	103
1,2-Dichlorobenzene	99
1,2,4-Trichlorobenzene	93
Hexachlorobutadiene	93
TPH ref. to Gasoline (MW=100)	100

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	98	70-130
Toluene-d8	99	70-130
4-Bromofluorobenzene	100	70-130



Air Toxics

Client Sample ID: CCV

Lab ID#: 1609423A-09C

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092706	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/27/16 02:22 PM

Compound	%Recovery
Freon 12	90
Freon 114	91
Chloromethane	91
Vinyl Chloride	87
1,3-Butadiene	88
Bromomethane	91
Chloroethane	88
Freon 11	89
Ethanol	93
Freon 113	88
1,1-Dichloroethene	93
Acetone	86
2-Propanol	95
Carbon Disulfide	92
3-Chloropropene	92
Methylene Chloride	90
Methyl tert-butyl ether	91
trans-1,2-Dichloroethene	89
Hexane	92
1,1-Dichloroethane	91
2-Butanone (Methyl Ethyl Ketone)	95
cis-1,2-Dichloroethene	95
Tetrahydrofuran	90
Chloroform	91
1,1,1-Trichloroethane	89
Cyclohexane	89
Carbon Tetrachloride	91
2,2,4-Trimethylpentane	92
Benzene	89
1,2-Dichloroethane	86
Heptane	93
Trichloroethene	88
1,2-Dichloropropane	87
1,4-Dioxane	88
Bromodichloromethane	90
cis-1,3-Dichloropropene	90
4-Methyl-2-pentanone	86
Toluene	90
trans-1,3-Dichloropropene	84
1,1,2-Trichloroethane	81
Tetrachloroethene	80
2-Hexanone	84



Air Toxics

Client Sample ID: CCV

Lab ID#: 1609423A-09C

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092706	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/27/16 02:22 PM

Compound	%Recovery
----------	-----------

Dibromochloromethane	84
1,2-Dibromoethane (EDB)	81
Chlorobenzene	81
Ethyl Benzene	85
m,p-Xylene	81
o-Xylene	84
Styrene	89
Bromoform	86
Cumene	84
1,1,1,2-Tetrachloroethane	82
Propylbenzene	84
4-Ethyltoluene	86
1,3,5-Trimethylbenzene	86
1,2,4-Trimethylbenzene	86
1,3-Dichlorobenzene	82
1,4-Dichlorobenzene	85
alpha-Chlorotoluene	89
1,2-Dichlorobenzene	84
1,2,4-Trichlorobenzene	94
Hexachlorobutadiene	94
TPH ref. to Gasoline (MW=100)	100

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	100	70-130
1,2-Dichloroethane-d4	98	70-130
4-Bromofluorobenzene	107	70-130

Client Sample ID: LCS

Lab ID#: 1609423A-10A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name: 20092403

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/24/16 09:07 AM

Compound	%Recovery	Method Limits
Freon 12	100	70-130
Freon 114	94	70-130
Chloromethane	92	70-130
Vinyl Chloride	94	70-130
1,3-Butadiene	90	70-130
Bromomethane	114	70-130
Chloroethane	92	70-130
Freon 11	92	70-130
Ethanol	90	70-130
Freon 113	80	70-130
1,1-Dichloroethene	81	70-130
Acetone	88	70-130
2-Propanol	86	70-130
Carbon Disulfide	80	70-130
3-Chloropropene	84	70-130
Methylene Chloride	84	70-130
Methyl tert-butyl ether	82	70-130
trans-1,2-Dichloroethene	86	70-130
Hexane	85	70-130
1,1-Dichloroethane	88	70-130
2-Butanone (Methyl Ethyl Ketone)	86	70-130
cis-1,2-Dichloroethene	82	70-130
Tetrahydrofuran	89	70-130
Chloroform	92	70-130
1,1,1-Trichloroethane	90	70-130
Cyclohexane	86	70-130
Carbon Tetrachloride	101	70-130
2,2,4-Trimethylpentane	89	70-130
Benzene	95	70-130
1,2-Dichloroethane	101	70-130
Heptane	99	70-130
Trichloroethene	92	70-130
1,2-Dichloropropane	100	70-130
1,4-Dioxane	89	70-130
Bromodichloromethane	106	70-130
cis-1,3-Dichloropropene	91	70-130
4-Methyl-2-pentanone	106	70-130
Toluene	95	70-130
trans-1,3-Dichloropropene	101	70-130
1,1,2-Trichloroethane	91	70-130
Tetrachloroethene	87	70-130
2-Hexanone	92	70-130

