

Memorandum

To: Steve Teel, Washington State Department of Ecology
Copies: Drew Zabrowski, Avenue 55; Scott Hooton, Port of Tacoma
From: Tom Colligan and Kristin Anderson, Floyd|Snider
Date: January 7, 2020
Project No: Ave 55-Taylor Way
**Re: Sampling Plan Addendum for Post-Construction Vapor Intrusion Assessment
1514 Taylor Way Development, Tacoma, Washington**

This sampling plan is presented as an addendum to Appendix B of the Interim Action Work Plan (IAWP; Floyd|Snider 2017) for the Taylor Way property, which is part of the larger Taylor Way and Alexander Avenue Fill Area Site. Appendix B of the IAWP presented procedures for a pre-construction methane survey and preliminary vapor intrusion (VI) assessment at the Taylor Way property. This addendum presents procedures for post-construction VI assessment based on the comments received from the Washington State Department of Ecology (Ecology) via a letter dated November 14 (Ecology 2019).

BACKGROUND

Two prior VI assessments have been performed on the property to date. A methane survey and preliminary VI assessment were performed between December 2016 and May 2018 during the preloading phase of construction of two above-grade warehouse buildings (Building A and Building B). Soil gas samples were collected at several locations within each building pad footprint and along the future drive aisle between the two buildings. The vapor samples were field analyzed for methane using a landfill gas detector. At a subset of the locations, soil gas samples were collected for laboratory analysis of volatile organic compounds (VOCs).

The results of the methane survey and preliminary VI assessment were summarized in a memorandum to Ecology dated June 2018 (Floyd|Snider 2018a). Methane was not detected in soil gas at concentrations that necessitated further action per the IAWP. The maximum detected soil methane concentration was 1.4 percent by volume.

On the western portion of Building A, however, VOC analysis detected chloroform at a concentration exceeding the Model Toxics Control Act (MTCA) soil gas screening level for industrial worker exposure. Benzene was also detected at a concentration less than its industrial

screening level but greater than the residential screening level. A number of additional VOCs were detected but at concentrations less than residential MTCA screening levels.

At Building B, VOC sampling conducted during wet-season construction was complicated by excessive moisture and perched wet lenses in the soil and pad backfill. Multiple attempts were made to acquire samples free of moisture but were abandoned due to water in the sampling point. In the sample that was able to be collected, the laboratory reported excessive water vapor as well as excessive residual vacuum in the Summa canister that was used for sample collection. Chloroform, benzene, and other VOCs exceeded their MTCA industrial screening levels at this location. The results of the preliminary assessment indicated concentrations greater than MTCA screening levels under the footprint of the planned future buildings. In order to mitigate delays to the construction schedule, a passive vapor mitigation system was installed under each of the two office “node” locations in both buildings. The office nodes within the two buildings are shown on Figure 1. These node locations can be used as either normal open warehouse space or can be converted to interior offices if a tenant so desires. As described in the June 2018 memorandum, the passive mitigation system includes perforated PVC piping laid in trenches under the subgrade of the office areas. The piping is connected to aboveground riser vents that are currently stubbed off and capped 2 to 3 feet above floor level. After the piping was installed, it was overlain with a single sheet PVC membrane. The concrete floor slab was subsequently poured over the membrane. The passive system is designed to allow sub-slab ventilation driven by atmospheric pressure differentials, if needed (i.e., soil vapor at pressure exceeding atmospheric pressure can be vented via the riser so vapor pressure cannot build up below the floor slab). Additionally, the vertical riser allows for the installation of an inline blower as an option to convert the system from passive ventilation to an active venting system.

The second VI assessment was completed following pouring of the floor slabs and erection of the building walls and roof, but prior to the finalization of construction. The assessment included two rounds of sub-slab vapor sampling from permanently installed vapor implants installed in both buildings in September 2018. Eight vapor pin implants (VP-1 through VP-8) were installed in Building A and six implants (VP-9 through VP-14) were installed in Building B. Two vapor pins were installed adjacent to the limits of the membrane installed in the four office nodes. The remainder of the pins were distributed uniformly across the warehouse spaces. Results of the two rounds of sub-slab sampling were provided to Ecology in a memorandum dated December 2018 (Floyd|Snider 2018b). During the first round of testing in September, a number of compounds exceeded MTCA Method C sub-slab screening levels at several locations. However, during re-sampling in October, no compounds exceeded the screening levels.¹ The sampling plan

¹ Leak detection consisting of shut-in vacuum tests of the sampling train was performed on all locations during the September and October sampling events. No vacuum leakage was detected. For the September event, helium leak testing was also performed to confirm that leakage did not occur between the vapor pin and the floor slab. However, helium leak testing was not performed during the October event because leakage around the vapor pins did not occur during the September event. Therefore, it is not possible to confirm the lack of leakage during the October sampling event.

described below is proposed to evaluate the current post-construction VI concentrations and determine if follow up actions are necessary or warranted.

PROPOSED POST-CONSTRUCTION VAPOR INTRUSION ASSESSMENT

The additional VI assessment includes the following scope of work:

- Completion of a building survey
- Measurement of cross-slab differential pressures
- Sub-slab soil vapor sampling
- Indoor air sample collection concurrent with soil vapor sampling
- Ambient air sample collection
- Data evaluation and reporting

Building Survey

A survey of both buildings was performed on December 13, 2019, using a form provided by Ecology. The survey included inspection of the condition of the existing vapor pins, examination for floor slab cracks or open penetrations, and noting the materials stored and/or chemicals used in each building. The completed building survey form is provided in Attachment 1.

It was observed during the survey that approximately the western third of Building A is currently used for storage and distribution of dental supplies. It is separated from the unused remainder of Building A by an interior partition wall. Forklift operators transfer pallets from the loading bays located across the main warehouse space. A small single break room, bathroom, and manager's office enclosure totaling approximately 1,000 square feet are built out over a portion of the office node, as shown in Figure 1. This area has its own heat and ventilation system. The rest of Building A, as well as Building B, do not have ventilation systems, as is typical of warehouse space.

The new floor slabs of both buildings were found to be in excellent condition with no cracks. One comparatively wide expansion joint was observed in the approximate center of the unoccupied portion of Building A. Few penetrations in the concrete were observed and all were sealed except for the gravel-filled flange around the large fire water supply lines that are located in the southwest corner of each building, as shown in Figure 1. The fire supply lines are enclosed within a small mechanical room in Building A and are not enclosed in Building B. The PVC riser pipes for the office node sub-slab piping were located for all office nodes; these risers are currently cut off 2 to 3 feet above floor level and capped inside each building.

The previously installed vapor pin implants were located in Building A with one exception; vapor pin VP-6 in the dental supply operations area was not able to be located and is believed to be located under permanently installed warehouse shelving. All pins were located and found to be accessible in Building B.

The dental office supplies stored in the western portion of Building A included liquids such as acetone and ethanol, a variety of cleaning/sanitizing solutions, and dental adhesives. These chemicals are stored in sealed containers and not opened or used on-site.

During site visits subsequent to the initial building survey, gasoline-fueled vehicles belonging to building subcontractors (heating/cooling, electrical, etc.) performing work in the unoccupied portion of Building A were also observed.

Measurement of Cross-Slab Differential Pressures

Cross-slab differential pressures were measured to determine whether soil vapor pressure under the building is at times, greater than, less than, or equal to ambient air pressure inside the building. Cross-slab differential pressure measurements were collected using a differential pressure data logger connected to both the indoor air of the building and an existing vapor pin implant. Cross-slab differential pressure data were collected between the slab and main warehouse at VP-1, located next to the eastern office node of Building A, and between the slab and enclosed office space at VP-7, next to the western office node. Cross-slab differential pressure data are currently being collected at VP-3 in the central portion of Building A. Measurements were taken continuously for 1 week using a data logger with a resolution of 0.001 inches of water. The specification sheet for the data logger is included in Attachment 2.

Results from the cross-slab differential pressure monitoring for VP-1 and VP-7 compared to atmospheric barometric pressure data collected by the National Weather Service (Tacoma, WA Station N7WGJ/station ID AT582) are presented in Attachment 3; additional cross-slab data for VP-3 will be included in the vapor intrusion assessment data report. These plots present the maximum and minimum cross-slab pressure differential (in inches of water) and barometric pressure for each 15-minute interval during the monitoring period. At both VP-1 and VP-7, the maximum and minimum values were clustered near zero with approximately equal positive (greater pressure under the slab) and negative (greater pressure in ambient air) variation. Consistent trends indicating sustained higher pressure under the slab were not noted at either location. At VP-7, the data logger was connected by tubing run along the floor of the dental supply company workspace to span the distance between the vapor implant and the enclosed break room/office. At this location, greater variation was observed during the work day due to workers periodically rolling loaded carts over the tubing causing temporary spikes in pressure readings.

Over the same monitoring period, low and high atmospheric pressures were observed but were not correlated with cross-slab differential pressures at either location. These data demonstrate that sub-slab and ambient air pressure are approximately in equilibrium during all weather conditions and atmospheric pressure should not be a factor in sample collection.

