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Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

March 25, 2022

Mr. John Mefford
Washington State Department of Ecology
1250 West Alder Street
Union Gap, WA 98903-0009

SUBJECT: BIOVENTING PILOT TEST WORK PLAN
Big B Mini Mart
1611 Canyon Road
Ellensburg, Washington

Dear Mr. Mefford:

Floyd|Snider has prepared this Bioventing Pilot Test Work Plan as a component of the Cleanup Action Plan (CAP) that was approved by the Washington State Department of Ecology in November 2020 at the Big B Mini Mart Site (Site; Facility Site ID [FSID] #386, Cleanup Site ID [CSID] #4901) located at 1611 Canyon Road in Ellensburg, Washington (Figure 1 Vicinity Map). Bioventing is a key component of the cleanup action, and the pilot test will provide useful information on the performance of bioventing at the Site and help determine its radius of influence (ROI) at the Site.

DESCRIPTION

In accordance with the CAP, Phase I remedial activities were conducted between May 2021 and June 2021, which included the excavation of approximately 481 cubic yards of petroleum-impacted soil beneath the Site, north of the Big B Mini Mart and Astro Station Mini Mart (herein referred to as Toad's) property boundary. A total of 424 tons of impacted soil was hauled off-site for disposal at Waste Management's Greater Wenatchee facility, and approximately 250 tons was treated on the property using landfarming methods. Impacted soil was excavated to remediation levels defined in the CAP, which is greater than Method A cleanup levels (Figure 2). Therefore, residual total petroleum hydrocarbons, greater than the Model Toxics Control Act Method A cleanup levels in soil, were left in place. The remaining impacted soil will be treated using a bioventing system beneath the property.

Bioventing will be used to remediate impacted soil remaining in the vadose/smear zone after excavation activities are completed to ensure protection of groundwater. The potential proposed bioventing design layout is shown on Figure 2, pending pilot test results and the final extent of the 2022 excavation. Bioventing wells can be installed horizontally or vertically; both methods will have the screens placed in the vadose zone just above the high groundwater table in areas with remaining residual contamination. However, a pilot test needs to be conducted prior to the installation of a full-scale system in order to determine the Site-specific ROI and assist in final design layout (whether it be horizontal or vertical piping). Generally, the ROI can range from 5 feet for fine-grained soils to 100 feet for coarse-grained soils (USEPA 2017).

The proposed bioventing field activities will include the following: 1) installation of the vapor monitoring points and pilot test set up, 2) baseline measurements, 3) an air injection test to approximate system ROI, and 4) post-injection measurements.

PILOT TEST SET UP

Attachment 1 includes a schematic diagram of a basic air injection system that will be utilized during the bioventing pilot test. The system is relatively simple involving a blower and monitoring points spaced at increasing distances from the injection point. Fresh air is injected at a low-flow rate and will not produce significant air emissions or require aboveground vapor-phase treatment. Due to shallow groundwater, it is not necessary to install vapor screens at various depths.

As part of the pilot test, a minimum of four vapor monitoring points will be installed and spaced at increasing distances (5, 10, 20, 30 feet, etc.) from the injection point. One monitoring point will be installed in an area without hydrocarbon impacts, adjacent to PZ-12, and the rest will be installed within an area with known hydrocarbon impacts (Figure 2). All vapor monitoring points will be installed with a rotohammer creating a 1-inch-diameter pilot hole to install the screen and tubing to a depth of 3 feet bgs to ensure that the screens will not be submerged during high groundwater levels (refer to Floyd|Snider Standard Guidelines on Vapor Intrusion included in Attachment 2 for soil vapor probe installation details).

The existing piezometers and wells PZ-6, PZ-7, MW-10, PZ-12, and MW-8 could potentially be used as air injection and/or monitoring points. Criteria for well and piezometer selection include approximately 1 foot or more of open well screen above the groundwater table. The piezometers were set with a screen interval of 3 to 8 feet bgs. Monitoring well MW-10 has a 10-foot screen and a total depth of 13.48 feet below top of casing, indicating that the screen was set with an approximate screen interval of 3.5 to 13.5 feet. Depth to groundwater will be checked in each location prior to using as a monitoring or injection point, and the injection and monitoring points will be decided in the field. If the existing well or piezometers do not meet the criteria, a 2-inch polyvinyl chloride (PVC) casing and screen will be installed with the same method and materials used during the installation of the piezometers in 2016, but with the goal to obtain 1 foot or more of open screen above the groundwater table.

A small 1.5 horsepower regenerative blower will be placed above ground and tied into a monitoring well or piezometer that meets the above criteria. An inline check valve will be used to regulate the air flow into the well. This blower will be sufficient to provide fresh air at a low-flow rate to the subsurface soils for a short-term study to determine the ROI and to stimulate aerobic biodegradation. At a minimum, the blower will be capable of producing a maximum airflow of 50 cubic feet per minute (cfm); however, given the volume of contaminated soil at the

Site, it is likely that the air flow required would be much less than 20 cfm, per equation in Example 2-2 in the U.S. Environmental Protection Agency's Manual for Bioventing Principles and Practice Volume II: Bioventing Design (USEPA 1995). The blower will be secured inside a locked shed to be placed in the southeast corner of the property (Figure 2).

BASELINE MEASUREMENTS

Prior to providing fresh air to a well or piezometer (either MW-10 or PZ-6 would be good candidates), baseline measurements of carbon dioxide, oxygen, hydrogen sulfide, and lower explosive limit (LEL) for methane will be measured from all monitoring points using a 4-gas meter (MultiRAE Lite), and volatile organic compounds (VOCs) will be measured using a photoionization detector (PID). The MultiRAE lite measures methane percent by volume in LEL% until there is a measurable level of methane, which will then be reported in parts per million. The operating manual for the MultiRAE Lite is provided in Attachment 3. If measurements are collected from existing piezometers or monitoring wells, well caps will be modified with barbed fittings for collection of soil gas measurements. Three tubing volumes will be purged using a peristaltic pump prior to recording baseline measurements. A low-flow extraction of 0.03 to 0.07 cfm will be used.

During purging, measurements of VOCs, carbon dioxide, oxygen, hydrogen sulfide, and LEL (methane) will be recorded at 3- to 5-minute intervals. Purging will continue until parameters are approximately stable (within 10%) for three consecutive readings, or until a maximum of 30 minutes of purging has elapsed. Final measurements will be recorded as baseline concentrations.

AIR INJECTION TEST

Air injection testing will consist of two parts: step testing with different injection flow rates and a 24-hour continuous injection. Fresh air will be provided to MW-10 or PZ-6, depending on groundwater levels and final locations of the vapor monitoring points, which will be determined in the field. However, it will be preferable to use a well, such as MW-10, to provide fresh air because it was installed with a bentonite seal.

The pilot test may also include measuring the pressure effect in an adjacent well and/or piezometer location. This will be accomplished by using a Magnehelic™ or equivalent pressure gauge fixed to a 2-inch PVC cap. The cap with a pressure gauge will be placed over the top of casing of adjacent monitoring wells or piezometers that will not be used for collecting soil gas samples or injecting air, such as MW-10, PZ-6, PZ-7, or PZ-12, pending final layout and air injection point. The initial pressure will be recorded, and once the blower is turned on, the pressure over time will be recorded. Typical record sheets for the bioventing pilot test study are included in Attachment 1.

During step testing, the regenerative blower will be used to apply three different injection flow rates for approximately 1 hour each. Injection flow rate steps will be applied at approximately 10 cfm, 15 cfm, and 20 cfm. Actual flow rates may vary based on site conditions. Pressure response will be measured in the wells identified above at approximately 30-minute intervals during the step tests with a pressure gauge. If short circuiting is observed at the low flow rate, additional tests will be performed on other wells.

After the completion of step testing, the 24-hour continuous injection test will commence at the test well. The injection rate will be determined based on results of the step test. If there is no power at the property, a portable generator can be used to supply power to the injection blower during the test.