Client Sample ID: LCS

Lab ID#: 1609423A-10A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	20092403	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/24/16 09:07 AM

Compound	%Recovery	Method Limits
Dibromochloromethane	108	70-130
1,2-Dibromoethane (EDB)	97	70-130
Chlorobenzene	90	70-130
Ethyl Benzene	94	70-130
m,p-Xylene	93	70-130
o-Xylene	94	70-130
Styrene	94	70-130
Bromoform	110	70-130
Cumene	97	70-130
1,1,2,2-Tetrachloroethane	102	70-130
Propylbenzene	92	70-130
4-Ethyltoluene	81	70-130
1,3,5-Trimethylbenzene	94	70-130
1,2,4-Trimethylbenzene	88	70-130
1,3-Dichlorobenzene	86	70-130
1,4-Dichlorobenzene	80	70-130
alpha-Chlorotoluene	108	70-130
1,2-Dichlorobenzene	86	70-130
1,2,4-Trichlorobenzene	75	70-130
Hexachlorobutadiene	72	70-130
TPH ref. to Gasoline (MW=100)	Not Spiked	

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	108	70-130
Toluene-d8	110	70-130
4-Bromofluorobenzene	100	70-130

Client Sample ID: LCSD

Lab ID#: 1609423A-10AA

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name: 20092404

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/24/16 09:46 AM

Compound	%Recovery	Method Limits
Freon 12	100	70-130
Freon 114	92	70-130
Chloromethane	99	70-130
Vinyl Chloride	94	70-130
1,3-Butadiene	89	70-130
Bromomethane	115	70-130
Chloroethane	91	70-130
Freon 11	93	70-130
Ethanol	92	70-130
Freon 113	82	70-130
1,1-Dichloroethene	81	70-130
Acetone	88	70-130
2-Propanol	88	70-130
Carbon Disulfide	82	70-130
3-Chloropropene	85	70-130
Methylene Chloride	85	70-130
Methyl tert-butyl ether	84	70-130
trans-1,2-Dichloroethene	89	70-130
Hexane	88	70-130
1,1-Dichloroethane	89	70-130
2-Butanone (Methyl Ethyl Ketone)	88	70-130
cis-1,2-Dichloroethene	84	70-130
Tetrahydrofuran	91	70-130
Chloroform	94	70-130
1,1,1-Trichloroethane	92	70-130
Cyclohexane	88	70-130
Carbon Tetrachloride	104	70-130
2,2,4-Trimethylpentane	92	70-130
Benzene	91	70-130
1,2-Dichloroethane	96	70-130
Heptane	96	70-130
Trichloroethene	87	70-130
1,2-Dichloropropane	94	70-130
1,4-Dioxane	85	70-130
Bromodichloromethane	105	70-130
cis-1,3-Dichloropropene	88	70-130
4-Methyl-2-pentanone	103	70-130
Toluene	93	70-130
trans-1,3-Dichloropropene	99	70-130
1,1,2-Trichloroethane	92	70-130
Tetrachloroethene	87	70-130
2-Hexanone	92	70-130

Client Sample ID: LCSD

Lab ID#: 1609423A-10AA

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	20092404	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/24/16 09:46 AM

Compound	%Recovery	Method Limits
Dibromochloromethane	107	70-130
1,2-Dibromoethane (EDB)	96	70-130
Chlorobenzene	89	70-130
Ethyl Benzene	94	70-130
m,p-Xylene	92	70-130
o-Xylene	93	70-130
Styrene	93	70-130
Bromoform	110	70-130
Cumene	97	70-130
1,1,2,2-Tetrachloroethane	102	70-130
Propylbenzene	91	70-130
4-Ethyltoluene	81	70-130
1,3,5-Trimethylbenzene	90	70-130
1,2,4-Trimethylbenzene	84	70-130
1,3-Dichlorobenzene	84	70-130
1,4-Dichlorobenzene	79	70-130
alpha-Chlorotoluene	108	70-130
1,2-Dichlorobenzene	84	70-130
1,2,4-Trichlorobenzene	78	70-130
Hexachlorobutadiene	75	70-130
TPH ref. to Gasoline (MW=100)	Not Spiked	

