REPORT

Interim Phase 2 Sitewide Investigation Report and Work Plan Addendum

221 Sunset Drive, Camdenton, Missouri

May 2018

Prepared by

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Acronyms and Abbreviations

bgs	below ground surface
CH2M	CH2M HILL Engineers, Inc.
CCTV	closed-circuit television
1,1-DCA	1,1-dichloroethane
DCE	dichloroethene
DPT	direct-push technology
EPA	U.S. Environmental Protection Agency
facility	221 Sunset Drive in Camdenton, Missouri
IDW	investigation-derived waste
MDNR	Missouri Department of Natural Resources
PCE	tetrachloroethene
PID	photoionization detector
PSG	passive soil gas
PVC	polyvinyl chloride
1,1,1-TCA	1,1,1-trichloroethane
TCE	trichloroethene
VC	vinyl chloride
VOC	volatile organic compound

SECTION 1

Introduction

This report presents the procedures and results associated with the Phase 2 sitewide investigation activities related to the presence of volatile organic compounds (VOCs) in soil vapor at the facility located at 221 Sunset Drive (formerly 179 Sunset Drive) in Camdenton, Missouri (facility). This report also serves as a work plan addendum to the original Sitewide Investigation Work Plan (CH2M 2016a) to present the recommended path forward and proposed plan for future activities at the site. Proposed sampling and data analysis will be conducted in accordance with U.S. Environmental Protection Agency (EPA) QA/R-5 quality assurance project plan (QAPP) requirements, satisfied by the Sitewide Investigation Work Plan (CH2M 2016a).

1.1 Project Background

The facility was constructed in 1967 and produced aluminum and copper heat-transfer units. The facility was expanded four times (1970, 1973, 1979, and 1983) after it was constructed. Until 1990, the manufacturing processes included a vapor degreasing process that used trichloroethene (TCE). From 1990 through 1993, 1,1,1-trichloroethane (1,1,1-TCA) was used as part of the vapor degreasing process. In 1993, the 1,1,1-TCA was replaced with methylene chloride, which was used in facility operations until 1997, when the degreasing equipment was removed.

The building located at the facility underwent complete interior renovation in 1997, during which time the degreasing units were removed and recessed portions of the building floor were brought to grade. Between 1997 and March 2012, the facility produced radiators using a manufacturing process that did not include the use of chlorinated solvents. Facility operations ceased in March 2012, and the facility has been vacant since April 2012.

Investigations and remedial activities have been conducted at the facility since 1992. Activities that occurred before March 2015 are detailed in the RCRA Facility Investigation Report (CH2M HILL Engineers, Inc. [CH2M] 2009) and the Indoor Air and Subslab Sampling Quality Assurance Project Plan (CH2M 2013). The regulatory history and previous investigations conducted since March 2015 are presented in the Sitewide Investigation Work Plan (CH2M 2016a) and the Phase 1 Sitewide Soil Vapor Investigation Report (CH2M 2017a).

1.2 Purpose

The *Sitewide Investigation Work Plan Addendum – Phase 2* (CH2M 2017b) was submitted to the Missouri Department of Natural Resources (MDNR) on December 6, 2017, and approved on December 13, 2017. The work plan addendum presented an investigation approach that included the addition of passive soil gas sampling and short-term vapor extraction testing into the Phase 2 sitewide investigation at the facility. The overall objective of the investigation activities was to collect data to obtain a better understanding of shallow subsurface conditions and potential VOC pathways underneath the facility and assist in guiding future intrusive investigation activities (such as, drilling and soil sampling) within the building.

Investigation activities described in this report are consistent with the work plan addendum and communications with MDNR. Activities included in the Phase 2 sitewide soil vapor investigation are as follows:

- Utility locating to identify the exact locations of utilities located beneath the building
- A closed-circuit television (CCTV) investigation to inspect the integrity and connectivity of sewer lines located underneath the building
- Passive soil gas (PSG) subslab sampling underneath the building using BESURE Passive Sample Collection Kits from Beacon Environmental

- Short-term vapor extraction tests to provide insight into the spatial distribution of vapors

This evaluation included careful placement of sampling locations based on potential hot spots identified during review of historical documentation, the utility locates, and CCTV investigation. The investigation findings were used to propose a recommended path forward herein.

SECTION 2

Preliminary Investigation Activities

This section summarizes the approach and methods that were used as part of investigation activities completed beneath the building. The following activities were completed during the Phase 2 sitewide investigation:

- Subsurface utility locate investigation
- CCTV investigation
- PSG sampling investigation

Appendix A includes a map of existing and historical features within the building footprint developed based on multiple lines of evidence, including the subsurface utility locate investigation, CCTV investigation, and review of historical facility drawings.

2.1 Subsurface Utility Locate Investigation

A subsurface utility-locate investigation was conducted by CH2M and subcontractor Blood Hound, LLC (Blood Hound) of Brownsburg, Indiana, in March 2017. The purpose of this investigation was to locate the subsurface utilities, including sanitary sewer lines, underneath the facility. During the 3-day field investigation, CH2M and Blood Hound located all existing subsurface utility lines using either electromagnetic and/or ground-penetrating-radar equipment. In addition to locating existing subsurface utility lines underneath the facility, CH2M and Blood Hound also located the building blueprints in the facility's office area. The building blueprints depicted the locations of existing and historical subsurface utility lines and operation features.

2.2 CCTV Investigation

A CCTV investigation of the subsurface utility lines was conducted by CH2M and subcontractor All Clear Pumping and Sewer (All Clear) of Jefferson City, Missouri, in August 2017. The purpose of this investigation was to evaluate the current condition of the sanitary sewer lines in order to aid in the understanding of the sanitary sewer line system's connectivity. Additionally, compromised parts of the sanitary sewer lines (such as cracks, breaks, or both), if any, were to be identified in order to assist in guiding subsequent field investigation activities.

The field team was unable to inspect and video-record some of the sanitary sewer lines due to debris and/or standing liquid within the sanitary sewer line. The video inspection confirmed the layout and the orientation of the sanitary sewer lines that were located during the subsurface utility-locate investigation. Under the current sanitary sewer line configuration, liquids drain out of the building from centralized discharge locations along the east, west, and northern exterior walls.

In general, the video inspection of the sanitary sewer lines revealed that most of the lines underneath the facility's concrete floor are composed of standard schedule 40 polyvinyl chloride (PVC) piping that is chemically glued together using standard plumber's glue solvent. While PVC was the mostly commonly found building material for the sanitary sewer lines, black steel and clay tile pipe were found to make up some of the older segments of the sanitary sewer line system. Overall, the video inspection found that the inspected sanitary sewer lines appeared generally intact; however, the inspection did indicate that the pipe joints at multiple locations were not fully secured/connected (that is, a small gap could be seen between the male and female PVC connections).

2.3 Passive Soil Gas Sampling

PSG sampling was performed by CH2M in December 2017. The purpose of the PSG sampling was to identify potential drilling locations where soil VOC concentrations likely are elevated. PSG sampling was conducted using BESURE Passive Sample Collection Kits from Beacon Environmental of Forest Hill, Maryland, to collect qualitative VOC data in subslab soil gas beneath the facility. PSG sampling locations shown in Figure 1 in Appendix B were selected based on estimated locations of underground utilities as determined from the utility locate, CCTV survey, and other site information. A total of 68 passive soil gas samples was installed and collected within the building; this includes 62 sampling locations as shown in Figure 1 (Appendix B), as well as 6 quality control samples (5 field duplicates and 1 trip blank).

PSG samplers were installed to collect soil gas samples directly below the concrete in the soil beneath the building. Concrete thickness varied from 6 to 16 inches, with an average thickness of 9.9 inches and a median of 10 inches. Thirty-nine of the 62 sampling locations had only clay directly underneath the concrete slab while the remaining 23 locations had some combination of clay, sand, or gravel. A detailed standard operating procedure for the installation and collection of PSG probes is presented as an attachment to the *Sitewide Investigation Workplan Addendum – Phase 2* (CH2M 2017b) and also within the PSG Survey – Analytical Report from Beacon Environmental (Appendix B).

As described in the *Sitewide Investigation Workplan Addendum – Phase 2*, each PSG sampler was placed beneath the building floor, the borehole used to place the sampler was sealed, and the sampler was left in place for a week. While in place, VOCs in soil vapor near the sampler sorbed to the sampler. The greater the VOC soil concentration, the greater the amount of VOC mass that sorbed to the sampler. After remaining in place for 1 week, the samplers were retrieved and sent to the laboratory for analysis.

2.4 Short-term Vapor Extraction Tests

Short-term vapor extraction tests were not performed during investigation activities. The decision to abandon the short-term vapor extraction tests was made after the PSG samplers were installed and clay was observed directly beneath a majority of the PSG soil sample locations. The presence of clay would have greatly inhibited the efficacy of the vapor extraction test and limited results.

SECTION 3

Results, Conclusions, and Path Forward

3.1 Results

TCE and total VOC results for the PSG samplers are presented in Figures 2 and 3, respectively, of the PSG Survey – Analytical Report from Beacon Environmental (Appendix B). Tabulated results are also presented in Table 1 of the PSG Survey – Analytical Report from Beacon Environmental (Appendix B). The units for the PSG sampler's results are nanograms. A nanogram is one one-thousandth of a microgram. Thus, each value presented in Figures 2 and 3 of Appendix B represents the TCE or total VOC mass that was sorbed to the sampler while placed beneath the building floor. The greater the amount of mass sorbed to the PSG sampler, the greater the VOC soil gas concentration beneath the building floor. Thus, areas shown in Figures 2 and 3 of Appendix B with the greatest values are expected to likely correlate with the presence of greater VOC concentrations in soil.