Sub-Slab Soil Vapor Sampling

Prior to collection of the soil gas samples, concentrations of methane, carbon dioxide, oxygen, and nitrogen will be collected using a portable landfill gas analyzer as was used for the prior

methane survey as specified in the IAWP. The portable gas analyzer achieves accuracy of 0.3 percent by volume for methane and carbon dioxide and 1 percent by volume for oxygen.² Cross-slab differential pressure at each location will also be measured using a landfill gas analyzer or standalone manometer with a resolution of 0.001 inches of water. Final methane, carbon dioxide, oxygen, and nitrogen concentrations will be recorded after purging three volumes from the sub-slab sampling point using the gas analyzer's pump.

Sub-slab soil vapor samples will be collected from the accessible existing vapor pin implant locations at Buildings A and B. VP-6, which is under permanent shelving, is not accessible for sampling. Samples will be collected in accordance with Ecology guidance for vapor intrusion assessment (Ecology 2018) using laboratory-certified 1-liter evacuated Summa canisters equipped with a flow control device and laboratory-provided manifolds and polytetrafluoroethylene tubing. Detailed protocols for sub-slab soil vapor collection are included in the Standard Guideline for Vapor Intrusion evaluations provided in Attachment 4 and are summarized below. Prior to sample collection, a shut-in (or closed valve) test will be performed that will assess the sampling train for air leaks. The closed-valve test will be conducted for a period of 5 minutes. If the sampling train maintains its original vacuum for 5 minutes, the equipment is assumed to be functional with no leaks. If the vacuum of the canister begins to decrease, connections will be checked and tightened before re-testing the canister. Only canisters that pass the shut-in test will be used for sample collection.

A tracer gas test will be performed during sampling to test for leaks that may occur in the seal between the vapor pin implant and surrounding slab. A tracer will be applied by placing towels soaked with isopropyl alcohol (2-propanol) over the implant and around all connections during the filling of the Summa canister. Isopropyl alcohol was previously detected in soil vapor in samples in September 2018 (i.e., VP-02, VP-05) at concentrations up to 300 micrograms per cubic meter. The vapor pin implant will be considered improperly sealed if isopropyl alcohol concentrations in the sample as measured by the laboratory are significantly greater than the maximum isopropyl alcohol vapor concentration detected in previous sub-slab samples. Vapor pin implants that are found to be improperly sealed will be resampled in coordination with Ecology if necessary to complete the vapor intrusion assessment.

Samples will be collected after purging the sample line of at least three volumes of sub-slab vapor within the sampling train at a flow rate less than 200 milliliters per minute (mL/min). After the sampling train is purged, soil gas samples will be collected over a 5-minute period at a flow rate of less than 150 mL/min. Sample collection will be stopped before the vacuum in the canister is fully depleted.

Once the sampling period is completed, the inlet port of the canister will be tightly sealed for transportation to the analytical laboratory. The initial canister vacuums, vacuum testing times,

² Nitrogen concentration is calculated as the gas balance by subtracting the sum of methane, carbon dioxide, and oxygen from 100 percent.

purging times, purged volumes, sampling start and end times, and final vacuum readings will be recorded on soil vapor sampling sheets, which are included in Attachment 4.

Indoor Air Sampling

Indoor air samples will be collected during the period of sub-slab sampling. Indoor air samples will be collected over a period of 8 hours. Within the occupied portion of Building A, three air samples will be collected; one sample will be collected from the current break room, one sample will be collected in the main warehouse area, and one sample will be collected inside the mechanical room next to the open penetration for the fire supply lines in the southwest corner of the building. Within the unused area of Building A, one sample will be collected near the wide expansion joint and one at the office node. In the smaller unoccupied Building B, three samples will be collected; one sample will be collected over each office node and one sample will be collected next to the open penetration for the fire supply lines in the southwest corner of the building. Proposed locations are shown on Figure 1.

Indoor air samples will be collected using a laboratory-certified evacuated 6-liter summa canister fitted with a flow control device. The canisters will be placed at a height of 3 feet. Vacuum readings will be collected at the start of sampling and monitored for a period of 5 to 10 minutes after opening the canister to ensure that the flow control device is working properly. If any canisters appear to be losing vacuum too quickly, the connection to the flow control device will be tightened and re-checked. Only canisters with leak-free connections to the flow control device will be used for sampling.

Ambient Air Sampling

One ambient air background sample will be collected along the property boundary at an appropriate upwind location. The upwind direction will be obtained from current reporting at the same primary National Weather Service weather station used to collect barometric pressure data. The ambient air sample will be collected concurrently with indoor air sampling by filling a laboratory-certified evacuated 6-liter Summa canister over a period of 8 hours.

Passive Ventilation System Evaluation

The need for active vapor mitigation system in both buildings will be evaluated by review of the data collected in accordance with this plan. The presence of sub-slab compounds that exceed the applicable MTCA Method C screening levels in sub-slab soil vapor and are also detected in indoor air at concentrations that are close to or exceed indoor air cleanup levels is a key factor in the decision to perform additional periodic monitoring or vapor mitigation (such as venting the riser pipes to the outdoors or converting the currently passive system to an active system).

Field QC Sampling, Laboratory Analysis, and Reporting

Field quality assurance samples will consist of a field duplicate sub-slab sample collected per day using a laboratory-supplied flow splitter.

Soil gas and air samples will be analyzed for the following:

- The targeted list of VOCs detected in soil vapor during initial sub-slab sampling, plus isopropyl alcohol, ethylene dibromide, and methylene chloride, using USEPA Modified Method TO-15/TO-15 SIM
- Volatile compounds by Method MA Air-Phase Hydrocarbons

The targeted list of analytes includes compounds previously detected in sub-slab soil vapor samples are presented in Table 3 of the sub-slab vapor investigation summary memorandum (Floyd|Snider 2018b), and additional analytes listed above were requested by Ecology in the November 14 letter.

The results of additional VI assessment will be presented to Ecology in a summary memorandum, which will include laboratory analytical results for sub-slab soil vapor and indoor air samples compared to the applicable MTCA industrial screening levels and indoor air cleanup levels. Recommendations for additional mitigation, if determined to be necessary by the VI assessment, will also be presented in the summary memorandum.

REFERENCES

Floyd|Snider. 2017. *Interim Action Work Plan, 1514 Taylor Way Development*. Prepared for Avenue 55, LLC. June.

_____. 2018a. *Summary of Soil Vapor Survey Data and Vapor Mitigation Plan for the 1514 Taylor Way Site*. Memorandum from Tom Colligan and Kristin Anderson, Floyd|Snider, to Steve Teel, Washington State Department of Ecology. 8 June.

_____. 2018b. *Summary of Sub-Slab Soil Vapor Assessment, 1514 Taylor Way, Tacoma, Washington*. Memorandum from Tom Colligan and Gabriel Cisneros, Floyd|Snider, to Nick Acklam, Washington State Department of Ecology. 4 December.

Washington State Department of Ecology (Ecology). 2018. *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action*. April.

_____. 2019. Letter from Steve Teel, Ecology, to Scott Hooton, Port of Tacoma, re: Comments on Summary of Sub-Slab Soil Vapor Assessment, Response to Submittal of Draft Environmental Covenant, and List of Remaining Deliverables. 14 November.