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	112	70-130
Toluene-d8	103	70-130
4-Bromofluorobenzene	100	70-130



Air Toxics

Client Sample ID: LCS

Lab ID#: 1609423A-10B

EPA METHOD TO-15 GC/MS

File Name: j092703

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/27/16 11:13 AM

Compound	%Recovery	Method Limits
Freon 12	104	70-130
Freon 114	98	70-130
Chloromethane	97	70-130
Vinyl Chloride	102	70-130
1,3-Butadiene	100	70-130
Bromomethane	102	70-130
Chloroethane	105	70-130
Freon 11	117	70-130
Ethanol	119	70-130
Freon 113	109	70-130
1,1-Dichloroethene	120	70-130
Acetone	115	70-130
2-Propanol	115	70-130
Carbon Disulfide	85	70-130
3-Chloropropene	97	70-130
Methylene Chloride	124	70-130
Methyl tert-butyl ether	104	70-130
trans-1,2-Dichloroethene	102	70-130
Hexane	113	70-130
1,1-Dichloroethane	108	70-130
2-Butanone (Methyl Ethyl Ketone)	94	70-130
cis-1,2-Dichloroethene	113	70-130
Tetrahydrofuran	95	70-130
Chloroform	106	70-130
1,1,1-Trichloroethane	103	70-130
Cyclohexane	110	70-130
Carbon Tetrachloride	102	70-130
2,2,4-Trimethylpentane	105	70-130
Benzene	102	70-130
1,2-Dichloroethane	95	70-130
Heptane	96	70-130
Trichloroethene	109	70-130
1,2-Dichloropropane	98	70-130
1,4-Dioxane	102	70-130
Bromodichloromethane	101	70-130
cis-1,3-Dichloropropene	90	70-130
4-Methyl-2-pentanone	98	70-130
Toluene	98	70-130
trans-1,3-Dichloropropene	103	70-130
1,1,2-Trichloroethane	98	70-130
Tetrachloroethene	101	70-130
2-Hexanone	105	70-130



Air Toxics

Client Sample ID: LCS

Lab ID#: 1609423A-10B

EPA METHOD TO-15 GC/MS

File Name: j092703

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/27/16 11:13 AM

Compound	%Recovery	Method Limits
Dibromochloromethane	99	70-130
1,2-Dibromoethane (EDB)	100	70-130
Chlorobenzene	96	70-130
Ethyl Benzene	101	70-130
m,p-Xylene	101	70-130
o-Xylene	103	70-130
Styrene	106	70-130
Bromoform	106	70-130
Cumene	99	70-130
1,1,1,2-Tetrachloroethane	101	70-130
Propylbenzene	103	70-130
4-Ethyltoluene	100	70-130
1,3,5-Trimethylbenzene	100	70-130
1,2,4-Trimethylbenzene	100	70-130
1,3-Dichlorobenzene	98	70-130
1,4-Dichlorobenzene	98	70-130
alpha-Chlorotoluene	107	70-130
1,2-Dichlorobenzene	100	70-130
1,2,4-Trichlorobenzene	94	70-130
Hexachlorobutadiene	92	70-130
TPH ref. to Gasoline (MW=100)	Not Spiked	

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	97	70-130
Toluene-d8	102	70-130
4-Bromofluorobenzene	100	70-130