Respirometry testing will be conducted periodically during air injection. This will include collection of VOC readings via PID and carbon dioxide, oxygen, hydrogen sulfide, and LEL measurements from the newly installed measuring points using a four-gas meter over time. These measurements will be compared with baseline measurements. Typically, measurement of soil gas will be conducted at 2, 4, 6, and 8 hours, depending on permeability of the soil. Increases in oxygen and decreases in carbon dioxide concentrations indicate that fresh air is influencing the sampling point. Prior to the end of the test, a final round of wellhead pressure measurements and air readings will be collected to evaluate the oxygen/carbon dioxide concentrations and pressure ROIs relative to the injection location.

The pressure ROI will be estimated based on plotting the wellhead pressure measurements versus distance from the test well. A value of 0.1 inches of water will indicate adequate pressure distribution. Respirometry test results will be analyzed to estimate biodegradation rates based on oxygen utilization rates.

POST INJECTION MEASUREMENTS

After the injection test, the blower will be turned off and measurements will be collected again from adjacent locations over time, depending on the rate at which oxygen is utilized. If oxygen uptake is rapid, more frequent monitoring is required. If it is slower, less frequent readings are acceptable. Increases in carbon dioxide and decreases in oxygen concentrations are indications of biological metabolism of constituents. Typical record sheets for the bioventing pilot test study are included in Attachment 1.

ENGINEERING DESIGN REPORT ADDENDUM

After the pilot test, air monitoring results will be evaluated. If the pilot test indicates that the lateral ROI is at least 20 feet at reasonably low injection rates of 10 to 20 cfm, then the proposed bioventing system will consist of 2-inch piping with either horizontal or vertical screens placed above the groundwater table with areas of remaining residual contamination as shown on Figure 2. If results indicate that the lateral ROI is greater or less than 20 feet, the system layout will be redesigned to be more efficient or more effective, respectively. An Engineering Design Report addendum will be prepared following the pilot test to provide details such as the field limits of residual soil contamination, pilot test results, and a proposed final design and specifications of the system. The addendum will also include an Operations and Maintenance Plan. If results show that providing fresh air with a blower does not produce ideal results, then other options will be discussed with Ecology, such as providing fresh air in one location and pulling air out at another location. This would provide a single point to sample for respirometry testing and avoid channelization.

SCHEDULE

Field activities for this scope of work will be conducted in the late spring or early summer of 2022 during the mobilization of the Phase II remedial activities that will be performed on the Toad's property. Refer to Appendix D of the 2020 Floyd|Snider Engineering Design Report for the Health and Safety Plan associated with the bioventing pilot test field activities.

REFERENCES

U.S. Environmental Protection Agency (USEPA). 1995. *Manual for Bioventing Principles and Practice Volume 2: Bioventing Design.* EPA 540/R-95/534a. September.

_____. 2017. *How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites*. A Guide For Corrective Action Plan Reviewers. EPA 510-B-17-003. October.

Sincerely,
FLOYD | SNIDER

Gabe Cisneros, LG
Senior Geologist

Encl.: Figure 1 Vicinity Map
Figure 2 Approximate Extent of Soil Excavation and Bioventing Pilot Test Area
Attachment 1 Bioventing Forms and Schematic
Attachment 2 Standard Guidelines
Attachment 3 RAE Systems MultiRAE Lite Operation Manual

Figures

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Bioventing Pilot Test Work Plan
Big B Mini Mart Site
Ellensburg, Washington

Figure 1
Vicinity Map

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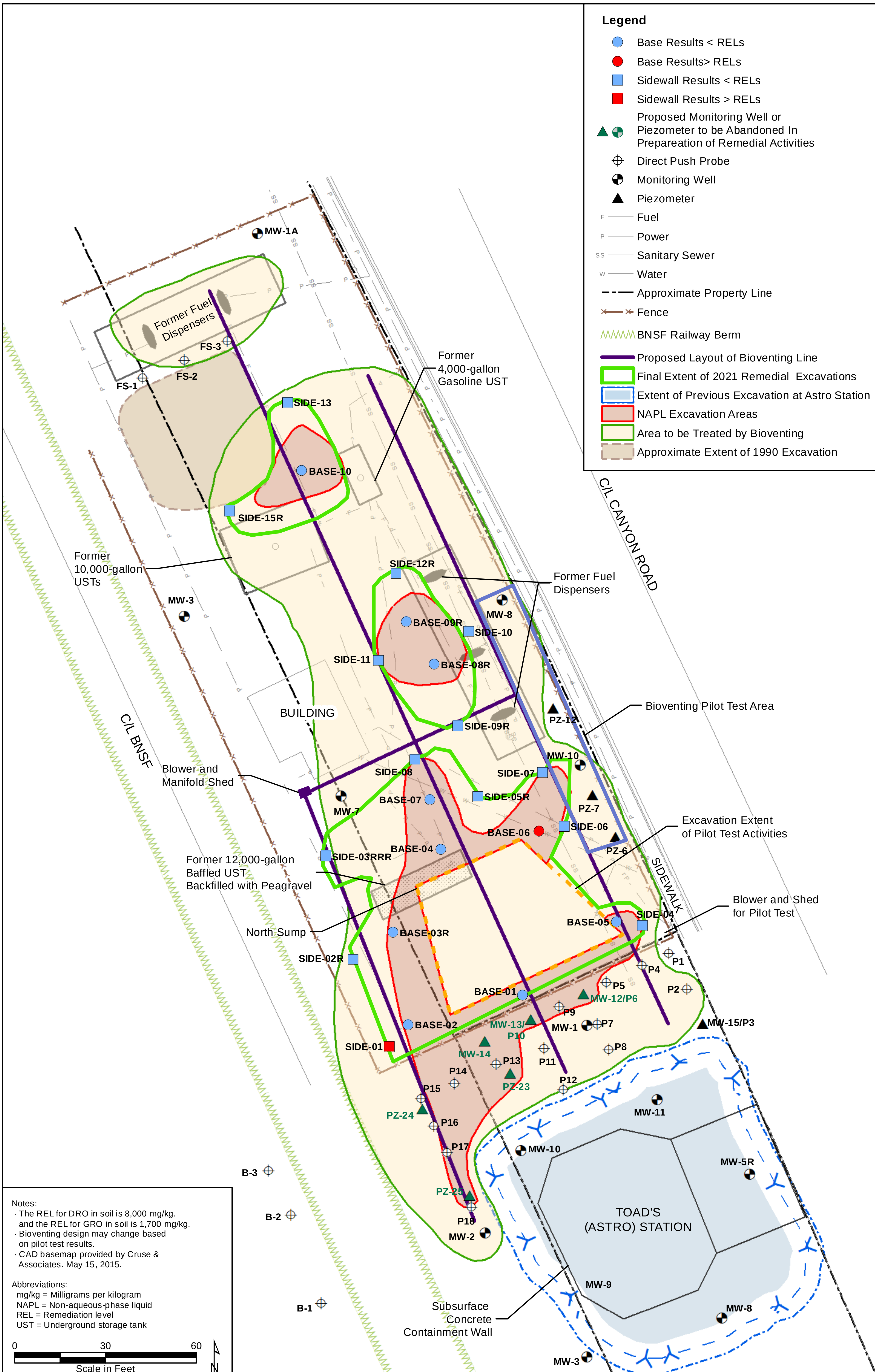

Notes:
- The REL for DRO in soil is 8,000 mg/kg. and the REL for GRO in soil is 1,700 mg/kg.
- Bioventing design may change based on pilot test results.
- CAD basemap provided by Cruse & Associates. May 15, 2015.