LIST OF ATTACHMENTS

Figure 1 Proposed Sample Locations

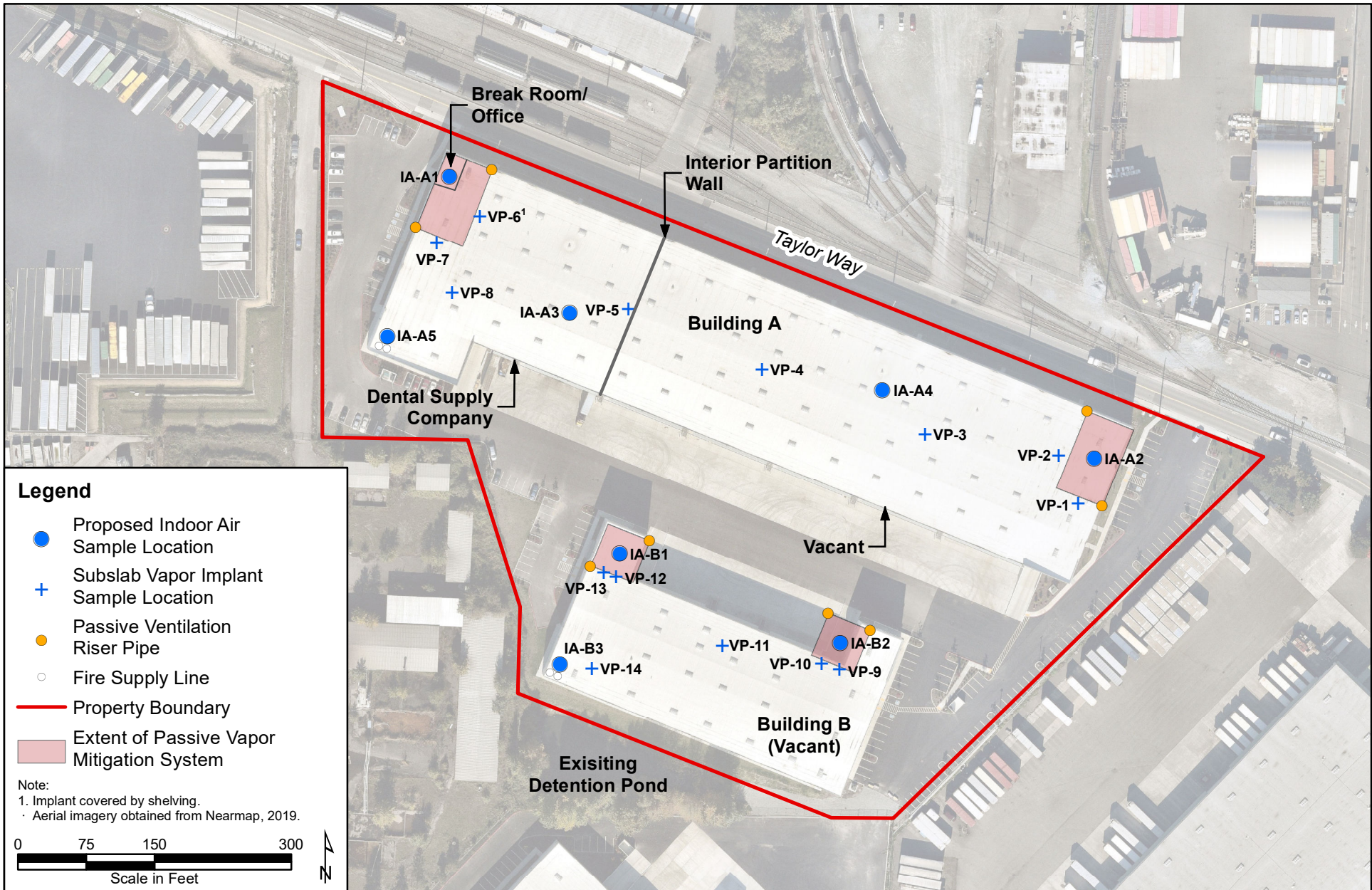
Attachment 1 Building Survey Form

Attachment 2 Equipment Specification Sheet for Differential Pressure Data Logger

Attachment 3 Cross-Slab Differential Pressure Plots

Attachment 4 Vapor Intrusion Field Sampling Standard Guideline

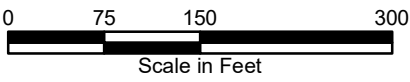
Figure



Legend

- Proposed Indoor Air Sample Location
- + Subslab Vapor Implant Sample Location
- Passive Ventilation Riser Pipe
- Fire Supply Line
- Property Boundary
- Extent of Passive Vapor Mitigation System

Note:
 1. Implant covered by shelving.
 · Aerial imagery obtained from Nearmap, 2019.



**Sampling Plan Addendum for Post-Construction Vapor Intrusion Assessment
 1514 Taylor Way Development
 Tacoma, Washington**

Figure 1
 Proposed Sample Locations

Attachment 1
Building Survey Form

Building Feature and Water Use Survey

1. Building Ownership and Occupancy

1a. Occupant

| | | | |
|----------|--------------------------|-------------|--|
| Date: | 12/13/2019 | | |
| Name: | dental supply company | | |
| Address: | (west portion of bldg A) | | |
| | 1514 Taylor Way, Tacoma | | |
| Phone: | Home () | Work () | |

1b. Owner or Landlord (check if same as occupant)

| | | | |
|----------|----------------|-------------|--|
| Date: | 12/13/2019 | | |
| Name: | Port of Tacoma | | |
| Address: | | | |
| | | | |
| Phone: | Home () | Work () | |

2. General Building Information: What type of building is this? Check all appropriate responses below

| | | | |
|-------------------------------------------|------------------------------------------|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> Single Family | <input type="checkbox"/> Multiple Family | <input type="checkbox"/> School | <input checked="" type="checkbox"/> Commercial |
| <input type="checkbox"/> Ranch | <input type="checkbox"/> 2-Family | | <input type="checkbox"/> Building is being used as a day care center What type of business is conducted in your building? |
| <input type="checkbox"/> Raised Ranch | <input type="checkbox"/> Duplex | | |
| <input type="checkbox"/> Cape | <input type="checkbox"/> Apartment House | | |
| <input type="checkbox"/> Colonial | # of units _____ | | |
| <input type="checkbox"/> Split Level | <input type="checkbox"/> Condominium | | |
| <input type="checkbox"/> Mobile Residence | # of units _____ | | |
| <input type="checkbox"/> Other (specify) | <input type="checkbox"/> Other (specify) | | |

2a. Number of floors? 1

2b. What was the original construction date of the building? March 2019

2c. Are there drains or sumps present (circle one)? YES NO
If so, describe each, including information on contents:

2d. Are elevator shafts present (circle one)? YES NO
If so, describe each:

3. Building Occupants (workers or residents)

| Age (if under 18) | Sex (M or F) | Occupation | Number of years working or living here | Number of hours spent in building per day |
|-------------------------------------|--------------|-------------------------------------------|----------------------------------------|-------------------------------------------|
| <u> </u> | M+F | warehouse : inventory, forklift operation | <1 | 8 |
| <u> </u> | M+F | construction | <1 | 8 |
| ~ 20 individuals total work in bldg | | | | |

4. Heating and Ventilation System(s)

4a. Please describe the type of materials your building is constructed out of (For example, wood, stone, concrete, etc.)

concrete slab on grade, poured concrete floors, metal roof structure - gypsum board interior partitions

4b. Has your building been weatherized with any of the following? (Circle all that apply)

Insulation Storm Windows Energy-Efficient Windows Other (specify) _____
(office enclosure)

4c. What type of foundation does your building/residence have? (Circle all that apply)

Full basement Crawlspace Concrete Slab (j.e. concrete floor that is not below ground level)

Other (specify) _____

4d. Does the basement/crawlspace have air vents leading out of the structure? *NA*

- If it has vents, are these vents always open, always closed, or opened and closed based on the season?

- Is the crawlspace lined with a plastic layer?

- If so, what is the position of that plastic layer? (Circle one)

On the ground Attached to the floor joist Attached to the foundation

- What is the condition of that plastic layer? (Circle one)

Whole Absent in places Torn

5. Foundation Type

5a. Basement characteristics (Check yes or no)

| | | |
|----------------------------------------------------|-----|-----------|
| Do you have a basement? | Yes | <u>No</u> |
| Is there a basement sump (pit where water drains)? | | <i>No</i> |
| Is your basement finished? | | <i>NA</i> |

5b. Does the basement have any additional characteristics that might permit soil vapor entry, such as utility conduits , a portion of the wall missing or exposed soils around sump? If so, please describe.

NA

5c. Describe your foundation (Check all that apply)

| Foundation floor is: | | Foundation walls are: | | Inside of the foundation is: | |
|----------------------|-------------------------------------|-----------------------|-------------------------------------|------------------------------|-------------------------------------|
| Concrete | <input checked="" type="checkbox"/> | Poured concrete | <input checked="" type="checkbox"/> | Wet | <input type="checkbox"/> |
| Dirt | <input type="checkbox"/> | Cinder block | <input type="checkbox"/> | Damp | <input type="checkbox"/> |
| Other (specify) | <input type="checkbox"/> | Laid up stone | <input type="checkbox"/> | Dry | <input checked="" type="checkbox"/> |

5d. Are there cracks in the foundation? (Circle one) Yes **No**

5e. How would you describe them? (Check the box that best describes cracks in your foundation)

| None | Few (1-2) | Some (3-6) | Many (more than 6) |
|------|-----------|------------|--------------------|
| | | | NA |

5f. Has the original structure of the building been altered by construction? For example, have half basements or spaces under the building been constructed? If so, please describe alterations.

NO

Floor Slab Characteristics

| | YES | NO | DON'T KNOW |
|--------------------------------------------------------------------------------------------|----------|----------|------------|
| 5g. Was a vapor barrier installed under the floor slab? | X | | |
| If so, describe: vapor barrier under office nodes | | | |
| 5h. Were any other liners installed under the floor slab? | | X | |
| If so, describe: | | | |
| 5i. Were fibers or additional rebar added to the concrete floor slab to minimize cracking? | X | | |
| If so, describe: | | | |
| 5j. Were other techniques used to restrict vapor migration through the floor slab? | X | | |
| If so, describe: sub-slab capillary break | | | |

6. Heating and Ventilation System(s)

6a. What type of heating system(s) is/are used in your building? (Circle all that apply)

(office enclosure)
Hot Air Circulation

Heat Pump

Steam Radiation

Wood Stove

Hot Air Radiation

Unvented Kerosene Heater

Electric Wall/ Baseboard

Other, specify:

6b. What type(s) of fuel(s) are used in your building/residence? (Circle all that apply)

Natural Gas
 Electric
 Coal
 Fuel Oil
 Wood
 Solar
 Other, specify

6c. Does your building have a fireplace? (Circle one) Yes No

6d. What types of mechanical ventilation systems are present in your building ? (Circle all that apply)

Central Air Conditioning
 Mechanical Fans
 Bathroom Ventilation Fan
 Kitchen Range Hood Fan
 Air-to-Air heat Exchanger
 Individual Air Conditioning Units
 (office enclosure)
 Other, please specify:

6e. Does your building have roof vents? (Circle the one that applies) Yes No

7. Sources of Chemical Contamination:

Are any of these items present in the building? (Check all that apply)

| Present? | Potential Source of Chemical | Location of Source |
|----------|-------------------------------------------------------------------------------------------|--------------------|
| | Paints or paint thinners | |
| X | Cleaning solvents | dental supply area |
| | Air fresheners | |
| | Oven cleaners | |
| | Carpet/upholstery cleaners | |
| | Hairspray | |
| | Nail polish / polish remover | |
| | Bathroom cleaner | |
| | Appliance cleaner | |
| | Furniture polish | |
| | Perfume / colognes | |
| | Hobby supplies (For example, solvents, paints, thinners, glues, photo darkroom chemicals) | |
| | Scented trees, wreaths, potpourri | |

- 7a. Do one or more smokers occupy this building on a regular basis? Yes No
- 7b. Do the occupants of the building have their clothes dry-cleaned once every other week or more? Yes No
- 7c. Was remodeling or painting done in the building in the last month? Yes No
- 7d. Are there any pressed wood products in the building (For example, Hardwood, plywood, wall paneling, particleboard or fiberboard)? Yes No
- If so, please describe their location:
- 7e. Within the last month, have you gotten new upholstery, drapes or Other textiles in the building? Yes No
- 7f. Has the building been treated with any insecticides or pesticides? Yes No
- If so, what chemicals are used and how often are they applied?
- 7g. Does your property contain any underground storage tanks? Yes No
- If so, what type?