Client Sample ID: LCSD

Lab ID#: 1609423A-10BB

EPA METHOD TO-15 GC/MS

File Name: j092704

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/27/16 11:36 AM

Compound	%Recovery	Method Limits
Freon 12	106	70-130
Freon 114	104	70-130
Chloromethane	99	70-130
Vinyl Chloride	107	70-130
1,3-Butadiene	103	70-130
Bromomethane	105	70-130
Chloroethane	108	70-130
Freon 11	121	70-130
Ethanol	124	70-130
Freon 113	109	70-130
1,1-Dichloroethene	122	70-130
Acetone	126	70-130
2-Propanol	119	70-130
Carbon Disulfide	89	70-130
3-Chloropropene	100	70-130
Methylene Chloride	130	70-130
Methyl tert-butyl ether	106	70-130
trans-1,2-Dichloroethene	103	70-130
Hexane	116	70-130
1,1-Dichloroethane	110	70-130
2-Butanone (Methyl Ethyl Ketone)	98	70-130
cis-1,2-Dichloroethene	113	70-130
Tetrahydrofuran	100	70-130
Chloroform	111	70-130
1,1,1-Trichloroethane	108	70-130
Cyclohexane	114	70-130
Carbon Tetrachloride	108	70-130
2,2,4-Trimethylpentane	107	70-130
Benzene	106	70-130
1,2-Dichloroethane	98	70-130
Heptane	94	70-130
Trichloroethene	113	70-130
1,2-Dichloropropane	97	70-130
1,4-Dioxane	101	70-130
Bromodichloromethane	103	70-130
cis-1,3-Dichloropropene	90	70-130
4-Methyl-2-pentanone	102	70-130
Toluene	100	70-130
trans-1,3-Dichloropropene	101	70-130
1,1,2-Trichloroethane	94	70-130
Tetrachloroethene	100	70-130
2-Hexanone	106	70-130



Air Toxics

Client Sample ID: LCSD

Lab ID#: 1609423A-10BB

EPA METHOD TO-15 GC/MS

File Name: j092704

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/27/16 11:36 AM

Compound	%Recovery	Method Limits
Dibromochloromethane	98	70-130
1,2-Dibromoethane (EDB)	98	70-130
Chlorobenzene	97	70-130
Ethyl Benzene	100	70-130
m,p-Xylene	100	70-130
o-Xylene	102	70-130
Styrene	102	70-130
Bromoform	106	70-130
Cumene	100	70-130
1,1,1,2-Tetrachloroethane	101	70-130
Propylbenzene	101	70-130
4-Ethyltoluene	95	70-130
1,3,5-Trimethylbenzene	112	70-130
1,2,4-Trimethylbenzene	101	70-130
1,3-Dichlorobenzene	100	70-130
1,4-Dichlorobenzene	101	70-130
alpha-Chlorotoluene	108	70-130
1,2-Dichlorobenzene	103	70-130
1,2,4-Trichlorobenzene	109	70-130
Hexachlorobutadiene	106	70-130
TPH ref. to Gasoline (MW=100)	Not Spiked	

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	99	70-130
Toluene-d8	101	70-130
4-Bromofluorobenzene	102	70-130

Client Sample ID: LCS

Lab ID#: 1609423A-10C

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092707	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/27/16 02:57 PM

Compound	%Recovery	Method Limits
Freon 12	87	70-130
Freon 114	90	70-130
Chloromethane	88	70-130
Vinyl Chloride	83	70-130
1,3-Butadiene	82	70-130
Bromomethane	87	70-130
Chloroethane	86	70-130
Freon 11	86	70-130
Ethanol	92	70-130
Freon 113	84	70-130
1,1-Dichloroethene	90	70-130
Acetone	82	70-130
2-Propanol	93	70-130
Carbon Disulfide	78	70-130
3-Chloropropene	86	70-130
Methylene Chloride	85	70-130
Methyl tert-butyl ether	86	70-130
trans-1,2-Dichloroethene	86	70-130
Hexane	86	70-130
1,1-Dichloroethane	85	70-130
2-Butanone (Methyl Ethyl Ketone)	93	70-130
cis-1,2-Dichloroethene	88	70-130
Tetrahydrofuran	82	70-130
Chloroform	86	70-130
1,1,1-Trichloroethane	84	70-130
Cyclohexane	84	70-130
Carbon Tetrachloride	87	70-130
2,2,4-Trimethylpentane	89	70-130
Benzene	87	70-130
1,2-Dichloroethane	85	70-130
Heptane	90	70-130
Trichloroethene	86	70-130
1,2-Dichloropropane	85	70-130
1,4-Dioxane	87	70-130
Bromodichloromethane	90	70-130
cis-1,3-Dichloropropene	83	70-130
4-Methyl-2-pentanone	88	70-130
Toluene	88	70-130
trans-1,3-Dichloropropene	82	70-130
1,1,2-Trichloroethane	79	70-130
Tetrachloroethene	78	70-130
2-Hexanone	85	70-130

