

# **PASSIVE SOIL GAS TESTING: STANDARD FOR SITE CHARACTERIZATION**



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***Beacon is the recognized leader in  
passive soil gas and air sampling***

**DoD ELAP, NELAP, and ISO/IEC 17025 Accredited Laboratory  
NEFAP Accredited Field Sampling Organization  
Accreditation No. 72690**

## **PASSIVE SOIL GAS TESTING: STANDARD FOR SITE CHARACTERIZATION**

### **Background and Introduction**

Passive soil gas surveys utilize adsorbent samplers that are emplaced subsurface to adsorb volatile and semivolatile organic compounds (VOCs and SVOCs) in soil gas without forcing the flow rate of gas, that can yield a more representative sample than active soil gas methods. Samplers are typically placed in a grid pattern to simultaneously sample trace levels of compounds in soil gas that originate from contamination in soil or groundwater. By sampling all locations at the same time, the temporal variations in soil-gas concentrations that are known to occur daily and even hourly are normalized. In addition, the spatial variability of contamination is better defined with a passive soil gas survey because the lower sampling and analytical costs of the method allow for more locations to be sampled than normally would be with a fixed budget. Passive soil gas (PSG) methods have been demonstrated to be more sensitive and reproducible than active soil gas methods and are able to target a broad range of organic compounds from vinyl chloride to polynuclear aromatic hydrocarbons (PAHs) and other SVOCs.

The analytical results for a passive soil gas method are presented in units of mass (e.g., nanograms of each individual compound) for comparison between sample locations to identify source areas, identify the potential for vapor intrusion, to delineate the lateral extent of contamination, including migration pathways, and to monitor remediation programs. When requested, the mass measured (ng) can be converted to a concentration by dividing the mass (ng) by the sampler uptake rate (ml/min) and the sampling period (min), which is then multiplied by a value of 1,000 to convert ng/ml to ug/m<sup>3</sup>. The Beacon PSG Sampler has verified uptake rates when sampling in air for a suite of chlorinated and BTEX compounds. For soil gas sampling, the concentrations reported represent the concentration of the identified compounds under steady state (natural) conditions by passive sampling, as opposed to active sampling with a pump or evacuated canister that may create a momentary vacuum in the soil during the time of sampling. If the soils at the site have low porosity, the formation itself could limit transport of soil gas to the samplers resulting in the reported concentration being biased low. However, the Beacon sampler has a low and controlled uptake rate to limit this bias from occurring.

Passive soil gas (PSG) results are based on a higher level of QA/QC than can be achieved with other field screening methods. Measurements are based on a five-point initial calibration with the lowest point on the calibration curve at or below the practical quantitation limit of each compound. Internal standards and surrogates are included with each analysis – per EPA Method 8260C – to provide proof of performance that the system was operating properly for each sample and to provide consistent reference points for each analysis, which enables an accurate comparison of measured quantities. Trip blanks are analyzed with each batch of samples and because two sets of hydrophobic adsorbent cartridges are provided in each Sampler, duplicate or confirmatory analyses can be performed for any of the sample locations. A representative list of compounds that can be targeted with passive soil gas surveys is provided in **Table 1**.

**Table 1  
Passive Soil-Gas Survey  
Representative List of Target Compounds**

TPH C <sub>4</sub> -C <sub>9</sub>	Chlorobenzene
TPH C <sub>10</sub> -C <sub>15</sub>	Ethylbenzene
Vinyl Chloride	p & m-Xylene
1,1-Dichloroethene	Bromoform
Methylene Chloride	1,1,2,2-Tetrachloroethane
1,1,2-Trichlorotrifluoroethane (Freon 113)	o-Xylene
trans-1,2-Dichloroethene	1,2,3-Trichloropropane
Methyl-t-butyl ether (MTBE)	Isopropylbenzene
1,1-Dichloroethane	1,3,5-Trimethylbenzene
cis-1,2-Dichloroethene	1,2,4-Trimethylbenzene
Chloroform	1,3-Dichlorobenzene
2,2-Dichloropropane	1,4-Dichlorobenzene
1,2-Dichloroethane	1,2-Dichlorobenzene
1,1,1-Trichloroethane	n-Butylbenzene
1,1-Dichloropropene	1,2,4-Trichlorobenzene
Carbon Tetrachloride	Naphthalene
Benzene	Hexachlorobutadiene
1,2-Dichloropropane	Trichlorobenzenes
Trichloroethene	2-Methylnaphthalene
1,4-Dioxane	Tetrachlorobenzenes
1,1,2-Trichloroethane	Acenaphthylene
Toluene	Acenaphthene
1,3-Dichloropropane	Pentachlorobenzene
1,2-Dibromoethane (EDB)	Hexachlorobenzene
Tetrachloroethene	Phenanthrene
1,1,1,2-Tetrachloroethane	Anthracene