3.2 Conclusions

The objectives defined in the *Sitewide Investigation Workplan Addendum – Phase 2* (CH2M 2017b) and summarized in Section 1.2 were met as follows:

- Locate sanitary sewer lines and other utilities underneath the facility.
- Use CCTV technology to determine the connectivity and integrity of the sanitary sewer line underneath the facility.
- Deploy Beacon Environmental's BESURE Passive Soil Gas Samplers to identified potential VOC migration pathways underneath the building.

TCE is the site-specific VOC that is most widely present and has the greatest potential for vapor migration (Figure 2 of Appendix B).

Additionally, short-term soil vapor extraction testing at six locations throughout the facility was initially recommended in the *Sitewide Investigation Workplan Addendum – Phase 2* (CH2M 2017b). The presence of clay soil inhibits the efficacy of soil vapor extraction; therefore, these short-term vapor extraction tests were not performed.

3.3 Path Forward

Based on the findings of the Phase 2 sitewide investigation performed in March, August, and December 2017, the recommended path forward is to perform a drilling and soil sampling investigation to determine the location and magnitude of potential sources of TCE in soil beneath the facility. Details depicting the proposed drilling and soil sampling investigation are identified in the following subsections. All proposed drilling and sampling activities will be performed in accordance with procedures presented in the original Sitewide Investigation Work Plan (CH2M 2016a).

3.3.1 Sampling Program Sitewide Investigation

Tables 1 and 2 summarize soil boring locations and associated quality assurance/quality control samples, respectively. Proposed soil boring locations are presented in Figure 1. The shallow subsurface soil investigation sampling and analysis protocols will be conducted in accordance with the means and methods presented herein.

3.3.2 General Investigation Approach

A total of 31 shallow soil borings will be advanced beneath the facility floor using direct-push technology (DPT) drilling methods for the purpose of collecting shallow soil samples (Figure 1). The locations include those adjacent to the PSG samples with the greatest VOC mass, as well as locations in areas where lesser amounts of VOC mass were found in PSG samples to provide soil investigation coverage throughout the building. Sample locations shown on Figure 1 are estimated and may change based on field conditions, e.g., overhead structures or presence of underground utilities. A limited number of additional shallow soil borings (assumption of up to nine) may be installed to refine the delineation of elevated VOC locations, as measured using a field photoionization detector (PID), depending on the progress of the work and results observed during the field investigation.
One of the shallow soil borings will be advanced to document the deeper site stratigraphy and confirm the depth to bedrock. Bedrock has historically been observed between 40 and 50 feet below ground surface (bgs).

3.3.3 Soil Boring Advancement and Sampling

Soil borings will be advanced using DPT tooling and a macrocore sampler or core barrel assembly for the purpose of collecting subsurface soil samples. Borings will be advanced from ground surface to a depth of approximately 20 feet bgs. Should refusal be encountered due to abundant chert associated with the site geology, rock coring methods will be used to advance the boring until macrocore sampling can continue. Upon retrieval of the macrocore sampler from the boring, the entire length of each soil core sample will be screened with a PID, inspected to log the boring stratigraphy, and visually inspected to identify the possible presence of staining and groundwater. Soil borings will be logged as described in *SOP-Soil Boring Logging* (CH2M 2016a). In the event that field condition indicate contamination may be present deeper than 20 feet bgs, some boring locations may be drilled to deeper depths. If additional deeper investigation is required, investigation may occur during this investigation or a subsequent phase. Although unlikely, if sufficient groundwater is encountered during drilling, a groundwater sample will be collected using low-flow sampling methods (i.e., peristaltic pump) through a screened drilling rod (i.e., Geoprobe) screenpoint sampler.

Collected samples will be analyzed by an offsite laboratory for site-specific VOCs by EPA Methods SW-846 8260C (soil) and SW-846 8260C (groundwater). The site-specific list of VOCs investigated included the following: 1,1,1-TCA, 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (DCE), cis-1,2-DCE, trans-1,2-DCE, methylene chloride (also referred to as dichloromethane), tetrachloroethene (PCE), TCE, and vinyl chloride (VC). The site-specific VOC list is based on chemicals used in past manufacturing processes (TCE, 1,1,1-TCA, and methylene chloride), chemicals detected in groundwater or soil during past investigations (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and 1,1-DCE), and other degradation products of 1,1,1-TCA and TCE (1,1-DCA and VC).

Soil borings will be abandoned in accordance with Missouri State Regulations using either bentonite pellets or a high-solids sodium bentonite slurry tremied from the terminal depth of the soil boring to approximately 1 foot bgs. The upper 1 foot will be backfilled by the drilling subcontractor with a clean concrete patch so that the patch matches the existing grade. As required, the drilling subcontractor will complete and submit the MDNR Geological Survey Program plugging registration record for each abandoned soil boring.

Subsurface Soil Samples

Up to three native shallow soil samples will be collected from each soil boring location based on visual inspection and PID readings. The target soil collection intervals are from 0 to 6 feet bgs, 6 to 13 feet bgs, and 13 to 20 feet bgs, with an emphasis on soil within each of those intervals that has the highest PID reading. If elevated PID readings are not observed, a sample will be retained from the midpoint of the soil collection interval. If other soils with particularly elevated PID readings are noted, additional soil samples may also be collected.

Each soil sample will be collected using a Terra Core sampler, as described in *SOP-Recommended Use of a Terra Core Sampler* (CH2M 2016a), provided by the designated laboratory performing the offsite analysis. Each soil sample will be given a unique sample designation code as defined in Table 1. Table 2 shows quality assurance/quality control samples for soil. Field duplicates will be collected at a rate of 1 for every 10 native samples collected. Matrix spike and matrix spike duplicates will be collected at a rate of 1 for every 20 native samples collected. Equipment blanks will be collected during this field investigation for each media (soil and groundwater) at a rate of one per week; these samples will be collected by running laboratory-grade and laboratory-provided deionized water over decontaminated drill rig tooling into sample containers. A trip blank will be included with each cooler containing VOC samples.

Metals Sampling and Analysis

A review of historical soil sampling data indicates that several metals (lead and chromium) have been detected at concentrations above current industrial Regional Screening Levels in soil collected outside the building or in sediment collected from within a former sewer line. For this reason, soil samples will be collected for lead and hexavalent chromium analysis at select boring locations to evaluate the potential presence of these metals in soil beneath the building. Eight boring locations have been selected for collection of samples for metals analysis, as follows:

- Boring locations along the western building wall, adjacent to former waste treatment areas (Borings SB-323, SB-324, and SB-331)
- Boring locations adjacent to former metal cleaning pits (SB-313, SB-329, SB-305, and SB-322)
- One boring location near a former degreaser (SB-320)

At least two soil samples will be collected at each of these boring locations, one from the shallow (0 to 6 feet bgs) and one from the intermediate (6 to 13 feet bgs) sampling intervals. The soil samples for metals will be collected from a portion of the sampling interval showing staining or other evidence of potential contamination. If no evidence of contamination is apparent, the samples will be collected from the lower portion of the sampling interval. Each sample will be collected in glassware provided by the laboratory for this purpose. Individual samples will be collected for lead and hexavalent chromium analysis.

Samples for lead will be shipped to CT Laboratories for analysis using EPA Method SW6010B. Samples for hexavalent chromium will be shipped to Lancaster Laboratories for analysis using EPA Method SW7199/ 3060A. Samples for hexavalent chromium will also be analyzed for pH and oxidation-reduction potential to allow for proper evaluation of results and matrix spike recovery data.

Groundwater Samples

It is assumed that up to 8 groundwater samples may be collected across the existing soil boring locations if sufficient water is present. Each groundwater sample will be collected through the DPT drill rig screened drill rod using a peristaltic pump and dedicated tubing. Groundwater samples will be collected as described in *SOP-Groundwater Sampling using Low-Flow Methods* and *SOP-Water Sample Collection for Volatile Organic Compounds* (CH2M 2016a). Each groundwater sample will be given a unique sample designation code as defined in Table 1 in the notes section. Table 2 shows quality assurance/quality control samples for groundwater. Field duplicates will be collected at a rate of 1 for every 10 native samples collected. Matrix spike and matrix spike duplicates will be collected at a rate of 1 for every 20 native samples collected. An equipment blank will be collected at a rate of one per week, assuming 2 weeks while groundwater sampling could occur. A trip blank will be included with each cooler containing VOC samples.

3.3.4 Decontamination

Nondisposable tooling and equipment that contacts potentially contaminated media will be decontaminated between sample intervals or locations using a non-phosphate detergent and clean potable water rise, as described in *SOP-Decontamination of Personnel and Equipment* (CH2M 2016a).

3.3.5 Investigation-Derived Waste

Investigation-derived waste (IDW) will be properly containerized and staged onsite in new, labeled 55-gallon steel drums that meet United Nations specifications as required by Department of Transportation regulations. It is assumed that approximately 16 drums of soil, 12 drums of decontamination water and disposable materials (e.g., sample liners, sample tubing, etc.), and one frac tank for drilling water will be produced. Separate IDW characterization samples will be collected and analyzed for both solid and aqueous waste. CH2M will coordinate and supervise IDW profiling, manifesting, and offsite disposal.

3.3.6 Reporting and Schedule

Once the Phase 2 Sitewide Shallow Soil Sampling Investigation activities have been completed, a report describing the methods used, deviations from this work plan (if any), and results will be prepared and submitted to MDNR. It is expected that preparation of the report may take approximately 60 days after completion of all field activities.

Analytical laboratory results will be reviewed and validated by the project chemist upon receipt. VOC concentrations will be compared to health-based screening levels developed by EPA based on current toxicity information for human health protection as presented in the Sitewide Investigation Work Plan (CH2M 2016a) and *Property No. 9 Soil and Groundwater Investigation Technical Memorandum* (CH2M 2016b). The health-based screening levels will be updated as appropriate at the time of reporting based on the most current regional screening levels.