Client Sample ID: LCS

Lab ID#: 1609423A-10C

EPA METHOD TO-15 GC/MS FULL SCAN

File Name: a092707

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/27/16 02:57 PM

Compound	%Recovery	Method Limits
Dibromochloromethane	81	70-130
1,2-Dibromoethane (EDB)	79	70-130
Chlorobenzene	79	70-130
Ethyl Benzene	81	70-130
m,p-Xylene	78	70-130
o-Xylene	85	70-130
Styrene	86	70-130
Bromoform	86	70-130
Cumene	82	70-130
1,1,2,2-Tetrachloroethane	81	70-130
Propylbenzene	85	70-130
4-Ethyltoluene	83	70-130
1,3,5-Trimethylbenzene	85	70-130
1,2,4-Trimethylbenzene	85	70-130
1,3-Dichlorobenzene	82	70-130
1,4-Dichlorobenzene	84	70-130
alpha-Chlorotoluene	90	70-130
1,2-Dichlorobenzene	84	70-130
1,2,4-Trichlorobenzene	100	70-130
Hexachlorobutadiene	98	70-130
TPH ref. to Gasoline (MW=100)	Not Spiked	

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130
1,2-Dichloroethane-d4	98	70-130
4-Bromofluorobenzene	107	70-130

Client Sample ID: LCS D

Lab ID#: 1609423A-10CC

EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	a092708	Date of Collection: NA
Dil. Factor:	1.00	Date of Analysis: 9/27/16 03:22 PM

Compound	%Recovery	Method Limits
Freon 12	89	70-130
Freon 114	90	70-130
Chloromethane	92	70-130
Vinyl Chloride	87	70-130
1,3-Butadiene	82	70-130
Bromomethane	85	70-130
Chloroethane	87	70-130
Freon 11	87	70-130
Ethanol	91	70-130
Freon 113	86	70-130
1,1-Dichloroethene	93	70-130
Acetone	81	70-130
2-Propanol	93	70-130
Carbon Disulfide	79	70-130
3-Chloropropene	84	70-130
Methylene Chloride	86	70-130
Methyl tert-butyl ether	87	70-130
trans-1,2-Dichloroethene	92	70-130
Hexane	87	70-130
1,1-Dichloroethane	88	70-130
2-Butanone (Methyl Ethyl Ketone)	95	70-130
cis-1,2-Dichloroethene	88	70-130
Tetrahydrofuran	83	70-130
Chloroform	88	70-130
1,1,1-Trichloroethane	86	70-130
Cyclohexane	86	70-130
Carbon Tetrachloride	89	70-130
2,2,4-Trimethylpentane	91	70-130
Benzene	87	70-130
1,2-Dichloroethane	86	70-130
Heptane	92	70-130
Trichloroethene	87	70-130
1,2-Dichloropropane	86	70-130
1,4-Dioxane	87	70-130
Bromodichloromethane	90	70-130
cis-1,3-Dichloropropene	82	70-130
4-Methyl-2-pentanone	86	70-130
Toluene	89	70-130
trans-1,3-Dichloropropene	82	70-130
1,1,2-Trichloroethane	80	70-130
Tetrachloroethene	78	70-130
2-Hexanone	83	70-130