**Note:** Additional compounds may be targeted to meet project specific requirements. The reporting quantitation level (RQL) for each compound is 25 nanograms (ng) and the RQL for TPH is 5,000 ng; however, the demonstrated limit of quantitation (LOQ) for each compound is typically 10 ng.

## **Passive Soil Gas Testing: Standard for Site Characterization**

The following document is broken into two separate parts:

1. General Overview of Passive Soil Gas Investigation for Site Characterization
2. Step-by-Step Passive Soil Gas Sampler Installation and Retrieval

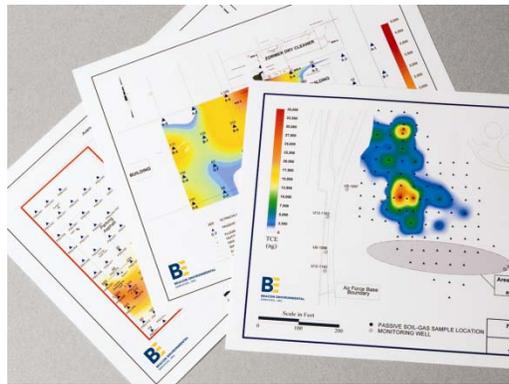
For the complete site characterization, Beacon Environmental recommends a passive soil gas survey be performed followed by a limited and focused soil and/or groundwater sampling program to measure the concentrations of identified compounds. The primary purpose of this document is to describe the methods and procedures used to perform a passive soil gas investigation.

### **Part 1: General Overview of Passive Soil Gas Investigation for Site Characterization**

#### **1.0 Survey Design**

The survey design varies depending on the amount of historical and other site information that is available prior to initiating the passive soil gas (PSG) survey. Typically an unbiased grid is established across the site with additional biased sample locations to target specific features. The spacing between sample locations is dependent upon the expected depth of the chemicals of concern (CoC), the soil types, and the size of the area to be investigated. Generally, a grid with 25-foot spacing between sample locations is used to identify source areas, but the actual spacing will be dependent additionally on the size of the area of investigation and the project budget. Wider grids and transects are used to track groundwater contamination. Global positioning system (GPS) equipment can be used to collect the sample location coordinate data.

Beacon Environmental provides a BESURE Sample Collection Kit™ with detailed instructions to allow samples to be collected by an environmental field technician. Following collection in the field, the samplers are returned to Beacon Environmental's laboratory for analysis using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) instrumentation following EPA Method 8260C. A comprehensive survey report is provided by Beacon Environmental that includes results in tabular form as well as on color isopleth maps showing the distribution of compounds identified in the investigation (see **Figure 1** below).



**Figure 1 – Example Color Isopleth Maps**

### **2.0 Soil-Gas Sampling Procedures**

To perform the soil-gas investigation, Beacon Environmental provides a BESURE Sample Collection Kit™ with all the materials necessary to collect the requested number of soil-gas samples. To collect soil-gas samples, an approximately one-inch diameter hole is advanced to the appropriate depth to meet the objectives of the survey (e.g., one to three feet). The PSG Sampler (which contains two sets of *hydrophobic adsorbent* cartridges) is installed in the hole and covered with an aluminum foil plug and soil to seal the sampler in the ground. The adsorbent cartridges used by Beacon Environmental are hydrophobic, which allows the samplers to be effective even in water-saturated conditions. Extensive empirical evidence, which is supported by a government study, has proven that hydrophobic adsorbents work perfectly well in high moisture conditions and should not be encased by a hydrophobic membrane.