The following is the proposed schedule for the completion of the Phase 2 Sitewide Shallow Soil Sampling Investigation activities:

- Submit Phase 2 Sitewide Investigation Report/Work Plan: April/May 2018
- Procure Subcontractors to Complete Investigation Activities: April/May 2018
- Resolve MDNR comments and Receive Report/Work Plan Approval: May 2018
- Complete Phase 2 Sitewide Shallow Soil Sampling Investigation: May/June 2018
- Laboratory Analysis and Data Evaluation: July 2018
- Prepare Phase 2 Sitewide Shallow Soil Sampling Investigation Report: July to August 2018
- Submit Phase 2 Sitewide Shallow Soil Sampling Investigation Report: September 2018

Significant modifications to the proposed investigation schedule included in this work plan will be communicated to MDNR in a timely manner, as necessary.

SECTION 4

References

CH2M HILL Engineers, Inc. (CH2M). 2009. *Final RCRA Facility Investigation Report, Modine Manufacturing Facility, Camdenton, Missouri*. July.

CH2M HILL Engineers, Inc. (CH2M). 2013. *Final Quality Assurance Project Plan, Indoor Air and Subslab Sampling, Modine Manufacturing Facility, Camdenton, Missouri*.

CH2M HILL Engineers, Inc. (CH2M). 2016a. *Sitewide Investigation Work Plan, 221 Sunset Drive,* Camdenton, Missouri. July.

CH2M HILL Engineers, Inc. (CH2M). 2016b. *Property No. 9 Soil and Groundwater Investigation Technical Memorandum, 221 Sunset Drive,* Camdenton, Missouri. July.

CH2M HILL Engineers, Inc. (CH2M). 2017a. *Phase 1 Sitewide Soil Vapor Investigation Report, 221 Sunset Drive, Camdenton, Missouri*. August.

CH2M HILL Engineers, Inc. (CH2M). 2017b. *Sitewide Investigation Workplan Addendum – Phase 2, 221 Sunset Drive, Camdenton, Missouri.* December.

Tables

Table 1. Soil Sample Summary

Interim Phase 2 Sitewide Investigation Report and Work Plan Addendum

221 Sunset Drive, Camdenton, MO

Soil Boring	Number of Samples per Boring	Sample Type
SB-301	3	Primary
SB-302	3	Primary
SB-303	3	Primary
SB-304	3	Primary
SB-305	3	Primary
SB-306	3	Primary
SB-307	3	Primary
SB-308	3	Primary
SB-309	3	Primary
SB-310	3	Primary
SB-311	3	Primary
SB-312	3	Primary
SB-313	3	Primary
SB-314	3	Primary
SB-315	3	Primary
SB-316	3	Primary
SB-317	3	Primary
SB-318	3	Primary
SB-319	3	Primary
SB-320	3	Primary
SB-321	3	Primary
SB-322	3	Primary
SB-323	3	Primary
SB-324	3	Primary
SB-325	3	Primary
SB-326	3	Primary
SB-327	3	Primary
SB-328	3	Primary
SB-329	3	Primary
SB-330	3	Primary
Total:	**90**	

Notes:

Up to 10 step-out soil boring locations will be advanced based on observed field conditions. These borings are not shown on Figure 1. If installed, they will be named with respect to the soil boring location they are stepped-out from (i.e., SB-301-A-0-6-MMDDYY, where 'A' indicates it is a step out location from soil boring 301 and '0-6' indicates the sampling depth interval of 0 to 6 feet below ground surface. Up to 8 groundwater samples will be collected from the existing soil boring locations if sufficient water is present. These samples will be named with respect to the soil boring location from which they are collected (i.e., SB-301-0-6-GW-MMDDYY, where '0-6' indicates the sampling depth interval of 0 to 6 feet below ground surface.

D = day

GW = groundwater

M = month

SB = soil boring

Y = year

Table 2. QA/QC Sample Summary

Interim Phase 2 Sitewide Investigation Report and Work Plan Addendum

221 Sunset Drive, Camdenton, MO

Sample Type	Analysis	Raw Samples	FD	MS/MSD	EB	TB	TOTAL
Soil	VOC (SW-846 8260C)[a]	120[c]	12	6	0	15	**153**
Water	VOC (SW-846 8260C)[b]	8	1	1	2	3	**15**

Notes:

[a] Soil VOC samples collected using Terra Core™ samplers

[b] Water VOC samples collected in (3) 40 milliliter glass vials.

[c] Summary includes 90 samples from the 30 primary borings plus 30 samples from the 10 step-out soil borings.

EB = equipment blank (collected one per week)

FD = field duplicate (collected at 10 percent frequency [or 1 in 10 samples])

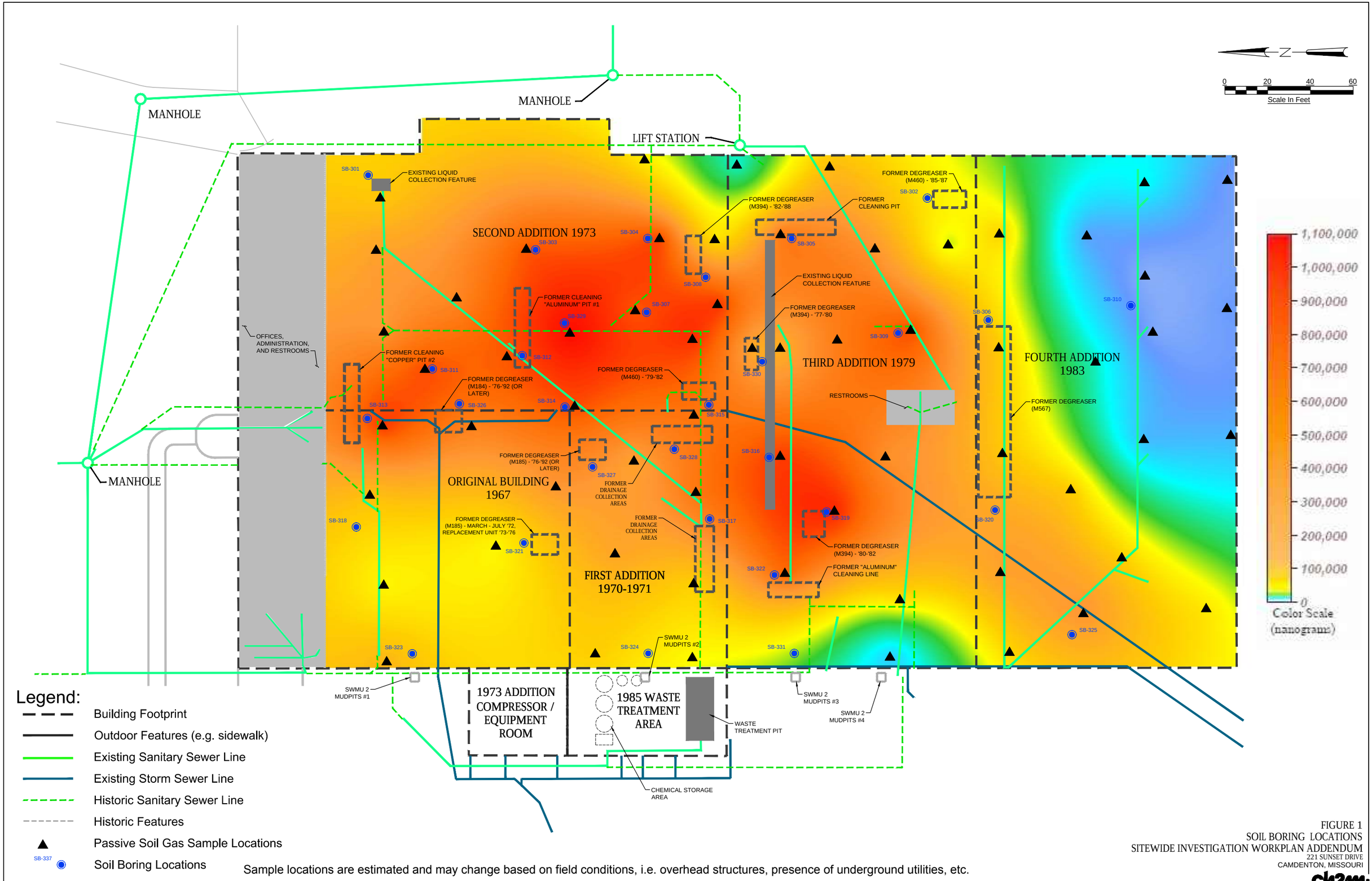
MS = matrix spike (collected at 5 percent frequency [or 1 in 20 samples])

MSD = matrix spike duplicate (collected at 5 percent frequency [or 1 in 20 samples])

TB = trip blank (submitted with each cooler containing VOC samples per field day)

VOC = volatile organic compound

Figure



Sample locations are estimated and may change based on field conditions, i.e. overhead structures, presence of underground utilities, etc.