8. General Comments:

Is there any other information about the structural features of this building, the occupants or potential sources of chemical contaminants to the indoor air that may be of importance in facilitating the evaluation of the indoor air quality of the building?

a few unsealed penetrations around fire water supply lines - E wall + SW corner of bldg A, SW corner of bldg B

per Arc 55 all floor slab joints sealed

9. Water Use Survey

Please check ALL of the boxes below that apply to your property.

| Land uses, Property use or Activity Type | Historic Use | Current Use | Planned Future Use |
|------------------------------------------|--------------|-------------|--------------------|
| Residential | | | |
| Commercial | NA | X | X |
| Industrial | | | |
| Agricultural | | | |
| Recreational | | | |
| Other, Describe: | | | |

9a. Do you use the public water supply provided by the city? **Yes**

9b. Do you have a private well? **No**

9c. If you have a private well, when was it last used? **NA**

9d. If you have a private well, circle all of the uses for that water: **NA**

Drinking water

Irrigation

Livestock

Vegetable Garden

Industrial Process

9e. Additional comments concerning water use

THANK YOU!

**We appreciate your participation in this survey!
 If you have any questions about the survey, or need help filling it out,
 please contact Steve Teel with the Department of Ecology
 at 360-407-6247 or stee461@ecy.wa.gov.**

Attachment 2
Equipment Specification Sheet for
Differential Pressure Data Logger



FIELD ENVIRONMENTAL INSTRUMENTS, INC.

www.fieldenvironmental.com 1-800-393-4009

OMNIGUARD™ 4

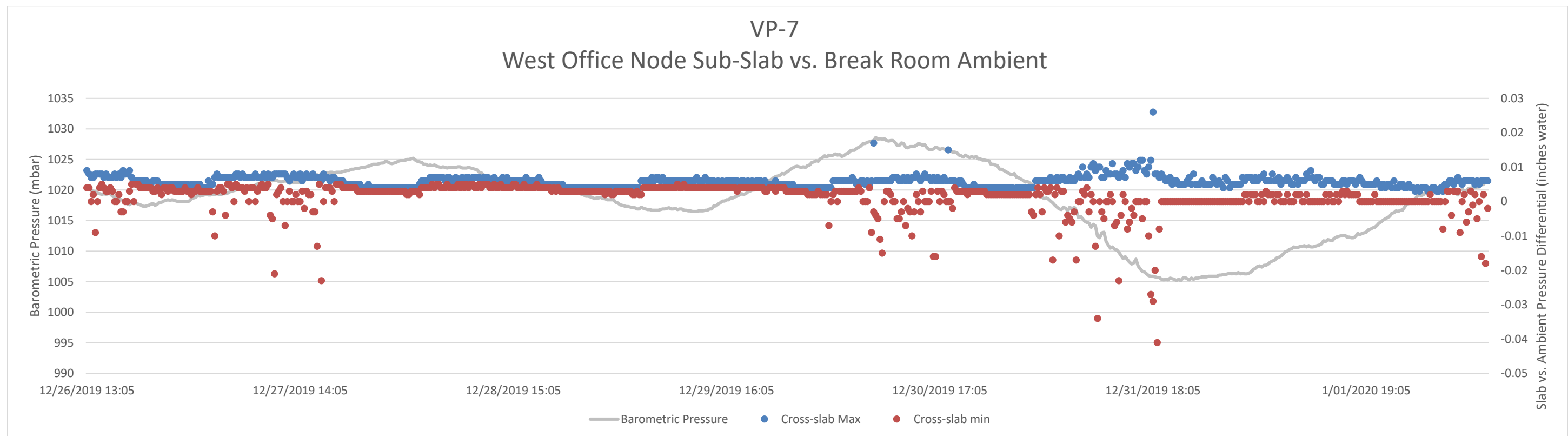
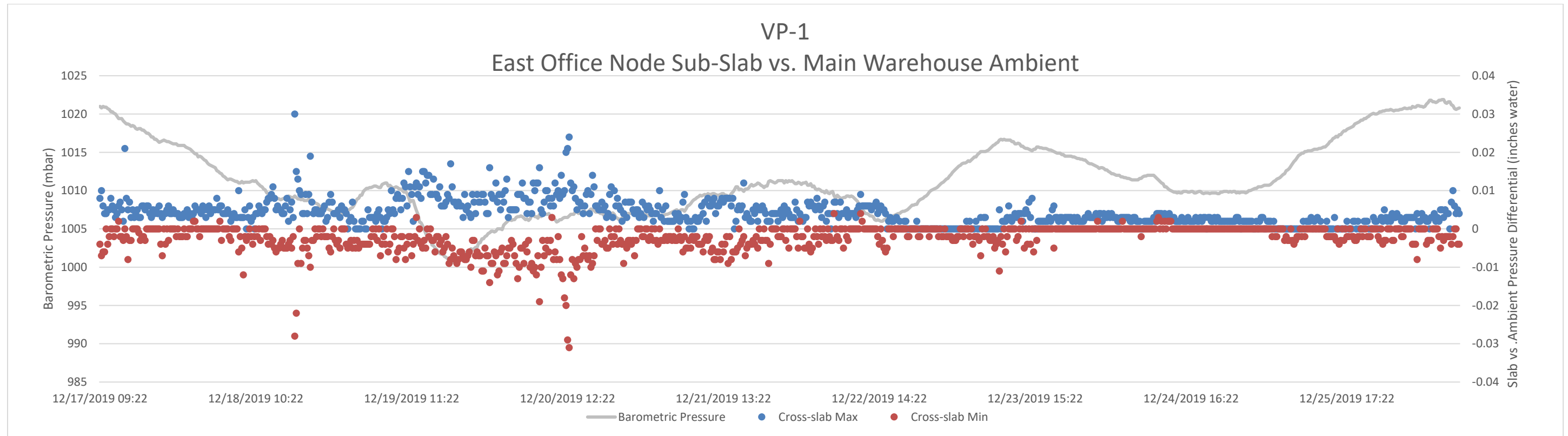


The Omniguard 4 is the clear choice for monitoring and documenting Vacuum and Pressure in a containment area. Ideal for Asbestos, Lead and Mold abatement and Clean Room monitoring. The Omniguard 4 utilizes state of the art pressure measurement technology to accurately monitor pressure inside a containment area.

| | |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Operating Range | +/- 0.250 inches Water Column (+/- 6.35 mm WC, +/- 62.5 Pascals) |
| Resolution | 0.001 inches Water Column (+/- 0.05 mm WC, +/- 0.5 Pascals) |
| Accuracy | +/- 0.003 inches Water Column or +/- 1% of reading whichever is greater |
| Pressure Units Displayed | "WC (inches Water Column), mmWC (millimeters Water Column), Pa (Pascals) |
| Calibration | Zero Cal function, temperature compensated |
| Burst Pressure | 3 psi (20 kPa) on either port |
| Data Storage Capacity | 128,000 characters, 30+ days of readings (over 4000 logged events) in non-volatile memory (no battery required) (29500 characters, 7+ days of readings, 30 data data retention for Omniguard III) |

| | |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Display | Graphic Liquid Crystal Display (LCD) with adjustable backlight and over 3.5 sq. inch viewing area |
| Internal Clock | the internal clock is powered by a self-charging lithium-ion battery that provides 30+ days of clock operation when AC or DC power is not present |
| Printer | 20 character wide thermal printer (uses 2.2" wide thermal paper) |
| Printing/Logging Rates | Normal Operation -- highest and lowest pressure readings printed/logged at intervals of 5, 15, 30 minutes or OFF Alarm Condition -- current pressure reading printed/logged at intervals of 15, 30, 60 or 120 seconds for first 10 minutes of alarm condition, increasing to 15 minute intervals thereafter |
| Alarms | Two programmable alarm setpoints, 95db audible alarm with flashing LED and on-screen warning indicate alarm condition |
| Pressure Inlets | Two 3/16" OD barbed hose connectors, 10 ft of hose provided |
| Serial Port | DB-9 Male, RS232 |
| USB Port | USB V1.0 Type-B |
| Aux Alarm Port | 1/8" stereo phono jack, relay contact outputs: NC, NO and Common rated 1A @ 30Vdc or 0.5A @ 115VAC |
| Power | 115 VAC 60Hz with 6 ft power cord (220 VAC 50Hz optional, 6VDC battery pack optional) |
| Case | Dimensions 9.25" x 7.5" x 4.5", Shipping Weight 6 lbs., Copolymer polypropylene case with polycarbonate window in the lid and stainless steel hanging hook |

Attachment 3
Cross-Slab Differential Pressure Plots



Attachment 4
Vapor Intrusion Field Sampling
Standard Guideline

F|S STANDARD GUIDELINE

Vapor Intrusion

DATE/LAST UPDATE: February 2019

These procedures should be considered standard guidelines and are intended to provide useful guidance when in the field, but are not intended to be step-by-step procedures, as some steps may not be applicable to all projects.