For locations covered by asphalt or concrete surfacing, an approximately 1 ½-inch diameter hole is drilled through the surfacing to the underlying soils. A ½” to 1” diameter drill bit can then be used to advance the hole to a three foot depth to increase the sensitivity of the method. The upper 12 inches of the hole is sleeved with a sanitized metal pipe provided in the Kit. After the Sampler is installed inside the metal pipe, the hole is patched with an aluminum foil plug and a thin concrete patch to effectively protect the sampler.

The samplers are exposed to subsurface gas for approximately three to 14 days, with the exact length of time appropriate to meet the objectives of the survey. The sampler is shipped to the site with a length of wire wrapped around the vial and twisted around the shoulder of the vial to expedite retrieval from the ground. Following the exposure period, the Samplers are retrieved and shipped to Beacon Environmental's laboratory for analysis. It is not necessary to use ice or preservatives during shipment; however, the samplers are sealed and shipped under established chain-of-custody procedures. Trip blanks, which remain with the other samples during preparation, shipment, and storage, are included at a typical rate of five percent of the total number of field samples. **Figure 2** shows a PSG Sampler as it looks when received in the BESURE Kit™.



**Figure 2 – Beacon PSG Sampler**

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A two-person team can install approximately 50 to 100 samplers per day depending on the number of sample locations that are covered with asphalt, concrete, or gravel surfacing. For retrieval of the Samplers, one person can retrieve approximately 50 samplers per day and patch the holes through the surfacing. **Figure 3** shows installation through asphalt and grass surfaces, respectively.



**Figure 3 — Installation of Samplers with Beacon Environmental’s BESURE Kit™**

The amount of days required to complete the installation and retrieval procedures is dependent upon the number of personnel deployed for the execution of the fieldwork, weather conditions, and health and safety considerations.

### **3.0 Analytical Procedures**

A chain-of-custody accompanies the field samples at all times from the time the samples are collected until final analysis. BESURE Kits™ are shipped with tug-tight custody seals to ensure that samplers are not tampered with during transport (see **Figure 4**). Once samples are received at the laboratory, the sample custodian receives the samples and logs the samples into the laboratory’s Sample Receipt Log.



**Figure 4 – BESURE Sample Collection Kit™**

Beacon Environmental’s laboratory is maintained in a safe and secure manner at all times. The facility is locked when not occupied and is monitored for fire and unauthorized access. Beacon Environmental personnel escort all visitors at all times while inside the facility. Neither soil nor water analyses are performed at Beacon Environmental, so no solvents are stored or used that

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can create background contamination problems as experienced by wet labs. This ensures that a clean laboratory environment is maintained for trace analyses.

Soil gas samples are analyzed by Beacon Environmental using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) instrumentation, following EPA Method 8260C procedures. Samples are routinely analyzed for a list of approximately 40 compounds, which can additionally include total petroleum hydrocarbons (TPH). Results are based on an **initial five-point calibration**. In addition, a BFB tune is performed daily and a method blank is run following the daily calibration verifications. **Internal standards and surrogates** are included with each sample analysis. The laboratory's reported quantitation level (RQL) for each of the targeted compounds is 10 or 25 nanograms (ng); however, the limit of quantitation (LOQ) is 10 ng and the limit of detection (LOD) is 5 ng. MDL studies are performed, as well. As an option, tentatively identified compounds (TICs) can be reported for each sample, with the results based on the closest internal standard to the TIC.

Beacon Environmental is known for providing the highest level of accuracy and quality assurance and quality control (QA/QC) procedures for the analysis of soil gas samples in the industry. The table below summarizes these analytical procedures.

<b>Description</b>	<b>Included</b>
Analysis by thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) following EPA Method 8260C - Accredited	√
Analytical results based on 5-point initial calibration	√
MDLs are based on a seven replicate study with contiguous analyses	√
Limit of Detection (LOD) and Limit of Quantitation (LOQ) studies performed quarterly	√
Internal standards and surrogates included with each run	√
BFB tunes (5 to 50 nanograms through GC, per method)	√
Continuing calibration checks and method blanks	√

Analyses of the samples are performed at Beacon Environmental's laboratory using state-of-the-art instruments that are listed below. The Markes thermal desorption instruments outperform other older thermal desorption equipment, which cannot target as broad a range of compounds with as much sensitivity or accuracy.

- Agilent 7890 Gas Chromatograph / 5975 Mass Spectrometer,
- Markes Ultra autosampler and Unity thermal desorber,
- Markes TD100 and TD100xr, and
- Markes Mass Flow Controller Module.

## 4.0 Reporting

Following analysis and a thorough data review, a comprehensive survey report is provided that contains:

- project objectives,
- the investigation plan,
- the QA/QC program and findings,
- laboratory data,
- color isopleth maps showing the distribution of detected compounds,
- field procedures,
- laboratory procedures,
- Field Deployment Reports, and
- Chain-of-Custody documentation.

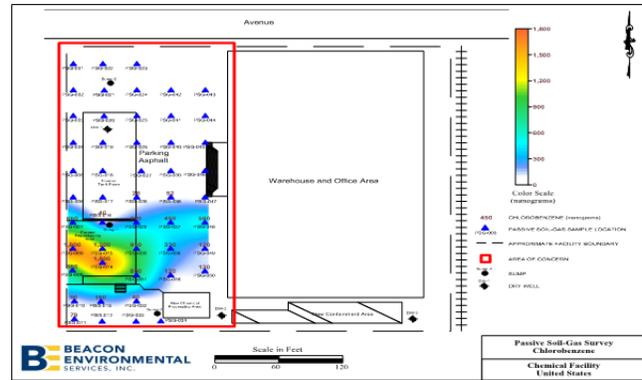


Figure 5 – Example Color Isopleth Map

Beacon Environmental requests a CAD drawing of the site is provided with coordinate data for each location to facilitate creation of color isopleth maps. BEACON can provide the color isopleth maps as layers for use with CAD software or provide data files of the contours for use with GIS software. Beacon Environmental provides post survey support to assist in interpreting the data, when requested.

### Biography of Author

Harry O’Neill is the President of Beacon Environmental Services and has managed soil gas and vapor intrusion investigations for more than 25 years, working on federal, state, and commercial projects throughout the United States, as well as internationally across six continents. Under his direction since 1999, Beacon Environmental has achieved DoD ELAP, NELAP, and ISO/IEC 17025 accreditation for the analysis of soil gas and air samples to target trace concentrations of organics using sorbent samplers. In addition, Mr. O’Neill oversaw the implementation of the quality program that enabled Beacon to become the first National Environmental Field Activities Program (NEFAP) accredited field sampling and measurement organization (FSMO) in the United States, and the company’s accreditation is for the collection of soil gas and air samples. Mr. O’Neill has been on the forefront of the acceptance of passive sampling technologies at the national and international level and has managed the implementation of thousands of soil gas and air sampling surveys. He is a member of AWMA, ITRC, and ASTM, and is the lead author of ASTM Standard D7758: *Standard Practice for Passive Soil Gas Sampling in the Vadose Zone* and has published and presented findings throughout the United States, as well as internationally across four continents as an invited speaker. Mr. O’Neill can be contacted at [Harry.ONeill@Beacon-usa.com](mailto:Harry.ONeill@Beacon-usa.com) or by phone at 1-410-838-8780.

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## **Part 2: PSG Sampler Step-by-Step Installation and Retrieval Procedures**

### **PSG Sampler Installation**

1. At each survey point, clear vegetation as necessary and, using a hammer drill and drill bit (or comparable equipment), create a 1"- to 1½"-diameter hole approximately 12 inches deep, but can be as shallow as 6 inches. When appropriate, use a ½" to 1" diameter drill bit to extend the hole to a three foot depth. Note: In areas of very organic topsoil or landscaped areas (*i.e.*, mulched areas, gardens, etc.) it is important to get beneath the organic soil layer to the underlying soil below. For locations covered with asphalt or concrete, an approximately 1½"-diameter hole is drilled through the surfacing to the underlying soils and the hole is sleeved with a 12" long pre-cleaned, aluminum pipe provided in the BeSure Sample Collection Kit. The pipe is then pushed or tapped ½" to 1" into the base of the hole using a hammer and tapping dowel also provided in the Kit.
2. After the hole is created, remove a Beacon PSG Sampler (a rugged, borosilicate glass vial containing two sets of **hydrophobic adsorbent cartridges**) and unwind the retrieval wire wrapped around it. Holding the capped end of the vial in one hand, pull the wire tight (to straighten it) with the other hand. Remove the solid cap on the Sampler Vial and replace it with a Sampling Cap (a one-hole cap with a screen meshing insert). Store the solid cap in the Cap Storage Container.
3. Lower the Sampler with the screened-capped-end pointing down into the hole. If the hole was created to a greater depth it is only necessary to suspend the sampler in the upper portion of the hole because compounds in soil gas that enter the hole will migrate up to the sampler. With the retrieval wire extending from the hole, plug the top of the hole with aluminum foil and use a hammer to collapse the soils above the foil plug. Coil the wire and lay it flat on the ground surface. For those locations through concrete or asphalt, lower the Sampler into the aluminum pipe and bend the end of the wire over the top of the pipe so that the coil of wire hangs over the top and outside the pipe. Next, plug the top of the hole with a wad of aluminum foil and a thin concrete patch (approximately ¼" thick) to effectively seal the Sampler in the ground. **Figure 6** depicts sampler installation options.
4. Close the Kit, and on the Chain of Custody record: (a) sample-point number; (b) date and time of emplacement; and (c) other relevant information (*e.g.*, soil type, vegetation, proximity to potential source areas). Be sure to mark the sample location and take detailed notes (*i.e.*, compass bearings and distances from fixed reference points or GPS coordinates).
5. Move to next location.