FIGURE 1
SOIL BORING LOCATIONS
SITEWIDE INVESTIGATION WORKPLAN ADDENDUM
221 SUNSET DRIVE
CAMDENTON, MISSOURI

ch2m

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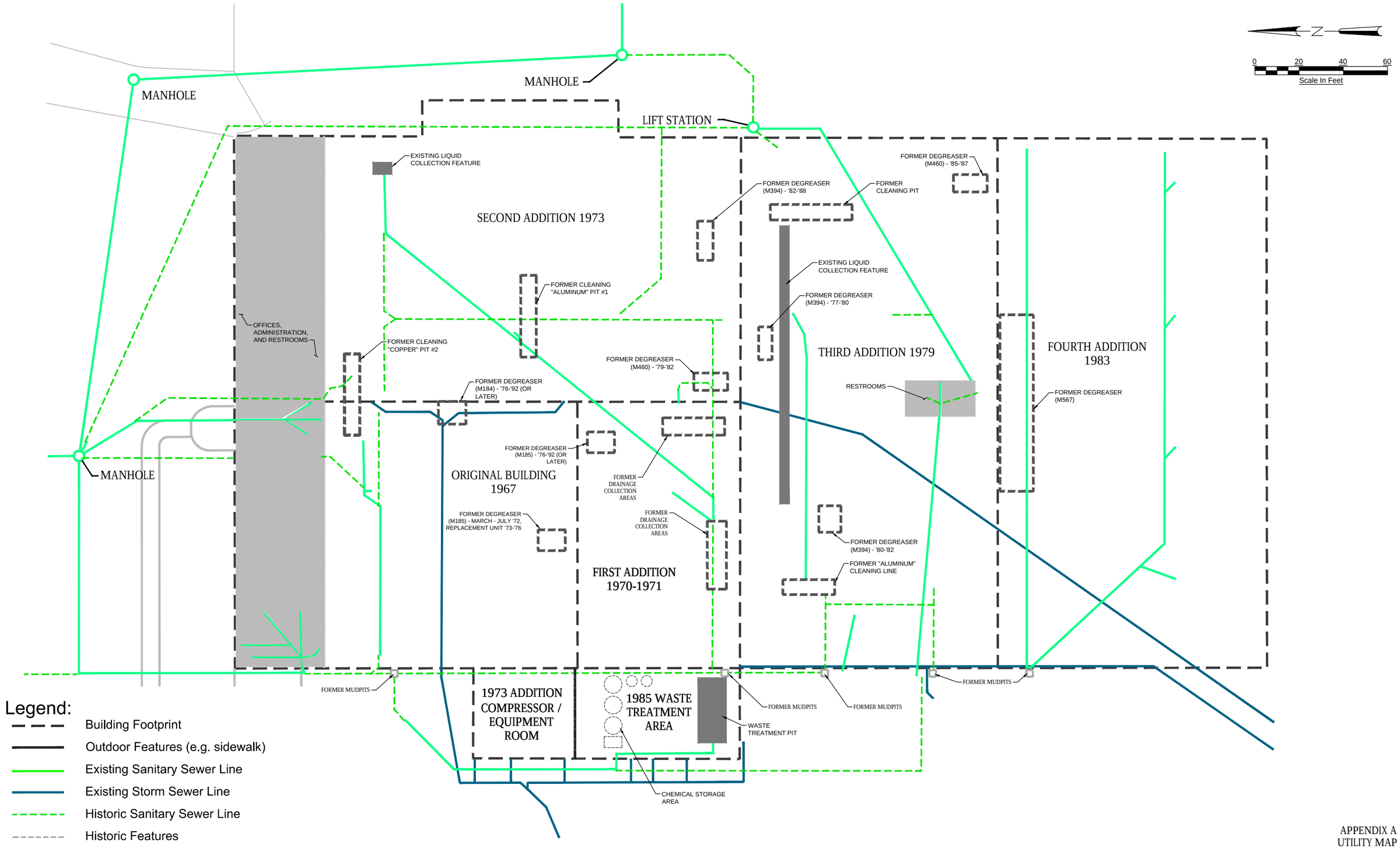
Appendix A
Existing and Historical Features (Sourced from the Subsurface Utility Locate Investigation, CCTV Investigation, and Facility Drawings)



APPENDIX A
UTILITY MAP
SITEWIDE INVESTIGATION WORKPLAN ADDENDUM
221 SUNSET DRIVE
CAMDENTON, MISSOURI

ch2m

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Appendix B
Beacon Environmental PSG Survey—Analytical Report

CH2M
25 West Cedar Street, Suite 350
Pensacola, FL 32502
Attn: Monica Schneider

Passive Soil Gas Survey – Analytical Report
Date: April 3, 2018

Beacon Project No. 3945 Rev4

Project Reference:	221 Sunset Drive, Camdenton, MO
Samplers Installed:	December 11 through 14, 2017
Samplers Retrieved:	December 20 and 21, 2017
Samples Received:	December 22, 2017
Analyses Completed:	January 8, 2018
Laboratory Data Issued:	January 11, 2018

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

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

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

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

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

The trip blank is a sampler prepared, transported, and analyzed with other samples but intentionally not exposed. Any target compounds identified on the trip blanks are reported in the laboratory data. The analysis of the trip blank (labeled TB-001 in **Table 1**) reported none of the targeted compounds.

Passive Soil-Gas Survey Notes

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

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

BEACON's passive soil-gas samplers are prepared with two sets of adsorbent cartridges for subsequent duplicate or confirmatory sample analysis. At the client's request, duplicate analysis was performed for six (6) field samples. The field sample duplicates were designated "Dup" following the sample number. When comparing quantitative results, a duplicate correspondence should be considered when the relative percent difference (RPD) between the two samples is less than or equal to 100%. For the purpose of calculating correspondences, all non-detections should be assigned, as a baseline value, the RL for the specific contaminant. Based on these assumptions, a 93% correlation was found between the field sample duplicates and their base samples.

Project Details

Samplers were deployed December 11 through 14, 2017, and were retrieved December 20 and 21, 2017. **Attachment 2** describes standard field procedures. Individual deployment and retrieval times will be found in the Chain of Custody Form (**Attachment 3**).

Sixty-two (62) field samples, six (6) field sample duplicates, and one (1) trip blank were received by BEACON on December 22, 2017. Adsorbent cartridges from the passive samplers were thermally desorbed, then analyzed using gas chromatography/mass spectrometry (GC/MS) equipment, in accordance with EPA Method 8260C, as described in **Attachment 4**. BEACON's laboratory analyzed each sample for the targeted compounds; analyses were completed on January 8, 2018. Following a laboratory review, results were provided on January 11, 2018.

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

Figure No.	**2**	**3**
Compound	Trichloroethene	Total VOCs
Frequency	62	62
Reporting Limit (nanograms)	25	10
Max Value (nanograms)	1,108,919	1,152,829
Transformation Method	Log	Log
Interpolation Method	Kriging	Kriging

Attachments:

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

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

Steven C. Thornley
Laboratory Director

Patti J. Riggs
Quality Manager

Table 1

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

Analysis by EPA Method 8260C

		TB-001	PSG-001	PSG-002	PSG-003	PSG-004
Client Sample ID:	LB180102c	122117	122017	122017	122017	122117
Project Number:		3945	3945	3945	3945	3945
Lab File ID:	C18010203	C18010205	C18010206	C18010207	C18010208	C18010209
Received Date:		12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/2/2018	1/2/2018	1/2/2018	1/2/2018	1/2/2018	1/2/2018
Analysis Time:	12:51	13:35	13:57	14:19	14:40	15:02
Matrix:			Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	<10	<10	<10	<10	<10	<10
1,1-Dichloroethene	<10	<10	**58**	**32**	<10	**242**
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	<10	**26**	**40**	<10	**111**
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	<10	<10	**130**	**408**	**66**	**1,031**
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Trichloroethene	<25	<25	**41,880**	**18,733**	**1,047**	**59,666**
Tetrachloroethene	<10	<10	**60**	**25**	**25**	**70**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-005	PSG-006	PSG-007	PSG-008	PSG-009	PSG-010
Client Sample ID:	122117	122117	122017	122017	122017	122017
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	C18010305	S18010809	C18010212	C18010213	C18010214	C18010215
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/3/2018	1/8/2018	1/2/2018	1/2/2018	1/2/2018	1/2/2018
Analysis Time:	15:10	15:25	16:03	16:25	16:47	17:09
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	<10	<10	<10	**8 J**	**14**	<10
1,1-Dichloroethene	<10	<10	**180**	**839**	**888**	**71**
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	<10	**228**	**412**	**474**	**57**
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	**8 J**	<10	**617**	**6,049**	**15,095**	**434**
1,1,1-Trichloroethane	<25	<25	<25	**783**	**372**	<25
Trichloroethene	**693**	**47**	**113,030**	**492,715**	**588,105**	**21,893**
Tetrachloroethene	**29**	<10	**152**	**3,209**	**8,661**	**50**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-011	PSG-011	PSG-012	PSG-013	PSG-014	PSG-015
Client Sample ID:	122017	122017-Dup	122117	122117	122017	122117
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	C18010216	C18010217	C18010218	C18010219	C18010220	S18010810
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/2/2018	1/2/2018	1/2/2018	1/2/2018	1/2/2018	1/8/2018
Analysis Time:	17:31	17:53	18:15	18:36	18:58	15:48
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	**81**	**87**	**6 J**	<10	**10**	**11**
1,1-Dichloroethene	**4,186**	**4,162**	**260**	**63**	**395**	**27**
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	**5,538**	**5,451**	**211**	**7 J**	**53**	<10
1,1-Dichloroethane	**51**	**46**	<25	**45**	**103**	<25
cis-1,2-Dichloroethene	**1,372**	**1,101**	**1,708**	**61**	**813**	<10
1,1,1-Trichloroethane	**81**	**82**	**49**	**184**	**155**	<25
Trichloroethene	**270,105**	**264,216**	**141,444**	**9,272**	**31,958**	**76**
Tetrachloroethene	**2,023**	**2,014**	**239**	**149**	**2,003**	**21**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-016	PSG-017	PSG-018	PSG-019	PSG-020	PSG-021
Client Sample ID:	122117	122117	122017	122017	122017	122017
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	S18010811	S18010812	C18010224	C18010225	C18010226	C18010227
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/8/2018	1/8/2018	1/2/2018	1/2/2018	1/2/2018	1/2/2018
Analysis Time:	16:12	16:35	20:25	20:47	21:09	21:31
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	<10	<10	<10	**21**	**14**	**13**
1,1-Dichloroethene	<10	<10	**236**	**1,309**	**1,024**	**283**
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	<10	<10	**168**	**1,524**	**697**	**662**
1,1-Dichloroethane	<25	<25	**27**	<25	<25	<25
cis-1,2-Dichloroethene	<10	<10	**1,270**	**22,195**	**16,864**	**1,411**
1,1,1-Trichloroethane	<25	<25	**1,025**	<25	**180**	**126**
Trichloroethene	**29**	**57**	**201,799**	**506,982**	**703,948**	**148,516**
Tetrachloroethene	<10	**23**	**250**	**6,561**	**9,637**	**152**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-022	PSG-023	PSG-024	PSG-025	PSG-026	PSG-027
Client Sample ID:	122017	122017	122017	122017	122117	122117
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	C18010228	C18010229	C18010230	C18010231	C18010232	C18010233
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/2/2018	1/2/2018	1/2/2018	1/2/2018	1/2/2018	1/2/2018
Analysis Time:	21:53	22:14	22:36	22:58	23:20	23:42
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	**21**	**30**	**6 J**	<10	<10	**19**
1,1-Dichloroethene	**831**	**1,409**	**226**	**276**	**949**	**4,094**
Methylene Chloride	<25	**34**	<25	<25	<25	<25
trans-1,2-Dichloroethene	**5,757**	**2,039**	**138**	**136**	**182**	**558**
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	**30,978**	**64,855**	**1,544**	**1,482**	**2,920**	**27,074**
1,1,1-Trichloroethane	**255**	**49**	<25	<25	<25	**100**
Trichloroethene	**1,108,919**	**754,927**	**90,861**	**80,348**	**262,802**	**535,124**
Tetrachloroethene	**6,067**	**9,621**	**104**	**86**	**444**	**1,588**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-027	PSG-028	PSG-029	PSG-030	PSG-031	PSG-032
Client Sample ID:	122117-Dup	122117	122117	122117	122017	122017
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	C18010234	C18010235	C18010236	S18010813	C18010238	C18010239
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/3/2018	1/3/2018	1/3/2018	1/8/2018	1/3/2018	1/3/2018
Analysis Time:	0:04	0:26	0:48	16:58	1:31	1:53
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	**15**	**16**	**5 J**	<10	**40**	**29**
1,1-Dichloroethene	**3,196**	**690**	**55**	<10	**3,007**	**1,526**
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	**410**	**21**	<10	<10	**603**	**795**
1,1-Dichloroethane	<25	**120**	<25	<25	**1,196**	**76**
cis-1,2-Dichloroethene	**21,665**	**324**	**14**	<10	**9,487**	**9,302**
1,1,1-Trichloroethane	**105**	**612**	<25	<25	**47,575**	**9,069**
Trichloroethene	**497,022**	**38,368**	**1,101**	**36**	**558,672**	**495,535**
Tetrachloroethene	**1,594**	**41**	<10	<10	**1,836**	**2,079**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-033	PSG-034	PSG-035	PSG-036	PSG-036	PSG-037
Client Sample ID:	122017	122017	122017	122017	122017-Dup	122017
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	C18010306	C18010241	C18010242	C18010243	C18010244	C18010307
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/3/2018
Analysis Time:	15:31	2:33	2:54	3:16	3:38	15:53
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	**46**	**44**	**41**	**67**	**53**	**9 J**
1,1-Dichloroethene	**1,249**	**1,963**	**2,641**	**211**	**291**	**1,779**
Methylene Chloride	<25	<25	**27**	<25	<25	<25
trans-1,2-Dichloroethene	**640**	**415**	**2,041**	**1,984**	**1,812**	**1,585**
1,1-Dichloroethane	**377**	**1,845**	**60**	<25	<25	<25
cis-1,2-Dichloroethene	**10,742**	**4,034**	**9,180**	**3,440**	**3,842**	**5,862**
1,1,1-Trichloroethane	**28,661**	**69,132**	**3,436**	**333**	**606**	**43**
Trichloroethene	**679,337**	**228,908**	**556,481**	**108,354**	**149,500**	**314,054**
Tetrachloroethene	**736**	**2,282**	**1,746**	**265**	**184**	**606**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-038	PSG-039	PSG-040	PSG-041	PSG-042	PSG-043
Client Sample ID:	122017	122117	122117	122117	122117	122117
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	C18010246	C18010247	C18010248	C18010249	S18010814	S18010815
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/8/2018	1/8/2018
Analysis Time:	4:17	4:39	5:01	5:22	17:22	17:46
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	**26**	**5 J**	**80**	**21**	<10	<10
1,1-Dichloroethene	**1,555**	**403**	**881**	**80**	<10	<10
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	**356**	**135**	**47**	**36**	<10	<10
1,1-Dichloroethane	<25	<25	**159**	<25	<25	<25
cis-1,2-Dichloroethene	**7,054**	**2,115**	**533**	**517**	<10	<10
1,1,1-Trichloroethane	**134**	<25	**1,537**	<25	<25	<25
Trichloroethene	**645,147**	**165,110**	**40,777**	**36,899**	**132**	**116**
Tetrachloroethene	**1,803**	**290**	**91**	**51**	<10	**27**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-044	PSG-045	PSG-045	PSG-046	PSG-047	PSG-048
Client Sample ID:	122017	122017	122017-Dup	122017	122117	122017
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	C18010252	C18010253	C18010254	C18010255	C18010256	C18010257
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/3/2018
Analysis Time:	6:28	6:50	7:11	7:34	7:57	8:19
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	**134**	**103**	**20**	<10	**99**	**40**
1,1-Dichloroethene	**228**	**1,130**	**539**	**237**	**1,539**	**134**
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	**178**	**1,603**	**2,362**	**830**	**755**	**54**
1,1-Dichloroethane	<25	**248**	**788**	<25	<25	<25
cis-1,2-Dichloroethene	**3,502**	**4,068**	**6,573**	**3,170**	**35,490**	**711**
1,1,1-Trichloroethane	**964**	**21,481**	**44,892**	**84**	<25	<25
Trichloroethene	**51,439**	**147,236**	**269,194**	**303,761**	**821,017**	**15,024**
Tetrachloroethene	**199**	**280**	**377**	**231**	**7,104**	**26**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-049	PSG-050	PSG-051	PSG-052	PSG-053	PSG-054
Client Sample ID:	122017	122017	122017	122117	122117	122117
Project Number:	3945	3945	3945	3945	3945	3945
Lab File ID:	C18010258	C18010259	C18010260	C18010261	C18010262	C18010263
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/3/2018
Analysis Time:	8:41	9:03	9:25	9:46	10:08	10:30
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	**344**	**29**	<10	**14**	<10	**7 J**
1,1-Dichloroethene	**570**	**471**	**49**	**809**	**49**	**728**
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	**1,479**	**2,101**	**48**	**287**	**20**	**240**
1,1-Dichloroethane	**81**	**25**	<25	<25	<25	<25
cis-1,2-Dichloroethene	**4,340**	**2,891**	**189**	**4,205**	**170**	**2,331**
1,1,1-Trichloroethane	**4,420**	**515**	<25	**55**	<25	<25
Trichloroethene	**14,737**	**103,432**	**34,286**	**392,197**	**24,181**	**115,234**
Tetrachloroethene	**101**	**197**	**18**	**567**	**15**	**115**

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

Table 1

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

Analysis by EPA Method 8260C

	PSG-055		PSG-056	PSG-056	PSG-057	PSG-057
Client Sample ID:	122117	LB180103c	122117	122117-Dup	122117	122117-Dup
Project Number:	3945		3945	3945	3945	3945
Lab File ID:	C18010264	C18010303	C18010309	C18010310	C18010311	C18010312
Received Date:	12/22/2017		12/22/2017	12/22/2017	12/22/2017	12/22/2017
Analysis Date:	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/3/2018	1/3/2018
Analysis Time:	10:52	14:25	16:44	17:06	17:29	17:51
Matrix:	Soil Gas		Soil Gas	Soil Gas	Soil Gas	Soil Gas
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	**238**	<10	<10	<10	<10	<10
1,1-Dichloroethene	**457**	<10	**47**	**44**	**25**	**58**
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	**135**	<10	**30**	**25**	**11**	**46**
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	**1,955**	<10	**197**	**194**	**104**	**366**
1,1,1-Trichloroethane	<25	<25	**73**	<25	<25	<25
Trichloroethene	**144,913**	<25	**33,822**	**25,264**	**20,590**	**20,253**
Tetrachloroethene	**162**	<10	**29**	**20**	**15**	**20**