Air Toxics

Client Sample ID: LCSD

Lab ID#: 1609423A-10CC

EPA METHOD TO-15 GC/MS FULL SCAN

File Name: a092708

Date of Collection: NA

Dil. Factor: 1.00

Date of Analysis: 9/27/16 03:22 PM

Compound	%Recovery	Method Limits
Dibromochloromethane	82	70-130
1,2-Dibromoethane (EDB)	77	70-130
Chlorobenzene	78	70-130
Ethyl Benzene	82	70-130
m,p-Xylene	78	70-130
o-Xylene	83	70-130
Styrene	86	70-130
Bromoform	85	70-130
Cumene	81	70-130
1,1,2,2-Tetrachloroethane	81	70-130
Propylbenzene	85	70-130
4-Ethyltoluene	83	70-130
1,3,5-Trimethylbenzene	85	70-130
1,2,4-Trimethylbenzene	83	70-130
1,3-Dichlorobenzene	81	70-130
1,4-Dichlorobenzene	84	70-130
alpha-Chlorotoluene	89	70-130
1,2-Dichlorobenzene	84	70-130
1,2,4-Trichlorobenzene	103	70-130
Hexachlorobutadiene	101	70-130
TPH ref. to Gasoline (MW=100)	Not Spiked	

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130
1,2-Dichloroethane-d4	98	70-130
4-Bromofluorobenzene	107	70-130

9/27/2016

Mr. Eric Jensen
Tetra Tech
737 Bishop Street
Suite 2340
Honolulu HI 96813

Project Name: LAGOON DRIVE
Project #: 10351902611
Workorder #: 1609423B

Dear Mr. Eric Jensen

The following report includes the data for the above referenced project for sample(s) received on 9/16/2016 at Air Toxics Ltd.

The data and associated QC analyzed by Modified ASTM D-1946 are compliant with the project requirements or laboratory criteria with the exception of the deviations noted in the attached case narrative.

Thank you for choosing Eurofins Air Toxics Inc. for your air analysis needs. Eurofins Air Toxics Inc. is committed to providing accurate data of the highest quality. Please feel free the Project Manager: Brian Whittaker at 916-985-1000 if you have any questions regarding the data in this report.

Regards,



Brian Whittaker
Project Manager

WORK ORDER #: 1609423B

Work Order Summary

CLIENT: Mr. Eric Jensen
Tetra Tech
737 Bishop Street
Suite 2340
Honolulu, HI 96813

BILL TO: Accounts Payable
Tetra Tech
3746 Mt. Diablo Blvd.
Suite 300
Lafayette, CA 94549

PHONE: 808-441-6600

P.O. #

FAX: 808-836-1689

PROJECT # 10351902611 LAGOON DRIVE

DATE RECEIVED: 09/16/2016

CONTACT: Brian Whittaker

DATE COMPLETED: 09/27/2016

<u>FRACTION #</u>	<u>NAME</u>	<u>TEST</u>	<u>RECEIPT VAC./PRES.</u>	<u>FINAL PRESSURE</u>
01A	S-1 [Box #1]	Modified ASTM D-1946	12 "Hg	4.8 psi
02A	S-1 (DUP) [Box #1]	Modified ASTM D-1946	10.6 "Hg	4.9 psi
03A	S-2 [Box #1]	Modified ASTM D-1946	17.6 "Hg	4.9 psi
04A	S-3 [Box #1]	Modified ASTM D-1946	18 "Hg	5.1 psi
05A	S-4 [Box #2]	Modified ASTM D-1946	21.2 "Hg	5 psi
06A	S-5 [Box #2]	Modified ASTM D-1946	15.9 "Hg	4.8 psi
07A	AMBIENT [Box #2]	Modified ASTM D-1946	6.7 "Hg	5 psi
08A	Lab Blank	Modified ASTM D-1946	NA	NA
09A	LCS	Modified ASTM D-1946	NA	NA
09AA	LCSD	Modified ASTM D-1946	NA	NA

CERTIFIED BY:



Technical Director

DATE: 09/27/16

Certification numbers: AZ Licensure AZ0775, NJ NELAP - CA016, NY NELAP - 11291,
TX NELAP - T104704434-15-9, UT NELAP CA0093332015-6, VA NELAP - 8113, WA NELAP - C935
Name of Accreditation Body: NELAP/ORELAP (Oregon Environmental Laboratory Accreditation Program)
Accreditation number: CA300005, Effective date: 10/18/2015, Expiration date: 10/17/2016.

Eurofins Air Toxics Inc., certifies that the test results contained in this report meet all requirements of the NELAC standards

This report shall not be reproduced, except in full, without the written approval of Eurofins Air Toxics, Inc.