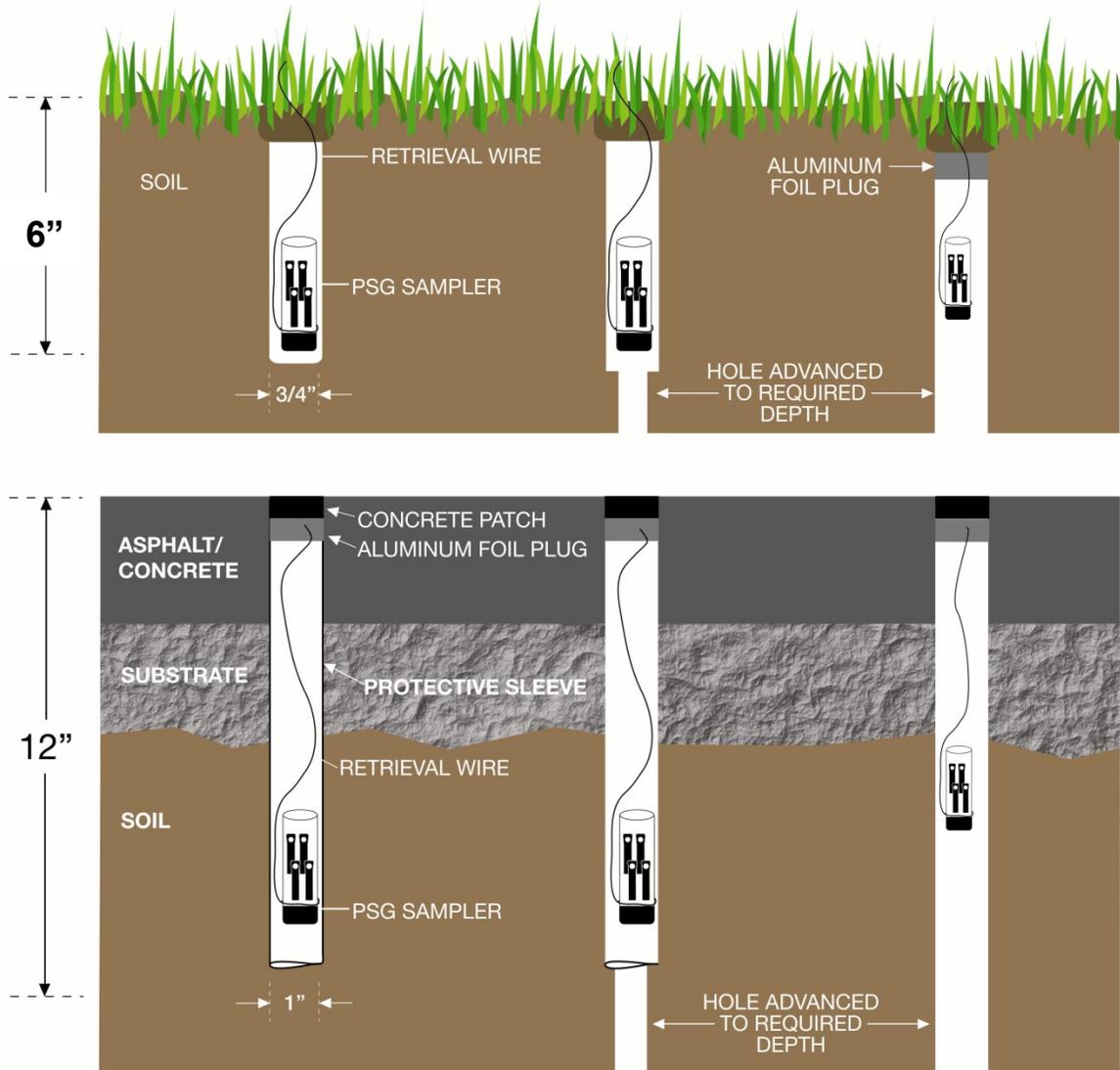


Figure 6 – Sampler Installation Options

**PSG Sampler Retrieval**

1. At each sample location open the BeSure Sample Collection Kit and place it and the wire cutters within easy reach. Remove a square of gauze cloth and place it and a clean towel on the open Kit. Remove a solid cap from the Cap Storage Container and place it on the Kit, also.
2. Expose the Sampler by pulling on the wire when in soils or using a small chisel and hammer to chip the thin concrete patch away when in asphalt/concrete. Retrieve the Sampler from its hole by pulling on the retrieval wire. Holding the Sampler upright, clean the sides of the vial with the clean towel (especially close to the Sampling Cap). Remove the Sampling Cap, cut the wire from the vial with the wire cutters, and clean the vial threads completely with the gauze cloth.
3. Firmly screw the solid cap on the Sampler Vial and with a ballpoint pen record the sample number, corresponding to the sample location, on the cap's label.
4. On the Field Deployment Report, record: (a) date and time of retrieval (to nearest minute); and (b) any other relevant information.
5. Return the sampling cap to the Sampling Cap container. Place the sealed and labeled Sampler Vial in a 3" x 4" re-sealable Sampler Bag. Then place the individually bagged and labeled sampler into the larger bag labeled "Return Shipment Bag." Each sampler is to be individually bagged and placed in a Return Shipment Bag, with at least one trip blank per Return Shipment Bag included with the PSG Samplers.
6. On the Chain of Custody, record: (a) date and time of retrieval; and (b) any other relevant information. After all samples have been retrieved, verify that the caps on each Sampler are sealed tightly and that the seals on the Sampler Bags are closed. Verify that all Samplers are stored in the Return Shipment Bag, which contains an adsorbent pack. Seal the Return Shipment Bag and place it in the upper tray of the Kit, and place the provided tools and materials in the lower compartment of the Kit.
7. Complete the chain-of-custody for shipment of Samplers. Seal the BESURE Sample Collection Kit with the provided tug tight custody seal, provided in the Kit, which has a unique identification number that is documented on the chain-of-custody. Place the Kit and paperwork in a cardboard box and ship via overnight delivery to Beacon Environmental Services for analysis of the samples.