Abbreviations:
mg/kg = Milligrams per kilogram
NAPL = Non-aqueous-phase liquid
REL = Remediation level
UST = Underground storage tank

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Bioventing Pilot Test Work Plan
Big B Mini Mart Site
Ellensburg, Washington

Figure 2
Approximate Extent of Soil Excavation and Bioventing Pilot Test Area

I:\GIS\Projects\CL-Ellensburg\MXD\Bioventing Pilot Test Work Plan\Figure 2 Approximate Extent of Soil Excavation and Bioventing Pilot Test Area.mxd
3/14/2022

Attachment 1
Bioventing Forms and Schematic

SITE:	**MONITORING POINTS:**
DATE:	**4-GAS METER SERIAL NO.:**
LOCATION:	**PID SERIAL NO.:**
SAMPLERS:	**SHUTDOWN DATE & TIME:**

Date/ Time	VOCs (ppm)	CO_2%	O_2%	Hydrogen Sulfide (ppm)	%LEL (methane)	Comments	Date/ Time	VOCs (ppm)	CO_2%	O_2%	Hydrogen Sulfide (ppm)	%LEL (methane)	Comments

Date/ Time	VOCs (ppm)	CO_2%	O_2%	Hydrogen Sulfide (ppm)	%LEL (methane)	Comments	Date/ Time	VOCs (ppm)	CO_2%	O_2%	Hydrogen Sulfide (ppm)	%LEL (methane)	Comments

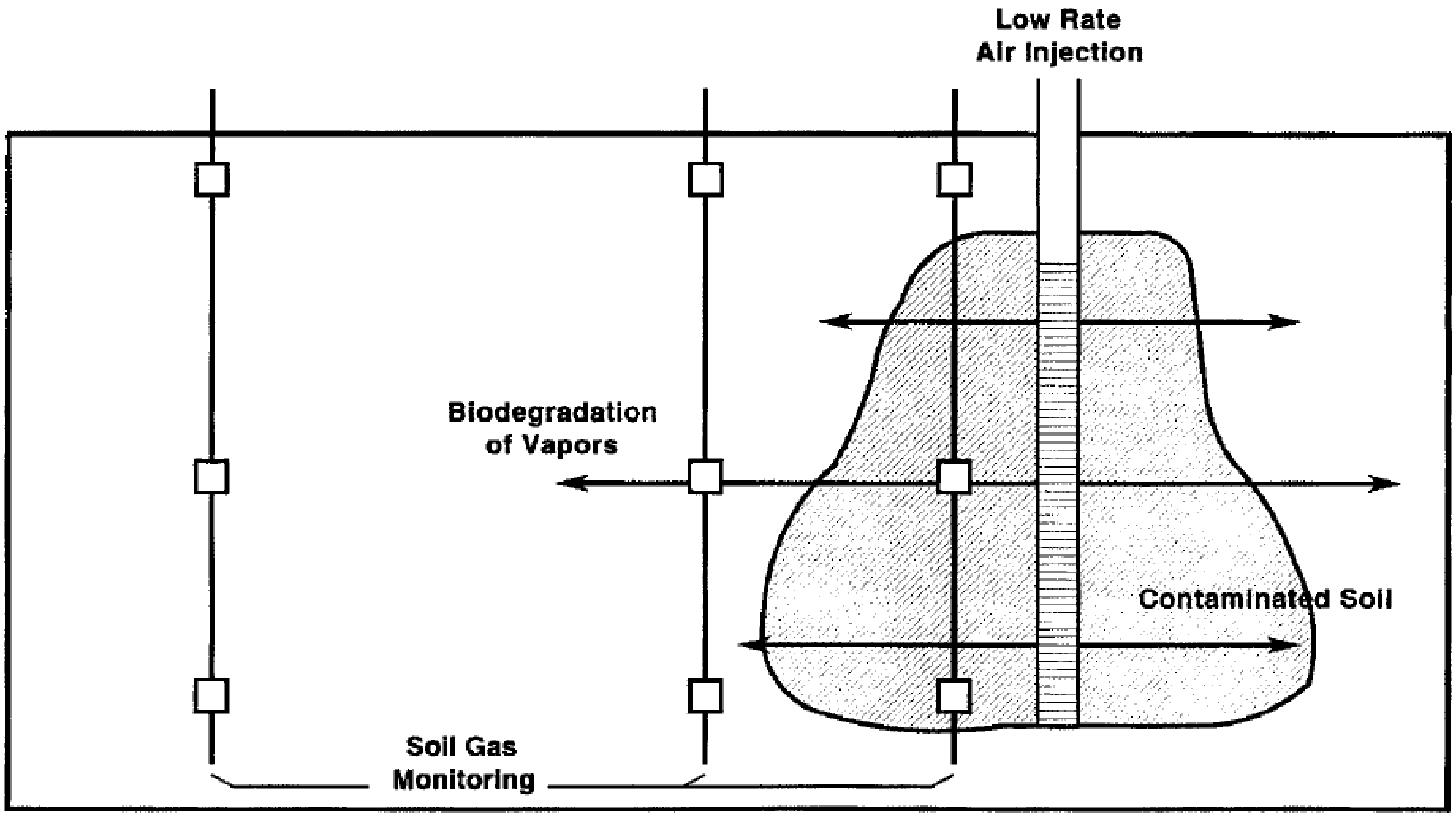
Air Permeability Test.

SITE____
DATE ____
SAMPLER(S)____________________________________

TYPE OF TEST____
TEST DATE____
TIME ____

Pressure/Vacuum
("H_20)

Distance from Injection Well (ft)						Distance from Injection Well (ft)					
Time	In(t)	**MP1**	**MP2**	**MP3**	**MP4**	Time	In(t)	**MPS**	**MP&**	**IIP7**	**IIP8**



Air injection configuration for a bioventing system.

Schematic diagram of a basic air injection system that will be utilized during the bioventing pilot test. The system is relatively simple involving a blower and monitoring points spaced at increasing distances from the injection point. Fresh air is injected at a low-flow rate and will not produce significant air emissions or require aboveground vapor-phase treatment. Schematic from Figure 2-6 in USEPA's 1995 *Bioventing Principles and Practices Volume II: Bioventing Design*.

Attachment 2
Standard Guidelines

Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

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.

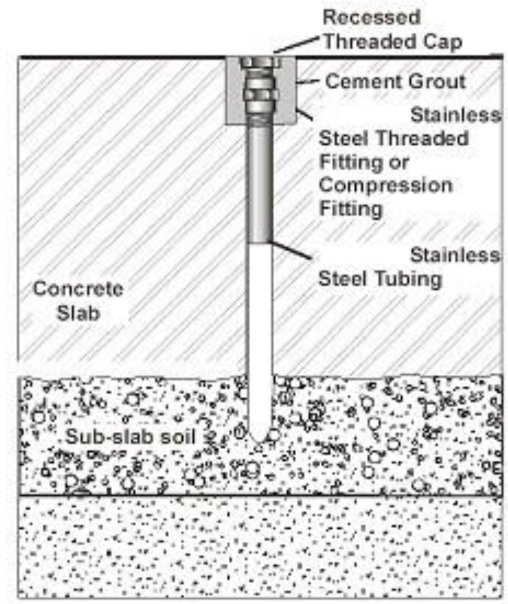
e. For flush mount installations, cover the Vapor Pin® with a flush mount cover, using either the plastic cover or the optional stainless-steel Secure Cover provided by Vapor Pin®.

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 treads. 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 ($\mu g/m^3$):

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

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.

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_____. 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.

_____. 2018b. *Petroleum Vapor Intrusion (PVI): Updated Screening Levels, Cleanup Levels, and Assessing PVI Threats to Future Buildings: Implementation Memorandum No. 18*. Prepared by the Toxics Cleanup Program. Publication No. 17-09-043. January.

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 Grade: _____________ ☐ Basement ☐ Slab-On-Grade ☐ Crawl Space

Bldg Dimensions: Width:______ Length: ________ Height: _________

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

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:_____________

<u>Outside Contaminant Sources</u>

Nearby surrounding property sources: Gas Stations / Emission Stacks

Soil Contamination: Petroleum Hydrocarbons / Solvents

Heavy Vehicle Traffic: Yes / No

<u>Indoor Contaminant Sources</u>

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		

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: ____________________________________

	Vacuum Test		Purging				Helium		Sampling				PID		
Soil Vapor Sampling Point ID	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	Notes
					167										
					167										

Notes:

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Standard Operating Procedure
Installation and Extraction of the Vapor Pin®

Updated September 9, 2016

Scope:

This standard operating procedure describes the installation and extraction of the VAPOR PIN® for use in sub-slab soil-gas sampling.