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630

(916) 985-1000 . (800) 985-5955 . FAX (916) 985-1020

LABORATORY NARRATIVE
Modified ASTM D-1946
Tetra Tech
Workorder# 1609423B

Seven 6 Liter Summa Canister (100% Certified) samples were received on September 16, 2016. The laboratory performed analysis via Modified ASTM Method D-1946 for fixed gases in air using GC/TCD. The method involves direct injection of 1.0 mL of sample.

On the analytical column employed for this analysis, Oxygen coelutes with Argon. The corresponding peak is quantitated as Oxygen.

Method modifications taken to run these samples are summarized in the table below. Specific project requirements may over-ride the EATL modifications.

<i>Requirement</i>	<i>ASTM D-1946</i>	<i>ATL Modifications</i>
Calibration	A single point calibration is performed using a reference standard closely matching the composition of the unknown.	A minimum of 5-point calibration curve is performed. Quantitation is based on average Response Factor.
Reference Standard	The composition of any reference standard must be known to within 0.01 mol % for any component.	The standards used by ATL are blended to a $\geq 95\%$ accuracy.
Sample Injection Volume	Components whose concentrations are in excess of 5 % should not be analyzed by using sample volumes greater than 0.5 mL.	The sample container is connected directly to a fixed volume sample loop of 1.0 mL on the GC. Linear range is defined by the calibration curve. Bags are loaded by vacuum.
Normalization	Normalize the mole percent values by multiplying each value by 100 and dividing by the sum of the original values. The sum of the original values should not differ from 100% by more than 1.0%.	Results are not normalized. The sum of the reported values can differ from 100% by as much as 15%, either due to analytical variability or an unusual sample matrix.
Precision	Precision requirements established at each concentration level.	Duplicates should agree within 25% RPD for detections $> 5 \times$ the RL.

Receiving Notes

The Chain of Custody (COC) information for samples S-3 [Box #1] and AMBIENT [Box #2] did not match the information on the canister with regard to canister identification. The client was notified of

the discrepancy and the information on the canister was used to process and report the samples.

The Chain of Custody (COC) information for samples S-1 [Box #1], S-1 (DUP) [Box #1], S-2 [Box #1], S-3 [Box #1], S-4 [Box #2], S-5 [Box #2] and AMBIENT [Box #2] did not match the entries on the sample tags with regard to sample identification. Therefore the information on the COC was used to process and report the samples.

Samples S-2 [Box #1], S-4 [Box #2] and S-5 [Box #2] were received with significant vacuum remaining in the canister. The residual canister vacuum resulted in elevated reporting limits.

Analytical Notes

There were no analytical discrepancies.

Definition of Data Qualifying Flags

Seven qualifiers may have been used on the data analysis sheets and indicate as follows:

B - Compound present in laboratory blank greater than reporting limit.

J - Estimated value.

E - Exceeds instrument calibration range.

S - Saturated peak.

Q - Exceeds quality control limits.

U - Compound analyzed for but not detected above the detection limit.

M - Reported value may be biased due to apparent matrix interferences.

File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified

b-File was quantified by a second column and detector

r1-File was requantified for the purpose of reissue

Summary of Detected Compounds

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

Client Sample ID: S-1 [Box #1]

Lab ID#: 1609423B-01A

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.22	19
Carbon Dioxide	0.022	0.92

Client Sample ID: S-1 (DUP) [Box #1]

Lab ID#: 1609423B-02A

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.23	21
Carbon Dioxide	0.023	1.1

Client Sample ID: S-2 [Box #1]

Lab ID#: 1609423B-03A

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.32	17
Carbon Dioxide	0.032	2.2

Client Sample ID: S-3 [Box #1]

Lab ID#: 1609423B-04A

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.34	17
Carbon Dioxide	0.034	2.0

Client Sample ID: S-4 [Box #2]

Lab ID#: 1609423B-05A

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.46	17
Carbon Dioxide	0.046	2.5

Summary of Detected Compounds
MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

Client Sample ID: S-5 [Box #2]

Lab ID#: 1609423B-06A

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.28	17
Carbon Dioxide	0.028	2.6

Client Sample ID: AMBIENT [Box #2]