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

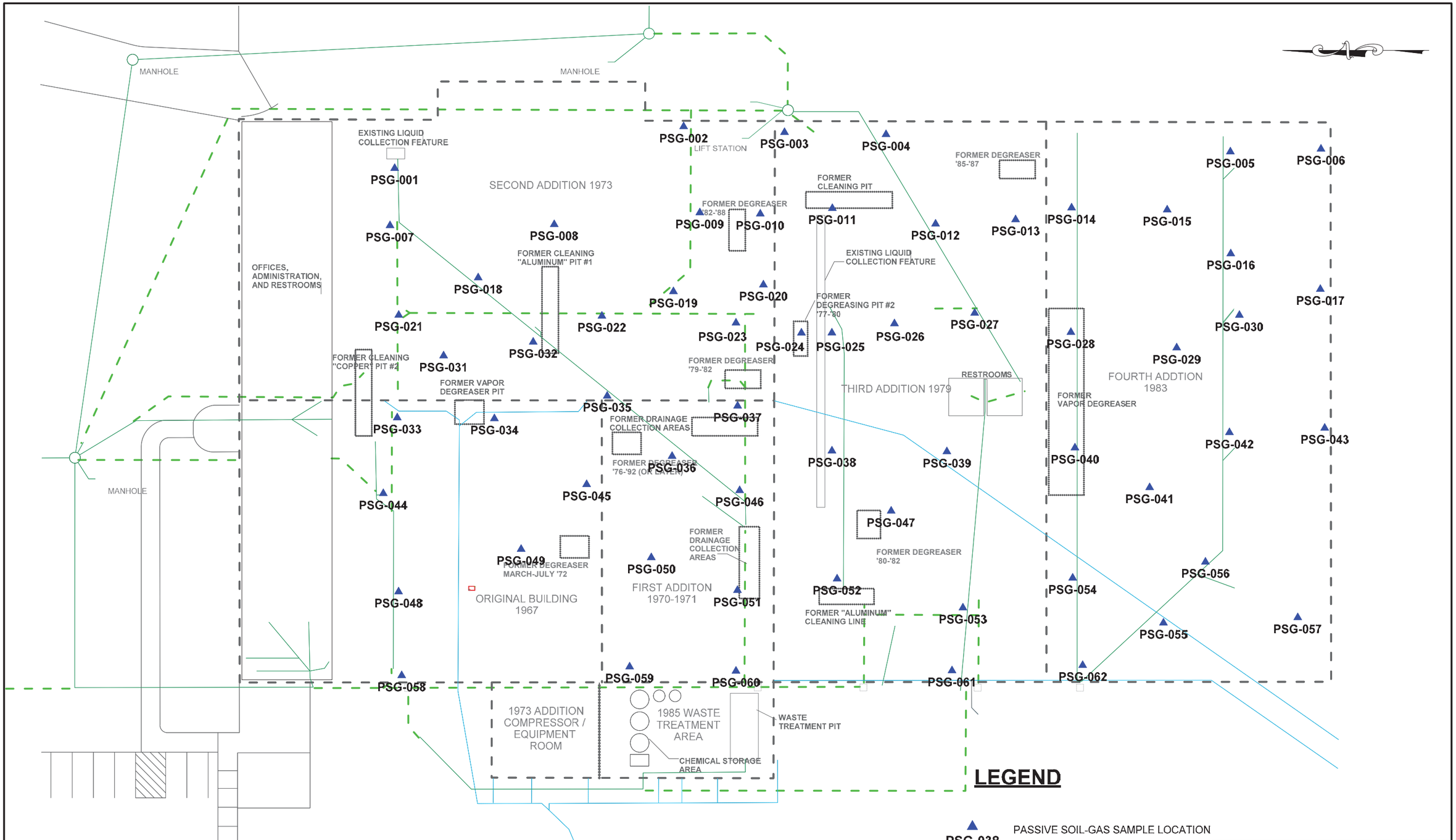
Table 1

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

Analysis by EPA Method 8260C

	PSG-058	PSG-059	PSG-060	PSG-061	PSG-062	
Client Sample ID:	122017	122017	122017	122117	122117	LB180108s
Project Number:	3945	3945	3945	3945	3945	
Lab File ID:	C18010313	C18010314	C18010315	S18010816	C18010317	S18010803
Received Date:	12/22/2017	12/22/2017	12/22/2017	12/22/2017	12/22/2017	
Analysis Date:	1/3/2018	1/3/2018	1/3/2018	1/8/2018	1/3/2018	1/8/2018
Analysis Time:	18:13	18:34	18:56	18:09	19:40	13:05
Matrix:	Soil Gas	Soil Gas	Soil Gas	Soil Gas	Soil Gas	
Units:	ng	ng	ng	ng	ng	ng
COMPOUNDS						
Vinyl Chloride	<10	**6 J**	<10	<10	**8 J**	<10
1,1-Dichloroethene	**121**	**135**	**28**	<10	**136**	<10
Methylene Chloride	<25	<25	<25	<25	<25	<25
trans-1,2-Dichloroethene	**56**	**206**	**18**	**7 J**	**114**	<10
1,1-Dichloroethane	<25	<25	<25	<25	<25	<25
cis-1,2-Dichloroethene	**580**	**691**	**59**	**71**	**956**	<10
1,1,1-Trichloroethane	<25	<25	<25	<25	<25	<25
Trichloroethene	**65,120**	**35,764**	**13,250**	**209**	**31,124**	<25
Tetrachloroethene	**151**	**31**	**10**	**8 J**	**30**	<10

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



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2203A Commerce Road, Suite 1, Forest Hill, MD 21050 USA
www.Beacon-USA.com 1-410-838-8780
Beacon Project No. 3945, January 2018

Figure 1
Passive Soil-Gas Survey Sample Locations

221 Sunset Drive
Camdenton, MO

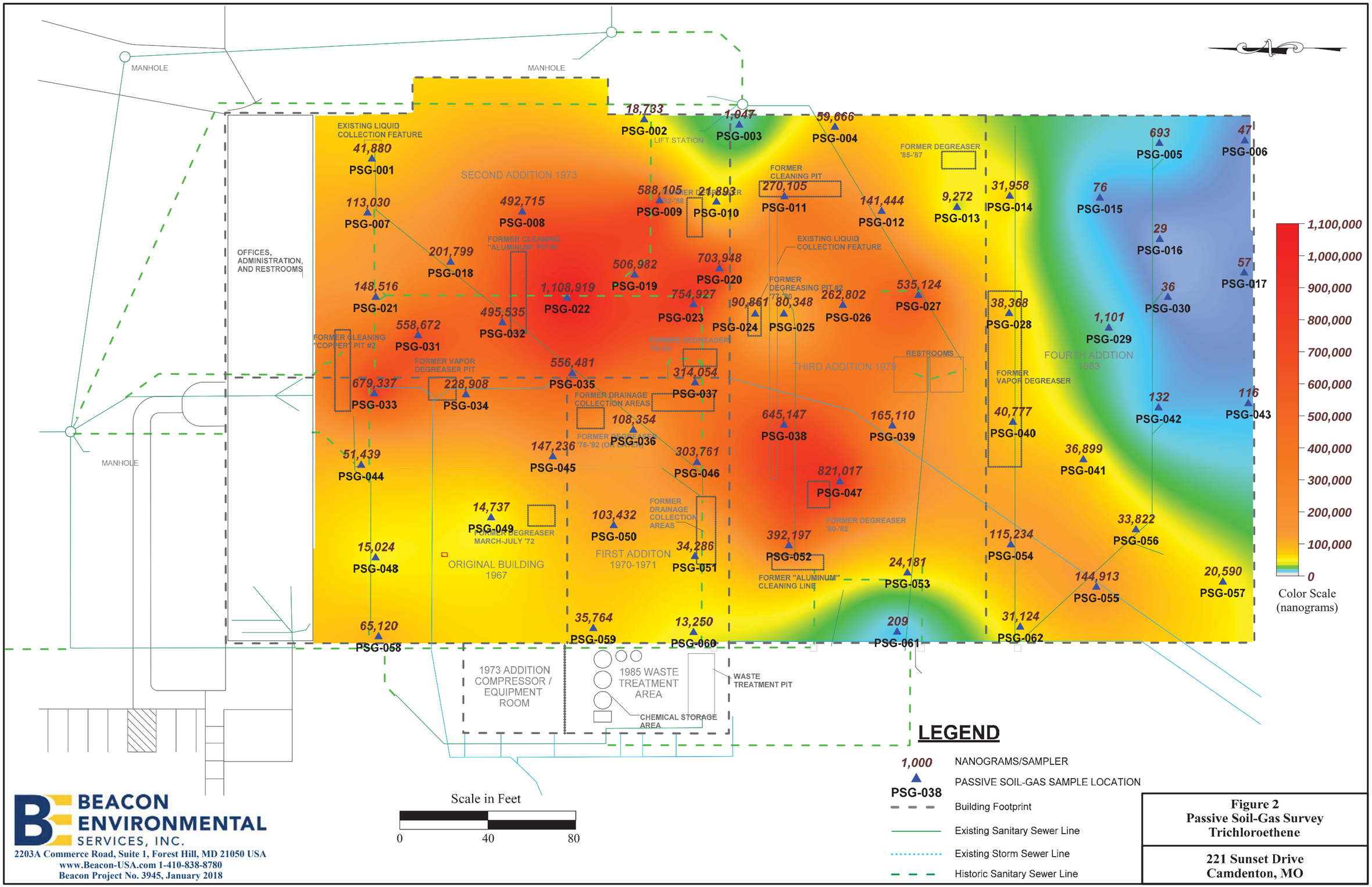
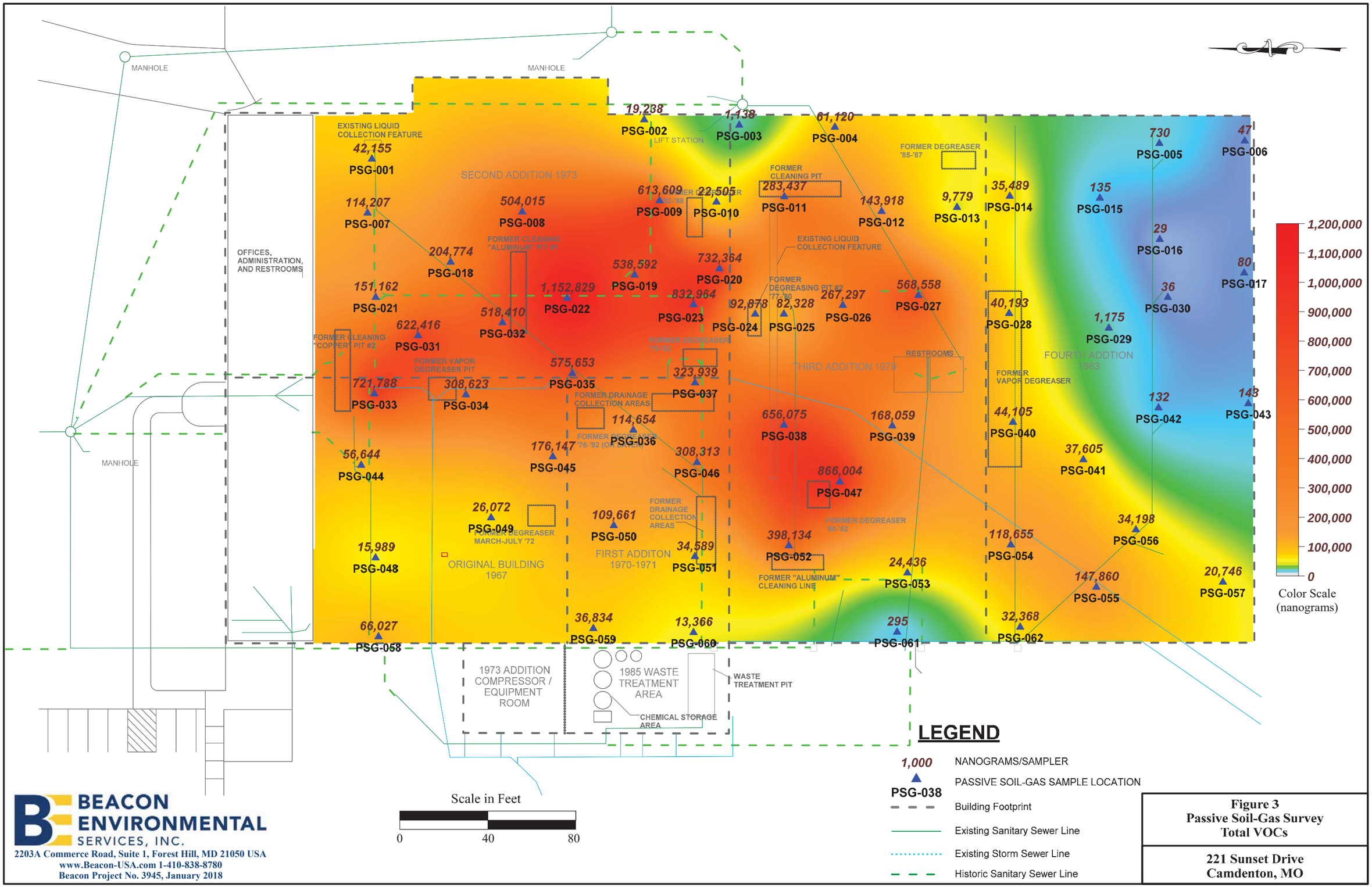


Figure 2
Passive Soil-Gas Survey
Trichloroethene

221 Sunset Drive
Camdenton, MO



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Beacon Project No. 3945, January 2018

Figure 3
Passive Soil-Gas Survey
Total VOCs

221 Sunset Drive
Camdenton, MO

Attachments

Attachment 1

APPLYING RESULTS FROM PASSIVE SOIL-GAS SURVEYS

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

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

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

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

Attachment 2

FIELD PROCEDURES FOR PASSIVE SOIL-GAS SURVEYS

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

A. Field personnel carry a BESURE Sample Collection Kit™ and support equipment to the site and deploy the passive samplers in a prearranged survey pattern. A passive sampler consists of a borosilicate glass vial containing hydrophobic adsorbent cartridges with a length of wire attached to the vial for retrieval. Although samplers require only one person for emplacement and retrieval, the specific number of field personnel required depends upon the scope and schedule of the project. Each Sampler emplacement generally takes less than two minutes.

B. At each survey point a field technician clears vegetation as needed and, using a hammer drill with a 1″- to 1½″-diameter bit, creates a hole 12 to 14 inches deep. [Note: For locations covered with asphalt, concrete, or gravel surfacing, the field technician drills a 1″- to 1½″-diameter hole through the surfacing to the soils beneath]. The technician then, using a hammer drill with a ½″ diameter bit, creates a hole three-feet deep. The hole is then sleeved with a 1″-diameter metal sleeve.

C. The technician then removes the solid plastic cap from a sampler and replaces it with a Sampling Cap (a plastic cap with a hole covered by screen meshing). The technician inserts the sampler, with the Sampling Cap end facing down, into the hole (**see attached figure**). The sampler is then covered with an aluminum foil plug and soils for uncapped locations or, for capped locations, an aluminum foil plug and a concrete patch. The sampler's location, time and date of emplacement, and other relevant information are recorded on the Field Deployment Form.

D. One or more trip blanks are included as part of the quality-control procedures.

E. Once all the samplers have been deployed, field personnel schedule sampler recovery and depart, taking all other equipment and materials with them.

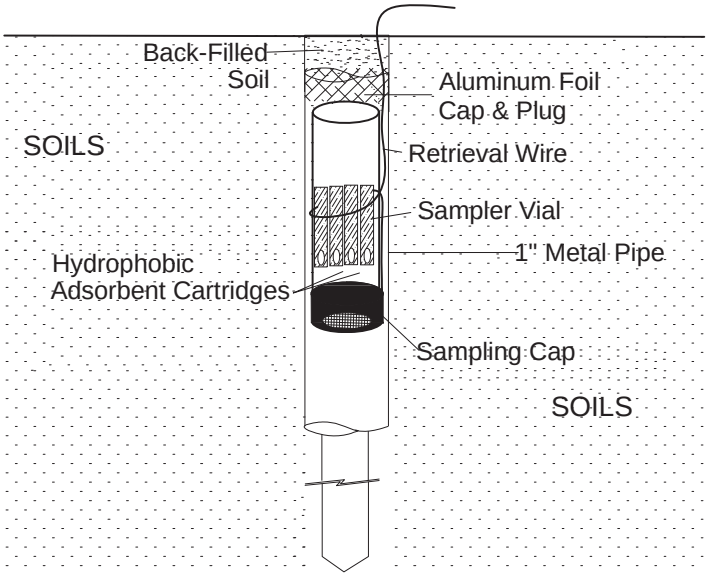
F. Field personnel retrieve the samplers at the end of the exposure period. At each location, a field technician withdraws the sampler from its hole, removes the retrieval wire, and wipes the outside of the vial clean using gauze cloth; following removal of the Sampling Cap, the threads of the vial are also cleaned. A solid plastic cap is screwed onto the vial and the sample location number is written on the label. The technician then records sample-point location, date, time, etc. on the Field Deployment Form.

G. Sampling holes are refilled with soil, sand, or other suitable material. If samplers have been installed through asphalt or concrete, the hole is filled to grade with a plug of cold patch or cement.

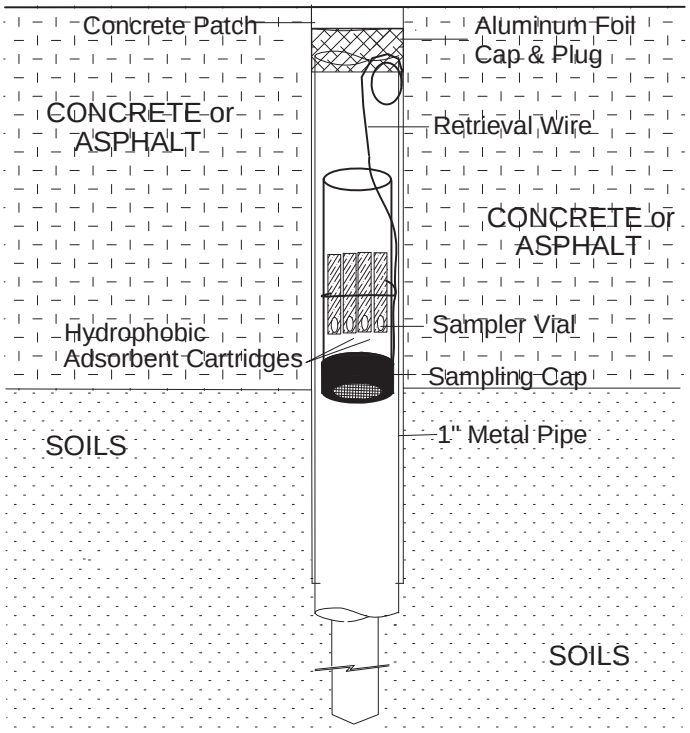
H. Following retrieval, field personnel ship or transport the passive samplers to BEACON's laboratory.

BEACON'S PASSIVE SOIL-GAS SAMPLER

DEPLOYMENT THROUGH SOILS



DEPLOYMENT THROUGH AN ASPHALT/CONCRETE CAP



Attachment 3

Chain of Custody Form

BEACON ENVIRONMENTAL SERVICES, INC.

CHAIN-OF-CUSTODY PASSIVE SOIL-GAS SAMPLES

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

Project Information		Client Information		
Beacon Project No.:	3945	Company Name:	CH2M	Client PO No.: 681225.02.01
Site Name:	221 Sunset Drive	Office Location:	St. Louis, MO	
Site Location	Camdenton, MO	Samples Submitted By:	E. Hogan	Expedited Turnaround Time
Analytical Method:	U.S. EPA Method 8260C	Contact Phone No.:	573-476-5656	☐ Rush (Specify): 7 Days
Target Compounds:	1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethylene, cis-1,2-DCE, trans-1,2-DCE, methylene chloride, tetrachloroethylene, TCE, Vinyl chloride			

Field Sample ID	Date Emplaced / Time Emplaced	Date Retrieved / Time Retrieved	Sampling Hole Depth (inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)
PSG-001-122017	12/11/17, 1445	12/20/17, 1125	36	Concrete	0.0 ppm
PSG-007-122017	12/11/17, 1515	12/20/17, 1135			1.5 ppm
PSG-021-122017	12/11/17, 1535	12/20/17, 1139			2.2 ppm
PSG-031-122017	12/11/17, 1545	12/20/17, 1142			34.5 ppm
PSG-033-122017	12/11/17, 1555	12/20/17, 1148			85.3 ppm
PSG-044-122017	12/11/17, 1615	12/20/17, 1154			16.1 ppm
PSG-048-122017	12/11/17, 1640	12/20/17, 1200			2.2 ppm
PSG-058-122017	12/12/17, 0815	12/20/17, 1205			10.5 ppm
PSG-049-122017	12/12/17, 0830	12/20/17, 1210			2.5 ppm
PSG-045-122017	12/12/17, 0845	12/20/17, 1214			76.4 ppm
PSG-045-122017-DUP	12/12/17, 0845	12/20/17, 1214			76.4 ppm Duplicate
PSG-034-122017	12/12/17, 0905	12/20/17, 1222			122.4 ppm
PSG-032-122017	12/12/17, 0915	12/20/17, 1225			295.5 ppm
PSG-018-122017	12/12/17, 0940	12/20/17, 1229			9.3 ppm
PSG-002-122017	12/12/17, 1005	12/20/17, 1233			0.8 ppm

Special Notes/Instructions:

Shipment of Field Kit to Laboratory - Custody Seal # 0568590 Intact? (Y) N

Relinquished By:	Date/Time	Courier	Received By:	Date/Time
Ethan Hogan	12-21-17 1400	FedEx	Augusto Benavides	12/22/17 15:00

Please contact Shannon Olson with laboratory info/results: Shannon.Olson@ch2m.com

BEACON ENVIRONMENTAL SERVICES, INC.

CHAIN-OF-CUSTODY
PASSIVE SOIL-GAS SAMPLES

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

Project Information		Client Information		
Beacon Project No.:	3945	Company Name:	CH2M	Client PO No.: 681225.02.01
Site Name:	221 Sunset Dr	Office Location:	St. Louis, MO	
Site Location	Camdenton, MO	Samples Submitted By:	E. Hogen	Expedited Turnaround Time
Analytical Method:	U.S. EPA Method 8260C	Contact Phone No.:	573-476-5656	☐ Rush (Specify): 7 Days
Target Compounds:	See page 1			

Field Sample ID	Date Emplaced / Time Emplaced	Date Retrieved / Time Retrieved	Sampling Hole Depth (Inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)
PSG-008-122017	12/12/2017, 1040	12/20/2017, 1412	36	Concrete	45.2 ppm
PSG-009-122017	12/12/2017, 1015	12/20/2017, 1416			34.7 ppm
PSG-019-122017	12/12/17, 1100	12/20/17, 1420			173.0 ppm
PSG-022-122017	12/12/17, 1310	12/20/17, 1423			31.1 ppm
PSG-035-122017	12/12/17, 1320	12/20/17, 1427			105.2 ppm
PSG-036-122017	12/12/17, 1345	12/20/17, 1433			18.7 ppm
PSG-036-122017-DUP	12/12/17, 1345	12/20/17, 1433			18.7 ppm Duplicate
PSG-050-122017	12/12/17, 1400	12/20/17, 1437			1.5 ppm
PSG-059-122017	12/12/17, 1420	12/20/17, 1441			8.9 ppm
PSG-060-122017	12/12/17, 1455	12/20/17, 1444			0.5 ppm
PSG-051-122017	12/12/17, 1510	12/20/17, ~~1510~~ 1448 (EH)			3.4 ppm
PSG-046-122017	12/12/17, 1525	12/20/17, 1452			3.9 ppm
PSG-037-122017	12/12/17, 1545	12/20/17, 1501			11.4 ppm
PSG-023-122017	12/12/17, 1600	12/20/17, 1505			4.3 ppm
PSG-020-122017	12/13/17, 0815	12/20/17, 1509			201.1 ppm
PSG-010-122017	12/13/17, 0830	12/20/17, 1512			0.4 ppm
PSG-003-122017	12/13/17, 0845	12/20/17, 1515			0.1 ppm
PSG-011-122017	12/13/17, 0930	12/20/17, 1518			101.3 ppm
PSG-011-122017-DUP	12/13/17, 0930	12/20/17, 1518			101.3 ppm Duplicate
PSG-025-122017	12/13/17, 0945	12/20/17, 1530			5.0 ppm

Special Notes/Instructions: ~~2.5 ppm~~ (EH)

BEACON ENVIRONMENTAL SERVICES, INC.

CHAIN-OF-CUSTODY
PASSIVE SOIL-GAS SAMPLES

2203A Commerce Road, Suite 1
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Project Information		Client Information		
Beacon Project No.:	3945	Company Name:	CH2M	Client PO No.: 681225.02.01
Site Name:	221 Sunset Dr	Office Location:	St. Louis, MO	
Site Location	Camdenton, MO	Samples Submitted By:	Ettogan	Expedited Turnaround Time
Analytical Method:	U.S. EPA Method 8260C	Contact Phone No.:	(EH) ~~573-46~~ 573-476-5656	☐ Rush (Specify): 7 Days
Target Compounds:	See page 1			

Field Sample ID	Date Emplaced / Time Emplaced	Date Retrieved / Time Retrieved	Sampling Hole Depth (Inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)
PSG-024-122017	12/13/17, 1000	12/20/17, 1526	36	Concrete	2.5 ppm
PSG-038-122017	12/13/17, 1015	12/20/17, 1532			10.0 ppm
PSG-047-122117	12/13/17, 1030	12/21/17, 1019			210.1 ppm
PSG-052-122117	12/13/17, 1045	12/21/17, 1023			30.3 ppm
PSG-061-122117	12/13/17, 1110	12/21/17, 1027			0.1 ppm
PSG-053-122117	12/13/17, 1310	12/21/17, 1031			0.1 ppm
PSG-039-122117	12/13/17, 1325	12/21/17, 1034			13.5 ppm
PSG-026-122117	12/13/17, 1345	12/21/17, 1038			10.7 ppm
PSG-027-122117	12/13/17, 1400	12/21/17, 1041			27.0 ppm
PSG-027-122117-DUP	12/13/17, 1400	12/21/17, 1041			27.0 ppm Duplicate
PSG-012-122117	12/13/17, 1420	12/21/17, 1044			50.0 ppm
PSG-004-122117	12/13/17, 1435	12/21/17, 1048			0.1 ppm
PSG-013-122117	12/13/17, 1535	12/21/17, 1052			3.5 ppm
PSG-014-122117	12/13/17, 1545	12/21/17, 1056			1.5 ppm
PSG-028-122117	12/13/17, 1605	12/21/17, 1100			4.5 ppm
PSG-040-122117	12/13/17, 1620	12/21/17, 1103			0.2 ppm
PSG-054-122117	12/14/17, 0830	12/21/17, 1107			14.5 ppm
PSG-062-122117	12/14/17, 0845	12/21/17, 1113			1.5 ppm
PSG-055-122117	12/14/17, 0915	12/21/17, 1117			24.4 ppm
PSG-056-122117	12/14/17, 0930	12/21/17, 1120			0.5 ppm

Special Notes/Instructions:

BEACON ENVIRONMENTAL SERVICES, INC.

CHAIN-OF-CUSTODY
PASSIVE SOIL-GAS SAMPLES

2203A Commerce Road, Suite 1
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P: 1-410-838-8780 | F: 1-410-838-8740

Project Information		Client Information		
Beacon Project No.:	3945	Company Name:	CHZM	Client PO No.: 681225.02.01
Site Name:	221 Sunset Dr	Office Location:	St. Louis, MO	
Site Location	Camdenton, MO	Samples Submitted By:	E. Hogan	Expedited Turnaround Time
Analytical Method:	U.S. EPA Method 8260C	Contact Phone No.:	573-476-5656	☐ Rush (Specify): 7 Days
Target Compounds:	See page 1			

Field Sample ID	Date Emplaced / Time Emplaced	Date Retrieved / Time Retrieved	Sampling Hole Depth (Inches)	Type of Surface (Soil/Asphalt/Concrete/Gravel)	Optional Sample Information (e.g., Description of Sample Location, Sample Condition, PID/FID Readings)
PSG-056-122117-DUP	12/14/17, 0930	12/21/17, 1120	36	Concrete	0.5 ppm Duplicate
PSG-041-122117	12/14/17, 1000	12/21/17, 1123			19.0 ppm
PSG-042-122117	12/14/17, 1015	12/21/17, 1126			5.9 ppm
PSG-029-122117	12/14/17, 1030	12/21/17, 1129			1.8 ppm
PSG-030-122117	12/14/17, 1040	12/21/17 1132			5.7 ppm
PSG-015-122117	12/14/17, 1055	12/21/17, 1135			2.4 ppm
PSG-016-122117	12/14/17, 1105	12/21/17, 1138			0.5 ppm
PSG-005-122117	12/14/17, 1120	12/21/17 1141			0.9 ppm
PSG-006-122117	12/14/17, 1240	12/21/17 1143			1.0 ppm
PSG-017-122117	12/14/17, 1255	12/21/17, 1146			0.9 ppm
PSG-043-122117	12/14/17, 1305	12/21/17, 1149			0.8 ppm
PSG-057-122117	12/14/17, 1315	12/21/17, 1151			0.6 ppm
PSG-057-122117-DUP	12/14/17, 1315	12/21/17, 1151			0.6 ppm Duplicate
TB-001-122117					Trip Blank

Special Notes/Instructions:

Attachment 4

LABORATORY PROCEDURES FOR PASSIVE SOIL-GAS SAMPLES

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

A. The adsorbent cartridges are loaded with internal standards and surrogates prior to loading the autosampler with the cartridges. The loaded cartridges are purged in a helium flow. Then the cartridges are thermally desorbed in a helium flow onto a focusing trap. Any analytes in the helium stream are adsorbed onto a focusing trap.

B. Following trap focusing, the trap is thermally desorbed onto a Rxi-624Sil MS 20m, 0.18 mm ID, 1.00 micron film thickness capillary column.

C. The GC/MS is scanned between 35 and 300 Atomic Mass Units (AMU) at 3.12 scans per second.

D. BFB tuning criteria and the initial five-point calibration procedures are those stated in method SW846-8260C. System performance and calibration check criteria are met prior to analysis of samples. A laboratory method blank is analyzed after the daily standard to determine that the system is contaminant-free.

E. The instrumentation used for these analyses includes:

- Agilent 7890-5975c Gas Chromatograph/Mass Spectrometer;
- Markes Unity2 thermal desorber;
- Markes UltrA2 autosampler; and
- Markes Mass Flow Controller Modules.

and

- Agilent 7890-5975c Gas Chromatograph/Mass Spectrometer; and
- Markes TD100 thermal desorption system.