Purpose:

The purpose of this procedure is to assure good quality control in field operations and uniformity between field personnel in the use of the VAPOR PIN® for the collection of sub-slab soil-gas samples or pressure readings.

Equipment Needed:

- Assembled VAPOR PIN® [VAPOR PIN® and silicone sleeve(Figure 1)]; Because of sharp edges, gloves are recommended for sleeve installation;
- Hammer drill;
- 5/8-inch (16mm) diameter hammer bit (hole **must** be 5/8-inch (16mm) diameter to ensure seal. It is recommended that you use the drill guide). (Hilti™ TE-YX 5/8" x 22" (400 mm) #00206514 or equivalent);
- 1½-inch (38mm) diameter hammer bit (Hilti™ TE-YX 1½" x 23" #00293032 or equivalent) for flush mount applications;
- ¾-inch (19mm) diameter bottle brush;
- Wet/Dry vacuum with HEPA filter (optional);
- VAPOR PIN® installation/extraction tool;
- Dead blow hammer;
- VAPOR PIN® flush mount cover, if desired;
- VAPOR PIN® drilling guide, if desired;
- VAPOR PIN® protective cap; and
- VOC-free hole patching material (hydraulic cement) and putty knife or trowel for repairing the hole following the extraction of the VAPOR PIN®.

Figure 1. Assembled VAPOR PIN®

Installation Procedure:

1) Check for buried obstacles (pipes, electrical lines, etc.) prior to proceeding.

2) Set up wet/dry vacuum to collect drill cuttings.

3) If a flush mount installation is required, drill a 1½-inch (38mm) diameter hole at least 1¾-inches (45mm) into the slab. Use of a VAPOR PIN® drilling guide is recommended.

4) Drill a 5/8-inch (16mm) diameter hole through the slab and approximately 1-inch (25mm) into the underlying soil to form a void. Hole **must** be 5/8-inch (16mm) in diameter to ensure seal. It is recommended that you use the drill guide.

5) Remove the drill bit, brush the hole with the bottle brush, and remove the loose cuttings with the vacuum.

6) 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 over the vapor pin to protect the barb fitting, and tap the vapor pin into place using a dead blow hammer (Figure 2). Make sure the installation/extraction tool is aligned parallel to the vapor pin to avoid damaging the barb fitting.

Figure 2. Installing the VAPOR PIN®

During installation, the silicone sleeve will form a slight bulge between the slab and the VAPOR PIN® shoulder. Place the protective cap on VAPOR PIN® to prevent vapor loss prior to sampling (Figure 3).

Figure 3. Installed VAPOR PIN®

7) 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 (Figure 4).

Figure 4. Secure Cover Installed

8) Allow 20 minutes or more (consult applicable guidance for your situation) for the sub-slab soil-gas conditions to re-equilibrate prior to sampling.

9) Remove protective cap and connect sample tubing to the barb fitting of the VAPOR PIN®. This connection can be made using a short piece of Tygon™ tubing to join the VAPOR PIN® with the Nylaflow tubing (Figure 5). Put the

Nylaflow tubing as close to the VAPOR PIN® as possible to minimize contact between soil gas and Tygon™ tubing.

Figure 5. VAPOR PIN® sample connection

10) Conduct leak tests in accordance with applicable guidance. If the method of leak testing is not specified, an alternative can be the use of a water dam and vacuum pump, as described in SOP Leak Testing the VAPOR PIN® via Mechanical Means (Figure 6). For flush-mount installations, distilled water can be poured directly into the 1 1/2 inch (38mm) hole.

Figure 6. Water dam used for leak detection

11) Collect sub-slab soil gas sample or pressure reading. When finished, replace the protective cap and flush mount cover until the next event. If the sampling is complete, extract the VAPOR PIN®.

Extraction Procedure:

1) Remove the protective cap, and thread the installation/extraction tool onto the barrel of the VAPOR PIN® (Figure 7). Turn the tool clockwise continuously, don't stop turning, the VAPOR PIN® will feed into the bottom of the installation/extraction tool and will extract from the hole like a wine cork, DO NOT PULL.

2) Fill the void with hydraulic cement and smooth with a trowel or putty knife.

Figure 7. Removing the VAPOR PIN®

- Prior to reuse, remove the silicone sleeve and protective cap and discard. Decontaminate the VAPOR PIN® in a hot water and Alconox® wash, then heat in an oven to a temperature of 265° F (130° C) for 15 to 30 minutes. For both steps, **STAINLESS – ½ hour, BRASS 8 minutes**

3) Replacement parts and supplies are available online.

Cox-Colvin & Associates, Inc. Environmental Services

Standard Operating Procedure Leak Testing Vapor Pin™ Via Mechanical Means

December 3, 2013

Scope:

The operating procedure describes the methodology to test a Vapor Pin™ or equivalent sub-slab sampling device and sample train for leakage of indoor air. Mechanical leak testing is generally simpler and less costly than testing with tracer gases such as helium, but relevant state, program, or other guidance documents should be consulted to determine if a specific type of leak test is needed.

Purpose:

The purpose of this procedure is to ensure that indoor air does not leak past the Vapor Pin™ or associated tubing and hardware and dilute the sub-slab soil gas sample with indoor air.

Equipment Needed:

Stick-up installation: 2-inch diameter plastic pipe couple, Play-Doh, Sculpey, or modeling clay (clay) free of volatile organic compounds (VOCs). Stick-up and flush-mount installations: distilled water; Vapor Pin™; vacuum pump (hand-operated or peristaltic); vacuum gauge; stopcock; and sample train, including sample tubing, tee fittings, vacuum gauge and other hardware, and sample container.

Procedures:

1. Drill a 5/8" diameter hole in the concrete slab and install the Vapor Pin™ as per the Standard Operating Procedure (SOP). For a flush-mount installation, drill the 1-1/2" diameter hole first, and follow Use of the Vapor Pin™ Drilling Guide and Secure Cover. Testing evacuated ("Summa") canisters and regulators in accordance with ASTM standard D7663-11 or Restek Corporation's *A Guide to Whole Air Canister Sampling* prior to starting field work eliminates most risk of leakage when sampling with the Vapor Pin™.

2. Install the Vapor Pin™ as described in the SOP Installation and Extraction of the Vapor Pin™.

3. Clean the slab within a 2-inch radius of the Vapor Pin™ to remove all dust. Avoid wetting the concrete or wait until the concrete is dry before proceeding, and avoid cleaning with VOC-containing substances. A whisk broom or shop vacuum is recommended. Remaining dust can be picked up with a scrap of clay.

4. For a flush-mount installation, water is poured directly into the 1-1/2" depression without the need for a water dam - proceed to the next step. For a stick-up installation, roll a 1-inch diameter ball of clay between your palms to form a "snake" approximately 7 inches long and press it against the end of the 2" pipe couple. Push the couple against the slab to form a seal between the pipe and the concrete. Notice that water soluble clays such as Play-Doh may absorb enough water to be unsuitable for tests lasting more than one hour.

5. Assemble the sample train (tubing, sample canister, tee fittings, stopcock, vacuum pump, etc.) separately from the Vapor Pin™ and impose a vacuum of 15" mercury equivalent (in Hg). Close the stopcock and verify that the sample train can hold a vacuum for one to five minutes with no more than 0.5 in Hg loss of vacuum. Depending on sample configuration, the stopcock might or might not remain in the sample train during sampling. An example is shown in Figure 1.