Lab ID#: 1609423B-07A

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.17	21
Carbon Dioxide	0.017	0.042



Air Toxics

Client Sample ID: S-1 [Box #1]

Lab ID#: 1609423B-01A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name:	10092205b	Date of Collection: 9/14/16 11:41:00 AM
Dil. Factor:	2.22	Date of Analysis: 9/22/16 10:34 AM

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.22	19
Carbon Dioxide	0.022	0.92

Container Type: 6 Liter Summa Canister (100% Certified)



Air Toxics

Client Sample ID: S-1 (DUP) [Box #1]

Lab ID#: 1609423B-02A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name:	10092206b	Date of Collection: 9/14/16 11:41:00 AM
Dil. Factor:	2.26	Date of Analysis: 9/22/16 11:22 AM

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.23	21
Carbon Dioxide	0.023	1.1

Container Type: 6 Liter Summa Canister (100% Certified)



Air Toxics

Client Sample ID: S-2 [Box #1]

Lab ID#: 1609423B-03A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name:	10092207b	Date of Collection: 9/14/16 11:58:00 AM
Dil. Factor:	3.21	Date of Analysis: 9/22/16 11:48 AM

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.32	17
Carbon Dioxide	0.032	2.2

Container Type: 6 Liter Summa Canister (100% Certified)



Air Toxics

Client Sample ID: S-3 [Box #1]

Lab ID#: 1609423B-04A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name:	10092208b	Date of Collection: 9/14/16 12:11:00 PM
Dil. Factor:	3.36	Date of Analysis: 9/22/16 12:18 PM

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.34	17
Carbon Dioxide	0.034	2.0

Container Type: 6 Liter Summa Canister (100% Certified)



Air Toxics

Client Sample ID: S-4 [Box #2]

Lab ID#: 1609423B-05A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name:	10092209b	Date of Collection: 9/14/16 12:24:00 PM
Dil. Factor:	4.58	Date of Analysis: 9/22/16 12:45 PM

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.46	17
Carbon Dioxide	0.046	2.5

Container Type: 6 Liter Summa Canister (100% Certified)



Air Toxics

Client Sample ID: S-5 [Box #2]

Lab ID#: 1609423B-06A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name:	10092210b	Date of Collection: 9/14/16 12:42:00 PM
Dil. Factor:	2.83	Date of Analysis: 9/22/16 01:35 PM

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.28	17
Carbon Dioxide	0.028	2.6

Container Type: 6 Liter Summa Canister (100% Certified)



Air Toxics

Client Sample ID: AMBIENT [Box #2]

Lab ID#: 1609423B-07A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name:	10092211b	Date of Collection: 9/14/16 12:35:00 PM
Dil. Factor:	1.73	Date of Analysis: 9/22/16 02:07 PM

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.17	21
Carbon Dioxide	0.017	0.042

Container Type: 6 Liter Summa Canister (100% Certified)



Air Toxics

Client Sample ID: Lab Blank

Lab ID#: 1609423B-08A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name: 10092204b
Dil. Factor: 1.00

Date of Collection: NA
Date of Analysis: 9/22/16 09:53 AM

Compound	Rpt. Limit (%)	Amount (%)
Oxygen	0.10	Not Detected
Carbon Dioxide	0.010	Not Detected

Container Type: NA - Not Applicable



Air Toxics

Client Sample ID: LCS

Lab ID#: 1609423B-09A

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name: 10092202b
Dil. Factor: 1.00

Date of Collection: NA
Date of Analysis: 9/22/16 09:00 AM

Compound	%Recovery	Method Limits
Oxygen	98	85-115
Carbon Dioxide	102	85-115

Container Type: NA - Not Applicable



Air Toxics

Client Sample ID: LCSD

Lab ID#: 1609423B-09AA

MODIFIED NATURAL GAS ANALYSIS BY ASTM D-1946

File Name: 10092224b
Dil. Factor: 1.00

Date of Collection: NA
Date of Analysis: 9/22/16 08:32 PM

Compound	%Recovery	Method Limits
Oxygen	98	85-115
Carbon Dioxide	102	85-115

Container Type: NA - Not Applicable