All field staff should be sufficiently trained in the standard guidelines for the sampling method they intend to use and should review and understand these procedures prior to going into the field. It is the responsibility of the field staff to review the standard guidelines with the field manager or project manager and identify any deviations from these guidelines prior to field work. When possible, the project-specific Sampling and Analysis Plan should contain any expected deviations and should be referenced in conjunction with these standard guidelines.

1.0 Scope and Purpose

This standard guideline provides details necessary to complete vapor intrusion monitoring, which may include soil vapor point and sub-slab installation, soil vapor point monitoring and/or sampling, indoor air sampling, and remediation system compliance monitoring. Field screening for volatile organic compounds (VOCs) is most often conducted with a photoionization detector (PID) and confirmed via analytical sample collection. The most common sampling methods are included herein. These guidelines are designed to meet or exceed guidelines set forth by the Draft Washington State Department of Ecology's (Ecology's), [Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action](#) (Ecology 2015 and 2018a). In addition, refer to Ecology's [Updated Process for Initially Assessing the Potential for Petroleum Vapor Intrusion: Implementation Memorandum No. 14](#) (Ecology 2016), Ecology's [Petroleum Vapor Intrusion \(PVI\): Updated Screening Levels, Cleanup Levels, and Assessing PVI Threats to Future Buildings: Implementation Memorandum No. 18](#) (Ecology 2018b), and the U.S. Environmental Protection Agency's (USEPA's) [Technical Guide For Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites](#) and [OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air](#) (USEPA 2015a and 2015b). Defining the lateral and vertical inclusion zones will determine if soil vapor sampling is required. The Interstate Technology and Regulatory Council (ITRC) [online guidance for soil vapor intrusion](#) (ITRC 2014) is another good source of information.

2.0 Equipment and Supplies

The following is a list of typical equipment and supplies that may be necessary to complete vapor intrusion monitoring. It is important to note that this list is for a typical project; site-specific conditions may warrant additional or different equipment for completion of the work.

Sub-Slab, Soil Vapor Point, and Vapor Pin® Installation:

- Rotary hammer drill
- Drill bit
- Vapor point (AMS or similar)
- Stainless steel (SST) dummy tip (optional)
- Teflon™, nylon, or stainless steel tubing
- Sand pack
- Bentonite chips
- Protective cover for permanent point
- Swagelok® on/off valve (optional)
- Caps or compression fittings
- Quick set (concrete) or hydraulic cement
- Paper towels
- Nylon ferrules
- Vapor Pin® Kits (Cox-Colvin & Associates), which include the following:
 - Brass or stainless steel Vapor Pins®
 - Vapor Pin® sleeves
 - Vapor Pin® caps
 - Plastic or stainless steel flush mount covers
 - Spanner screwdriver
 - Stainless steel drilling guide
 - Installation and extraction tool
 - Bottle brush
 - Water dam for leak testing
 - Vapor Pin® Standard Operating Procedures (SOP)
- Shop vac

Soil Vapor Point or Remediation System Screening and/or Sampling:

- PID
- Connector
- Teflon™ or nylon tubing
- Air sampling pump or peristaltic pump
- Tedlar® bag or SUMMA® canisters
- Two adjustable wrenches (to tighten SUMMA® canister connections)
- Duplicate sampling (as necessary if duplicate sample collection is required)
- Soil gas manifolds
- Ferrules/fittings
- Helium (or other detection gas, such as isopropyl alcohol, if leak detection is necessary)
- Helium detector (if leak detection is necessary with helium)
- Soil vapor sampling sheet (attached)

Indoor Air Sampling:

- PID
- Flow regulator
- SUMMA® canisters (6-liter, lab certified)
- Sampling cane (optional)
- At least two adjustable wrenches
- Indoor air building survey form (enclosed)

3.0 Standard Procedures

Soil vapor samples and/or indoor air samples should be collected from a sufficient number of locations to assess the presence of VOCs and potential exposure to workers or occupants of potentially impacted buildings or future building locations.

3.1 PRE-SCREENING ASSESSMENT

When completing a vapor intrusion survey or indoor air sampling, it is important to complete a pre-sampling survey to document potential activities or storage items that may cause interference with sample results. Some important things to note (list is not comprehensive):

- If smoking has occurred in the building

- Storage of potential contaminants (cleaners, fuels, paints, or paint thinners, etc.)
- HVAC system operation (on or off)
- Temperature and weather (wind direction, barometric pressure, etc.)
- Vehicle maintenance or industrial activities on the property or in the immediate vicinity (especially upwind)
- If new carpet or furniture is present

A pre-sampling soil vapor building survey form can be found at the end of this document. Be mindful of your surroundings and make a comprehensive list of potential factors that may influence sample results.

3.2 SOIL VAPOR POINT INSTALLATION

Soil vapor points can be installed along the outside perimeter of a building or in the lowest level of a building directly through the slab (or beneath the floor into the subsurface if there is not a slab). It is important to evaluate the presence of utilities prior to drilling into the subsurface or through a concrete slab.

If the sampling point is for one time use, tubing inserted into a hole drilled in the slab is sufficient. However, if the sampling is to be part of a long-term monitoring program, a more robust sampler, such as a Geoprobe or AMS probe for permanent soil gas point is recommended. Five different methods for installing soil vapor installation points are described here.

1. For temporary sub-slab points:
 - a. Drill a hole into the subsurface. Using a rotary hammer drill and a 3/8-inch drill bit (typical diameter size but not necessary), drill a hole through the concrete floor slab of the building and into the sub-slab material to some depth (e.g., 7 to 8 centimeters [cm] or 3 inches). Drilling into the sub-slab material will create an open cavity, which will prevent obstruction of the tubing intake by small pieces of gravel. Once the thickness of the slab is known, the tubing will be cut to ensure that the probe tubing does not reach the bottom of the hole in order to avoid obstruction with sub-slab material. Sample tubing can be placed directly into the sub-slab. Evaluate and note the sub-slab conditions.
 - b. Care should be taken to reduce cross-contaminating sub-slab vapor and indoor air vapor. This may be done by sealing the sample point with VOC-free hydraulic cement, hydrated bentonite, or with VOC-free putty to the top of the slab. Once sealed, wait 15 to 30 minutes before sampling.

2. Installation guidelines for a sub-slab Vapor Pin®:¹



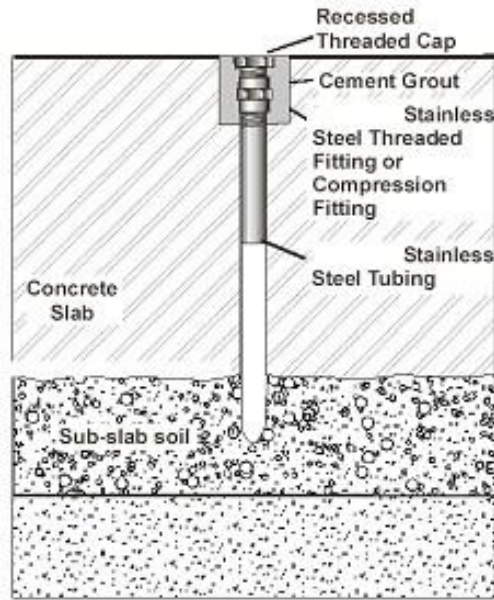
Figure 1. Assembled VAPOR PIN®

- a. Check for buried obstacles and utilities. Set up wet/dry vacuum to collect drill cuttings. Also, look for nearby cracks or other holes in the slab that may cause short circuiting and influence from indoor air.
- b. Drill a 1.5-inch (38 millimeters [mm]) diameter hole at least 1.75 inches (45 mm) into the slab. Use of a Vapor Pin® drilling guide is recommended in the SOP.
- c. Drill a 0.625-inch (16 mm) diameter hole through the slab and approximately 1 inch (25 mm) into the underlying soil to form a void. Hole must be 0.625 inches (16 mm) in diameter to ensure proper seal. The Cox-Colvin SOP recommends using the drill guide provided in the kit. Remove the drill bit, brush the hole with the bottle brush provided in the kit, and remove the loose cuttings with a vacuum.
- d. Place the lower end of Vapor Pin® assembly into the drilled hole. Place the small hole located in the handle of the installation/extraction tool provided in the kit over the vapor pin to protect the barb fitting, and tap the Vapor Pin® into place using a dead blow hammer or rubber mallet. Make sure the installation/extraction tool is aligned parallel to the Vapor Pin® to avoid damaging the barb fitting.
- e. For flush mount installations, cover the Vapor Pin® with a flush mount cover, using either the plastic cover or the optional stainless-steel Secure Cover provided by Vapor Pin®.
- f. Allow 48 hours or more for the sub-slab soil-gas conditions to re-equilibrate prior to sampling.