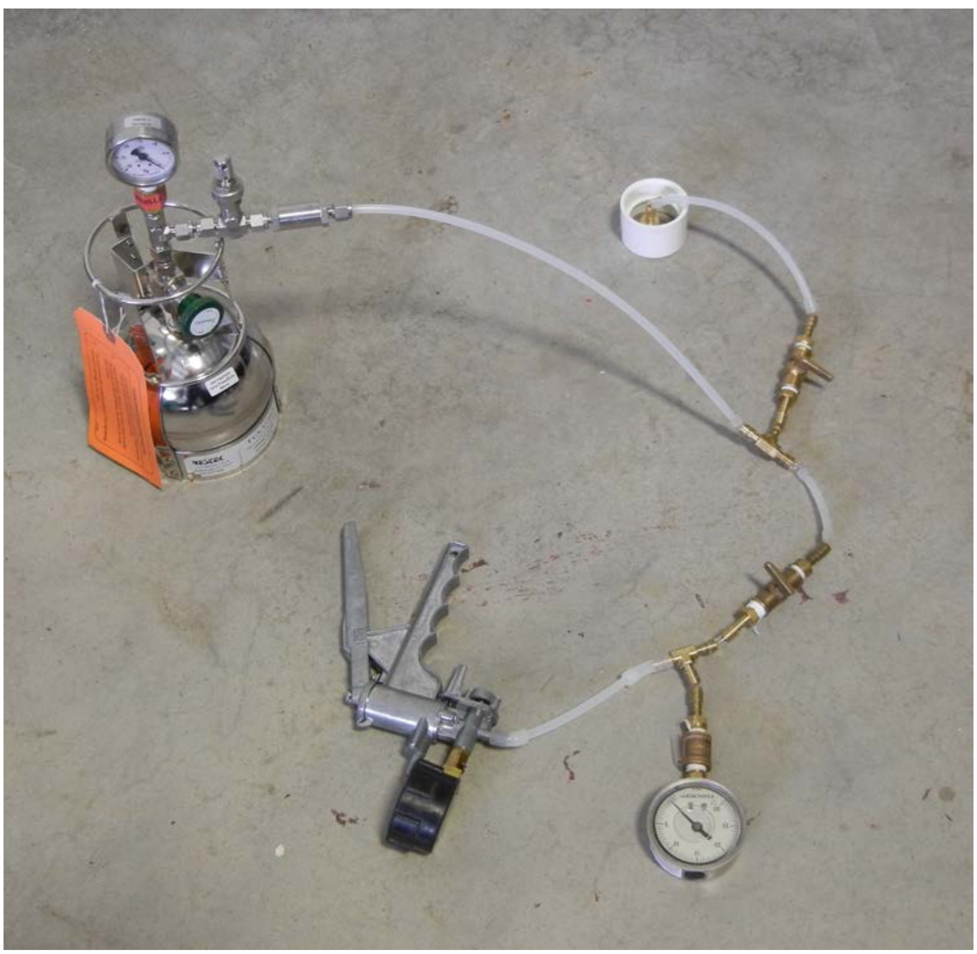

Figure 1. Example of Sub-Slab Sampling and Leak-Test Setup

6. Attach the sample tubing to the top of the Vapor Pin™ and pour enough distilled water into the pipe couple or flush-mount depression to immerse the tubing connection to the Vapor Pin™.

7. Purge and sample the sample point as required by the data quality objectives. Water level might drop slightly due to absorption into the concrete, but if there is a sudden drop in water level, the appearance of water in sample tubing, or other indication of water entering the sub-slab, remove the distilled water from the couple or depression, and reposition the Vapor Pin™ to stop the leakage before resuming the leak test and sampling. In Figure 1, the stopcocks are used to isolate the Vapor Pin™ during vacuum testing and subsequently to allow the vacuum gauge and hand pump to be removed prior to sampling.

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Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

F|S STANDARD GUIDELINE

COVID-19 Health and Safety Guidelines

This Special Condition must be appended to all Floyd|Snider Standard Guidelines beginning immediately (March 26, 2020) and until such a time that the COVID-19 crisis is no longer a Washington health risk as determined by the Governor of the State of Washington.

Floyd|Snider is dedicated to helping our community during this unique time in history. Our work is essential to the continued protection of our community and the environment. As such, this special condition is to inform our staff on how to both comply with the "Stay Home – Stay Healthy" Order issued by the Washington Governor effective March 25, 2020, and continue our business safely.

Much of our work can be done from home, but there is vital work that must be done in the field to collect data, implement construction, and move forward our clients' essential work. We will continue our field work in a safe and thoughtful manner, acknowledging that there may be cases where it is determined that field work will be delayed, due to lack of needed supplies; concerns with availability of staff or teaming partners; or concerns regarding potential exposure risks to our staff members, clients, subcontractors or the public.

DATE/LAST UPDATE: March 27, 2020

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 and special procedures 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 and special conditions 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 and special conditions.

1.0 Special Condition Applicability

Much of our field work is done outside and can be done while maintaining safe social distancing (defined as maintaining 6 feet of distance between people at all times). Adjustments will be made as needed to move field work forward while ensuring staff safety. Decisions regarding going forward with field work or postponing will be made on an event-by-event basis by the Project Manager (PM), in consultation with Principals as necessary.

ALL field staff have stop work authority. If at any time you feel uncomfortable with the planned work, or cannot safely complete a task once onsite, stop work and communicate with your project team. Employee health and safety takes precedence over schedule and budget. Keep your PM informed of any concerns so the team can identify a solution.

2.0 Equipment and Supplies

The following is a list of additional equipment and supplies necessary to maintain health and safety during the COVID-19 pandemic. This list is intended as a guide to facilitate planning and preparation and is not intended to be all encompassing.

- Project-specific personal protection equipment (PPE), including but not limited to, disposable nitrile gloves, work gloves, and safety glasses
- Hand cleaner, including soap and water or hand sanitizer. 5-gallon buckets may be used to create a temporary wash station.
- Surface cleaner, including disinfection wipes, paper towels, and spray disinfectant
  - Bleach (or similar disinfectant solution)
  - Distilled or deionized water
  - Spray bottles
- Trash bags
- Informational “dash card” with talking points explaining our work

3.0 Special Condition Guidelines and/or Procedures

This special condition outlines Floyd|Snider’s general requirements to keep employees safe including requirements regarding staying home when sick, considerations in determining if field work can proceed, additional field preparation requirements, safety precautions to take while in the field, and communication protocols at the completion of field events.

If you or someone you are in direct extended contact with are at high-risk for severe illness from COVID-19 (are age 65 or older; live in a nursing home or long-term care facility; suffer from heart conditions, lung disease, asthma; are immunocompromised; or are pregnant) and you are not available to perform field work due to heightened risk, communicate with your PM and help to identify suitable backup personnel to complete the field work.

As mentioned above, everyone has stop work ability. If you feel uncomfortable with an assigned task, before or during fieldwork, pause and speak with your PM.

3.1 FLOYD|SNIDER GENERAL REQUIREMENTS AROUND COVID-19

It is critical that individuals NOT report to work, which includes field work, while they or anyone they have come in direct contact with is experiencing symptoms of illness such as fever, cough, gastrointestinal symptoms, loss of sense of taste or smell, shortness of breath, sore throat, runny/stuffy nose, body aches, chills, or fatigue. Individuals should consult their doctor over the phone and potentially seek medical attention if they develop these symptoms, especially any respiratory illness. If you or anyone you have come in direct contact with are sick and exhibit ANY of the COVID-19 symptoms described above, you must do the following:

- If you are experiencing any of the symptoms listed above, stay home and do not return to work until you are free of fever (100.4 °F [38.0 °C] or greater using an oral thermometer), signs of a fever, and any other symptoms for at least 72 hours, without the use of fever-reducing or other symptom-altering medicines (e.g., cough suppressants), and at least 7 days have passed since symptoms first appeared.
- You should monitor your health for fever, cough, and shortness of breath during the 14 days after the last day you were in close contact with a person with confirmed or suspected COVID-19. You should not go to work or school and should avoid public places for 14 days.
- Notify your PM if you are part of a field team and help to identify suitable backup personnel to complete the field work.
- If you have a suspected case of COVID-19, do not go back to work until testing has come back negative, or a 14-day quarantine period has passed following subsidence of symptoms.
- If you have a confirmed case of COVID-19, you must tell Tiffany Volosin immediately, and she will relay information to the firm and any subconsultants you have come in contact with in the field, without revealing your identity. You will then be required to remain home until cleared by a medical professional.

As mentioned above, everyone has stop work ability. If you feel uncomfortable with an assigned task, before or during fieldwork, pause and speak with your PM.

3.2 GENERAL CDC GUIDANCE ON STAYING HEALTHY

General guidelines from the Centers for Disease Control and Prevention (CDC) can be found at https://www.cdc.gov/coronavirus/2019-nCoV/index.html. Basic hygiene requirements provided by the CDC include the following:

- Practice and encourage good hand hygiene.

- Wash your hands often with soap and water for at least 20 seconds, especially after coming in contact with high-touch surfaces; direct contact with another person; going to the bathroom; before eating; and after blowing your nose, coughing, or sneezing.
- If soap and water are unavailable, use an alcohol-based hand sanitizer that contains at least 60 percent alcohol to clean hands. Soap and water should be used preferentially if hands are visibly dirty.
- Avoid touching your face.

- Practice and encourage good respiratory etiquette.
  - Cover your nose and mouth when coughing and sneezing. Sneeze into your elbow, not your hands. If you do cough or sneeze into your hands, wash your hands immediately, per above.
  - Avoid close (within 6 feet) contact with other people. Because COVID-19 can be carried by people who do not show symptoms, proper distancing is necessary to reduce potential for transfer.
  - If you or someone you are in direct contact with are ill, you must stay home.

3.3 PLANNING FOR FIELD WORK

As part of the field work planning process, the project team must review the following to make a threshold decision regarding whether the work may go forward or should be postponed due to the inability to ensure social distancing and to safely follow other mandatory procedures essential to the task.

- Does the work require use of subcontractors or equipment or involve other conditions that would make maintaining a safe social distance (6 feet) difficult?
- Is interacting closely with the public required to conduct the work?

Decisions regarding postponing a field event will be made on an event-by-event basis by the PM, in consultation with Principals as necessary. Reasons for postponing may include management concerns, field staff concerns, availability of field equipment or PPE necessary to complete the work, or subcontractor availability or safety concerns.

If it is determined that the field work will move forward, field planning must include the following steps:

- Confirm subcontractor/subconsultants have COVID-19 policies/procedures in place for their and your protection:
  - What is their corporate stance on the current condition?
  - What protocols will they put in place to ensure that their workers are safe?
  - What protocols will they put in place to reduce potential exposure to our workers and the public?

- Confirm with your laboratory and equipment vendors (if using rental equipment) what protocols they have in place for pickup/drop off, business hours, and any other changes from their standard operating procedures and turnaround times that may affect your fieldwork.
- If fieldwork is out of town, coordinate with the hotel to confirm they are still open and ensure they are sanitizing rooms appropriately.
  - If feasible, consider commuting to jobsites from home rather than booking a hotel to minimize potential exposure.
- Discuss potential risk factors that may arise during the work with your project team. Take extra caution to limit the potential for these risk factors to impact you.
- Prior to mobilization, coordinate with the client or local businesses to identify restroom and hand-washing facilities available for use and confirm their sanitation practices.
  - Consider renting portable restrooms and hand-washing stations for field events that do not have a restroom onsite. It may not be possible to find a nearby business that will allow you to enter and use the restroom.
  - Request additional/increased sanitation (disinfecting) of portable toilets and hand-washing stations, at least twice per week, and ensure they are fully stocked.
- Identify additional gear/supplies that may be necessary for increased health and safety protection that are not typical on our job sites: If you are using a lot of reusable equipment that will require decontamination (both of the equipment and its storage cases, coolers, etc.), consider if use of a bleach/water wash and towels/rags would be better than use of disposable disinfectant wipes that are in high demand and low supply.
- Conduct an inventory check for PPE including gloves, paper towels, soap and water, sanitizer wipes, and hand sanitizer. If any of these necessary items are not available in sufficient quantity, coordinate with Tyler Scott or Terry Duncan, and if not available in time, coordinate with your PM to determine if work can be rescheduled. Identify additional supplies to bring to the site to support safe work. For example:
  - **Work Stations:** Think through how you will maintain social distancing (minimum of 6 feet) at all times on your site. If you are processing soil or sediment samples, bring two tables to allow for two different workspaces. Identify alternative methods for moving heavy equipment if it is usually a two-person job, and have the equipment necessary to complete this work in a safe manner.
  - **Hand-Washing Stations:** If you will not have access to a restroom facility, bring extra buckets, deionized water, and soap to set up your own hand-washing station onsite.
- Bring sufficient copies of field documents/forms and pens, etc., to allow for each employee to have their own set and use electronic communication whenever

possible. Determine which staff member will use field notebooks and pens and maintain that individual setup throughout the day's work. Do not share hand-held supplies, unless gloves are used at all times to handle those supplies until those supplies are disinfected.

3.4 PERFORMING FIELD WORK

3.4.1 Prior to Fieldwork and Entering the Site

The day before fieldwork: The Health and Safety Officer (HSO) should call all employees to confirm healthy status prior to mobilization to the field. If a staff member answers "yes" to any of the questions below, they will not be allowed to complete the fieldwork. For all subcontractors, the HSO should contact the subcontractor to ask the following questions to their field staff assigned to the job prior to their arrival at the site. If a subcontractor answers "yes" to any of the questions, request that someone else get assigned to the job as they will not be allowed onsite.

- Have you, or anyone in your household, been in contact with a person that has tested positive for COVID-19 within the last 14 days?
- Have you, or anyone in your household, been in contact with a person that is in the process of being tested for COVID-19 or suspects they are ill from COVID-19?
- Have you been medically directed to self-quarantine due to possible exposure to COVID-19?
- Are you having trouble breathing or have you had flu-like symptoms within the past 48 hours, including fever, cough, gastrointestinal symptoms, loss of sense of taste or smell, shortness of breath, sore throat, runny/stuffy nose, body aches, chills, or fatigue?

Prior to Entering the Site: The Site Safety Officer (SSO) or Field Lead must ask the above questions again to all staff (Floyd|Snider and subcontractors) prior to beginning work and should continue to assess throughout the day.

- Anyone who has met any of the above criteria and **is not displaying symptoms** must immediately leave the site, the HSO shall notify their PM, and the employee may not return to the site for 14 days.
- Anyone meeting any of the above criteria who **is displaying symptoms** or starts to feel unwell onsite must immediately leave the site, should seek immediate medical advice, notify Tiffany Volosin (and their office manager if a subcontractor), and remain home until medical clearance is received.
- If any person arriving onsite shows obvious symptoms of illness, they will be sent home immediately, prior to accessing the jobsite.

3.4.2 During Mobilization

- Wear gloves during equipment and cooler loading.
- Keep field vehicles stocked with disinfecting wipes and hand sanitizer.
- If using the field van or a rental vehicle, wipe down the door handles (inside and out), steering wheel, shifters (gearing, windshield wipers, turn signals, etc.), radio dials, and any other frequently touched area with a disinfecting wipe (or spray and wipe with disinfectant solution) when you enter and when you exit the vehicle.
- If ice is necessary to complete the field work, avoid visiting supermarkets during times set aside for vulnerable populations, which are typically in the morning. Purchase ice at a different time of day or at another business such as a gas station.

3.4.3 During Field Work

- Maintain 6-foot distance from others at all times. When close contact is unavoidable, stop work and discuss how to proceed, such as dividing tasks or additional disinfection methods.
    - Conduct Safety Meetings in small groups while maintaining distance. The Field Lead/SSO will note all attendees rather than passing around sign in sheets to confirm attendance.
- Implement "Take 5"s. Take 5 minutes between EACH task to identify new hazards, possible ways for unacceptable contact to occur, and methods to avoid those conditions. Record results of these Take 5s in the field notebook.
- Gloves should be worn at all times while onsite. This includes wearing gloves when handling coolers and equipment, when packing equipment and gear, during bottle delivery to the laboratory, and during completion of the work. While wearing gloves for all activities, also be cognizant of the limited supply of these materials. Change gloves only when needed per our standard sampling procedures, and for compliance with this Special Condition.
    - The type of glove worn should be appropriate to the task, and work gloves should be used when acceptable rather than nitrile, recognizing the limited supply of these PPE. If gloves are not typically required for the task, then any type of glove is acceptable, and work gloves are recommended.
    - Wash hands after removing gloves.
    - Store gloves close to the point where they will be used to avoid touching multiple surfaces to obtain fresh gloves – for example if using multiple vehicles to transport equipment to different places onsite, ensure there is a supply of gloves in each vehicle.
- Isolate sick field staff. CDC recommends that employees who become sick during the day should be sent home immediately. If they are unable to make their way home on

their own, the employee or subconsultant should be separated from other employees. If necessary, call 911 for transport and be sure to mention any COVID-19 symptoms so emergency responders are prepared.

- Do not share tools or any multi-user devices and accessories such as iPads, laptops, hand-held radios, computer stations, etc., unless sanitized between users.
- Do not share PPE.
- Sanitize reusable PPE per manufacturer's recommendation prior to each use.
- Ensure used disposable PPE is disposed of properly.
- Eye protection should be worn all times while onsite.
- Job site offices/trailers and break/lunchrooms must be cleaned at least twice per day (doorknobs, keyboards, counters, and other surfaces).
- Do not use a common water cooler. All staff should bring their own filled water bottles sufficient for the day.
- Utilize disposable hand towels and no-touch trash receptacles, when possible.
- Avoid cleaning techniques, such as using pressurized air or water sprays, that may result in the generation of bioaerosols. If these methods are required, ensure that all other staff are outside of and well away from the spray area, and confirm use of proper PPE, including eye protection, before starting cleaning.

3.4.4 Throughout the Field Event

- Commute separately to field sites to maintain social distancing (minimum of 6 feet). Check with your PM to determine whether separate vehicles are a project-billable or admin expense.
- Use paper towel or wipes (or wear protective gloves) when using pay parking kiosks, fueling vehicles, or at other locations that require contact with surfaces touched by others, such as gas nozzles and keypads. Wipe down credit cards after use.
- Identify specific locations and practices for daily trash such as paper, hand towels, gloves, and food containers.
- Trash from trailers or the job site should be changed frequently by someone wearing gloves. After changing the trash, the employee should throw the gloves away and wash their hands.
- Floyd|Snider staff will provide a copy of this Special Condition to all employees on the jobsite, pointing out this list of key CDC recommendations:
  - How to Protect Yourself: https://www.cdc.gov/coronavirus/2019-ncov/prepare/prevention.html
  - If You are Sick: https://www.cdc.gov/coronavirus/2019-ncov/if-you-are-sick/index.html
  - COVID-19 Frequently Asked Questions: https://www.cdc.gov/coronavirus/2019-ncov/faq.html

3.3.5 During Demobilization

- Wear gloves during equipment and cooler loading and unloading.
- Keep field vehicles stocked with disinfecting wipes and hand sanitizer.
- If using the field van or a rental vehicle, wipe down the door handles (inside and out), steering wheel, shifters (gearing, windshield wipers, turn signals, etc.), radio dials, and any other frequently touched area with a disinfecting wipe when you enter and when you exit the vehicle.
- At the end of each use for hand-held field equipment, or at the end of the workday, decontamination procedures listed above for all equipment and vehicles should be conducted prior to packing vehicles or leaving the site. This includes all reusable field equipment and hand-held equipment and cases (even if used with gloves), such as GPS, pumps, pump cords, and meters.
- Close down and secure the site each day. Do not leave any equipment or gear onsite overnight.
- Communicate the status of equipment inventory to Terry Duncan and Tyler Scott at the end of the field event. Send an email indicating the remaining quantities in the supply room for gloves, disinfectant wipes, deionized water, Alconox, paper towels, bleach, and shop rags.
- Workers should wash work clothes prior to wear again and change immediately upon arriving home to avoid transfer to your home environment.

4.0 What to Do If Your Team Is Approached by Law Enforcement or the Public

If you are approached by a member of the public, a land owner, or law enforcement inquiring about your work or with a concern with compliance with the "Stay Home – Stay Healthy" Order, you may choose to respond by informing them that you are conducting work on an environmental cleanup site, which is considered by the state to be an essential service. Reference "Dash Cards" may be used to provide additional information to the questioning party. If they have additional concerns, they may call Allison Geiselbrecht, Kate Snider, Jessi Massingale, or Tiffany Volosin to discuss.

If you determine that you need to demobilize from the Site earlier than planned, conduct demobilization activities as listed above before leaving the Site. Notify your PM as soon as it is appropriate to do so. Your safety from all angles is paramount.

Attachment 3
RAE Systems MultiRAE Lite
Operation Manual

Honeywell RAE SYSTEMS

MultiRAE Lite

Wireless Portable Multi-Gas Monitor

The MultiRAE Lite is the optimal one-to-six[1]-gas monitor for personal protection and leak detection applications. The MultiRAE Lite is available in pumped and diffusion versions and features the broadest selection of sensor options in its class. The MultiRAE Lite can be configured to exactly meet the detection needs and compliance requirements of various countries, industries, and applications.

The MultiRAE Lite's optional wireless capability improves safety by providing commanders and safety officers real-time access to instrument readings and alarm status from any location for better situational awareness and faster incident response.

Confined space testing with the MultiRAE Lite

APPLICATIONS

- Personal protection and multi-gas leak detection in industries such as:
  - Chemical
  - Food and beverage
  - Oil and gas (downstream)
  - Pharmaceutical
  - Telecommunications
  - Wastewater treatment
- Fire overhaul

- *Available in pumped and diffusion versions*
- *Highly versatile and customizable*
- *Man Down Alarm with real-time remote wireless notification*
- *Easy maintenance with replaceable sensors, pump, and plug-and-play battery*
- *Fully automatic bump testing and calibration with AutoRAE 2*

FEATURES & BENEFITS

- Wireless access to real-time instrument readings and alarm status from any location
- Unmistakable five-way local and remote wireless notification of alarm conditions including Man Down Alarm[2]
- Over 25 interchangeable sensor options, including PID[4] for VOCs, NDIR5 and catalytic for combustibles, and NDIR for CO_2
- Intelligent sensors store calibration data, so they can be swapped in the field[6]
- Large graphical display with easy-to-use, icon-driven user interface
- Continuous datalogging (6 months for 5 sensors, 24x7)
- Device Management with Honeywell SafetySuite

MultiRAE Lite Specifications

INSTRUMENT SPECIFICATIONS[7]	
SIZE	- Pumped model: 7.6" H x 3.8" W x 2.6" D (193 x 96.5 x 66 mm) - Diffusion model: 6.9" x 3.8" x 2.2" (175 x 96.5 x 56 mm)
WEIGHT	- Pumped model: 31 oz (880 g) - Diffusion model: 26.8 oz (760g)
SENSORS	Over 25 intelligent interchangeable field-replaceable sensors including PID for VOCs, electrochemical sensors for toxic gases and oxygen, combustible LEL and NDIR sensors, and CO_2 NDIR sensor
BATTERY OPTIONS, RUNTIME[8] AND RECHARGE TIME	- Rechargeable Li-ion ~12-hr. (pumped)/18-hr. (diffusion) runtime, < 6-hr. recharge time - Extended duration Li-ion ~18-hr. (pumped)/28-hr. (diffusion) runtime, < 9-hr. recharge time - Alkaline adapter with 4 x AA batteries ~6-hr. (pumped)/8-hr. (diffusion) runtime
DISPLAY	Monochrome graphical LCD display (128 x 160) with backlighting. Automatic screen "flip" feature
DISPLAY READOUT	- Real-time reading of gas concentrations; PID measurement gas and correction factor; Man Down Alarm on/off; visual compliance indicator; battery status; datalogging on/off; wireless on/off and reception quality. - STEL, TWA, peak, and minimum values
KEYPAD BUTTONS	Automatic with AutoRAE 2 Test and Calibration System3 or manual
SAMPLING	Built-in pump or diffusion
CALIBRATION	Automatic with AutoRAE 2 Test and Calibration System or manual
ALARMS	Wireless remote alarm notification; audible (95 dB @ 30 cm), vibration, visible (flashing bright red LEDs), and on-screen indication of alarm conditions - Man Down Alarm with pre-alarm and real-time remote wireless notification[2]
DATALOGGING	Continuous datalogging (6 months for 5 sensors at 1-minute intervals, 24/7) - User-configurable datalogging intervals (from 1 to 3,600 seconds)
COMMUNICATION AND DATA DOWNLOAD	- Data download and instrument set-up and upgrades on PC via desktop charging and PC comm. cradle, travel charger, or AutoRAE 2 Automatic Test and Calibration System[3] - Wireless data and alarm status transmission via built-in RF modem (optional)
WIRELESS NETWORK	ProRAE Guardian Real-Time Wireless Safety System or EchoView Host-based Closed-Loop System
WIRELESS RANGE (TYPICAL)	MultiRAE Lite to RAELink3 [Z1] Mesh modem ~330 feet (100 meters) MultiRAE Lite to EchoView Host, RAEMesh Reader or RAEPoint ~660 feet (200 meters) MultiRAE Lite to Wi-Fi Access Point - 330 feet (100 meters)
OPERATING TEMPERATURE	-4° to 122°F (-20° to 50°C)
HUMIDITY	0% to 95% relative humidity (non-condensing)
DUST AND WATER RESISTANCE	IP-65 (pumped); IP-67 (diffusion) ingress protection rating
SAFETY CERTIFICATIONS	CSA: Class I, Division 1, Groups A, B, C and D, T4 Class II, Division 1, Groups E, F, G T85°C ATEX: 0575 II 1G Ex ia IIC T4 Ga 2G Ex ia d IIC T4 Gb with IR Sensor installed I M1 Ex ia I Ma IECEx: Ex ia IIC T4 Ga Ex ia d IIC T4 Gb with IR Sensor installed I M1 Ex ia I Ma IECEx/ANZEx: Ex ia IIC T4 Ga Ex ia d IIC T4 Gb with IR Sensor installed Ex ia I Ma
EMC/RFI[8]	EMC directive: 2004/108/EC
PERFORMANCE TESTS	LEL CSA C22.2 No. 152; ISA-12.13.01
LANGUAGES	Arabic, Chinese, Czech, Danish, Dutch, English, French, German, Indonesian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Russian, Spanish, Swedish, and Turkish
WARRANTY	- Four years on Liq O_2 sensors - Three years on CO and H_2S sensors - Two years on non-consumable components and catalytic LEL sensors - One year on all other sensors, pump, battery, and other consumable parts
WIRELESS FREQUENCY	ISM license free band. IEEE 802.15.4 Sub 1GHz - Wi-Fi 802.11 b/g
WIRELESS APPROVALS	FCC Part 15, CE R&TTE, Others[10]
RADIO MODULE	Supports RM900A

SENSOR SPECIFICATIONS[7]	RANGE	RESOLUTION
PID SENSORS[4]		
VOC 10.6 EV	0 to 1,000 ppm	1 ppm
COMBUSTIBLE SENSORS		
CATALYTIC LEL	0 to 100% LEL	1% LEL
NDIR (0-100% LEL METHANE)	0 to 100% LEL	1% LEL
NDIR (0-100% VOL. METHANE)[5]	0 to 100% Vol.	0.1% Vol.
CARBON DIOXIDE SENSOR		
CARBON DIOXIDE (CO_2) NDIR	0 to 50,000 ppm	100 ppm
ELECTROCHEMICAL SENSORS		
AMMONIA (NH_3)	0 to 100 ppm	1 ppm
CARBON MONOXIDE (CO)	0 to 500 ppm	1 ppm
CARBON MONOXIDE (CO), EXT. RANGE	0 to 2,000 ppm	10 ppm
CARBON MONOXIDE (CO), H_2-COMP.	0 to 2,000 ppm	10 ppm
CARBON MONOXIDE (CO) +	0 to 500 ppm	1 ppm
HYDROGEN SULFIDE (H_2S) COMBO	0 to 200 ppm	0.1 ppm
CHLORINE (CL_2)	0 to 50 ppm	0.1 ppm
CHLORINE DIOXIDE (CLO_2)	0 to 1 ppm	0.03 ppm
ETHYLENE OXIDE (ETO-A)	0 to 100 ppm	0.5 ppm
ETHYLENE OXIDE (ETO-B)	0 to 10 ppm	0.1 ppm
ETHYLENE OXIDE (ETO-C), EXT. RANGE[9]	0 to 500 ppm	10ppm
FORMALDEHYDE (HCHO)	0 to 10 ppm	0.05 ppm
HYDROGEN (H_2)[9]	0 to 1,000 ppm	10ppm
HYDROGEN CYANIDE (HCN)	0 to 50 ppm	0.5 ppm
HYDROGEN SULFIDE (H_2S)	0 to 100 ppm	0.1 ppm
HYDROGEN SULFIDE (H_2S), EXT. RANGE[9]	0 to 1,000 ppm	1 ppm
METHYL MERCAPTAN (CH_3-SH)	0 to 10 ppm	0.1 ppm
NITRIC OXIDE (NO)	0 to 250 ppm	0.5 ppm
NITROGEN DIOXIDE (NO_2)	0 to 20 ppm	0.1 ppm
OXYGEN (O_2)	0 to 30% Vol.	0.1% Vol.
OXYGEN (LIQ O_2)	0 to 30% Vol.	0.1% Vol.
PHOSPHINE (PH_3)	0 to 20 ppm	0.1 ppm
PHOSPHINE H (PH_3 H)	0 to 20 ppm	0.1 ppm
SULFUR DIOXIDE (SO_2)	0 to 20 ppm	0.1 ppm

1 *A two-gas combination sensor is required for a 6-gas configuration.*
2 *Additional equipment and/or software licenses may be required to enable remote wireless monitoring and alarm transmission.*
3 *AutoRAE 2 supports the MultiRAE Lite pumped version only.*
4 *PID sensor requires a pumped configuration.*
5 *NDIR combustible sensors require a pumped configuration in CSA countries.*
6 *RAE Systems recommends calibrating sensors on installation.*
7 *Specifications are subject to change.*
8 *Specification for non-wireless monitors.*
9 *Supported in MultiRAE Lite Diffusion only.*
10 *Please contact RAE Systems for specific wireless approvals*

ORDERING INFORMATION (MODELS: PGM-6208 and PGM-6208D)

- Wireless[2] and non-wireless configurations are available
- Refer to the Portables Pricing Guide for part numbers for monitors, accessories, sampling and calibration kits, gas, sensors, and replacement parts

For more information
www.honeywellanalytics.com
www.raesystems.com

Europe, Middle East, Africa
Life Safety Distribution GmbH
Tel: 00800 333 222 44 (Freephone number)
Tel: +41 44 943 4380 (Alternative number)
Middle East Tel: +971 4 450 5800 (Fixed Gas Detection)
gasdetection@honeywell.com

Americas
Honeywell Analytics Distribution Inc.
Tel: +1 847 955 8200
Toll free: +1 800 538 0363
detectgas@honeywell.com
Honeywell RAE Systems
Phone: +1 408 952 8200
Toll Free: +1 888 723 4800

Asia Pacific
Honeywell Analytics Asia Pacific
Tel: +82 (0) 2 6909 0300
India Tel: +91 124 4752700
China Tel: +86 10 5885 8788-3000
analytics.ap@honeywell.com

Technical Services
EMEA: HAexpert@honeywell.com
US: ha.us.service@honeywell.com
AP: ha.ap.service@honeywell.com

Device Management with
Honeywell SafetySuite

honeywellanalytics.com/SafetySuite

Datasheet_MultiRAE Lite_DS-1071-11_US-EN

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