¹ Additionally, refer to Cox-Colvin [SOP Installation and Extraction of the Vapor Pin®](#), which is included with the Vapor Pin® kit.

3. Suggested installation guidelines for temporary outdoor soil gas points using a rotary hammer and drill bit:
 - a. Manufacturers, such as Geoprobe or AMS, make soil gas implant systems designed for use with their equipment. Stainless steel or polyvinyl chloride (PVC) screen can also be used to construct an appropriate soil gas point. The probe screen will be fitted with a Swagelok® or similar fitting and connected to a length of 0.25-inch outer diameter, rigid wall nylon or Teflon™ tubing that will be above grade. Refer to the manufacturer or driller's instructions for specific details regarding assembly and deployment.
 - b. To seal the point, the implant should be surrounded with a clean sand pack. Concrete (VOC-free hydraulic cement preferred) should be used above the seal to the top of the slab. Placement of some sort of cap or protective device is recommended if the sampling point will remain in place for some time after the soil gas sample is collected. Once sealed, wait 15 to 30 minutes before sampling.
4. Suggested installation guidelines for outside permanent points installed with a Geoprobe rig or hand auger:
 - a. Advance the boring using a geoprobe or hand auger to the required maximum depth. Install a 6-inch long by 0.75-inch diameter stainless steel screen that is capped on the bottom end and fitted with a Swagelok® fitting connected on the other end (or similar approved screen or soil vapor point). Attach a length of 0.25-inch outer diameter rigid wall nylon or Teflon™ tubing to the probe screen that will be above grade. The above grade end of the probe should be fitted with a stainless steel Swagelok® on/off control valve or similar valve (optional), which is used to prevent short-circuiting of ambient air into the probes and to conduct closed-valve tests. Teflon™ tape should be used on threaded joints to ensure a good seal. Depending on the work plan, it might be necessary to collect an air equipment blank sample through the vapor probe components prior to installation.
 - b. The 6-inch screen tip should be vertically centered in a 1-foot long interval containing standard sand pack, resulting in 3 inches of sand above and below the screen. The sand pack will be covered with a 1-foot interval of dry granular bentonite, which should be covered with at least 2 feet of pre-hydrated granular bentonite. The dry granular bentonite is emplaced immediately above the sand pack to ensure that pre-hydrated granular bentonite slurry does not flow down to the probe screen and seal it. The remainder of the borehole will be filled with pre-hydrated granular bentonite slurry (mixed at the surface and poured in) to approximately 12 inches below ground surface (bgs). The top portion should be completed with a 1-foot thick cement cap. A flush-mounted well box or other suitable protective cover should be installed to protect the nylon/Teflon™ tubing and on/off control valve.

5. Suggested equipment and installation guidelines for permanent sub-slab vapor points within a building; however, site-specific conditions may warrant additional or different equipment for completion of the work:
 - a. To install the sub-slab vapor probes, a rotary hammer drill will be used to create a “shallow” hole (e.g., ¼-inch deep) that partially penetrates the slab (do not completely penetrate the slab). A portable vacuum can be used to remove the drill cuttings from the hole without compromising the soil vapor samples. Next, a smaller diameter “inner” hole (e.g., 0.8 cm or 5/16 inch diameter) will be drilled through the remainder of the slab and into the sub-slab material to some depth (e.g., 7 to 8 cm or 3 inches). Drilling into the sub-slab material will create an open cavity which will prevent obstruction of the probes by small pieces of gravel. Once the thickness of the slab is known, the tubing will be cut to ensure that the probe tubing does not reach the bottom of the hole and in order to avoid obstruction with sub-slab material.
 - b. Each sub-slab vapor point should consist of vacuum-rated Nylon, Teflon™, or stainless steel tubing with ¼-inch outer diameter by 0.15-inch inner diameter, and stainless-steel compression to thread fittings (e.g., ¼-inch outer diameter Swagelok® (SS-400-7-4) NPT female thread connectors or similar equipment). This will be capped with sub-slab tamper resistant cap or other similar protective caps that will be inset into the floor to avoid trip hazards. When time to sample, the sub-slab tamper resistant cap will be removed and Nylon tubing will be attached to the sub-slab vapor point with a ¼-inch out diameter (SS-400-1-4) male NPT. Prior to the installation of one of the sub-slab vapor probes, an air equipment blank sample will be collected if required by the work plan (See Section 3.4.3).
 - c. Teflon™ tape should be used with all stainless steel threads. All fittings should be attached prior to installing the probe in the sub-slab. A sub-slab tamper resistant cap will be used to ensure that the top of the probe is flush with the surface so as not to interfere with day-to-day use of the building. Portland cement can be used as a surface seal and allowed to cure for at least 24 hours prior to sampling. Hydraulic cement may also be used if free of VOCs, and requires less cure time (typically less than one hour) prior to sample collection. A typical soil gas probe schematic is provided here for reference.



Sub-slab soil gas probe schematic (Source: Ecology 2016a)

3.3 SOIL VAPOR POINT SAMPLING USING TEDLAR® BAGS

The objective of the vapor sampling procedures is to collect representative samples of the targeted media and analyze the gas for the presence of VOCs. Typically, a low volume air pump is used to pull a sample through the sampling train.

1. Connect proper tubing to your sampling point and to your low volume air pump.
2. Purge for 3 to 5 minutes to ensure that you are collecting a representative sample.
3. After purging, connect your Tedlar® bag to your air pump and collect your sample (Note: Tedlar® bags should be filled at a rate of approximately 5 liters per minute).
4. A PID is typically used in conjunction with sample collection in a Tedlar® bag.
 - a. Connect the PID probe to the sample container using a section of tubing
 - b. Use the PID to read the organic vapor level present in the sample.

Soil Vapor samples are typically collected into 1-liter Tedlar® bags and have a short (typically less than 72-hours) holding time. Samples collected into Tedlar® bags should be transported to the laboratory immediately under chain-of-custody protocol and stored in a dark container at ambient temperature during transport out of direct UV-light. Do not ship Tedlar® bags to the laboratory using an air transportation method as the pressure could compromise the sample or the bag. If air transport is necessary, do not completely fill the Tedlar® to avoid bursting. Soil vapor grab samples can also be collected into 1-liter SUMMA® canisters to provide additional holding time, lower laboratory method detection limits for some analytes, or sample delivery alternatives.

3.4 SOIL VAPOR AND SUB-SLAB SAMPLING WITH SUMMA® CANISTERS

Prior to soil vapor sampling, check all soil vapor sampling supplies to ensure the right sampling equipment arrived from the lab including duplicate Tees, if duplicate sample collection is necessary, and purging canisters. Conduct the following:

- Confirm that all SUMMA® canisters have at least 27 to 30 inches of mercury (in. Hg) prior to going out in the field to sample.
- Check and record all manifold and SUMMA® canister tags and numbers.
- Make sure all connections on the SUMMA® canisters and manifolds are tight.
- Order Helium (or other tracer gas) if needed and rent a helium detector.

Once the sub-slab or soil vapor probes are installed and the concrete well seal at each vapor point has fully cured, vapor sampling activities may commence (ideally a minimum of 2 hours is necessary for probe equilibration, depending on surface seal cure time). Alternatively, existing monitoring wells that are appropriately screened for a vapor intrusion assessment may be used. If indoor air samples will be collected, they may be collected simultaneously during the sub-slab sampling activities (details found in Section 3.6) if required by the work plan. If feasible, vapor sampling should not be conducted during or immediately after a significant rain event (i.e., greater than an inch of rainfall) due to the reduced effective diffusion coefficient and decrease in relative vapor saturation in the unsaturated zone. For sub-slab or soil vapor probe sampling, 1-liter lab certified SUMMA® canisters should be used in order to minimize the volume of soil vapor collected.

A closed-valve test should be conducted prior to soil vapor sample collection to check for leaks in the sampling train. A closed-valve test is conducted by capping the ends with proper Swagelok caps and/or closing any valves at the sampling point and purge canister. Once all ends are closed tight, turn the sampling canister valve on for 5 minutes. If the sampling train maintains its original vacuum for 5 minutes, the equipment will be assumed to be functional and there are no leaks. If the vacuum reading starts to drop, turn off the valves right away, check all connections, tighten if necessary, and re-test. If this passes, the only location that a leak can occur is from the soil ground seal around the vapor probe, which will be tested using helium or another tracer gas during sampling (See Section 3.4.1).

After the close-valve test, a minimum of three tubing volumes should be purged. Purging can be completed using a non-certified 6-Liter SUMMA® canister or a vacuum pump. The maximum flow rate during purging will not exceed the flow rate limit used for subsequent sampling and care will be taken not to over purge. An excel spreadsheet to help calculate tubing volume and purging time can be found at the end of this document.

After the sampling train has been purged, sub-slab soil vapor samples will be collected over a 10 minute period at a flow rate of less than 167 milliliters per minute (mL/min). The flow rate will be controlled by a flow regulator, which is set by the lab. Sub-slab soil vapor samples will be collected in laboratory-certified and pre-evacuated 1-liter SUMMA® canisters. Each SUMMA®

canister will be supplied with an analytical test report certifying that the canister is “clean” to concentrations less than the respective method detection limits (MDLs). Each canister will be equipped with a pre-calibrated flow controller sampling train to allow collection of the desired sample. Prior to collecting the samples, the SUMMA® canister ID numbers will be recorded in the field notebook along with the initial canister vacuums, prior to sampling.

Soil vapor samples will be collected per the following steps:

1. Opening the valve on the top of the SUMMA® canister and recording the time in the log book;
2. Observing the vacuum gauge on the sampling train to ensure that the vacuum in the canister is decreasing over time;
3. Shutting off the valve once the vacuum gage reads between 4.0 and 5.0 inches of mercury (in. Hg).

3.4.1 Leak Testing

In addition to soil gas sampling activities, leak testing may be required at sampling locations and should be conducted using the following soil gas sampling set-up procedures:

When helium is being used as a tracer gas:

- Place a large plastic bag (or other acceptable shroud) around the SUMMA® canister, sampling apparatus, and vapor probe.
- Cut a small hole in the bag to allow tubing to be inserted to introduce tracer gas, such as helium, and to subsequently fill the plastic bag.
- Keep the tracer gas (i.e., helium) concentration in the bag at 10 percent by volume or higher.

When isopropyl alcohol is being used as a tracer gas:

- Soak towels in isopropyl alcohol.
- Place soaked towels over the sampling probe and wrap around all connections.

Detections of the tracer gas in the soil gas samples would indicate that the canister, valves, or ground surface seal to the sample probe have potentially leaked ambient air into the sample. Small amounts of sample train leakage is permissible; however, the leak percentage should not exceed 10 percent of the soil gas results. If the leak percentage exceeds 10 percent, the sampling point may have to be resampled. The integrity of the soil vapor samples can be assessed by estimating the percent leakage as shown here in micrograms per square meter ($\mu\text{g}/\text{m}^3$):

$$\% \text{ leakage} = 100 \times \frac{\text{helium concentration in soil vapor sample } [\mu\text{g}/\text{m}^3]}{\text{average helium concentration measured inside the shroud } [\mu\text{g}/\text{m}^3]}$$

The above equation for helium can be used because the known average helium concentration can be determined via field screening with a helium detector. Tracer gas leaks should not occur if the sampling train passes a properly performed closed-valve test and given the low flow rate of 167 mL/min.

3.4.2 Final Readings

Once the sampling is completed and the final vacuum is recorded, the sampling train will be removed from the canister and a Swagelok® cap will be tightly fitted to the inlet port of the canister. A PID can be used to record vapor readings from the manifold connection and logged in the notebook and/or soil vapor sampling sheet (enclosed). In addition, the initial canister vacuums, vacuum testing times, purging times, purged volumes, helium readings, sampling starts and times, final vacuum readings, and PID readings should be recorded on a vapor sampling sheet. Some of this information will also be required on the chain-of-custody.

3.4.3 Equipment Blank

Occasionally, the work plan requires an equipment blank to be collected. An equipment blank can be conducted by collecting a sample of clean air or nitrogen through the probe materials before installation in the ground. Analysis of the equipment blank can provide information on the cleanliness of new materials. Clean stainless steel, Nylon or Teflon® tubing and a certified regulator should be used. Lab-certified canisters (the sample canister and the source canister/cylinder, if applicable) or Tedlar® bags can be used to collect an equipment blank.

3.5 USE OF MONITORING WELLS FOR SOIL GAS SAMPLING

While dedicated soil gas probes are typically used to collect soil gas samples, existing monitoring wells that are appropriately located and screened can also be used for this purpose, with limitations. This is an advantage when evaluating the risk of vapor intrusion solely from contaminated aquifers (as compared to contaminated vadose zone soil) as the soil gas that will be sampled can reflect a soil gas sample that lies close to the zone of saturation and represents a worse case condition for equilibrium partitioning of contamination in groundwater to the gas phase. Also, monitoring wells are typically constructed at a deeper depth than soil vapor probes and are less influenced by changes in barometric pressure. They are also inherently constructed to be well sealed against breakthrough from atmospheric air (while purging and sampling). For an existing well to be used for soil gas sampling, it must have at least 2 to 3 feet of open screen above the water table during sample collection.

The main disadvantage of using existing monitoring wells is that the required purge volume would be much greater because of the significantly larger diameter of the well screen as compared to probes. This requires the use of a larger air pump or small blower instead of the SKC hand pump or peristaltic pump. While purging, care must be taken to minimize the vacuum in the well casing which may be large enough to raise the water column high enough to cover the exposed well screen and invalidate the use of the well for sampling soil gas. Appropriate

temporary fittings will need to be installed to allow the reduction of the well casing sufficient to allow connection to the collection tubing.

3.6 INDOOR AIR AND OUTDOOR AMBIENT AIR SAMPLE COLLECTION

Indoor air sampling should be conducted in an environment that is representative of normal building use. Indoor air and outdoor ambient air samples are typically collected into 6-liter SUMMA[®] canisters and can either be a grab (not often recommended) or time weighted samples. For time weighted samples, the laboratory will provide preprogrammed flow controllers for the samples for your desired sample duration. An 8-hour flow controller is the most common to assess typical working conditions or to provide a time-weighted average (TWA) to assess residential risk (a 24-hour flow controller may also be used for residential assessments). SUMMA[®] canisters should be placed in an area that is close to the breathing zone (i.e., 3 to 5 feet above the floor level), a sampling cane can be connected to the SUMMA[®] canister to sample indoor air at breathing zone height.

As a basic guideline and starting point, indoor air samples should at a minimum be collected from the basement (if applicable), first floor living or work area, and from outdoors (ambient/upwind). For a typical-size, one-floor residential building or a commercial building less than 1,500 square feet, USEPA recommends the collection of one time-integrated sample within the occupied area (USEPA 2015b). Other site-specific factors will influence the specific placement location of the SUMMA[®] canisters, such as proximity to subsurface source area(s) or penetrations through the slab or foundation.

Ambient air samples should be collected from a location protected from the elements (wind, rain, snow, or ice) and vehicle traffic on the upwind side of the building (5 to 15 feet away) during the same sampling event the indoor air samples are collected in order to provide information about the outside influences on indoor air quality (i.e., vapors from automotive fuels and exhaust). USEPA recommends that ambient air sampling begin at least 1 hour prior to indoor air sampling and should continue at least 30 minutes before indoor monitoring is complete (USEPA 2015b).

3.6.1 Connection Guidelines

Refer to specific guidelines provided by the laboratory, as equipment can be slightly different from lab to lab. It is important to note the initial vacuum reading on the gauge as well as the post-sampling vacuum. For reference, initial vacuum should be between 27 and 30 inches of mercury, while post-sample vacuum should be between 4 and 5 inches of mercury. Sample collection start and finish times should also be recorded. After sample collection, the SUMMA[®] canister valve should be shut and the flow controllers should be disconnected from the SUMMA[®] canisters. Both the controller and the canister ID (unique laboratory tracking ID) should be recorded on the chain-of-custody and the samples should be packed appropriately for delivery to the laboratory following chain-of-custody protocol.

3.6.2 Testing Method and Reporting Limit Considerations

Indoor air samples can be analyzed using various methods, such as TO-15, TO-15 SIM, and TO-17. When considering which analytical method to use, always consider current and future site use and analytical reporting limits to ensure that reporting limits for the selected methods can meet the cleanup levels applicable for the site.

3.7 REMEDIATION SYSTEM VAPOR SAMPLE COLLECTION

Remediation systems that have a soil vapor extraction (SVE) component often require compliance monitoring to evaluate mass removal and effluent discharge limits. Both screening (with a PID) and sampling are routinely conducted during active operation. Tedlar® bags are often used to simplify SVE system screening. Fill a bag following the procedures described in this section and use a PID to measure the VOCs in the sample. Record the maximum observed concentration. Vapor samples for laboratory analysis are most often collected in 1-liter Tedlar® bags, but SUMMA® canisters can also be used. It is a good idea to fill out the label on the Tedlar® bag prior to sample collection.

If the sample port is under vacuum (i.e., SVE manifold or wellhead), it is often necessary to reduce the flow somewhat and to use a hand or mechanical pump to extract the vapor from the line. If the sample port is under a high vacuum, it may be necessary to step down the flow (i.e., close the flow valve) in order to collect a sample. Follow steps in Section 3.3 for sample collection and delivery.

If the sample port is under pressure (i.e., SVE system discharge), the sample can be collected without the use of a pump. Simply attach a clean piece of tubing securely to the sample port, connect the Tedlar® bag to the tubing, open the Tedlar® bag, slowly open the sample port valve, and be careful not to overfill the bag. Remove the Tedlar® bag when full, close the Tedlar® bag (do not over-tighten), and close the sample port valve. Follow steps in Section 3.3 for sample delivery.

4.0 Field Documentation

Soil vapor probe and monitoring point installation field activities should be documented in field notebooks and completion diagrams or boring logs should be completed to document construction. Information recorded will include personnel present, total depth, type and length of implant or screen, screen and filter pack intervals, bentonite seal intervals and surface completion details. Photographs of construction activities should be taken. After probe and monitoring point installation is complete, location coordinates should be recorded with a global positioning system (GPS). If GPS cannot be used (i.e., location within a building), it is important to document the location by recording representative measurements to fixed points.

All sampling activities must be documented in a field notebook and/or on field forms appropriate for the sampling activity. Information recorded will include at a minimum personnel present,

date, and time of sample collection, length of sample purge time, and any deviations from the project's work plan or sampling and analysis plan.

Weather conditions should also be recorded and should include temperature, barometric pressure, wind direction and speed, humidity, and degree of cloud cover. Additional site-specific details should also be noted including surface soil conditions, presence of standing water, wet soil, irrigation activities, and if possible, groundwater elevations.

5.0 References

Interstate Technology Regulatory Council (ITRC). 2014. Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management. <<http://www.itrcweb.org/PetroleumVI-Guidance/>>. October.

Washington State Department of Ecology (Ecology). 2015. Vapor Intrusion Table Update. (Replaces Table B-1 of Ecology's Guidance for Evaluating Soil Vapor Intrusion in Washington State). <<https://ecology.wa.gov/Asset-Collections/Doc-Assets/Regulations-Permits/Guidance-technicalassistance/Vapor-Intrusion/2015VaporIntrusionUpdates>>. 6 April.

_____. 2016. *Updated Process for Initially Assessing the Potential for Petroleum Vapor Intrusion: Implementation Memorandum No. 14*. Publication No. 16-09-046. 31 March.

_____. 2018a. *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action*. Review Draft. Prepared by the Toxics Cleanup Program. Publication No. 09-09-047. Originally published October 2009; revised April.

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U.S. Environmental Protection Agency (USEPA). 2015a. *Technical Guidance for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites*. Prepared by the Office of Underground Storage Tanks. EPA 510-R-15-001. June.

_____. 2015b. *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. Prepared by the Office of Solid Waste and Emergency Response. OSWER Publication 9200.2-154. June.

Enclosures: Indoor Air Building Survey Form
Purge Volume Calculations during Soil Vapor Sampling
Soil Vapor Sampling Sheet

INDOOR AIR BUILDING SURVEY FORM

Date:

Site Name:

Title:

Building Use:

Occupants: _____

Building Address: _____

Property Owner: _____

Contact's Phone: _____

Number of Occupants: _____

Business or Residential: _____

Building Characteristics

Building Type: Residential Multifamily Office
 Commercial Industrial Mall

Describe Building: _____

Number of Floors Below Basement Slab-On-Grade Crawl Space

Grade: _____

Bldg Dimensions: Width: _____ Length: _____ Height: _____

Basement Floor: Dirt / Concrete / Painted? Foundation Walls: Concrete / Cinder Blocks / Stone

INDOOR AIR BUILDING SURVEY FORM

VENTILATION SYSTEM

- Central Air Conditioning Mechanical Fans Bathroom Vans
 Conditioning Units Kitchen Range Hood Outside Air Intake

Other: _____

HEATING SYSTEM

- Hot Air Circulation Hot Air Radiation Wood Steam Radiation
 Heat Pump Hot Water Radiation Kerosene Heater Electric Baseboard

Other: _____

Outside Contaminant Sources

Nearby surrounding property sources: Gas Stations / Emission Stacks

Soil Contamination: Petroleum Hydrocarbons / Solvents

Heavy Vehicle Traffic: Yes / No

Indoor Contaminant Sources

Identify all potential sources found in the building (including attached garages), the location of the source (floor and room), and whether the item was removed from the building 48 hrs prior to indoor sampling event. Any ventilation implemented after removal of the items should be completed at least 24 hours prior to the commencement of the indoor air sampling event.

| Potential Sources | Location(s) | Removed (Yes / No / NA) |
|----------------------------------|-------------|-------------------------|
| Gasoline storage cans | | |
| Gas powered equipment | | |
| Kerosene storage cans | | |
| Paints / Thinners / Strippers | | |
| Cleaning solvents / Dry cleaners | | |
| Oven cleaners | | |
| Carpet / upholstery cleaners | | |

INDOOR AIR BUILDING SURVEY FORM

| | | |
|-------------------------------|--------------------|--------------------------------|
| Other house cleaning products | | |
| Moth Balls | | |
| Potential Sources | Location(s) | Removed (Yes / No / NA) |
| Polishes / waxes | | |
| Insecticides | | |
| Furniture / floor polish | | |
| Nail polish / polish remover | | |
| Hairspray | | |
| Cologne / perfume | | |
| Air fresheners | | |
| Fuel tank (inside building) | | |
| Wood stove or fireplace | | |
| New furniture | | |
| New carpeting / New flooring | | |
| Hobbies – glues, paints | | |
| Other: _____ | | |
| Other: _____ | | |
| Other: _____ | | |

SAMPLING INFORMATION

Sampler(s) _____

- Indoor Air / Outdoor Air
 Sub-slab
 Soil Vapor Point
 Exterior Soil Gas
 Tedlar® Bag
 Sorbent
 SUMMA®
 Other _____

Analytical Method: TO-15 / TO-17 / Other: _____

WEATHER CONDITIONS

Was there a significant rain event in the last 24 hours? Yes / No

Temperature: _____ Atmospheric Pressure: _____ Pressure: Rising or Falling?

Describe the general weather conditions: _____

Wind Speed and Direction: _____

PURGE VOLUME CALCULATIONS DURING SOIL VAPOR SAMPLING

| Sample Tubing Purge | | | | | | | | | | | | |
|----------------------|----------|------------------------|------------------------------------------------------|-------------------------|------------------------------|-----------------------------------|----------------------------------|-------------------|------------------|---------------------|------------------|--|
| Tubing Length (feet) | Pi | Casing Radius (inches) | Area of Casing Radius (Pi(R ²)) (inches) | Length of casing (feet) | Conversion of feet to inches | Number of Casing Volumes to Purge | Conversion of cubic inches to mL | Purge Volume (mL) | Purge Volume (L) | Purge rate (mL/min) | Purge Time (min) | |
| 5 | 3.141593 | 0.125 | 0.049087 | 5 | 60 | 1 | 16.387064 | 48.263888 | 0.048264 | 167 | 0.29 | |
| 5 | 3.141593 | 0.125 | 0.049087 | 5 | 60 | 3 | 16.387064 | 144.79166 | 0.144792 | 167 | 0.87 | |
| 5 | 3.141593 | 0.125 | 0.049087 | 5 | 60 | 7 | 16.387064 | 337.84721 | 0.337847 | 167 | 2.02 | |

| Annular Space Purge | | | | | | | | | | | | | |
|-------------------------------|----------|------------------------|----------------------------------------------|----------------------------------|--------------------------------|---------------------------------------------------|-----------------------------------|----------------------------------|-------------------|------------------|---------------------|------------------|--|
| Annular Space Length (inches) | Pi | Boring Radius (inches) | Area of Boring Radius (radius ²) | Volume of Annular Space (inches) | Assumed Porosity of Sand Pack* | Air Filled Volume of Annular Space (cubic inches) | Number of Casing Volumes to Purge | Conversion of cubic inches to mL | Purge Volume (mL) | Purge Volume (L) | Purge rate (mL/min) | Purge Time (min) | |
| 12 | 3.141593 | 2 | 12.56637 | 150.7964 | 0.3 | 45.23893 | 1 | 16.387064 | 741.3333 | 0.741333 | 167 | 4.44 | |
| 12 | 3.141593 | 2 | 12.56637 | 150.7964 | 0.3 | 45.23893 | 3 | 16.387064 | 2224 | 2.224 | 167 | 13.32 | |
| 12 | 3.141593 | 2 | 12.56637 | 150.7964 | 0.3 | 45.23893 | 7 | 16.387064 | 5189.333 | 5.189333 | 167 | 31.07 | |

| Summary of Purge Durations | |
|----------------------------|-------|
| One Purge Volume | 4.73 |
| Three Purge Volumes | 14.18 |
| Seven Volumes | 33.10 |

SOIL VAPOR SAMPLING SHEET

Site Reference: _____

Date: _____

Address: _____

Personnel: _____

| Soil Vapor Sampling Point ID | Vacuum Test | | Purging | | | | Helium | | Sampling | | | | PID | | Notes |
|------------------------------|---------------------------|--------------------------|--------------------|-------------------|-----------------------|--------------------------|------------------------|--------------------|---------------------|--------------------|-----------------------------------------|----------------------------------------|---------------------|-------------|-------|
| | Time Start Vacuum Testing | Time Stop Vacuum Testing | Time Start Purging | Time Stop Purging | Purging Rate (mL/min) | Total Volume Purged (mL) | Time of Helium Reading | Helium Reading (%) | Time Start Sampling | Time Stop Sampling | Canister Vacuum Before Sampling (in Hg) | Canister Vacuum After Sampling (in Hg) | Time of PID Reading | PID Reading | |
| | | | | | 167 | | | | | | | | | | |
| | | | | | 167 | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
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Notes:
