Appendix B – Supplemental Guidance Information

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APPENDIX B.1

Alternate Approach for Demonstrating Compliance with the Volatilization to Indoor Air Pathway (Big Building Model)

Remediation and Redevelopment Division

ALTERNATE APPROACH
FOR
DEMONSTRATING COMPLIANCE WITH THE
VOLATILZATION TO INDOOR AIR PATHWAY

"Big Building Model"

Original Date of Issuance: January 19, 2012

Revision #: 1 Revision Date: December 7, 2012

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A policy guidance document cannot establish regulatory requirements for parties outside of the Michigan Department of Environmental Quality (MDEQ). It is explanatory and provides direction to staff, guidance to the regulated community, and consistency in enforcing the NREPA, but does not have the force and effect of law and is not legally binding on the public or the regulated community.

PLEASE NOTE:

This approach was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide an alternate approach to parties implementing a response action in Michigan. It was created to promote an alternate approach that is consistent with Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). This document is not a statutory requirement, but could be implemented as an alternate approach under R 299.5714(5) and R 299.5724(5).

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document also does not represent an endorsement of practitioners or products mentioned in the document nor does it ensure that this approach is appropriate for all sites. It is imperative that the environmental professional implementing this approach provide adequate justification.

This approach is made available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern. The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the approach was written for MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

Introduction

Because of the nature of large buildings (e.g., larger footprint, higher air exchange, taller ceilings, lack of a basement, thicker slabs of concrete, and occupational activity patterns resulting in less exposure), a generic approach to assessing the potential for vapor intrusion may overestimate the risk to users of the building. Therefore, the MDEQ has identified an approach that is referred to as the "Big Building Model" (BBM) with the intent to provide an alternative methodology for large nonresidential buildings to utilize multiple lines-of-evidence in demonstrating compliance with the volatilization to the indoor air exposure pathway (i.e., vapor intrusion pathway). The MDEQ approach relies primarily on a paper titled, "Prediction of Indoor Air Quality from Soil-Gas Data at Industrial Buildings (Eklund and Burrows, 2009)." The approach has been modified so that it may be utilized to demonstrate compliance with site-specific criteria allowed for under Part 201, including the use of the MDEQ's vapor intrusion screening values (SV_{vi}) as site-specific criteria in situations where the generic cleanup criteria do not apply.

Under Section 20120b, the MDEQ must review and approve all site-specific criteria. For those not approved by the MDEQ prior to the 2010 Amendments, this is now completed through the submittal of a Response Activity Plan.

When relying on soil gas and/or sub-slab soil gas sample data to evaluate the potential for unacceptable human health risks from the volatilization of subsurface contamination to the indoor air (i.e., vapor intrusion), it is common regulatory practice to rely on the maximum soil gas and/or sub-slab soil gas concentrations. This approach is reasonable and often necessary for assessing smaller buildings (less than 5,000 square feet) where a lack of characterization requires the assumption that contamination underlies the entire structure. However, when applied to large nonresidential structures, the use and reliance of the maximum concentration may be overly conservative, especially where localized or discrete areas of contamination have been identified.

1.0 BUILDING CHARACTERISTICS ASSUMED IN GENERIC CRITERIA

When comparing the differences and characteristics between small residential buildings and large nonresidential structures, there are several actual building characteristics that may influence how conservative the use of a maximum sub-slab soil gas concentration is. These include (but are not limited to):

- Building Footprint – 4,000 square feet (ft^2) (372 square meters (m^2)) was utilized as the floor space area in the development of the generic groundwater volatilization to indoor air inhalation criteria (GVIIC) and the soil volatilization to indoor air inhalation criteria (SVIIC) (MDEQ, 1998, 2009). However, as identified by Eklund and Burrows (2009), it is not uncommon for large manufacturing and warehouses (i.e., large nonresidential buildings) to have footprints that are greater than 10,500 ft^2 (1,000 m^2). The size of the floor space utilized in developing the Part 201 criteria was originally guided by a report entitled *Commercial Buildings Characteristics 1992* which documents the results of a Commercial Buildings Energy Consumption Survey (CBECS) conducted by the United States Department of Energy (DOE, 1994).

- Ceiling Height – Eight feet is the generic commercial building height used in the development of the generic GVIIC and SVIIC (MDEQ, 1998, 2009). It is also the default ceiling height listed in the United States Environmental Protection Agency (USEPA) modeling guidance (USEPA, 2004). However, it is not uncommon for many of the structures addressed by the generic nonresidential criteria (i.e., manufacturing, industrial operations, and warehousing) to exceed interior building heights of 16 feet (NAIOP, 2005). The larger air volume provided by the increased height provides a greater potential mixing, allowing for the potential for dilution of any chemicals that enter the building via vapor intrusion (Eklund and Burrows, 2009).

- Thickness of Flooring – Large nonresidential buildings generally have slabs that are thicker than the default standard established by the generic Part 201 criteria (MDEQ, 1998 and 2009) of six inches (15 centimeters (cm)). Eklund and Burrows (2009) identify that these structures often have slabs up to 12 inches (30 cm). With thicker slabs present, differential settling of the underlying soil is less likely to lead to cracking. In addition, any cracks that are present would be less likely to extend through the entire slab thickness thus creating a preferential pathway that would directly connect the indoor space to the pore spaces in the sub-slab fill material.

- Air Exchange Rates – Large nonresidential buildings used for manufacturing, industrial operations, and warehousing tend to have higher air exchange rates than single-family homes. Though typical ventilation rates for these nonresidential structures have not been reported, it can be assumed that the rates are equal to or exceed the rates for office buildings, especially for buildings with bay doors and limited insulation (Eklund and Burrows, 2009). In most large nonresidential buildings, areas of natural ventilation (random cracks, interstices, and other unintentional openings in the building envelope) are easily observable.

- Large Open Areas – Large nonresidential buildings may have large and continuous open areas (areas without walls or barriers) in order to complete their intended manufacturing or warehouse use. These areas can easily exceed 40,000 ft^2. The greater area of continuous open air allows for a greater potential of mixing for any chemicals that enter the building via vapor intrusion.

2.0 BUILDING CHARACTERISTICS NECESSARY FOR THE USE OF THE BBM

When it is desired to utilize the BBM methodology, certain building characteristics must exist that support the model. These characteristics are as follows:

- Large continuous open areas greater than 4,000 m^2 (43,000 ft^2)
- Ceiling heights greater than 5 m (16 ft)
- Slab-on-grade construction with thicknesses greater than 15 cm (6 inches)
- No dry wells, floor drains, sumps, or other building features are present that would provide a direct conduit to the subsurface are present
- When groundwater is present, concentrations are stable and/or decreasing

When these conditions are not present, it may be possible to provide additional justification for the use of the BBM. However, it should be noted that these situations will be rare and may not be cost efficient to collect the data necessary for the justification.

In addition to the building characteristics identified above, there must also be sufficient site characterization such that potential sources of vapors have been identified and a thorough understanding of the site geology and hydrogeology exists. This includes the expected seasonal variation of the groundwater elevation.

3.0 GENERAL APPROACH TO THE BIG BUILDING MODEL

Consistent with Eklund and Burrows (2009), the MDEQ's recommended approach is to divide the building footprint into a number of grids or zones (z_1, z_2, z_3 through z_n) that are assigned a representative sub-slab soil gas

concentration (C_z) and an area (A_z) that is a portion of the total area (A). The resulting zonal average sub-slab soil gas concentration can be compared directly to a screening concentration such as the MDEQ's screening concetrations for soil gas collected less than five feet bgs or the lowest point of a structure (SG_{vi-ss}).
As discussed in the MDEQ's document titled Guidance Document for the Vapor Intrusion Pathway (MDEQ VI Guidance Document the SG_{vi-ss} were developed using the acceptable indoor air criteria (AIAC) with an attenuation factor (alpha or α_{DEQ}) based on empirical data that a party may use under Part 201 as a site-specific criterion in situations where the generic criteria do not apply.

The zonal average sub-slab soil gas concentration is calculated as identified in Equation 1:

EQUATION 1:

$$C_{subslab} = (\sum C_z A_z)/A$$

As stated in Eklund and Burrows (2009), "The areas should represent a reasonably conservative estimate of the areal extent of the associated sub-slab soil gas concentration." Estimates of zone average concentrations, geometric mean, and maximum reported values may be included for comparison and discussion; however, in most cases enough data will not be collected to allow for a statistical evaluation including a population analysis of each zone.

3.1 Zones

Areas of the structure in which zones for the BBM will be established must be based on an interior structural survey. The structural survey must include the identification of all walls, floor drains, and sumps, and must document that the conditions in Section 2.0 are present. Any variations must be clearly identified in the submitted documentation.

Initial sampling locations within each zone must be biased toward each known or potential source of vapor intrusion as well as along walls or other features outside of the area that are known to contain a source of vapors. Though collecting sub-slab samples on a regular spacing interval and/or grid can be utilized; the larger the spacing utilized, the more difficult it may be to establish discrete zones of sub-slab soil gas concentrations above the SG_{vi-ss}. The MDEQ's experience has identified spacing intervals of 40 to 50 feet provides the optimum distance for the use with the BBM model. Distances further than 80 feet often do not provide the detail necessary and directly impact the BBM's ability to demonstrate that sub-slab soil gas vapors will not impact the indoor air above the AIAC. The smaller the area of higher concentrations, the easier it will be to generate the lines-of-evidence discussed below.

Larger zones may be utilized for use in the BBM by grouping smaller zones with similar sub-slab soil gas results. A geometric mean, 95 percent upper confidence level, or other statistical methods may be possible; however, in most cases there will not be enough data to complete a statistical evaluation that includes a population analysis. If there is not enough data in each zone to complete a statistical evaluation, an average concentration is not appropriate and a maximum concentration must be utilized.

The model must also be run using data collected with the appropriate sampling methods which include the use of the TO-15. Please refer to the MDEQ's Standard Operating Procedure for the collection and analysis of sub-slab soil gas as an approved sampling methodology.

It is important that temporal considerations also be taken into account when establishing sampling locations. For example, as identified by Eklund and Burrows (2009), if a groundwater plume has only reached one end of a building, any sub-slab soil gas measurements may not be predictive of future measurements. It is also necessary to repeat the analysis at select locations to ensure that the results remain consistent due to expected temporal and seasonal variation. In most circumstances, this can be accomplished by three rounds of sub-slab soil gas samples from consecutive quarters that are shown to either be stable or decreasing in concentrations.

Figure 1 shows a representative building with a sampling grid and zones across an open manufacturing area. Figure 2 represents a site where smaller zones are grouped together, using maximum concentrations, to create fewer large zones. This is desirable in that it results in having to run the model for less zones. This approach would be typical for sites where there are multiple sources present.

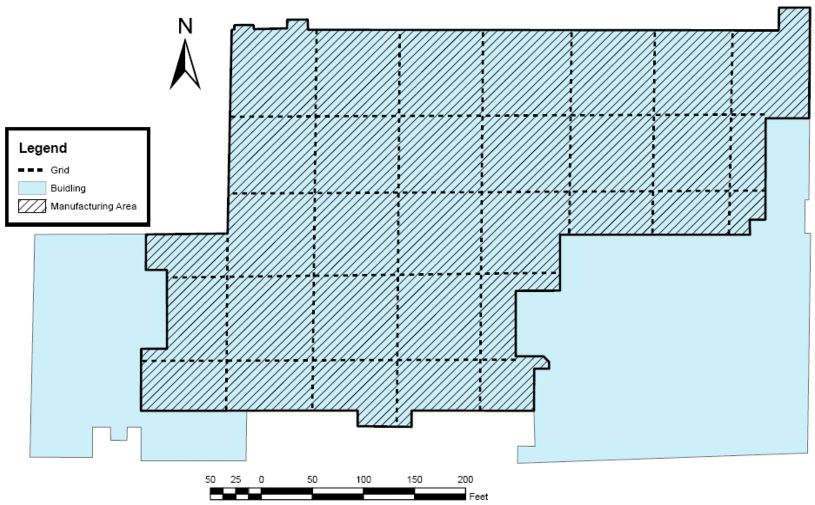

Figure 1 Building with open area and example zones identified.

Figure 2 – Grouping with similar concentrations.

3.2 Demonstrating Compliance With Site-Specific Criteria

Although the term “line-of-evidence” and “weight-of-evidence” is used frequently in assessing the potential for vapor intrusion; there is no consensus on its definition or how it can be applied quantitatively. Each evaluation (risk estimate) will have its own assumptions and associated uncertainties that may not be able to be expressed equivalently. Each line-of-evidence must be evaluated, organized, and explained so that a weight-of evidence evaluation can be made (Suter, 1993). The more the evaluation can be shown to remain protective, as the model inputs exceed the “normal” or “expected” site conditions, the stronger the line-of-evidence supporting the conclusion presented.

The weight of a line-of-evidence is reflected in three general characteristics:

- The weight assigned to each measurement
- The magnitude of response observed in the measurement endpoint
- The concurrence among outcomes of multiple measurements

Utilizing the BBM presented in this approach is not a line-of-evidence that can be supported <u>until</u> it can be shown that the site conditions can vary considerably from those identified and the site conditions still remain protective of human health. In essence, the larger the zones that can be utilized (over the identified extent of impact) and the higher the concentrations utilized in each zone (over what was detected in multiple rounds of sampling) that still indicate potential compliance with the $SG_{vi\text{-}ss}$, the stronger the weight-of-evidence.

To provide some general guidance on what conditions provide support and strength to the line-of-evidence if the building conditions established in Section 2.0 are met, the MDEQ has established the following guidelines based on a facility that has performed (or will) perform source removal:

- Extent of the known sources have been identified and delineated.
- Zones are established, are conservative, and at least two times larger in area. Data must not be interpreted between data points unless it can be shown to be overly conservative.
- The model still meets the $SG_{vi\text{-}ss}$ utilizing contamination levels that are at least three times the maximum level of contamination identified.
- No continued use of the contaminant and the source is expected to attenuate over time.
- The modeled area will remain open.

If source removal will not occur, the lines-of-evidence will need to be increased and strengthened. The strength of the evidence presented for the BBM is directly related to how much variation can be accounted for in the model. The less variation possible, the less potential that the BBM would support that a risk cannot occur without further remedial action.

3.3 Calculations

The BBM is analyzed using the following equation:

EQUATION 2:

$$BBM_{conc} = [(Zone1_{max} \times Zone1_{area})+(Zone2_{max} \times Zone2_{area})+(ZoneX_{max} \times ZoneX_{area})]/Area_{TOTAL}$$

Whereas:

BBM_{conc}	– Estimated sub-slab soil gas concentration average
$ZoneX_{max}$	– Maximum concentration identified in Zone X
$ZoneX_{area}$	– Area of Zone X
$Area_{TOTAL}$	– Total area

It is possible to compare the BBM_{conc} to the expected indoor air concentration (BBM_{air}) by multiplying the expected sub-slab soil gas concentration by the attenuation factor (α_{DEQ}). The resulting equation is:

EQUATION 3:

$$BBM_{air} = BBM_{conc} \times \alpha_{DEQ}$$

4.0 BIG BUILDING MODEL EVALUATION SITE - *EXAMPLE*

The following example is based on a site that has a single point of release within the structure. The MDEQ's $SG_{vi\text{-}ss}$ of 540 parts per billion by volume (ppbv) for trichloroethylene (TCE) was utilized as the appropriate site-specific criteria in accordance with Rules 714 and 724 of Part 201. This value represents an acceptable sub-slab soil gas screening concentration appropriate for a nonresidential exposure scenario.

The building is a long, single-story with a footprint of over 72,300 ft^2 of which 13,980 ft^2 are offices and 57,520 ft^2 is part of the manufacturing area. A structural survey and picture documentation confirms that the entire manufacturing area is open and there are no walls or partitions present. An additional 800 ft^2 of space on the manufacturing floor has been removed from consideration from the manufacturing area as that area contains a bathroom and an office area (no contamination, including vapors, has been found beneath either of these structures). Ceiling heights in the manufacturing area are 25 feet. The foundation is slab-on-grade construction that is at least eight inches thick, based on multiple cores. Figure 3 depicts the building.

The site was utilized for manufacturing up until operations ceased in 2007. It contained a former degreasing still and pit (see Figure 3). No other sources of TCE in the open area of the structure were identified. Upon investigation, soils and groundwater were found that contained levels of TCE above Part 201 C_{sat} criteria. In addition, groundwater was less than four feet below the ground surface. Therefore, the Part 201 GVIIC did not apply (see Checklist for Determining if the Generic Volatilization to Indoor Air Inhalation Criteria Apply, Appendix A.1)

The investigation identified sub-slab soil gas concentrations of up to 8,000 ppbv. In order to address the pathway, the company voluntarily performed a source removal around the former degreaser that was located within the structure and extracted groundwater from beneath the floor of the building in a continuing effort to reduce the remaining contaminant mass. Confirmation sampling over multiple sampling events showed that the concentrations of sub-slab soil gas continued to decrease; however, values still continued to exceed the MDEQ's $SG_{vi\text{-}ss}$. Maximum concentrations from the last three events are identified in Table 1 and the sampling locations are identified on Figure 3.

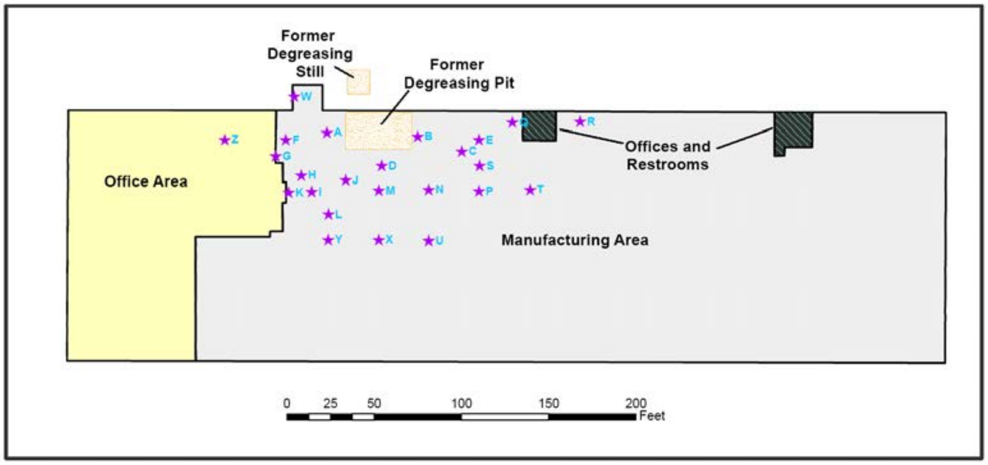

Figure 3 Building Figure

Table 1 Maximum Detected Soil Gas Concentrations For TCE

Point ID	TCE (ppbv)	Point ID	TCE (ppbv)	Point ID	TCE (ppbv)	Point ID	TCE (ppbv)
A	1000	G	ND	M	210	T	2
B	1500	H	290	N	130	U	2
C	580	I	730	P	23	W	260
D	330	J	600	Q	3	X	3
E	130	K	16	R	ND	Y	ND
F	79	L	5	S	140	Z	ND

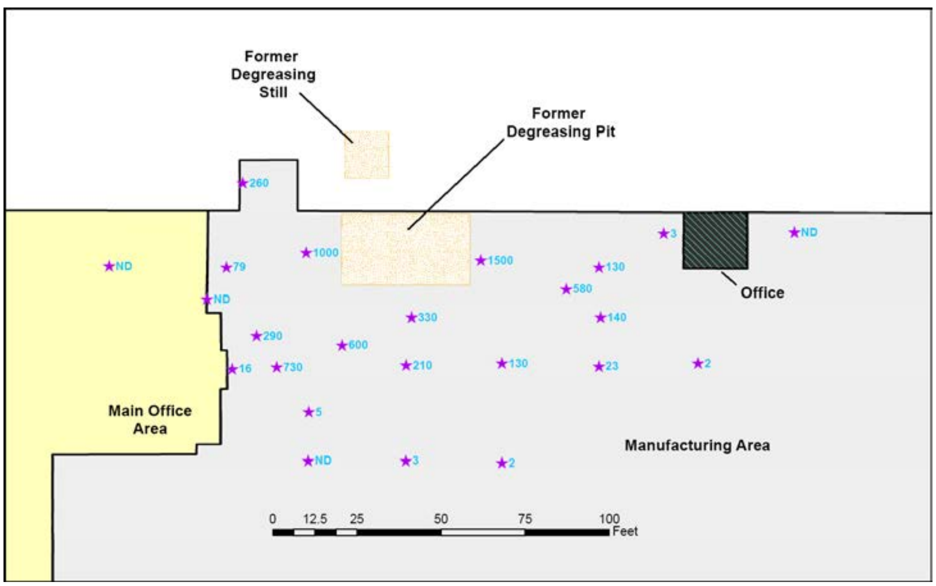

Figure 4 Maximum Concentrations Detected (ppbv of TCE)

The responsible party wished to utilize the BBM to further evaluate the site and determine if further response actions were necessary. Based upon the concentrations identified in Table 1 and Figure 4, the responsible party prepared Figure 5 that identified a contour for the area that remained above the $SG_{vi\text{-}ss}$ nonresidential concentration of 540 ppbv (Figure 6). The map also presented a contour that established concentrations below five ppbv (detection limit of the TO-15 analysis).

Zone 1 was established to represent the areas above the MDEQ's $SG_{vi\text{-}ss}$ of 540 ppbv and was expanded to a point that it contained 79 percent more area than presented in Figure 5. Zone 2 was established to represent a "transition" area between the areas with the sub-slab soil gas concentrations above the MDEQ's $SG_{vi\text{-}ss}$ and the areas where sub-slab soil gas points were analyzed to levels below the detection limit. It also provides an additional zone for modeling.

Final square footage of each area utilized in the BBM was: Zone 1 at 5,425 ft^2; Zone 2 at 4,300 ft^2; and Zone 3 at 47,795 ft^2. Zone 3's square footage was established by:

EQUATION 4:

$$Area_{ZONE3} = Area_{MANU} - (Area_{ZONE1} + Area_{ZONE2})$$

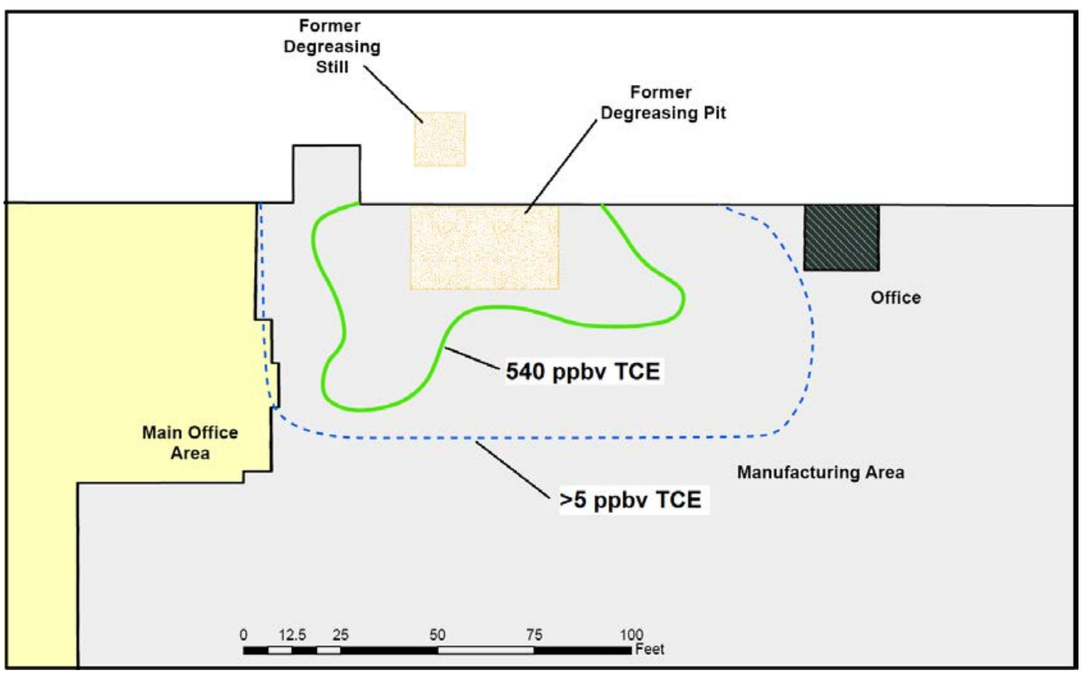

Figure 5 – Contours associated with the MDEQ's $SG_{vi\text{-}ss}$ value of 540 ppbv for TCE

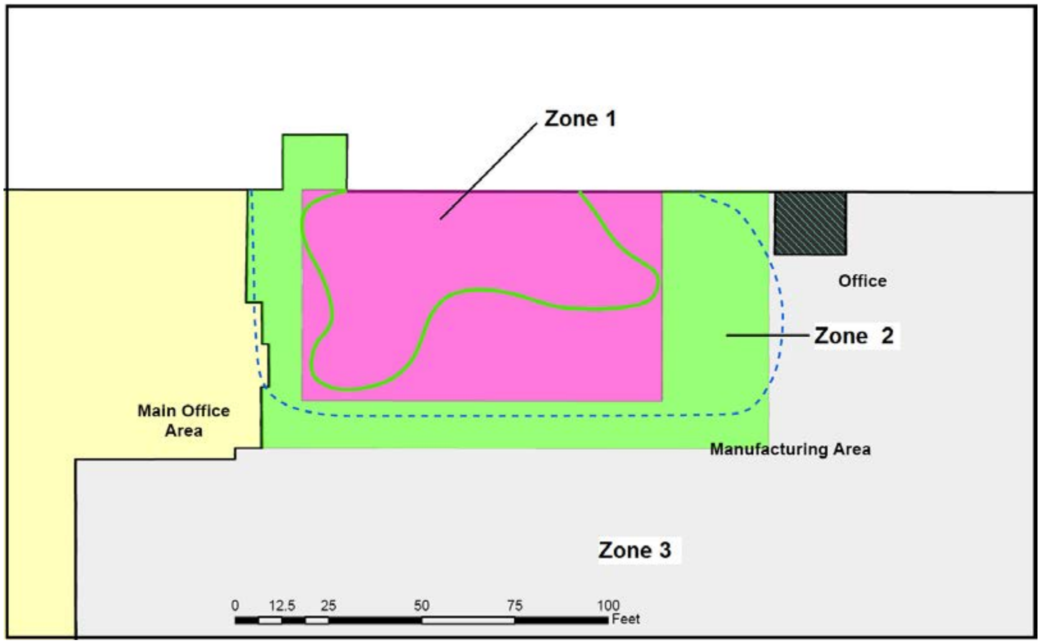

Figure 6 – Establishing the Zones

The inputs for all runs are identified in Table 2. Variations and modifications made for each run of the model are briefly described below. Again, it is important to note that the more the evaluation can be shown to remain protective as the model inputs exceed the "normal" or "expected" site conditions, the stronger is the line-of-evidence supporting the conclusion presented.

Run #1
Base run with expanded areas and maximum concentrations utilized. Even though 540 ppbv was not detected in Zone 2, the concentration is used as it would allow concentrations up to the MDEQ's $SG_{vi\text{-}ss}$ to exist. Zone 3 is run using the detection limit of the method. The BBM results indicate that the expected air concentration (BBM_{air}) for the above parameters would result in an indoor air concentration of 3.7 ppbv which is 60 percent less then the nonresidential AIAC of 11 ppbv.

The BBM in this analysis is conservative based on the following:

- Zone 1 was increased to encompass 79 percent more area than presented by the contour map in Figure 5.
- Zone 1 utilized a maximum concentration of 1,500 ppbv and most of the area did not have concentrations detected at that level.
- Zone 2 utilized the $SG_{vi\text{-}ss}$ for TCE of 540 ppbv even though the maximum concentration detected in this zone is less than 140 ppbv.
- Zone 3 utilized a concentration of five ppbv even though no source areas are present in the remaining manufacturing area and sub-slab soil gas concentrations have been successfully defined to below detection levels.

Run #2

The maximum concentration in Zone 1 is increased to 300 percent of the maximum detected value. All other zones remain the same. The BBM results indicate that expected air concentration (BBM_{air}) would result in an indoor air concentration of 9.4 ppbv which is 15 percent less then the nonresidential AIAC.

The BBM in this analysis is conservative based on the following:

- The Zone 1 was increased to encompass 79 percent more area than presented by the contour map in Figure 5.
- Zone 1 utilized a concentration of 300 percent of the maximum detected.
- Zone 2 utilized the $SG_{vi\text{-}ss}$ for TCE of 540 ppbv even though the maximum concentration detected in this zone is less than 140 ppbv.
- Zone 3 utilized a concentration of five ppbv, the method detection limit, even though no source areas are present in the remaining area and sub-slab soil gas concentrations have been successfully defined to below detection levels.

TABLE 2 – EXAMPLE DATA AND RESULTS TABLE

	Model Input Variables	*BBM Run #1*	*BBM Run #2*	*BBM Run #3*	*BBM Run #4*
Zone 1 Square Footage (ft²)	$Zone1_{area}$	5,425	5,425	5,425	10,850
Zone 2 Square Footage (ft²)	$Zone2_{area}$	4,300	4,300	4,300	8,600
Zone 3 Square Footage (ft²)	$Zone3_{area}$	47,795	47,795	47,795	38,070
Total Square Footage (ft²)		57,520	57,520	57,520	57,520
MDEQ Attenuation Factor (subslab)	$A_{subslab}$	0.02	0.02	0.02	0.02
MDEQ $SG_{vi\text{-}ss}$ for TCE (ppbv)	*540*	540	540	540	540
AIAC TCE Nonresidential (ppbv)	11	11	11	11	11
Zone 1 Max Concentration	$Zone1_{max}$	1,500	4,500	4,500	1,500
Zone 2 Max Concentration	$Zone2_{max}$	540	540	1,620	540
Zone 3 Max Concentration	$Zone3_{max}$	5	5	5	5
RESULTS					
BBM Soil Gas Concentration	BBM_{conc}	186	469	550	367
Modeled Air Concentration	BBM_{air}	3.7	9.4	11.0	7.3

Run #3

Zone 1 concentration remains at 300 percent of the maximum identified concentration. In addition, Zone 2 is increased to 300 percent of its previous value. Zone 3 remains at the detection limit. The BBM results indicate that the expected air concentration (BBM_{air}) would result in an indoor air concentration of 11 ppbv which is the nonresidential AIAC.

The BBM in this analysis is conservative based on the following:

- Zone 1 was increased to encompass 79 percent more area than presented by the contour map in Figure 5.
- Zone 1 utilized a concentration of 300 percent of the maximum detected.
- Zone 2 utilized a concentration of 300 percent of the $SG_{vi\text{-}ss}$ even though the maximum concentration detected in this zone is less than 140 ppbv.
- Zone 3 utilized a concentration of five ppbv, the method detection limit, even though no source areas are present in the remaining area and sub-slab soil gas concentrations have been successfully defined to below detection levels.

Run #4

Zones 1, 2, and 3 concentrations return to the maximum concentrations identified in Run #1; however, the overall area extent of Zone 1 and Zone 2 is doubled (which results in a decrease in Zone 3). The BBM results indicate that the expected air concentration (BBM_{air}) would result in an indoor air concentration of 7.3 ppbv which is 34 percent less than the nonresidential AIAC.

The BBM in this analysis is conservative based on the following:

- The area in Zone 1 and Zone 2 was increased to encompass double of the area in Run #1.
- Zone 1 utilized a maximum concentration of 1,500 ppbv.
- Zone 2 utilized the $SG_{vi\text{-}ss}$ for TCE of 540 ppbv even though the maximum concentration detected in this zone is less than 140 ppbv.
- Zone 3 utilized a concentration of five ppbv even though no source areas are present in the remaining manufacturing area and sub-slab soil gas concentrations have been successfully defined to below detection levels.

The submittal to the MDEQ included a detailed discussion of the results of the BBM as well as ranges and limitations that were experienced. In addition, the submittal contained the following additional information and supporting lines-of-evidence:

- Multiple sampling rounds were performed with full quality assurance/quality control, showing stable or decreasing concentrations.
- Building does not meet the generic assumptions identified in the generic Part 201 GVIIC and SVIIC.
  - Building area greatly exceeds generic assumptions
  - Building interior height greatly exceeds generic assumption
  - Cement is thicker than the generic assumptions
  - Air exchange rate is greater than identified in the model
- The area of impact is a small percentage of the entire open area.
  - Concentrations of sub-slab soil gas have been defined
  - Multiple rounds of sub-slab soil gas samples have been collected

- Mixing can/will occur
  - Air exchange rate exceeds one per hour
  - Space is large and open with no walls to prevent mixing of indoor air
- Floor has been repaired and sealed
- Deed and use restrictions
  - Deed restriction will prevent subdividing the manufacturing area without further testing and/or installation of a presumptive mitigation system
  - Use of TCE is prohibited
- Source removal has been performed
  - C_{sat} soils were removed and floors replaced with new cement

Other options that may be pursued as part of analyzing the output provided by the model include, but are not limited to:

- Breaking apart the hotter area into multiple zones; however, there is a strong balance between having enough data points in each area and being able to demonstrate that the concentrations represented in the model are conservative.
- Establishing multiple hot spots or sources across the facility (each area must be clearly defined by points containing lower concentrations).
- Selected mitigation of a portion of the manufacturing area – the model would allow for the evaluation of a partial mitigation system with data that is able to document that the system is effectively mitigating vapors from a discrete area.
- Mitigation of selected structures: this approach could be combined with various active or passive mitigation options if it was determined that offices or bathrooms may be at risk.

5.0 PUTTING IT TOGETHER FOR COMPLIANCE

Documentation to complete the line-of-evidence and provide justification that the site conditions are protective for a party's due care obligations or remedial actions will be needed to confirm that this alternate procedure was applied in a manner that provides reliable results .

This documentation should include, but is not limited to, the following information:

- Zoning and a description of the expected future use of the facility
- Foundation and/or floor thickness
- Source of vapors and/or recognized areas of environmental concern (ASTM Phase I)
- Discussion of source removal (if performed)
- Data collection methodology and quality assurance/quality control procedures implemented
- Monitoring data collected
- Detailed explanation on how each of the zones were established
- Pictures documenting the area for which the BBM is being utilized
- Multiple runs of the model with varying inputs
- Discussion of the results and how they document that the approach is conservative and therefore protective
- Provide a discussion of the limitations and assumptions that make the model valid
- Associated maps, figures, and tables

In order for the MDEQ to determine that site-specific criteria intended to be relied upon for remedial action are protective under Sections 20118 and 20120, the party must include the proposed deed restrictions for the property that addresses the following:

- Limit the property's future use to nonresidential, unless a presumptive mitigation system is installed or an evaluation of the potential for vapor intrusion occurs.
- Limit and prevent modifications to the building, including the construction of walls within the area of concern, without evaluating the potential for vapor intrusion or installing a mitigation system.
- Require all future new construction to evaluate the potential for vapor intrusion or install a presumptive vapor mitigation system.

It is also important to note that for a party pursuing this method as a way to document and fulfill its obligations under due care, the entire sample collection procedure outlined above does not necessarily need to be completed prior to acquisition; although, the initial sampling event should at least be conducted and evaluated to ensure that the approach appears to be reasonable and appropriate. The remaining sampling events could be conducted after acquiring the property, if the party's due care plan identifies a contingency plan if future sampling events show that there is a potential for risk or if the model does not achieve the appropriate results.

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APPENDIX B.2

Alternate Approach for Demonstrating Compliance with the Volatilization to Ambient Air Pathway

Remediation and Redevelopment Division

ALTERNATE APPROACH FOR DEMONSTRATING COMPLIANCE WITH THE VOLATILIZATION TO AMBIENT AIR PATHWAY

Original Date of Issuance: January 19, 2012

Revision #: 1 **Revision Date: January 25, 2013**

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A policy guidance document cannot establish regulatory requirements for parties outside of the Michigan Department of Environmental Quality (MDEQ). It is explanatory and provides direction to staff, guidance to the regulated community, and consistency in enforcing the NREPA, but does not have the force and effect of law and is not legally binding on the public or the regulated community.

Special thanks for assistance:
Conestoga-Rovers & Associates
Severstal North America, Inc.
Ford Motor Company
Hamp, Mathews & Associates

Alternate Approach for Compliance with VSIC

PLEASE NOTE:

This approach was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide an alternate approach to parties implementing a response action in Michigan. It was created to promote an alternate approach that is consistent with Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). This document is not a statutory requirement, but could be implemented as an alternate approach under R 299.5714 and R 299.5724.

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document also does not represent an endorsement of practitioners or products mentioned in the document nor does it ensure that this approach is appropriate for all sites. It is imperative that the environmental professional implementing this approach provide adequate justification of this approach.

This approach is made available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern. The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the approach was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

Alternate Approach for Compliance with VSIC

Volatilization of organic compounds from contaminated soil or groundwater into the ambient air represents a potential source of exposure (Radian, 1986). In Michigan under Part 201, the generic cleanup criteria for soil based on inhalation of volatile hazardous substance emissions to ambient air are called the volatile soil inhalation criteria (VSIC). The VSIC represent the concentrations of a contaminant that can remain in soil at a facility while still protecting people who inhale the ambient air. The concentration of the contaminant in the soil is converted to a concentration in ambient air based on assumptions about the upward flux of the contaminant from the soil surface (and indirectly from the groundwater below the soil) and the use of a dispersion model to estimate the contaminant's concentration in ambient air.

R 299.5726(8) states:

> *A person who is implementing response activity may demonstrate compliance with the generic criteria developed under this rule through the collection and analysis of ambient air samples within the facility boundaries, if the hazardous substance concentration in surficial soil is representative of facility conditions.*

Therefore, the rule requires the collection and analysis of air samples from the site to demonstrate compliance with the VSIC.

In 2009, the Waste and Hazardous Materials Division (WHMD, now known as the Resource Management Division, RMD) of the MDEQ requested the formation of a multi-disciplinary work group to discuss ways to evaluate the VSIC using ambient air samples. The work group, with members representing the MDEQ's RMD, Remediation Division (RD), and the Air Quality Division (AQD) concluded that traditional ambient air monitoring is rarely appropriate or technically feasible for demonstrating compliance with the VSIC.

The work group concluded that given the complexity of ambient air monitoring and the large number of factors that can contribute to data variability (e.g., sampling procedures, equipment, duration, weather, multiple sources, and data interpretation), each application of R 299.5726(8) would entail a time consuming and costly effort to develop a site-specific solution. Therefore, it was determined that most sites will pose significant technical challenges as a result of multiple stationary and mobile air emission sources, varying meteorological (e.g., wind speed, direction, and local influences) and weather conditions (precipitation and temperature), and site activities (e.g., vehicle traffic) that would make it extremely difficult to design and implement a reliable ambient air monitoring program to demonstrate compliance with the VSIC.

Upon consultation with multiple experts, the RD has established the approach identified in this document that, if implemented as described, would demonstrate compliance with the VSIC using ambient air data in accordance with R 299.5726(8). The approach contains three major steps in the evaluation process that consist of:

- Defining zones of similar volatile parameter flux from the subsurface
- Quantifying flux for each zone by flux chamber sample collection
- Using flux as input to dispersion model to estimate relevant receptor concentrations

This is done through the collection of ambient air samples within a flux chamber (flux chamber sampling). Flux chamber sampling addresses many of the concerns and issues identified by the MDEQ work group and provides a direct measurement of volatile organic compound (VOC) emissions from soil to the ambient air at the site. The MDEQ believes that the approach outlined below can be representative of the actual volatilization of organic compounds from contaminated soil into the ambient air if implemented with care.

Although flux chamber sampling is the approach preferred by the MDEQ, other methods for demonstrating compliance under R 299.5726(8) may be proposed with appropriate technical justification.

1.0 GENERAL INFORMATION

1.1 Emission Process

The rate of emissions from contaminated soil is controlled by the diffusion rate of the chemical compound through the air-filled pore spaces of the soil. The exception occurs when the contaminated material is on or very near the ground surface. In these situations, the emission process and rate can be highly influenced by the rate of evaporation. The parameters that affect the evaporation process are basically the properties of the waste itself (e.g., vapor pressure) and those that affect the air-surface interface (e.g., air temperature, humidity, wind speed, surface roughness). In most cases, the background concentration of the contaminant is usually very low and can be assumed to be negligible.

1.2 Flux Chambers

An enclosure or chamber is used to isolate a known area of soil in which the collected vapors are measured over a period of time to measure the direct emissions from a surface. See Figure 1 for a generic representation of a flux chamber. The flux chamber approach provides a direct measurement of the subsurface contaminant flux at the soil-air interface as driven by diffusion and atmospheric conditions, ideally without altering the emission of gases at the surface. The results can be used to evaluate the impact of contaminated soil and other media on ambient air quality. The assessment of soil emissions using flux chambers is usually done in conjunction with sample analysis by Method TO-14A (United States Environmental Protection Agency [USEPA], 1999a) or Method TO-15 (USEPA, 1999b), as appropriate. These methods will yield an analytical detection limit of 0.1 and 0.001 micrograms per liter, respectively, for air in a flux chamber (DTSC, 2004). Other analytical methods may be acceptable and appropriate, depending on the contaminant concentrations expected at the site and the reporting (detection) limits necessary for comparison with criteria.

A Standard Operating Procedure (SOP) for the MDEQ's use of a flux chamber is provided in Attachment D of the MDEQ's document titled *Sample Collection and Evaluation of the Vapor Intrusion to the Indoor Air Pathway when the Generic Criteria Do Not Apply.*

1.3 Soil Flux Chamber Measurements for the Evaluation of Outdoor Air

Flux chamber sampling provides a direct measurement of the rate at which the VOCs are entering outdoor air from the soil. Therefore, if the maximum flux at the surface can be measured with properly collected flux chamber samples, then human exposure to air contaminated with the VOCs from subsurface sources can be estimated using a modeling program (see Section 3.0).

1.4 Establishing Site-Specific Criteria

When using this approach it is imperative that the party include *all of the VOCs associated with the release and the extent of the facility* in the analysis and evaluation of potential risks. This approach will not be valid if only an area or the VOCs present at concentrations exceeding the generic criteria are used. Contributions from all ranges of contamination must be considered.

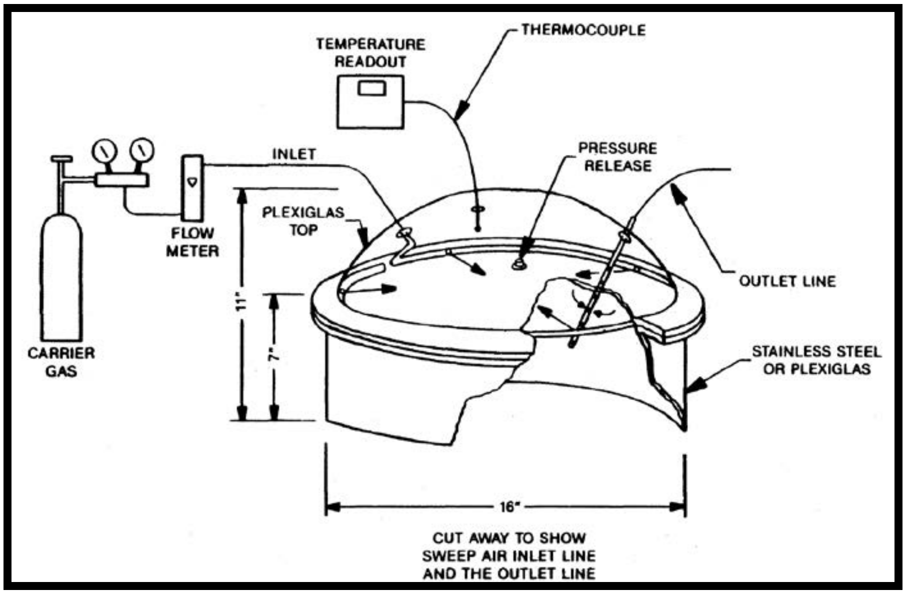

Figure 1 *General flux chamber construction diagram*

2.0 ALTERNATIVE APPROACH FOR DEMONSTRATING COMPLIANCE WITH THE VSIC

In general, the approach consists of the facility (i.e., all areas overlying impacted soil and groundwater) being divided into a number of zones (z_1, z_2, z_3 ... through z_n) and the emission rate for each zone is established. The established emission rates and supporting documentation is then submitted to the AQD by the RD to estimate expected ambient air concentrations at multiple compliance points throughout the facility using AERMOD.

The MDEQ has identified two methods for establishing zones to measure emission rates. One is for smaller (less than 4,000 square meters (m^2)) less complicated sites and the second is for larger (greater than 4,000 m^2) more complicated sites. The method for less complicated sites essentially involves reviewing the geology, topography, soil, and groundwater concentrations to define zones that are similar. With the zones defined you can choose to deploy flux chambers immediately. The method for more complicated sites involves deploying passive soil gas sampling to define areas of similar chemical parameter flux.

2.1 Establishing Zones to Determine Emission Rates Within

When establishing zones at the facility, it is imperative that each zone exhibit similar physical and chemical conditions for key characteristics, including (but not limited to):

- Concentrations of soil and/or groundwater contamination
- Contaminants of concern
- Depths/elevations of contamination
- Ground surface elevation

Zones may be irregular in shape but should be similar in size, unless a smaller zone is established over potential source areas. Smaller areas of potentially higher emission areas may successfully limit the area of higher emission rates to minimize potential areas of contribution to the ambient air in the model.

The following methodology provides a means to divide the facility into separate zones (Z) with an imaginary grid based on the overall areal extent of the facility:

- The extent of the facility is smaller than 4,000 m^2 - divide the facility into at least ten zones with areas not to exceed 200 m^2.
- The facility's areal extent is greater than 4,000 m^2 but smaller than 8,000 m^2 - divide the facility into at least 20 zones with areas not to exceed 400 m^2.
- The facility's areal extent is greater than 8,000 m^2 but smaller than 16,000 m^2 - divide the facility into areas not to exceed five percent of the total overall area.
- The facility's areal extent is greater than 16,000 m^2 - all zones must be smaller than 800 m^2 with no fewer than 20 zones.

Smaller zones and/or grid sizes may be utilized and are recommended as data has shown the ability to use smaller discrete areas is often beneficial during the modeling process.

It is imperative when using this approach that the extent of the contaminant's flux be established at the surface for the entire facility and not just an area that may exceed the generic criteria. Other methods may be acceptable for establishing zones of surface flux. However, many of the alternatives evaluated by the MDEQ are heavily site- or compound-specific. These methods are not described in this guidance document. The approach outlined here can be employed at the majority of sites across Michigan where a potential source of volatilization to ambient air is proposed to remain in place.

Below identifies two different approaches to establishing the emission rates of the zones based on the size of the facility. Each method could be used regardless of size; however, modification of the approach would be necessary.

2.1.1 Facilities Less Than 4,000 Square Meters

For smaller facilities, it can be beneficial and cost effective to go directly to the collection of emission rates. However, the collection of flux chamber samples is labor intensive and the number of flux chambers that can be properly deployed and sampled during a day often limits the size of the sampling program. Based on previous flux chamber sampling performed, the MDEQ has determined that collecting flux chamber samples at more than 15 locations on a facility often become logistically challenging. In such cases, the approach identified in 2.1.2 should be considered.

For small less complicated facilities, zones can be established using site-specific features that could include but are not limited to the following:

- Known subsurface sources of volatile chemical parameters (i.e., leaks from existing or historic process or storage equipment)
- Distribution of volatile chemical parameters in soil
- Distribution of volatile chemical parameters in groundwater
- Groundwater flow direction
- Topography
- Presence of obstructions to volatilization of chemical parameters (i.e., paved surfaces, concrete floor slabs of demolished buildings, engineered caps, etc.)
- Coverage of the lateral extent of the site
- Presence of fill material at ground surface

2.1.2 Facilities Greater Than 4,000 Square Meters

For facilities that contain more than 20 zones, it is often beneficial to first conduct a passive soil gas (PSG) survey with a larger number of measurement locations to group and establish zones with similar flux response levels and then to quantify emission rates in each zone using a smaller number of flux chambers (see Section 2.4). However, the survey must identify the relevant distribution of individual VOCs as opposed to "Total VOCs" or an overall response level.

Passive soil gas methods consist of the burial of an adsorbent into soil near the surface for a period of time (typically five to ten days) and the subsequent retrieval of the adsorbent for measurement. Contaminants "passively" diffuse and adsorb onto the collector over time. The method is easy to deploy and is proven to find areas of contamination (Hartman EPA-OUST Petroleum VI Workshop, 2010).

The use of these passive methods can be an effective tool in understanding the composition of subsurface soil gases and even identify the location of subsurface vapors, especially as it relates to the surficial flux. As most PSG sampling devices require deployment for extended periods of time, the data are less likely to be biased by site conditions that may vary throughout the day such as weather conditions, barometric pressure, or temperature.

2.2 Establishing the Grid Size for Deployment of Passive Soil Gas Samplers

Establishing a grid size for deploying PSG samplers across a site is a difficult balance between being cost effective and being able to provide enough data that discrete zones can accurately be established for modeling that addresses a wide range of emission values.

If PSG samplers are to be deployed, then the grid spacing identified in Section 2.1 can be used. The placement of these samplers should be based on the preexisting site knowledge of contamination and must include placing at least one of the samplers directly over the areas that is thought to contain the highest potential to produce the highest emission rates. It is highly recommended that over the known source areas (or areas of contamination within .5 meters of the surface) a more conservative approach be utilized by reducing the area of each zone by at least 50 percent. The tighter grid spacing over known source areas is highly beneficial in being able to establish smaller zones to input into the model for the areas with potential higher emission rates.

In any situation that the extent of the flux is not found to be decreasing toward the extent of the facility, it may be necessary for additional step-outs to occur.

2.3 Grouping Zones and Emission Rates from the Passive Soil Gas Survey

With known site conditions and the PSG results, it is possible to limit the amount of emission rates that would need to be collected.

This is done by first separating the site into areas with similar site physical and geological characteristics. This separation must occur across the facility based on site conditions (see Section 2.1) and not on response levels of the PSG survey. For instance, if part of the site has had a removal action and clean soil placed on top, it should be separated from areas of the site where a removal has not occurred. It may be beneficial to seek approval of the MDEQ project manager prior to proceeding with the PSG survey in areas with similar site physical and geological characteristics.

Each area can then be further refined and grouped based on the PSG response levels for each contaminant. Each group must then utilize the location of the maximum response level to establish the emission rate to be utilized in AERMOD (see Section 3.0).

With this approach, emission rates can be established across the facility based on the following requirements:

- One emission rate per zone per area
- One emission rate established for every four acres of facility
- A minimum of ten emission rates per sampling event

2.4 Collection of Flux Samples

There are two different types of flux chamber methods:

- Static-(Closed) Chamber Method: In this method, contaminants emitted from the soil surface are captured in a closed chamber and the contaminant concentration increases over time until it reaches equilibrium with the soil gas. After this "incubation period," a discrete sample is drawn from the chamber into an evacuated sample container (e.g., a SUMMA canister) and submitted for chemical analysis. Because the length of the incubation period is usually not known in advance, it is necessary to collect a time series of samples from the chamber at several intervals during the sampling event.
- Dynamic-Chamber Method: In this method, an inlet gas (sweep gas) is continuously introduced into the chamber during the incubation period and an equivalent amount of the chamber gas is allowed to escape. The system is assumed to reach a steady-state concentration after four or five chamber-residence times, where one residence time equals the chamber volume divided by the sweep-gas flow rate.

An SOP for the dynamic method is provided in Appendix D. Though both methods provide reliable results, the dynamic method is preferred by the MDEQ as there are less decision points to determine if an appropriate sample has been collected.

2.5 Establishing Compliance Points

Evaluation of the model to determine compliance with criteria will be based on compliance points modeled and compared to the appropriate acceptable indoor air criteria (AIACs). The AIACs are appropriate for use to evaluate the risk presented regardless whether a person is indoors or outdoors. Compliance points will be established across the facility based on the following minimum requirements:

- Perimeter of the facility on 100 foot grid spacing
- Closest point of a property with a sensitive population (i.e., school, day care, nursing home, etc.)
- Shallowest contamination present
- Source area

AERMOD will also establish the area of the highest concentration present. If this is different than one of the areas on the facility identified above, an alternative point of compliance will be established and compared to the appropriate AIACs. On any property that is zoned for nonresidential use and the expected use is to remain nonresidential, possibly (through the implementation of institutional controls) the nonresidential air standard will be utilized. All other properties will utilize the residential AIAC unless proper justification can be provided for alternative criteria.

3.0 AERMOD

The AERMOD modeling system replaced the ISCST3 as the preferred recommended model for most regulatory modeling applications, as announced in a November 9, 2005 Federal Register notice, and is listed as such in Appendix A of the USEPA's "Guideline on Air Quality Models," (also published as Appendix W of Title 40 of the Code of Federal Regulations (CFR) Part 51). Detailed information and guidance for the use of AERMOD can be found in the attached MDEQ AQD September 2009 document titled "Air Dispersion Modeling Guidance Document." The information reiterates some of the information found in the attachment; however, it also provides more detailed and specific recommendations and application of the AERMOD in demonstrating compliance with the volatilization to ambient air pathway under Part 201.

The responsible party has the option of conducting their own modeling or having the AQD perform the modeling. In either case, the supporting modeling information listed below must be submitted to the Part 201 project manager for submittal to the AQD to complete the models analysis or for confirmation of the results supplied.

3.1 Evaluating the Results of Model

Utilizing the model prior to the submittal to the MDEQ is a valuable tool for sites that may contain multiple source areas as it allows a responsible party to evaluate various selective response actions across the facility to further assess the potential benefit of a particular remedial action. It must be identified that an exceedance of the AIAC may not present a risk due to some of the conservative nature that is included within this methodology; however, further evaluation of the facility is necessary which could include reducing the area of each zone and/or potential remedial activities being performed.

3.2 Submittal of the Data to the MDEQ

The party is expected to provide all of the information identified below in one submittal. Failure to provide all the information may result in the submittal being returned to the party as insufficient. A CD or DVD should be attached to the report that contains all the necessary digital information including the appropriate tables and figures for processing. All coordinates must be provided in Universal Transverse Mercator (UTM) coordinates that indicate which North American Datum System was used (i.e., NAD 1927 or NAD 1983).

The report should contain a general discussion of the following:

- Site location including street address, city, and county
- General description of the facility and area up to 500 feet beyond the extent of the facility including approved zoning
- Contaminants of concern applicable to the project
- Discussion on how each zone was established and the methodology utilized to establish the representative emission rates with sample calculations
- Other sources of emissions on the facility, whether they are permitted or exempt, sampled emission rates (previous 12 months or maximum concentration identified), and stack heights up to 500 feet beyond the extent of the facility
- Discussion of data collection methodologies and analytical results
- Discussion of building elevations located in the area up to 500 feet beyond the extent of the facility
- Discussion on the quality assurance/quality control performed for the data collected
- Discussion of all sensitive receptors up to 500 feet beyond the extent of the facility
- Discussion of the location of the proposed compliance monitoring points for the model

For every stack with a discharge of VOCs within the facility, the report should contain:

- Name of stack or stack identifier
- Height of stack from ground level (feet or meters)
- Exit temperature of exhaust gas (°Fahrenheit or °Celsius)
- Inside diameter or length and width of stack (feet or meters)
- Exit velocity of exhaust gas (feet or meters per second) or volumetric flow rate (stand cubic feet per meter, cubic meters per second)
- Stack location (UTM or Local)
- Stack orientation (i.e., vertical, horizontal, gooseneck)
- Stack obstructions (rain caps, other)
- Emission rate of each pollutant from this stack (pounds per hour or gallons per second (lbs/hr or g/s))
- The heat content (Btu per cubic foot) and flow rate of the gas out of any installed flares

This information is required whether the applicant or AQD is performing the modeling. For multiple pollutants emitted from multiple stacks, the information may be submitted in a spreadsheet format.

For every zone that is established, a table in the report should contain:

- Zone name or identifier
- Volume of zone
- Coordinates that establish the lateral dimensions of the area by either establishing the coordinates of each corner (if the area is square) or by providing the coordinates every 50 feet around the exterior (and interior if necessary) perimeter
- Emission rate of each pollutant from this area (g/s-square meters)
- Release height if the elevation of the release height is not ground level

For every building that is established, a table in the report should contain:

- Peak roof height from ground level
- Heights of any higher sections (tiers) on main roof
- Building dimensions, length and width
- Building location via Local or UTM coordinates or plot plan

The report should contain the following figures which also should be included as a PDF on the CD or DVD included in the report. All figures must be to scale which is clearly identified.

- Site location map
- Extent of contamination in soil and groundwater above Part 201 criteria
- Site feature map that includes any fence lines, berms, and other public access barriers
- Site feature map that provides the location of all stacks, volumes, and areas being modeled
- Site feature map that identifies the location of all buildings/structures located up to 500 feet beyond the extent of the facility
- Site feature map that locates all sensitive receptors up to 500 feet beyond the extent of the facility (i.e., schools, day cares, nursing homes, hospitals, etc.)
- Flux chamber sample location map (recommended that callout boxes with data are also provided)

All figures must be to scale which is clearly identified.

If the responsible party has been conducting their own modeling and wishes the MDEQ to confirm the results, the following files should be provided:

- Copy of the modeling input files (*.inp, *.dat, *.dta, *.api)
- For AERMOD a copy of the Stage 1 and 3 AERMET input files (*.in1, *.in3)
- For AERMOD a copy of the AERMAP output file (*.rou)
- Copy of the building profile input program (BPIP) file (*.bpi)
- Copy of the modeling output files (not as important as the two first items, but helpful)
- Toxic air contaminant lists/spreadsheets including emission rates, screening levels, and impacts

Tables:

- All PSG sampling results including point name and coordinates
- Flux chamber results including point name and coordinates
- Site contour data tied to the United States Geological Survey elevations (+/- .2 foot)
- Center of all buildings located within the downwash area with building heights provided
- Center of all sensitive receptors located
- Coordinates of the proposed compliance monitoring points

Maps and figures (to scale):

- Entire site features map
- High-resolution aerial photo covering for three kilometers surrounding the project area
- Terrain and other identifiable features in the source area
- All buildings considered in the downwash analysis and plant property boundaries (building sizes and shapes on the map should be drawn to scale)
- Map of the facility clearly delineating the locations of all sources of vapors (groundwater and soil)
- Map of the facility clearly delineating the locations of all emissions
- Map of the zones established for the emission rates

4.0 COMPLAINCE WITH PART 201

If the modeling performed by the AQD demonstrates that the release does not pose a risk, compliance may be obtained by collecting two to three additional rounds of data. The data must be collected during the summer and during periods of little to no rain. If data is shown to be decreasing or stable, compliance may be obtained by a deed restriction of access and preventing any disturbance of the current cover. Installation of a protective barrier may be warranted if the contamination is within six inches of the surface to ensure the long-term protectiveness of the selected remedy.

If modeling has identified the potential for a risk, as identified in Section 3.1, further assessment and/or remedial action may be warranted due to some of the conservative nature that is included within this methodology.

5.0 REFERENCES

Department of Toxic Substances Control (DTSC). 2004. Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.

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United States Environmental Protection Agency. 1999a. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-14A, Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters With Subsequent Analysis By Gas Chromatography. Center for Environmental Research Information, Office of Research and Development, USEPA, Document No. EPA/625/R-96/010b.

United States Environmental Protection Agency. 1999b. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information, Office of Research and Development, USEPA, Document No. EPA/625/R-96/010b.

APPENDIX B.4

Approach for Demonstrating Compliance with a Crawlspace

(Currently Under Development)

Appendix C – Checklists for Evaluating Compliance with Part 201

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APPENDIX C.1

Checklist for Determining if the Generic Volatilization to Indoor Air Inhalation Criteria Apply

APPENDIX C.1

BACKGROUND

Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), and the associated Administrative Rules regulate most sites of environmental contamination in Michigan. The Part 201 Administrative Rules establish the generic cleanup criteria for the hazardous substances in vapors emanating from groundwater (R 299.5714) and soil (R 299.5724) to indoor air.

GROUNDWATER

Rule 714(2) identifies conditions for which the generic cleanup criteria for groundwater do not apply and a site-specific evaluation is required. If any of the conditions outlined in Rule 714(2)(a-c) apply, then a site-specific evaluation must be completed.

> Rule 714(2): Except as provided in subrule (1) of this rule, if any of the following conditions exist, the generic cleanup criteria developed pursuant to this rule shall not apply and a site-specific evaluation of indoor air inhalation risks shall be conducted:
> (a) There is a structure present or planned to be constructed at the facility which does not have a concrete block or poured concrete floor and walls.
> (b) The highest water table elevation of a contaminated saturated zone at the facility, considering seasonal variation, is within three meters of the ground surface.
> (c) There is a sump present that is not completely isolated from the surrounding soil by its materials of construction; or there is other direct entry of contaminated groundwater into the basement.

SOIL

Rule 724(2) identifies conditions for which the generic cleanup criteria for soil do not apply and a site-specific evaluation is required. If any of the conditions outlined in Rule 724(2)(a-b) apply, then a site-specific evaluation must be completed.

> Rule 724(2): Except as provided in subrule (1) of this rule, if any of the following conditions exist, the generic cleanup criteria developed pursuant to this rule shall not apply and a site-specific evaluation of indoor air inhalation risks shall be conducted:
> (a) There is a structure present or planned to be constructed at the facility which does not have a concrete block or poured concrete floor and walls.
> (b) There is a sump present that is not completely isolated from the surrounding soil by its materials of construction.

JOHNSON AND ETTINGER MODEL

The United States Environmental Protection Agency (USEPA) has identified a number of conditions under which the application of the Johnson and Ettinger Model is precluded. In accordance with 299.5705 and 299.5706 these conditions could result in concentrations that may not be protective of public health for the vapor intrusion pathway and therefore a site-specific approach should be undertaken.

Conditions include:

1. The actual or suspected presence of residual or free-phase light and dense non-aqueous phase liquids (LNAPL and DNAPL), i.e., fuels, solvents, etc., or smear zones in the subsurface
2. The presence of heterogeneous geologic materials between the vapor source and the building
3. The presence of geologic materials that are fractured, contain macropores, karst, or other preferential pathways
4. Sites where significant lateral flow of vapors occur due to preferential pathways
5. Shallow groundwater in contact with the building foundation
6. Small building air exchange rates (e.g., less than 0.25 building exchanges/hour)
7. Buildings with crawlspace structures or other significant openings to the subsurface (e.g., earthen floors, stone buildings, etc.)
8. Contaminated groundwater sites with large water table fluctuations

APPENDIX C.1
Checklist for Determining if the Generic Volatilization to Indoor Air Inhalation Criteria Apply

The information included in this checklist may be used by staff to determine if the generic criteria apply and a site-specific evaluation is necessary for evaluating hazardous substances in vapors for the volatilization to indoor air pathway.

Site Name:	Site ID:
Site Address:	County:

If any of the following apply then a site-specific evaluation in compliance with R 299.5714(5) and R 299.5724(5) is required:

For groundwater:

- ☐ *There is a structure present or planned to be constructed at the facility which does not have a concrete block or poured concrete floor and walls.*
- ☐ *The highest water table elevation of a contaminated saturated zone at the facility, considering seasonal variation, is within three meters of the ground surface.*
- ☐ *There is a sump present that is not completely isolated from the surrounding soil by its materials of construction; or there is other direct entry of contaminated groundwater into the basement.*

For soil:

- ☐ *There is a structure present or planned to be constructed at the facility which does not have a concrete block or poured concrete floor and walls.*
- ☐ *There is a sump present that is not completely isolated from the surrounding soil by its materials of construction.*

The USEPA has identified a number of conditions under which the application of the Johnson and Ettinger Model is precluded because these conditions can result in concentrations that may not be protective of public health for the vapor intrusion pathway.

- ☐ *The actual or suspected presence of free-phase non-aqueous phase liquids (LNAPL; DNAPL; i.e., fuels, solvents, etc.) or smear zones in the subsurface.*
- ☐ *The presence of heterogeneous geologic materials between the vapor source and the building.*
- ☐ *The presence of geologic materials that are fractured, contain macropores, karst, or other preferential pathways.*
- ☐ *Sites where significant lateral flow of vapors occur.*
- ☐ *Shallow groundwater in contact with the building foundation.*
- ☐ *Buildings with crawlspace structures or other significant openings to the subsurface (e.g., earthen floors, stone buildings, etc.).*
- ☐ *Contaminated groundwater sites with large water table fluctuations.*

The other condition identified by the USEPA (e.g., very small building air exchange rates) is not typically investigated during the course of an investigation. The condition, though not included above, should be considered and evaluated if warranted or knowledge indicates a necessity to consider.

APPENDIX C.2

Checklist for Developing a Conceptual Site Model

APPENDIX C.2

Developing a Conceptual Site Model

Developing a conceptual site model (CSM) is an important first step for assessing contaminated sites and the potential for vapor intrusion. Briefly, a CSM is a picture and narrative of the site contamination: how it got there, whether or not it is migrating or degrading, its distribution across the site, who might be exposed to it, and what risk-reduction strategies are most feasible. A CSM development actually begins during the Phase I Environmental Site Assessment with collection and evaluation of site history and reconnaissance information.

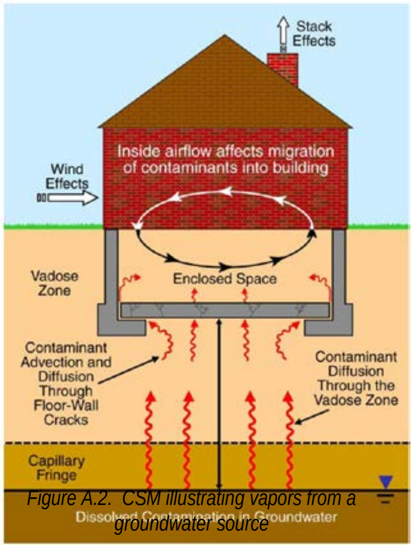

Figure A.2. CSM illustrating vapors from a groundwater source

During subsequent site characterization activities, the CSM can be augmented and refined, as necessary, with site-specific information on source areas, contaminant properties, stratigraphy, hydrogeology, exposure pathways, and potential receptors. Building and refining a thorough CSM may involve a combination of techniques and tools to understand the subsurface, but specifically, investigations for vapor intrusion often include collecting samples of soil, groundwater, soil vapor, and/or indoor air. Investigators may use sampling in combination with predictive models. Constructing a CSM for vapor intrusion requires the integration of important site characteristics to assist in understanding and evaluating the potential impacts that vapor intrusion risks pose to potential receptors.

The purpose for developing a CSM for the vapor intrusion pathway is to assemble a three-dimensional concept of the site that is as comprehensive as possible. This is based on reliable data describing the sources of the contamination, the release/transport mechanisms, the possible subsurface migration routes, the potential receptors, as well as historical uses of the site, cleanup concerns expressed by the community, and future land use plans. All the important features relevant to characterization of a site should be included in a CSM, and any irrelevant ones excluded.

Contents of the Conceptual Site Model

The CSM should present both a narrative and a visual representation of the actual or predicted relationships between the contaminants at the site and receptors (building occupants), as well as reflect any relevant background levels. A basic example of a visual representation is included as Figure A.2.

The CSM should also contain a narrative description that clearly distinguishes what aspects are known or determined and what assumptions have been made in its development. The CSM should also identify conditions that may result in alternate approaches. The CSM provides a conceptual understanding of the potential for exposure to compounds of concern at a site. It is an essential tool to aid management decisions associated with the site and serves as a valuable communication tool both internally with the site team and externally with the community. The CSM is a dynamic tool to be updated as new information becomes available after each stage of investigation. Below is a CSM checklist to assist in the review of this component of the vapor intrusion assessment.

APPENDIX C.2
Checklist for Developing a Conceptual Site Model

The information included in this checklist may be useful for evaluating a site-specific conceptual migration model and ensuring that the model contains the necessary elements. A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name: Site ID:
Site Address: County:

1.0 UTILITIES AND PROCESS PIPING

_____ Maps, figures, and cross-sections of the building provide the location and depths of all underground utilities and/or process piping near the soil or groundwater impacts.

2.0 BUILDINGS (RECEPTORS)

_____ Maps identify:

- Existing or proposed buildings
- Vacant parcels
- Property boundaries

_____ Description of the occupancy and use of all properties/buildings

_____ Construction of each structure includes (if applicable):

- General construction style (e.g., basement, crawlspace, slab on grade)
- Floor construction (e.g., concrete, dirt)
- Depth below grade of lowest floor
- Building layout (e.g., large and open, small rooms)
- Height (and number of floors)
- Sumps or foundation drains
- Alternate ventilation system
- Elevator(s)

_____ Heating, ventilation or air conditioning system in each structure is described and includes (if applicable):

- Type (e.g., forced air, radiant)
- Equipment location (e.g., basement, crawlspace, utility closet, attic, roof)
- Source of return air (e.g., inside air, outside air, combination)
- System design considerations relating to indoor air pressure (e.g., positive pressure may be the case for commercial office buildings)

_____ Installed sub-slab ventilation systems or moisture barriers present are described and identified on all building figures

3.0 SOURCE AREA(S)

_____ Description and known history of the release.

_____ Maps and figures identify and show the location of all vapor source(s) in relation to each structure (including the presence, distribution, and composition of any non-aqueous phase liquid at the site).

_____ Cross-sections showing example building, construction styles, and relationship to source of vapors (actual number will vary as appropriate).

_____ Description of the potential migration characteristics (e.g., stable, increasing, decreasing).

4.0 GEOLOGY/HYDROGEOLOGY

_____ Maps, figures, cross-sections, and/or description identify soil lithology and characteristics:

- Heterogeneity/homogeneity of soils and the lithologic units encountered including:
  - Depth and lateral continuity of any confining units that may impede contaminant migration
  - Depth and lateral continuity of any highly transmissive units that may enhance contaminant migration
- Depth of vadose zone, capillary fringe, and phreatic zone including:
  - Any seasonal water table fluctuations
  - Groundwater flow direction
  - Presence of any perched groundwater
  - Note where the water table intersects the well screen interval or the presence of a submerged screen.

_____ Description and location of distinct strata (soil type and moisture content, e.g., moist, wet, dry) and the depth intervals.

_____ Description and location of all fill or non-native materials.

_____ Depth to groundwater identified on all cross-sections.

_____ General groundwater characteristics provided (e.g., seasonal fluctuation, hydraulic gradient).

5.0 SITE CHARACTERISTICS

_____ Map of the site (to scale) showing all paved areas, surface cover, locations of all structures, and ground cover.

_____ Map identifying all potential sources of vapors.

6.0 REFERENCES

Interstate Technology & Regulatory Council. 2007. Vapor Intrusion Pathway: A Practical Guideline, January 2007. Accessed at http://www.itrcweb.org/Documents/VI-1.pdf.

APPENDIX C.3

Checklist for Reviewing Soil Gas Sampling Protocols and Laboratory Data

APPENDIX C.3
Checklist for Reviewing
Soil Gas Sampling Protocols and
Laboratory Data

The information included in this checklist may be useful for reviewing soil gas data collected outside of a building during the course of an investigation. It is important to understand that data are collected for a variety of purposes and the use of this checklist is only intended for evaluating the use of the data for compliance purposes. A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name: Site ID:
Site Address: County:

1.0 SOIL CONDITIONS

_____ Site conditions have not been influenced by precipitation prior to sample collection.

- *The waiting period will be dependent upon soil type, amount of rain, and previous soil moisture content (e.g., longer for clays, longer for heavy rains, shorter for coarse sands, etc.).*
- *Information should be provided showing justification of actual time elapsed between rain and sampling events.*
- *May not be necessary if collected within a structure.*

2.0 SOIL GAS SAMPLE COLLECTION

_____ Points purged before sampling.

- *Gas volume contained in the sampling point and apparatus identified.*
- *Minimum of three volumes was purged from entire sampling system.*
- *Purging rate is less than 200 milliliters per minute (ml/min).*

_____ Samples were collected in a manner that ensures no ambient air infiltration has occurred.

- *Probe is properly constructed and sealed.*
- *Sample collected at less than 200 ml/min.*
- *Points installed at least five feet below ground surface unless site conditions warrant shallower installation (e.g., shallow groundwater).*
- *Tracer gas or other similar quality assurance/quality control protocols utilized.*

_____ Peristaltic or vacuum pumps were not utilized for sample collection.

_____ Sampling point is documented as being in good condition.

_____ Disposable parts were not reused or parts were adequately decontaminated between samples.

_____ Flow controllers and sampling apparatus were not reused.

3.0 SOIL GAS SAMPLE ANALYSIS

_____ Samples analyzed by TO-15.

- *Lab sheets indicate TO-15.*
- *Holding time met.*
- *Tedlar sampling bags are not utilized.*
- *Samples* ***not shipped*** *on ice and stored at ambient air temperature.*
- *Chain of Custody review does not identify any issues of concern.*

OR

_____ Information supplied to evaluate analytical methodology utilized.

- *Alternative methods will need to seek approval.*

4.0 ADDITIONAL VERIFICATION OF FIELD METHODS UTILIZED

_____ Copies of the field notes are provided.

_____ Sampling results make sense to the field conditions and concentrations previously identified in soil and groundwater.

_____ Sampling containers were verified as being certified clean from the laboratory.

_____ Utilized Quality Assurance/Quality Control (QA/QC) protocols to verify sampling methodology.

_____ Excessive vacuum is not encountered.

APPENDIX C.4

Checklist for Reviewing Sub-Slab Sampling Protocols and Laboratory Data

APPENDIX C.4
Checklist for Reviewing Sub-Slab Sampling Protocols and Laboratory Data

The information included in this checklist may be useful for reviewing sub-slab soil gas data collected during the course of an investigation. It is important to understand that data are collected for a variety of purposes and the use of this checklist is only intended for evaluating the use of the data for compliance purposes. A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name: Site ID:
Site Address: County:

1.0 SUB-SLAB SOIL GAS SAMPLE COLLECTION

_____ Points purged before sampling.
- *Gas volume contained in the sampling point and apparatus identified.*
- *Minimum of three volumes was purged from entire sampling system.*
- *Purging rate is less than 200 milliliters per minute (ml/min).*

_____ Samples were collected in a manner that ensures no ambient air infiltration has occurred.
- *Probe is properly constructed and sealed.*
- *Sample collected at less than 200 ml/min.*
- *Tracer gas or other similar quality assurance/quality control protocols utilized.*

_____ Peristaltic or vacuum pumps were not utilized in the purging or in the sample collection.

_____ Small sample volumes collected.

_____ Disposable parts were not reused or parts were adequately decontaminated between samples.

_____ Flow controllers and sample trains were not reused unless they were adequately decontaminated between samples.

2.0 SUB-SLAB SOIL GAS SAMPLE ANALYSIS

_____ Samples analyzed by TO-15.
- *Lab sheets indicate TO-15.*
- *Holding time met.*
- *Samples* **not shipped** *on ice and stored at ambient air temperature.*
- *Chain of Custody review does not identify any issues of concern.*

OR

_____ Information supplied to evaluate analytical methodology utilized.
- *Alternative methods will need to seek approval.*

3.0 ADDITIONAL VERIFICATION OF FIELD METHODS UTILIZED

_____ Copies of the field notes.

_____ Sampling results make sense to the field conditions and concentrations previously identified.

_____ Sampling containers were verified as being certified clean from the laboratory and contain a statement from the laboratory.

_____ Utilized industry standard protocols to verify sample was obtained at the screened interval.

_____ Thickness and condition of flooring is documented.

APPENDIX C.5

Checklist for Reviewing the Design of an Active Mitigation System

APPENDIX C.5
Checklist for Reviewing the Design of an Active Mitigation System

The information included in this checklist may be useful for reviewing the design of an active mitigation system. Though it is generally understood that the actual design of the system may vary, many of the design components should be very similar in purpose. The information in this checklist is based on American Society for Testing and Materials (ASTM Standard E2121, 2009). A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name:	Site ID:
Site Address:	County:

1.0 DEFINITIONS

Backdrafting:	A condition where the normal movement of combustion products up a flue (due to the buoyancy of the hot flue gases) is reversed, so that the combustion products enter the building (see *pressure-induced spillage*).
Depressurization:	A negative pressure induced in one area relative to another.
Diagnostic tests:	Procedures used to identify or characterize conditions under, beside, and within buildings that may contribute to radon entry or elevated radon levels or that may provide information regarding the performance of a mitigation system.
Manifold piping:	Piping that collects the flow of soil gas from two or more suction points and delivers that collected soil gas to the vent stack piping. In the case of a single suction point system, there is no manifold piping since the suction point piping connects directly to the vent stack piping. The manifold piping starts where it connects to the suction point piping and ends where it connects to the vent stack piping.
Mitigation system:	Any system or steps designed to reduce concentrations of a contaminant in the indoor air of a building that originates in the subsurface.
Natural draft combustion appliance:	Any fuel burning appliance that relies on a natural convective flow to exhaust combustion products through flues to outside air.
Pressure-field extension:	The distance that a pressure change, created by drawing soil gas through a suction point, extends outward in a sub-slab gas permeable layer, under a membrane, behind a solid wall, or in a hollow wall (see *communication test*).
Pressure-field extension test:	A diagnostic test to evaluate the potential effectiveness of a sub-slab depressurization system by applying a vacuum beneath the slab and measuring, either with a micromanometer or with a heatless smoke device, the extension of the vacuum field.
Pressure-induced spillage:	The unintended flow of combustion gases from an appliance/venting system into a dwelling, primarily as a result of building depressurization (see *backdrafting*).

2.0 GENERAL

_____ Report identifies that the design does not interfere with the normal venting functions for appliances and backdrafting will not occur.

_____ Pressure field extension test (e.g., diagnostic communication test) has been performed.

- *For buildings over 10,000 square feet multiple tests throughout the building are completed.*

_____ Detailed specifications are provided on products utilized including fan, piping, and caulk.

_____ System is designed by a professional engineer with demonstrated experience designing mitigation systems.

_____ Building/Fire Codes: Document states mitigation systems shall be designed and installed to conform to applicable building and fire codes and maintain the function and operation of all existing equipment and building features including doors, windows, access panels, etc.

_____ Discharge Calculations: Estimated calculations for discharge pursuant to Part 55, Air Pollution Control, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA) and the associated Administrative Rules. Single-family homes are exempt.

3.0 SYSTEM SEALING REQUIREMENTS

Openings that could lessen the effectiveness of the mitigation system are sealed using methods and materials that are permanent and durable.

☐ Cracks and joints:

_____ Openings and cracks where the slab meets the foundation wall have been addressed.

_____ Concrete slab (flooring) above the active mitigation system is free of cracks or cracks have been adequately sealed.

_____ For joints greater than 1⁄2 inch (13 millimeters) in width, a foam backer rod or other comparable filler material should be inserted into the joint before the application of the sealant.

☐ Penetrations:

_____ Openings around the suction point piping penetrations of the slab have been adequately addressed.

_____ Vaults, sumps, other large openings, and utility access points in the foundation walls and/or floor slab are sealed using measures that still allow future access.

4.0 SYSTEM MONITORS AND LABELING

_____ Mitigation systems contain mechanisms to monitor performance (airflow or pressure).

_____ Mechanism is simple to read and interpret and is located where it is easily seen or heard.

_____ System provides a visual and/or audible indication of system degradation and failure.

☐ Monitor has reliable power source:

_____ If powered by house current, it shall be installed on a non-switched circuit and be designed to reset automatically after a power failure. Battery backup for the monitoring system in the event of power failure is recommended.

OR

_____ If the monitor is battery powered, it shall be equipped with a low-battery power warning feature.

_____ Mechanical system monitors, such as manometer type pressure gauges are clearly marked to indicate the initial pressure readings.

_____ System labels are placed on the mitigation system, the electric service entrance panel, and other prominent locations including the exterior venting locations.

_____ The circuit breaker(s) controlling the circuits on which the mitigation system and system failure warning devices operate are labeled using the word "Vapor Mitigation." For example, "Vapor Intrusion (VI) System" or if multiple circuits "VI System" and "VI Monitor" as appropriate. No other rooms or appliances should be on the same circuit.

_____ Description of signage and locations are provided.

- *Contain language indicating the mitigation vent that may contain volatile organic compounds.*
- *Figure identifying locations of all signs.*
- *Each roof exhaust point.*
- *Piping run (each individual exhaust line).*
  - *Vertical one per floor.*
  - *Horizontal one per 25 feet.*

_____ For tenants that will be occupying the structure, a notice has been prepared and provided for review.

5.0 PIPING

_____ All pipe joints and connections, both interior and exterior, are permanently sealed.

_____ System piping installed in the interior or on the exterior of a building should be insulated where condensation may occur inside the pipe; and then freeze or block the soil gas exhaust.

_____ Suction point pipes are supported and secured in a permanent manner that prevents their downward movement to the bottom of suction pits, sump pits, or into the soil.

_____ Horizontal piping runs in the mitigation system are sloped to ensure condensation drains downward into the ground beneath the slab.

_____ All vent stack piping is identified as solid, rigid pipe.

_____ For structures less than 2,500 square feet.

- *Exhaust piping not less than three inches (75 millimeters) inside diameter (ID).*
- *Vent stack piping's ID shall be at least as large as used in the manifold piping.*
- *Manifold piping's ID shall be as large as used in any suction point.*
- *Manifold piping to which two or more suction points are connected shall be at least four inches. (100 millimeters) ID.*
- *If smaller IDs are proposed, appropriate documentation showing design calculations has been submitted.*

OR

_____ For structures greater than 2,500 square feet.

- *Pipe sizes are identified and justified by field diagnostic measurements and estimated static pressure, air velocity, and rate of airflow measurements.*
- *Piping sizes are justified using the methodologies found in "Industrial Ventilation: A Manual of Standard Practice, 23rd Edition," or its equivalent.*

6.0 PIPING COMPLETION SPECIFICATIONS

_____ Pipes are completed with a rain cap or wind turbine.

_____ To reduce the risk of vent stack blockage, confirm that the discharge from vent stack pipes is:

- *Vertical and upward, outside the structure, at least ten feet (three meters) above the ground level, above the edge of the roof, and shall also meet the separation requirements below. Whenever practicable, they shall be above the highest roof of the building and above the highest ridge.*
- *Twenty feet (six meters) or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure, if the discharge point is not at least three feet (one meter) above the top of such openings.*
- *Twenty feet (six meters) or more away from any opening, vent, or occupiable spaces of any building (including adjacent structures). Chimney flues shall be considered openings into conditioned or otherwise occupiable space.*
- *For vent stack pipes that penetrate the roof, the point of discharge shall be at least 12 inches (0.3 meters) above the surface of the roof. For vent stack pipes attached to or penetrating the sides of buildings, the point of discharge shall be vertical and a minimum of 12 inches (0.3 meters) above the edge of the roof and in such a position that it can neither be covered with snow or other materials nor be filled with water from the roof or an overflowing gutter.*
- *When a horizontal run of vent stack pipe penetrates the gable end walls, the piping outside the structure shall be routed to a vertical position so that the discharge point meets the requirements described above.*
- *Points of discharge that are not in a direct line of sight from openings into conditioned or otherwise occupiable space because of intervening objects such as dormers, chimneys, windows around the corner, etc., shall meet the separation requirements as stated above.*

7.0 FAN INSTALLATION REQUIREMENTS

_____ Fan sizing calculations are provided that estimate the pressure difference and airflow characteristics under which the system will operate.

Schematics identify:

_____ Fan(s) are to be installed either outside the building or inside the building, outside of occupiable space, and above the conditioned (heated/cooled) spaces of a building.

_____ Fan(s) that are mounted on the exterior of buildings are rated for exterior use or installed within a weather proof protective housing.

_____ Fan(s) are to be connected to the vent pipe using removable couplings or flexible connections that can be tightly secured to both the fan and the vent pipe (facilitate maintenance and future replacement).

_____ Outside air intake vents of fan(s) are screened to prevent the intake of debris. Screens shall be removable to permit cleaning or replacement and building owners shall be informed of the need to periodically replace or clean such screens.

8.0 ADDITIONAL REQUIREMENTS IN THE DESIGN DOCUMENT

_____ Contractor identifies steps to document the effectiveness of the mitigation system. This is typically demonstrated by measuring the pressure differential across the building slab while the VI mitigation system is operating.

_____ Concentrations in the subsurface have been evaluated for the duration and frequency which the system can be out-of-service (including power outages) prior to implementing actions necessary to address the potential risk to the occupants.

_____ Actions are identified to address conditions during periods the system is not operating.

_____ Establish and identify a negative pressure that will be continuously maintained.

- Typically requires higher negative pressure than a radon mitigation system.
- Establish a monitoring program.

_____ Establish a monitoring program for Permit or Permit to Install Exemption pursuant to the Part 55 Rules.

9.0 REFERENCES

ASTM Standard E2121. 2009. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings.

APPENDIX C.6

Checklist for Reviewing the Design of a Passive Mitigation System

APPENDIX C.6
Checklist for Reviewing the Design of a Passive Mitigation System

The information included in this checklist may be useful for reviewing a passive mitigation system. Though it is generally understood that the actual design of the system may vary, many of the design components should be very similar in purpose. A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name: Site ID:
Site Address: County:

1.0 GENERAL

_____ Engineer or design firm is identified and mitigation system is designed by a professional engineer with demonstrated experience designing passive mitigation systems.

_____ Product manufacturer is provided.

_____ Requirements for installation are provided and if required by the manufacturer, the certification for the product applicator.

_____ General site conditions including a conceptual site model are provided.

_____ Concentrations identified at the site are provided including sampling methodology.

_____ All utility and other penetrations are identified on a print.

_____ Surface preparation is identified and includes:

- If applied onto an existing concrete surface it shall be free of any dirt, debris, loose material, release agents, or curing compounds.
- Voids more than 1/4 inch deep and 1/4 inch wide are filled.
- If applied directly on the sub-grade, the sub-grade shall be compacted to a minimum relative compaction of 90 percent or as specified by a civil/geotechnical engineer and the surface prep shall be smooth, uniform, and free of debris and standing water.

_____ Building/Fire Codes: Document states mitigation systems shall be designed and installed to conform to applicable building and fire codes and maintain the function and operation of all existing equipment and building features including doors, windows, access panels, etc.

_____ Drains that perforate the liner must be equipped with a dranjer style drain or dripline to a trap that allows water to flow into sumps and floor drains while sealing out soil gases from the sub-floor area or alternate method is provided.

2.0 LINER DESIGN AND SPECIFICATIONS

_____ Detailed specifications of the liner are provided including transmission rates and/or diffusion coefficients for compounds of interest.

_____ Concentrations in the subsurface have been evaluated for the liner including the required thickness applied and/or overall selection of the product by the engineer or design firm.

_____ Details are provided for areas that require specialized completion including all penetrations and terminations.

_____ Horizontal venting or perforated piping has a minimum in-plane flow rate of 21 gallons per minute per foot per unit width at a hydraulic gradient of 1.0 percent when tested in accordance with the American Society for Testing and Materials D 4716. Greater flow rates may justify greater spacing.

_____ Dewatering has been considered and incorporated into the design.

_____ Horizontal venting (or perforated piping) runs are identified at a maximum rate of one per every 50 feet perpendicular to the length of the run for the expected coverage. Calculations may provide justification for different spacing.

3.0 SYSTEM MONITORS AND LABELING

_____ System labels are placed on the mitigation system and other prominent locations including the exterior venting locations.

_____ Description of signage and locations are provided.

- *Contain language indicating the mitigation vent that may contain volatile organic compounds.*
- *Figure identifying locations of all signs.*
- *Each roof exhaust point.*
- *Piping run (each individual exhaust line).*
  - *Vertical one per floor.*
  - *Horizontal one per 25 feet.*

_____ For tenants that will be occupying the structure, a notice has or will be prepared.

4.0 PIPING

_____ When crossing pipe or pipe sleeves over or under footings or grade beams, document identifies it has been evaluated by an environmental engineer and/or structural engineer for appropriate use and placement materials.

_____ Preliminary piping and routing diagrams including manifolds are provided.

_____ Preliminary horizontal vent locations are identified on a print by the professional engineer.

_____ All pipe joints and connections, both interior and exterior, are permanently sealed.

_____ All exhaust pipes are supported and secured in a permanent manner.

_____ Horizontal piping runs in the mitigation system are sloped or designed to ensure condensation drains downward into the ground beneath the slab.

_____ All vent stack piping is identified as solid, rigid pipe.

_____ Justification of number and location of vent riser locations either based on Table A.6.1 or alternate method provided.

Table A.6.1
Spacing of Perforated Horizontal Piping and Number of Vent Risers

Vent Riser Pipe Diameter (inches)	Number of Vent Risers per Building Footprint Area (Square Feet)
1 1/2	1/1,250 (min of 2 risers)
2	1/2,500 (min of 2 risers)
2 1/2	1/5,000 (min of 3 risers)
3	1/7,500 (min of 4 risers)
4	1/10,000 (min of 4 risers)

Notes:
1) Riser length shall be a maximum of 100 foot measure along solid pipe including bends.
2) Vent risers maximum spacing shall be 100 feet between each.
3) When the application of the spacing and location requirement of this table results in the fractional number of vent risers, any fraction shall be construed as one vent riser.
4) Number of required vent risers shall be determined by the selected riser pipe diameter and the rate of vent riser per building footprint area.

_____ Vertical piping runs terminate in a location that can drain naturally or that can be verified to be free of water or moisture.

_____ For structures less than 2,500 square feet vertical piping is at least:

- *Not less than three inches (75 millimeters) inside diameter (ID).*
- *Vent stack piping's ID shall be at least as large as the largest used in the manifold piping.*
- *Manifold piping's ID shall be at least as large as that used in any suction point.*
- *Manifold piping to which two or more suction points are connected shall be at least four inches (100 millimeters) ID.*
- *If smaller IDs are proposed, appropriate documentation showing design calculations has been submitted.*

OR

_____ For structures greater than 2,500 square feet piping is:

- *Identified and justified by measurements and estimated static pressure, air velocity, and rate of airflow measurements, and head loss calculations based on preliminary exhaust piping design prints.*
- *Documented using the methodologies found in "Industrial Ventilation: A Manual of Standard Practice, 23rd Edition," or its equivalent.*

5.0 PIPING COMPLETION SPECIFICATIONS

(minimums, further distance may be required by exhaust concentrations and primary wind flow direction)

_____ Pipes are completed with a rain cap or wind turbine.

_____ To reduce the risk of vent stack blockage, confirm that the discharge from vent stack pipes is:

- *Vertical and upward, outside the structure, at least ten feet (three meters) above the ground level, above the edge of the roof, and shall also meet the separation requirements below. Whenever practicable, they shall be above the highest roof of the building and above the highest ridge.*
- *Twenty feet (six meters) or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure, if the discharge point is not at least three feet (one meter) above the top of such openings.*
- *Twenty feet (six meters) or more away from any opening, vent, or occupiable spaces of any building including adjacent structures. Chimney flues shall be considered openings into conditioned or otherwise occupiable space.*
- *For vent stack pipes that penetrate the roof, the point of discharge shall be at least 12 inches (0.3 meters) above the surface of the roof. For vent stack pipes attached to or penetrating the sides of buildings, the point of discharge shall be vertical and a minimum of 12 inches (0.3 meters) above the edge of the roof and in such a position that it can neither be covered with snow or other materials nor be filled with water from the roof or an overflowing gutter.*
- *When a horizontal run of vent stack pipe penetrates the gable end walls, the piping outside the structure shall be routed to a vertical position so that the discharge point meets the requirements described above.*
- *Points of discharge that are not in a direct line of sight from openings into conditioned or otherwise occupiable space because of intervening objects such as dormers, chimneys, windows around the corner, etc., shall meet the separation requirements as stated above.*

6.0 QUALITY ASSURANCE/QUALITY CONTROL INSTALLATION PLAN REQUIREMENTS IDENTIFIED IN THE DESIGN DOCUMENT

_____ Contractor identifies steps to document the effectiveness of the mitigation system.

- Coupon sampling – recommended at one sample per 500 square feet.
- Smoke testing – full coverage is necessary and must be based on the area that it can be confirmed that smoke has migrated to through visual observation.
- On-site installation oversight by the design firm.
- Documentation verifying the installation per project specification and that any areas noted for repair have been completed.
- Estimated quantities of the product to be utilized are provided.

Appendix D – Vapor Intrusion Screening Values

Table of Contents

Screening Values for the Vapor Intrusion Pathway

Sampling Location	Appropriate Vapor Intrusion Screening Value (SV_{vi})	Immediate Response Activity Screening Levels (IRASLs)
Soil sample	Soil concentration that identified a source of vapors (S_{vi})	- - - - -
Air within the interior space of a building derived from VI sources	Acceptable indoor air value for VI (IA_{vi})	Indoor air values for consideration of an acute exposure for VI (AIA_{vi})
Soil gas collected from the subsurface	Soil gas concentrations for VI (SG_{vi})	Soil gas concentrations for consideration of an acute exposure for VI (ASG_{vi})
Sub-slab soil gas from beneath a building slab	Soil gas concentrations collecting less than five feet bgs or lowest point of a structure (SG_{vi}-SS)	ASG_{vi} – see description above
Groundwater in contact with a structure	Groundwater concentrations when water is in contact or entering a structure for VI ($GW_{vi\text{-}sump}$)	Groundwater concentrations for consideration of an acute exposure when water is in contact or entering a structure for VI ($AGW_{vi\text{-}sump}$)
Groundwater beneath, but not in direct contact with a structure	Groundwater concentrations for VI (GW_{vi})	Groundwater concentrations for consideration of an acute exposure for VI (AGW_{vi})

APPENDIX F.1

Installation of a Soil Gas Probe/Vapor Monitoring Point to Support Vapor Intrusion Investigations

Remediation and Redevelopment Division

Standard Operating Procedure

INSTALLATION OF A SOIL GAS PROBE/VAPOR MONITORING POINT TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

Robert Wagner, Chief
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PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

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1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for installing a Soil Gas Probe/Vapor Monitoring Point. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Soil gas samples collected less than five feet below ground surface must be referenced as shallow soil gas samples. Though these samples may provide beneficial information to support various lines of evidence, the effects due to barometric pressure, temperature, and the potential breakthrough of ambient air from the surface have the potential to cause these samples to be less reliable than soil gas samples collected at depths greater than five feet below the surface.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. For example, considerations must be given to the types of chemicals of concern, lithology encountered, surrounding buildings and underground structures, and the depth of the vapor source. Samples collected deeper than any potential source of vapors may not fully characterize the potential risk and sampling points should never be installed or collected within the zone of saturation.

2.0 SAMPLING POINT INSTALLATION

Prior to selecting sample locations, an underground utility search is required. Miss Dig and, if necessary, the local utility companies must be contacted and requested to mark the locations of their underground lines. Each sample location should also be screened in the field with a metal detector or magnetometer to verify that no underground utilities or structures exist.

2.1 Boring Advancement

There are many methods to advance a boring intended to install a soil gas sampling point. It is highly recommended that the methodology utilized have the following characteristics:

- Nominal in diameter (less than three inches is recommended)
- Provide minimal disturbance to the surrounding soil
- Does not inject air or water fluids
- Provides a soil core that can be screened, visibly classified, and if necessary collected for chemical analysis

A hydraulic probe is often utilized to advance a boring utilizing two different sampling devices. Those are:

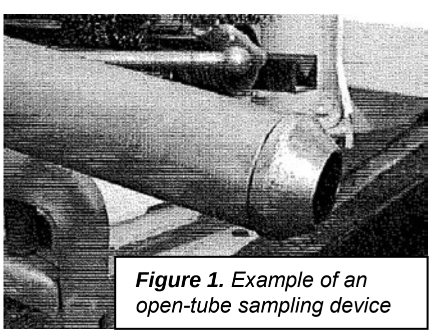

Figure 1. *Example of an open-tube sampling device*

- Open-tube sampling device – A direct push sampler for collecting continuous core samples of stable, unconsolidated materials. Although other lengths are available, a standard macro-core sampler (MC5) available from Geoprobe® is available in lengths between 48 and 60 inches with an outside diameter of 2.25 inches (Figure 1). Soil is collected inside a removable liner. Macro-core samplers are readily available and easy to use in most unsaturated soil conditions to at least ten feet below ground surface.

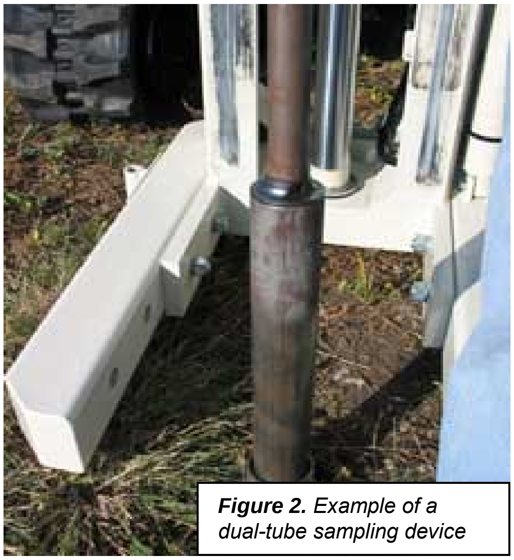

Figure 2. *Example of a dual-tube sampling device*

- Dual-tube sampling system – Dual-tube sampling systems are efficient methods of collecting continuous soil cores with the added benefit of a cased hole. Dual-tube sampling is beneficial in loose or unstable soils as a casing is advanced that prevents soil samples from falling into the boring (Figure 2).

Other methods for advancing boring include the use of hand augers, slab bars, and electric hammers. Each methodology has benefits and drawbacks and should be evaluated before a specific use is decided upon. The hydraulic probe methods identified above can be deployed in a wide variety of site conditions that allows the probe to be driven past some dense stratigraphic horizons.

2.2 Soil Gas Well Materials (General List of Materials)

Tubing – Sample probe tubing should be of a small diameter (1/8 to 1/4 inch) and made of materials that will not react or interact with target compounds. The size should also correspond to the size and construction of the sample point. Suggested materials are nylon, Teflon®, polyethylene, copper, polyvinyl chloride (PVC), or stainless steel. The choice of tubing type depends on site-specific considerations, but in general, nylon tubing is preferred as it exhibits lower adsorption rates and is more flexible and easier to work with than stainless steel

Figure 3. *Vapor point examples*

Soil Gas Well Screen – Screens must be less than six inches in length and configured to allow soil gas to enter along the entire length (Figure 3). This typically results in a fine mesh or screen being utilized to prevent dirt or other debris from entering into the sample tubing.

Sand Pack – The grain size of the sand pack should be sized appropriately (i.e., no smaller than the adjacent formation) and installed in a manner to minimize disruption of airflow to the sampling tip.

Bentonite – Bentonite is utilized to form a chemically resilient, low-permeability, flexible seal from above the well screen to the ground surface. In single vapor point well construction, granular bentonite or bentonite crumbles can be utilized. If multiple well screens are to be utilized, then a coated and compressed bentonite pellet or "tablet" must be utilized (1/4 inch) to prevent any bentonite dust from sealing portions of the borehole. It must be noted that adequately sealing soil gas sampling probes is very important to minimize the exchange of atmospheric air with the soil gas and to maximize the representativeness of the sample.

2.3 Soil Gas Well Installation

The following procedure does not account for the advancement of the boring due to the number of available methodologies available; however, it is imperative that for each boring a soil boring log is competed that provides details on the soil conditions and potential contamination encountered. The procedure below starts after the boring has been advanced and may need to be modified based on the boring methodology utilized. Construction details for each point must be documented in a field log.

A. Inspect the borehole to ensure that it has remained open and is free of water to the depth were the well screen is to be placed.
B. Place four to six inches of sand pack on the bottom of the boring.
C. Pre-assemble screen and tubing and lower into borehole in an upright position on top of the sand pack. If the boring is deep and narrow, adding a small inert weight (e.g., nut) may be utilized to facilitate the tube reaching the bottom.
D. Cut the tubing and temporarily terminate the surface end with a Swagelok cap or other fitting to prevent debris from entering into the line.
E. Mark tubing using tape and a ball-point pen to identify the probe location and depth. All marks should be on tags attached to the tubing and not on the tubing itself. Note: Permanent markers must not be used.
F. Place sand pack around the screen and extend the sand pack to six inches above the top of the screen.
G. Confirm the depth to the top of the sand pack.
H. Record all measurements on the field log.
I. Place one foot of dry granular bentonite or bentonite pellets on top of the sand pack.
J. Avoid lateral movement between the tubing and the bentonite as much as possible once a point has been installed.
K. Install bentonite pellets until six inches below the next screen interval and then hydrate with minimal water or one foot from the ground surface ensuring that the bentonite does not bridge during the placement. If an additional vapor point in the same boring is to be installed, return to Step A and repeat.
L. Ensure that the final bentonite seal is at least 2.5 feet thick.
M. Cut the protruding lengths of tubing successively shorter so the deepest sample tube is the longest length and the others progressively shorter. This is helpful if the labels on each tube are lost or illegible upon resampling.
N. Terminate surface ends of tubes with Swagelok caps, valves, or other desired terminations.
O. Complete all required field documentation.
P. Unless soil gas points are to be abandoned the same day they are installed, probes must be properly secured, capped, and completed to prevent infiltration of water or ambient air into the subsurface. For surface completions, the following components may be installed, as necessary:
    1. Fitting for connection to above ground sampling equipment
    2. Protective flush-mounted or above ground well vaults; and/or
    3. Guard posts

Examples of a single depth soil gas probe and a multi-depth or “nested” soil gas probe are shown in Figure 4. Figure 5 shows example pictures of surface completion.

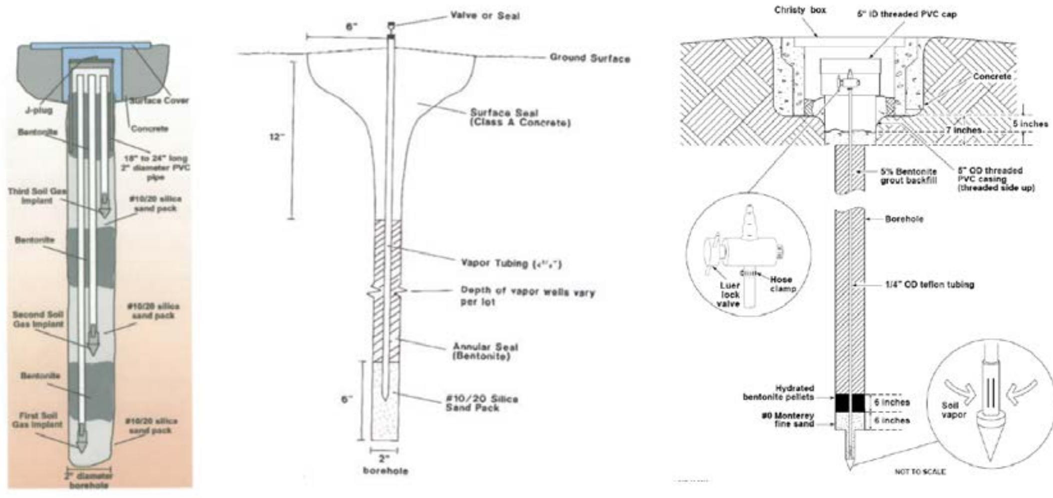

Figure 4. *Examples of complete vapor monitoring points*
[Hartman, 2004 (left and center) and Vonder Haar, S.*, 2000 (right)]*

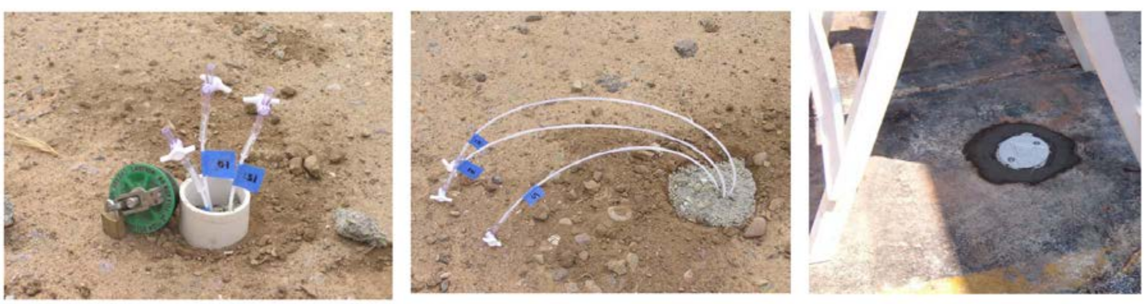

Figure 5*. Examples of various surface completions for vapor wells. (Hartman, 2004)*

2.4 Soil Gas Well Abandonment

All vapor monitoring wells, including those used for soil gas monitoring, must be abandoned upon completion of site activities.

Vapor wells constructed in the manner identified above and that are less than 20 feet in depth may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout and returned as close as possible to original site conditions.

If the tubing cannot be removed, the tubing should be filled with liquid grout and cut off at least one foot below the ground surface. All surface protective covers must be removed and the boring annulus backfilled with uncontaminated native material or grout and returned to as close as possible to original site conditions.

3.0 SOIL BORING LOGS AND VAPOR COMPLETION DIAGRAM

Boring logs and diagrams may be completed utilizing a variety of programs. The following information must be included for every vapor point installed:

- Project information
- Boring location
- Date Installed
- Total depth
- Project personnel including drilling contractor, driller, and geologist
- Drilling method
- Boring diameter
- Soil sampler utilized for lithology
- Sample recovery
- Soil description
- Field screening performed
- Samples sent for analysis
- Unified soil classification system classification
- Boring coordinates (state plane)
- A diagram representing installed sampling point that includes:
    - Surface completion
    - Bentonite seal used
    - Probe and screen construction materials and specifications
    - Depth of all installed materials including screen, bottom of screen, sand pack, tubing, and various bentonite seals

4.0 REFERENCES

Hartman, B., 2004. Vapor Monitoring Wells/Implants Standard Operating Procedures.

Vonder Haar, S., 2000. ERD SOP 1.10: Soil Vapor Surveys - Revision: 4.

Remediation and Redevelopment Division

Standard Operating Procedure

INSTALLATION OF A SUB-SLAB SOIL GAS PROBE/VAPOR MONITORING POINT TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date:** **February 1, 2013**

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This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

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1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for installing a sub-slab soil gas probe/vapor monitoring point. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Sub-slab soil gas samples are vapor samples collected within two feet of the floor of the lowest point of the structure and must be referenced as sub-slab soil gas samples. Though these samples may provide beneficial information to support various lines of evidence, the effects due to barometric pressure, temperature, and the potential breakthrough of ambient air from the surface have the potential to cause these samples to be less reliable than soil samples collected at depths greater than five feet below the surface.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. For example, considerations must be given to the types of chemicals of concern, lithology encountered, surrounding buildings and underground structures, and the depth of the vapor source.

2.0 SAMPLING POINT INSTALLATION

2.1 Boring Advancement

Borings should be through the use of a rotary hammer drill. The specific drill utilized must be capable of utilizing the drill and coring bits identified by the SOP (see below) as well as be of sufficient size to penetrate the expected thickness of concrete present.

2.2 Sub-Slab Point Well Materials (General List of Materials)

Tubing:	1/4 inch diameter x 0.35 inch wall thickness stainless steel tubing for implant
Screen (optional):	3 inch stainless steel implant with 1/4 inch stainless steel compression fittings
Misc:	Mini SST ball-valve adapter, rubber shaft plug, top plug, hose barb, ¾" diameter bottle brush, compression fittings
Expendable supplies:	Neat cement, bentonite, or volatile organic compounds (VOC)-free plumbers putty or modeling clay
Surface termination:	Various surface terminations are available and the selection often depends on whether the probes are temporary or permanent and whether they need to be installed flush with the surface. This SOP utilizes products available from AMS, Inc.
Tools:	Shop-Vac® with with HEPA filter (optional) Rotary hammer drill 1 inch x 16 inch x 21 inch SDS max bit 2 inch x 3 inch x 16 inch SDS max core bit 50 cubic centimeter (cc) syringe

2.3 Sub-Slab Vapor Probe Installation Protocol

Figure 1. Hammer Drill

Figure 2. Inner & Outer Holes

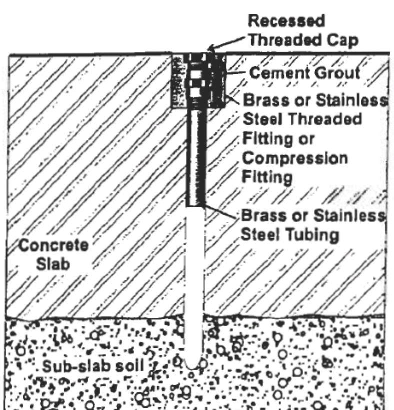

Figure 3. Typical sub-slab vapor probe (shown without a screen)

1. Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.

2. Prior to fabrication of the sub-slab vapor probes, use the rotary drill and the **two inch diameter drill bit** to create a shallow (e.g., 1/4 to 1/2 inch in depth) outer hole that **partially** penetrates the slab (Figure 1). This outer hole will allow the protective cap to be flush with the concrete surface.

3. Brush the hole with a bottle brush and use the small portable vacuum cleaner to remove cuttings from the outer hole.

4. Use the rotary hammer drill and the **one inch drill bit** to create a smaller diameter "inner" hole through the remainder of the slab and at least 6 inches into the underlying soil to form a void in the sub-slab material. Figure 2 illustrates the appearance of the "inner" and "outer" holes from the surface. Drilling into the sub-slab material will create an open cavity which will prevent obstruction of probes during sampling by small pieces of gravel.

5. Brush the hole with a bottle brush and use a small portable vacuum cleaner to remove cuttings from the hole. Cuttings should be removed prior to advancing completely through the cement as much as possible. Once through the slab, care should be taken to minimize the amount of vacuum applied beneath the slab.

6. Determine the thickness of the slab and record the measurement.

7. Assemble the vapor point using the basic design of a sub-slab vapor probe illustrated in Figure 3.

Figure 4. Complete Vapor point

8. Place the assembled vapor point (Figure 4) into the hole and ensure the screen, if utilized, extends beyond the concrete and the top of the probe will be completed flush with the slab once the tamper resistant cap is applied, so as not to interfere with day-to-day use of the buildings. Cut tubing if necessary (Figure 5).

9. Confirm the fit of the rubber shaft plug to the sides of the boring. It should be snug and no gaps present. If additional thickness is necessary, VOC-free plumbers putty or modeling clay can be added to the sides of the rubber.

10. Mix quick-drying Portland cement with water to form slurry. Portland cement may expand upon drying. Points installed for a single sampling event may use VOC-free plumbers putty or modeling clay.

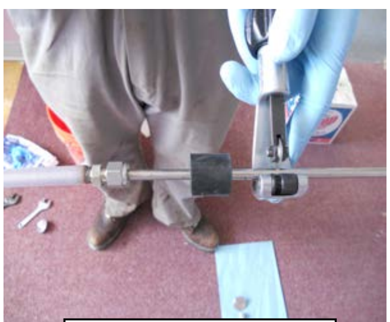

Figure 5. Cut tubing

11. Inject the Portland cement with a 50 cc syringe or push into the annular space between the probe and outside of the “outer” hole (Figure 6) until filled (Figure 7). If a tamper-resistant cap is to be used the cement should be left ¼” below the concrete surface.

12. Complete installed vapor point with a plug (Figure 8) or tamper-resistant cap (Figure 9).

13. Allow cement to cure for at least 24 hours prior to sampling. The time may be adjusted if quick-drying cement is utilized.

Figure 6. Seal annular space

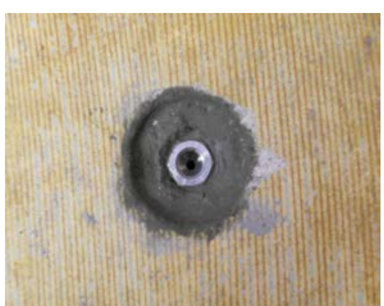

Figure 7. Seal complete

Figure 8. Plug

Figure 9. Tamper-resistant cap

2.4 Abandonment

All vapor monitoring wells, including those used for soil gas monitoring, must be abandoned upon completion of site activities.

Vapor wells constructed in the manner identified may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout and returned as close as possible to the original site conditions.

If the tubing cannot be removed, the tubing should be cemented in place. All surface protective covers must be removed and returned to as close as possible to original site conditions.

3.0 SOIL BORING LOGS AND VAPOR POINT COMPLETION INFORMATION

Boring logs and diagrams must be completed. A variety of programs may be utilized; however, the following information must be included for every sub-slab vapor point installed:

- Project information
- Boring location
- Date installed
- Total depth
- Thickness of concrete
- Project personnel including drilling contractor, driller, and geologist
- Boring diameter
- Soil description (if identified)
- Field screening performed
- A diagram representing installed sampling point that includes:
  - Surface completion
  - Seal used
  - Probe and screen construction materials and specifications
  - Depth of all installed materials including screen, bottom of screen, sand pack, and tubing

4.0 REFERENCES

Though not specifically referenced, the SOP is based upon the following:

DiGiulio, Dominic. DRAFT Standard Operating Procedure (SOP) for Installation of Sub-Slab Vapor Probes and Sampling Using EPA Method TO-15 to Support Vapor Intrusion Investigations. United States Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Ground-Water and Ecosystem Restoration Division, Ada, Oklahoma.

Hartman, B., 2004. Vapor Monitoring Wells/Implants Standard Operating Procedures.

Remediation and Redevelopment Division

Standard Operating Procedure

SAMPLING UTILIZING USEPA METHOD TO-15 *VIA* BOTTLE-VAC® TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

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1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for collecting a vapor sample through either a soil gas probe/vapor monitoring point and/or sub-slab monitoring point for the analysis of volatile organic compounds (VOCs) by the United States Environmental Protection Agency Method TO-15 (USEPA, 1999). Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. Considerations must be given to the types of chemicals of concern, lithology encountered, and the depth of the vapor source. Samples collected deeper than any potential source of vapors may not fully characterize the potential risk and sampling points should never be installed or collected within the zone of saturation.

The Method TO-15 in this procedure has been modified for use with one-liter Bottle-Vac® samplers by Entech Instruments, Inc. Bottle-Vacs® are utilized by the MDEQ's Laboratory in all soil gas sampling applications. Bottle-Vac® has been shown by internal testing performed by the MDEQ Laboratory to be reliable for both holding times and reporting requirements in soil gas sampling applications.

2.0 SOIL GAS COLLECTION

Most vapor wells are installed at relatively shallow depths (less than ten feet below ground surface) so minimum purge volumes and low-volume samples must be performed to minimize potential breakthrough from the surface or between sampling intervals. Tracer/leak gas is necessary to ensure breakthrough does not occur and that a leak does not occur at any fitting above grade. Samples must not be collected after any rain event and until site conditions (including moisture content) return to typical site conditions.

Samples from wells with multiple points installed must not be collected simultaneously and approximately 30 minutes must elapse between each sampled interval which should be documented on the field log. Sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize the potential for vacuum extraction of contaminants from the soil phase. Volumes of various tubing sizes are provided in Table 1 in order to aid in calculating purge volumes.

Table 1
Volumes for Select Tubing Sizes

Tubing Size (inches ID)	*Volume/ft. (liters)*
3/16	0.005
1/4	0.010
1/2	0.039

Care must be used during all aspects of sample collection to ensure that sampling error is minimized and high quality data are obtained. Care must also be taken to avoid excessive purging prior to sample collection and prevent pressure build-up in the enclosure during introduction of the tracer gas. Inspection of the installed sample probe, specifically noting the integrity of the surface seal and the porosity of the soil in which the probe is installed, will help to determine the tracer gas setup. The sampling team must avoid actions (e.g., fueling vehicles, using permanent marking pens, and wearing freshly dry-cleaned clothing or personal fragrances) which could potentially cause sample interference in the field.

IMPORTANT SAMPLING NOTES:

- An initial vacuum test must be performed on each point. This is done by attaching a 50-ml syringe and pulling back on a point to ensure that the point is able to provide adequate vapor without obtaining a vacuum. If a point is installed in which the syringe cannot be withdrawn without generating a vacuum, the sampling point may not be valid and may need to be replaced.
- If water droplets are observed in the tubing or in a Bottle-Vac®, the sampling crew must note the presence of water on the sample label and Chain of Custody and recollect the sample.
- Bottle-Vac® must remain out of the sun and not placed on ice or chilled.
- Collected Bottle-Vac® samples must be stored at room temperature and not left in a hot vehicle or freezing vehicle.
- Label all samples with the label provided by the lab using a ballpoint pen. *Do not use a Sharpie*!
- Wash hands or replace sampling gloves between samples to ensure the leak/tracer compound is not on your fingers when connecting fittings.
- Disposable equipment and supplies must not be used for multiple sampling points.
- *Do not write* on boxes provided by the MDEQ Laboratory.
- *Do not remove* the green tape from the flow regulator. Do not adjust; the flow regulator has been calibrated to the correct flow rate of 100 to 200 ml/min.
- The MDEQ provides a dedicated regulator for each sample that is collected. The ID of each regulator should be referenced on the sampling form and any issues reported to the MDEQ Laboratory.

2.1 Soil Gas Collection General List of Materials

The equipment required for soil gas sample collection is as follows:

Tooling and Supplies	Flow Meters and Detectors:
• Bottle-Vac® (one per location) • Regulated flow meter assembly set to a maximum of 200 ml/min (one per location) • 1/4 inch tubing (suggested materials are nylon, Teflon® polyethylene, or similar) and assorted fittings • Plastic housing for using tracer gas • 50 ml syringe (for purging) • Camera • Adjustable crescent wrenches, small to medium size, and/or open end combo wrenches 9/16 to 1/2 inch • Scissors/snips to cut tubing • Ballpoint pens • Nitrile gloves • Compound to be used as tracer gas - lab grade helium	• Flow regulator with vacuum gauge. Flow regulators provided by the MDEQ Laboratory are pre-calibrated to a specified flow rate (e.g., 100 ml/min). • Photoionization detector (with appropriate lamp • Helium detector • Methane meter for petroleum sites that is capable of also measuring percent of methane (CH_4), carbon dioxide (CO_2), and oxygen (O_2) • Optional meter to measure %LEL of methane **Forms:** • Chain of Custody forms • Soil gas sample collection log (example attached) • Field notebook

2.2 Soil Gas Tracer Compounds

A leak in the sampling assembly may allow ambient air into the system and dilute the soil gas results (Benton, 2007). Therefore, tracer gases must be utilized during the collection of soil gas samples to verify that the sample collected is from the installed sampling point. The presence of a tracer compound, whether liquid or gaseous, can confirm a leak in the sampling train and the usability of the sample will need to undergo further evaluation.

Careful thought and consideration must be used when choosing a leak check compound as a tracer as each compound utilized can have specific benefits and drawbacks that should be considered. Figure 1 depicts a typical sub-slab sampling setup utilizing helium as a tracer gas. Though other compounds may be utilized, the MDEQ Laboratory has identified a preference for helium.

Helium used as a tracer gas beneath a shroud as shown in Figure 1 allows for the screening of the sampling train in the field. The use of a field meter capable of detecting helium may be able to resolve and correct any leaks by reevaluating the sampling train and retightening all fittings prior to collecting the sample for analysis. If a leak has been detected and is unable to be resolved, the sampling point may need to be decommissioned and a new one installed. Lab grade helium must be utilized to eliminate possible contribution issues as helium available at general merchandise stores may contain secondary contaminants such as benzene (Figure 2).

Understanding the relationship between a leak and the concentration detected of the tracer gas used to check for leaks, the potential for absorption of the tracer gas (i.e., helium) onto sample train tubing, and the potential for interference by the tracer gas compound with VOCs is important in answering the data usability. An ambient air leak up to ten percent may be acceptable if quantitative tracer testing is performed. Otherwise, the soil gas vapor well should be decommissioned if the leak cannot be corrected. Replacement vapor wells should be installed at least five feet from the location where the original vapor well was decommissioned due to a confirmed leak.

***Figure 1**. Sampling shroud being pressurized with helium.*

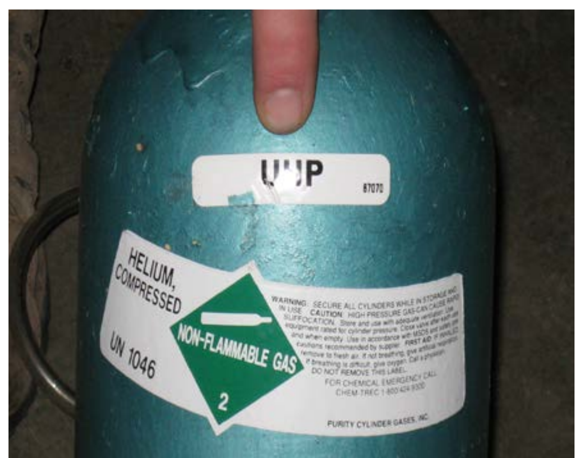

***Figure 2**. Use Ultra High Pure (UHP) grade helium to avoid background contaminants.*

2.3 Sample Collection Procedure

***Figure 3**. Sampling equipment.*

1. Allow for subsurface conditions to equilibrate and vapor concentrations to stabilize after vapor point installation:
   - Do not conduct the purge volume test, leak test, and soil gas sampling for at least 45 minutes.
   - Do not conduct the purge volume test, leak test, and soil gas sampling for at least 48 hours after vapor probe installation with augers.
   - Do not conduct the purge volume test, leak test, and soil gas sampling after any rain event until site conditions return to normal.

2. Assemble the aboveground sampling equipment which consists of new connector tubing, a designated regulated flow meter assembly including pressure gauge for each sample, purging equipment, and Bottle-Vac® (Figure 3).

3. Place the completed sampling label on the Bottle-Vac®.

***Figure 4.** Connect sampling line to point.*

***Figure 5**. Connect regulator to sampling line.*

***Figure 6**. Connect regulator assembly to shroud.*

4. Connect the above ground sampling line to the vapor monitoring point (Figure 4).

5. Connect the regulated flow meter assembly to sampling line (Figure 5).

6. Connect the regulated vapor flow meter assembly to the sampling shroud (Figure 6).

7. Calculate volume of air contained within the vapor point and sampling assembly up to the point where the sample will be collected and record on the field sampling form.

8. Check all sampling system connections and fittings for tightness and/or obvious deterioration.

Figure 7

Figure 8

Figure 9

9. Run all sampling lines through the helium shroud and place the enclosure on the ground (Figure 7). It may be appropriate to seal the enclosure to the ground using VOC-free plumbers putty, modeling clay, or hydrated bentonite.

10. Connect the sampling port line to the outside of shroud, making sure that the valve is closed (Figure 8).

11. Connect the helium cylinder to the tracer gas port. Opening the valve on the line from helium to the shroud, begin the flow of helium into the enclosure (Figure 9).

Figure 10

Figure 11

12. Confirm that the enclosure contains helium through the use of the helium detector.

13. Connect a 50 cubic centimeter (cc) syringe to the sampling port line and purge at least three volumes of air from the sampling system (Figure 10). After purging is complete, close the valve to the sampling line, disconnect the syringe, and close valve to the helium cylinder.

14. Calibrate the helium detector and zero for existing site conditions.

15. Connect the helium detector to the sampling port, collect, and record a reading (Figure 11).

16. If helium is detected, return to Step 5 and repeat process until no helium is detected. If a leak is unable to be resolved, the sampling point may need to be decommissioned and a new one installed.

17. Reaffirm that the enclosure contains helium through the use of the helium detector. If helium is not detected in the sampling enclosure, identify how the helium is leaving the enclosure and return to Step 6 and seal the enclosure as appropriate.

Figure 12

Figure 13

18. Disconnect or remove the sampling lines from the sampling enclosure leaving the flow regulator assembly and the lines connecting it into the sampling point in place (Figure 12).

19. Open the valve on sampling line.

20. Immediately connect the flow regulator assembly to the Bottle-Vac® using the quick connect adaptor and record the start time and vacuum gauge reading (Figure 13). The vacuum gauge should register about -28 millimeters mercury when it is first attached.

21. Check every two minutes and record the time at which the vacuum gauge reaches 0 pounds per square inch.

22. Calculate and confirm that the sampling rate is less than 200 ml/min. Record the flow regulator number on the sampling form and note any sampling discrepancies in the field notes and sampling form.

23. Disconnect the quick connect adaptor from the Bottle-Vac® and place paraffin on the top of the Entech Micro-QT® Valve.

24. Confirm the container has the proper label with the sample identification information.

25. Remove the flow regulator from the tubing and record the regulator number on the sampling form.

26. Complete the air volatiles request form. Be sure to circle Bottle-Vac® in the upper right.

27. Return everything including the Bottle-Vac®, adaptor, vacuum gauge, flow regulator assembly, and notes on equipment issues to the MDEQ Laboratory for analysis, cleaning, and calibration.

3.0 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES AND FIELD RECORDS

The Quality Assurance/Quality Control (QA/QC) procedures are an integral part of any sampling activities. The most important QA/QC procedures in collecting soil gas sampling are ensuring that the samples are representative of the subsurface conditions. For soil gas sampling, that means the QA/QC program identify procedures that verify that the sample is properly collected. Recording the pressure reading throughout the process is a critical component. Unlike soil or groundwater sampling, most of the containers and sampling devices utilized for sampling are verified clean. Upon request, the laboratory can provide laboratory batch cleaning results.

Trip blanks are typically not collected due to the sampling process and sampling devices that prevent the intrusion (or introduction) of air or other media into the sampling device. In addition, the failure of one flow regulator sampling assembly on a specific Bottle-Vac® does not provide an indication that any of the other sampling assemblies or Bottle-Vacs® have failed. Sampling blanks for soil gas sampling equipment including tubing and fittings may be collected if the source of the material is unknown or suspected to be contaminated.

Duplicate samples including blind duplicates are recommended to be collected to verify laboratory procedures and should include the collection of at least one field duplicate per sampling event or one per 20 samples, whichever is greater. When collecting duplicate samples in the field, it is imperative that the duplicate samples are collected simultaneous to collection of the primary sample using a sampling tee and at a combined sample rate to not exceed 200 ml/min from each point. Laboratory duplicate samples can also be collected from the same sampling Bottle-Vac® if the duplicate is not required to be a blind sample.

3.1 Soil Gas Sampling Record

The following information should be recorded in a field notebook or on sampling forms similar to those shown in Attachment 1 to document the procedures utilized at a specific site to collect soil gas data. In general, the fields should include the following information:

1. Sample identification information including the locations and depths at which the samples were collected, sample identifiers, date, and time
2. Identify the field personnel involved in the sample collection
3. Weather conditions (e.g., temperature, wind speed, barometric pressure, precipitation, etc.)
4. Sampling methods, devices, and equipment used
5. Purge volumes prior to sample collection. Relate the purge volumes to the volume of the sampling equipment, including the tubing connecting the sampling interval to the surface.
6. Volume of soil gas extracted (i.e., volume of each sample)
7. Vacuum of canisters before and after samples collected
8. Tracer gas utilized and whether it is a liquid or a solid
9. Field screening of any tracer gas

4.0 REFERENCES

Benton, Diane and Shafer, Nathan. 2007. Evaluating Leaks in a Soil Gas Sample Train, Paper #45 Extended Abstract, Air Toxics, Ltd.

United States Environmental Protection Agency. 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. Compendium Method TO-15 Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information, Office of Research and Development, United States Environmental Protection Agency. Document No. EPA/625/R-96/010b.

Attachment 1

Remediation and Redevelopment Division
Soil Gas Sampling Form

General Site Information:

Site Name:		Sample ID:	
Location:		Sampling Crew:	
Date:		Project Manager:	
Bottle No:		Regulator No:	

Weather Conditions:

Last rain:		Bar. pressure:	
Current temp:		Current weather:	

Volume Calculations:

Volumes for Tubing Sizes Per Foot		Calculations:		
(liters)	(inches ID)		Vapor Point ID:	
3/16"	0.005		Depth of Vapor Point:	
1/4"	0.01		Extra Tubing to Bottlevac:	
1/2"	0.039		Diameter:	
			Estimated Volume:	
			Purge Method:	
			Purge Volume:	

Instrument Readings:

GEM			
O_2:		CO_2:	
% CH_4:		Other:	
MultiRAE			
VOCs:		CO_2:	
O_2:		% LEL:	
Other:			
Other:			

Miscellaneous:

Vac Test Completed:	☐ Yes ☐ No	Starting Time:	
Tracer Gas Utilized:	☐ Helium ☐ IPA ☐ N/A	Initial BottleVac Pressure:	
Suspected COCs:	☐ Petroleum ☐ Solvent	Ending Time:	
Moisture Identified:	☐ Yes ☐ No	Final BottleVac Pressure:	

General Boring Location and Notes:

Remediation and Redevelopment Division

Standard Operating Procedure

INDOOR AIR SAMPLING *VIA* USEPA METHOD TO-15

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

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The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for the collection of an indoor air sample and the analysis of volatile organic compounds (VOCs) by the United States Environmental Protection Agency Method TO-15 (TO-15) (USEPA, 1999). Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

The objective of this SOP is to describe the equipment and techniques utilized for the collection of time-integrated air samples in a Summa canister, with the ultimate goal of ensuring that similar methods and protocols are used when collecting such samples for analysis of VOCs to evaluate vapor intrusion. This is a SOP (i.e., typically applicable) which may need to be varied or changed dependent on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented.

This SOP does not cover, nor is it intended to provide, a justification or rationale for when this sampling is conducted. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work.

The TO-15 Method in this procedure has been established for the use of a Summa canister equipped with a regulator that will collect an indoor air sample continually over a 24-hour period. If a shorter time frame is necessary to evaluate nonresidential conditions, the following procedures will need to be modified accordingly. Laboratory detection limits must be compared from each method to the acceptable indoor air concentrations (AIAC) to assure that the detection limits will be equal to or less than the corresponding generic AIACs.

2.0 PRE-SAMPLING INSPECTION

An adequate background review must be conducted before sampling to obtain information on each structure from which a sample is collected. The background review should include a visual survey of each structure to ascertain the basement, crawl space, or slab-on-grade building configuration; determine if sumps, wells, or cisterns are associated with each structure; evaluate the condition of the floors and walls; and describe the heating and ventilation system within each structure. These features may act as conduits that will facilitate the migration of VOC vapors from the subsurface. An attached garage, basement, or workshop may store products that can contribute to indoor air impacts.

Interviews should be conducted with the owner/occupant of the building(s) to assess the use of potential contaminants, frequency of use, storage, as well as methods of handling and disposal. This information is vital to adequately evaluate activities that may influence the air sampling results and includes, but is not limited to: the length of occupant residency; ages of adults and children living in the structure; if occupants smoke and how often; and any hobbies using paints, solvents, and/or other potential contaminants.

A pre-sampling inspection must be performed prior to each sampling event to identify conditions that may affect or interfere with the proposed testing. The inspection should evaluate the type of structure, floor layout, physical conditions, and airflow of the building(s) being studied. The inspection information should be identified on a form similar to those included in Attachment 1. In addition, potential sources of chemicals of concern should be evaluated within the building by conducting a product inventory. The primary objective of the product inventory is to identify potential air sampling interference by characterizing the occurrence and use of chemicals and products throughout the building, keeping in mind the goal of the investigation and site-specific contaminants of concern (COCs). For

example, it is not necessary to provide detailed information for each individual container of like items. However, it is necessary to indicate that "20 bottles of perfume" or "12 cans of latex paint" were present with containers in good condition. This information is used to help formulate the indoor environment profile.
Each room on the floor of the building being tested and on lower floors, if possible, should be inspected and an inventory provided. This is important because even products stored in another area of a building can affect the air of the room being tested. For example, when testing for a petroleum spill, all indoor sources of petroleum hydrocarbons should be scrutinized. These can include household and commercial products containing VOCs, petroleum products including fuel from gasoline-operated equipment, unvented space heaters and heating oil tanks, storage and/or recent use of petroleum-based finishes and paints, or products containing petroleum distillates. This information should be detailed in the survey forms in Attachment 1.

The presence and description of odors (e.g., solvent, moldy) and portable vapor monitoring equipment readings (e.g., photoionization detectors (PIDs) for VOCs, Jerome Mercury Vapor Analyzer for mercury) should be used to help evaluate potential sources. This includes taking readings near products stored or used in the building. Products in buildings should be inventoried every time air is tested to provide an accurate assessment of the potential contribution of volatile chemicals. If available, chemical ingredients of interest should be recorded for each product. If the ingredients are not listed on the label, record the product's exact full name, and the manufacturer's name, address, and phone number, if available. In some cases, Material Safety Data Sheets may be useful for identifying confounding sources.

3.0 PREPARATION OF BUILDING

Potential interference from products or activities releasing volatile chemicals may need to be controlled. Removing the source from the indoor environment prior to testing is the most effective means of reducing the interference. Ensuring that containers are tightly sealed may be acceptable. When testing for VOCs, containers should be tested with a field instrument to assess whether VOCs are leaking. The investigator should consider the possibility that chemicals may adsorb onto porous materials and may take time to dissipate. The goal of the testing is to evaluate the impact from products used or stored in the building (e.g., pesticide misapplications, school renovation projects). Depending on the field instrumentation utilized, small sources that may potentially impact indoor air may not be detected.

Once interfering conditions are corrected (if applicable), ventilation may be needed prior to testing to eliminate residual contamination in the indoor air. If ventilation is appropriate, it should be completed 24 hours or more prior to the scheduled sampling time. Where applicable, ventilation can be accomplished by operating the building's heating, ventilation, or air conditioning (HVAC) system to maximize outside air intake. Opening windows and doors and operating exhaust fans may also help or may be needed if the building has no HVAC system.

Air samples are sometimes designed to represent a typical exposure in a mechanically ventilated building, and the operation of the HVAC systems during sampling should be noted (see HVAC section on the attached indoor air quality questionnaire). In general, the building's HVAC system should be operating under normal conditions. Unnecessary building ventilation should be avoided within the 24 hours prior to and during testing. During colder months, heating systems should be operating under normal occupied conditions (i.e., 65° to 75°Fahrenheit) for at least 24 hours prior to and during the scheduled sampling time.

Depending on the goal of the indoor air sampling, some situations may warrant deviation from the above protocol regarding building ventilation. In such instances, building conditions and sampling efforts should be understood and noted within the framework and scope of the investigation.

FOR 24 HOURS PRIOR TO SAMPLING, ALL REASONABLE MEASURES SHOULD BE TAKEN TO AVOID:

- Smoking in the house
- Painting
- Using wood stoves, fireplaces, or other auxiliary heating equipment (e.g., kerosene heaters)
- Operating or storing automobiles in an attached garage
- Allowing containers of gasoline or oil to remain within the house, except for fuel oil tanks
- Cleaning, waxing, or polishing furniture or floors with petroleum- or oil-based products
- Using air fresheners or odor eliminators
- Engaging in any hobbies that use materials containing VOCs
- Using cosmetics, including hairspray, nail polish, nail polish removers, perfume/cologne, etc.
- Applying pesticides

4.0 COLLECTION OF SAMPLES

Air samples should be collected from an adequate number of locations to assess potential exposures to occupants. In private residences, air samples may be collected from each floor including: the basement, first floor living space, and from outdoors. The rate and number of sampling locations should be established by evaluating the building construction as well as the location of the sources. In general the number of samples should be collected at a rate of one indoor air sample per 1,000 sq ft of open space; however, the number of samples could be adjusted based on the following:

- A smaller number of samples may be appropriate for larger open spaces
- Samples need not be collected from the entire structure and should only be based on the location of the source of vapors
- Sampling locations should reflect where the inhabitants spend their time indoors and be centrally located to be representative of as large an area as possible, so living rooms or family rooms are often the sampling locations of choice
- Avoid locations where dilution air enters the building (e.g., near outside doorways) or where indoor emission sources may be nearby (e.g., utility rooms connecting the house to the garage)

Sampling devices should not be placed near doors, windows, stairways, or air supplies. In settings with diurnal occupancy patterns, such as schools and office buildings, samples should be collected during normally occupied periods to be representative of typical exposure. However, in special circumstances it may be necessary to collect air samples at other times in order to minimize disruptions to normal building activities. Sample collection intakes should be located to approximate the breathing zone for building occupants (i.e., three feet above the floor level where occupants are normally seated or sleep). To ensure that an air sample is representative of the conditions being tested and to avoid undue influence from sampling personnel, personnel should avoid lingering in the immediate area of the sampling device while samples are being collected. If the goal of the sampling is to represent average concentrations over longer time periods, then longer duration sampling periods may be appropriate. The sampling team members should avoid actions (e.g., fueling vehicles, using permanent marking pens) that can cause sample interference in the field.

4.1 Sample Analysis

Indoor air samples must be collected and analyzed in accordance with this SOP. In determining laboratory detection limits, the samples must be compared from each method to the AIACs to assure that the detection limits will be equal to or less than the corresponding generic AIACs.

Indoor air sampling to evaluate potential impacts from chemical contaminant sources (i.e., old spills, soil vapor, groundwater) should generally include the full list of compounds identified in Appendix C of the Remediation Division Guidance Document. The "Target Compounds List" identified in Appendix C includes a smaller subset of compounds than the entire list of compounds capable of being identified. Each analysis must also include the reporting of the top five Tentatively Identified Compounds greater than five parts per billion by volume that are not attributed to column breakdown, as compared to response of the nearest internal standard, when using the full-scan mode of the mass spectrometer. The laboratory will also report within the narrative if a hump is seen within the chromatogram such as is typical for gasoline, fuel oil, mineral spirits, etc.

4.2 Sampling Equipment

Time-integrated indoor air samples will be collected in specially prepared six liter (L) Summa canisters. Airflow into the canister is regulated by a sampling valve or a pneumatic flow controller attached to an in-line particulate filter. The sampling valve is typically used for short duration grab samples; however, the valve can be set for longer duration sampling. Flow controllers are precalibrated to regulate flow for sample collection times of 8 hours, 12 hours, or 24 hours.

Canisters will be cleaned and certified by the laboratory as per the USEPA TO-15 Method guidelines. During the planning stage for the sampling event, the laboratory will need information on the contaminants of interest, the analytical method, and reporting limits required for the project so that appropriately cleaned canisters can be selected. Also, the sampling team should consider requesting extra canisters and flow controllers from the laboratory due to the potential for equipment failure.

A vacuum gauge is utilized to measure and record the initial canister vacuum. A post-sampling vacuum reading is also taken to ensure that a sufficient sample has been collected and that some residual vacuum remains in the canister. The initial canister vacuum should be at least -26 inches of mercury (Hg). If the initial vacuum is less than -26 inches Hg (i.e., between 0 inches Hg and -25 inches Hg), the canister should be rejected and returned to the laboratory.

Stainless steel, Teflon, or nylon tubing can be attached to the in-line filter to obtain samples from the breathing zone or a remote location. The inlet manifold is placed in the breathing zone at approximately three to six feet above grade.

4.3 Quality Assurance/Quality Control

Extreme care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Appropriate quality assurance/quality control measures must be followed for sample collection and laboratory analysis. Items that should be addressed in sampling protocols include sampling techniques, certified-clean sampling apparatus, appropriate sample holding times, temperatures, and pressures. In addition, laboratory procedures must be followed including: field documentation (sample collection information and locations), Chain-of-Custody, field blanks, field sample duplicates and laboratory duplicates, as appropriate.

4.4 Sampling Information

Detailed information must be gathered at the time of sampling to document conditions prior to and during sampling to aid in the interpretation of the test results. The information should be recorded on the building inventory form along with the date and the investigator's initials. Floor plan sketches must be drawn for each floor and should include the floor layout with sample locations; chemical storage areas; garages; doorways; stairways; location of basement sumps; HVAC systems, including air supplies and returns; compass orientation (north); and any other pertinent information. In addition, observations such as odors, PID readings, and airflow patterns should be recorded on the building inventory form. Smoke tubes or other devices are helpful and should be used to confirm pressure relationships and airflow patterns, especially between floor levels and between suspected contaminant sources and other areas. Photos should be collected of each sampling container deployed within the structure.

Outdoor plot sketches must include the building site, area streets, outdoor sample location, the location of potential interference (e.g., gas stations, factories, lawn mowers), wind direction, and compass orientation (north arrow identified).

4.5 Sample Hold Time

The hold time is very compound-specific. For example, compounds such as chloroform, benzene, and vinyl chloride are typically stable in a canister for at least 30 days. The USEPA TO-15 Method states, "Fortunately, under conditions of normal usage for sampling ambient air, most VOCs may be recovered from canisters near their original concentrations for after storage times of up to thirty days." However, some VOCs degrade quickly and demonstrate low recovery even after seven days (Hayes, 2007).

5.0 SAMPLING PROCEDURES

5.1 Associated Hardware

5.1.1 Valve

A 1/4 inch stainless steel bellows valve (manufactured by Swagelok or Parker Instruments) should be mounted at the top of the canister. The valve allows vacuum to be maintained in the canister prior to sampling and seals off the canister once the sample has been collected. No more than a half-turn by hand is required to open the valve. Do not over tighten the valve after sampling or it may become damaged. A damaged valve can leak, possibly compromising the sample. Some canisters have a metal cage near the top to protect the valve (Hayes, 2007).

5.1.2 Brass Cap

Each canister comes with a brass cap (i.e., Swagelok 1/4 inch plug) secured to the inlet of the valve assembly. The cap serves two purposes: first, it ensures that there is no loss of vacuum due to a leaky valve or a valve that is accidentally opened during handling; second, it prevents dust and other particulate matter from fouling the valve. The cap is removed prior to sampling and replaced following sample collection (Hayes, 2007).

5.1.3 Particulate Filter

Particulate filters may be used when sampling with a canister. A separate filter (Figure 1) should be used for each sample collection to prevent any cross-contamination (Hayes, 2007).

Figure 1. Provided by Hayes, 2007

5.1.4 Fittings

Standard hardware fittings are 1/4 inch Swagelok; a 9/16 inch wrench is used to assemble the hardware. Compression fittings should be used for all connections; never use tube-in-tube connections. It is critical to avoid leaks in the sampling train. Leaks of ambient air through fittings between pieces of the sampling train (e.g., tubing to particulate filter) will dilute the sample and cause the canister to fill at a faster rate than desired (Hayes, 2007).

5.1.5 Vacuum Gauge

A vacuum gauge (Figure 2) is used to measure the initial vacuum of the canister before sampling and the final vacuum upon completion. A gauge can also be used to monitor the fill rate of the canister; however, most gauges should be considered as only a rough estimate of the pressure and should only be used to obtain a relative measure of "change" (Hayes, 2007).

Figure 2. Provided by Hayes, 2007

5.1.6 Flow Controllers

An air sample collected over time is referred to as an integrated sample and can provide information on compound concentrations in air averaged or composited over time. Illustrated here are some of the most common hardware configurations used to take an integrated sample. Flow controllers are devices that regulate the flow of air during sampling into an evacuated canister, (also known as flow restrictors). These devices enable a sampler to achieve a desired flow rate and, thus, a sampling interval. The flow controller (Figure 3) should allow the sample to be collected equally over a set period of time (Hayes, 2007).

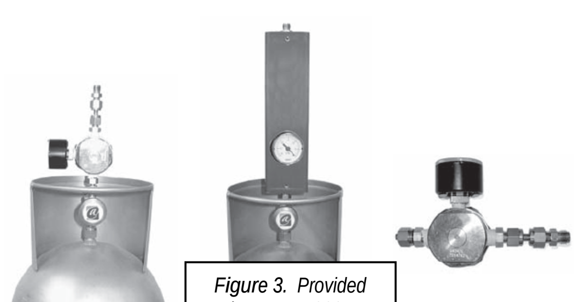

Figure 3. Provided by Hayes, 2007

5.2 Final Canister Vacuum and Flow Controller Performance

The final vacuum of a 6 L canister should be between five and ten inches Hg. As long as the differential pressure is greater than four inches Hg ambient pressure, the flow through the device will remain approximately constant as the canister fills. If there is insufficient differential pressure, the flow through the controller will decrease as the canister pressure approaches ambient. Because of the normal fluctuations in the flow rate (due to changes in ambient temperature, pressure, and diaphragm instabilities) during sampling, the final vacuum will range between two and ten inches Hg.

General considerations of the final canister vacuum include:

- If the residual canister vacuum is greater than five inches Hg (i.e., more vacuum), and less than 5 L of sample was collected in a 6 L canister. When the canister is pressurized to five pounds per square inch prior to analysis, sample dilution will be greater than normal. This will result in elevated reporting limits.
- If the residual canister vacuum is less than five inches Hg (i.e., less vacuum), the initial flow rate was high or there was a leak in the connection. Once the vacuum decreases below five inches Hg, the flow rate begins to drop significantly. This scenario indicates that the sample is skewed in favor of the first portion of the sampling interval.
- If the final vacuum is near ambient (i.e., less than one inch Hg), there is inadequate differential pressure to drive the flow controller. The sampler cannot be certain the desired sampling interval was achieved before the canister arrived at ambient conditions. Although the actual sampling interval is uncertain, the canister still contains a sample from the site.

Table 5.1 identifies the relationship between the final canister vacuum and the dilution factor, which may affect the ability of the sample to reach the required detection limits (Hayes, 2007).

Table 5.1: Relationship between Final Canister Vacuum, Volume Sampled, and Dilution Factor of a 6 L Canister

Final Vacuum (In. Hg)	0	2.5	5	7.5	10	12.5	15	17.5	20
Volume Sampled (L)	6	5.5	5.4	5	4	3.5	3	2.5	2
Dilution Factor*	1.34	1.46	1.61	1.79	2.01	2.30	2.68	3.22	4.02

* Canister pressurized to 5 psig for analysis

$$\text{Final Reporting Limit} = \text{Method Reporting Limit} \times \text{Dilution Factor}_{\text{(Canister Pressurization)}} \times \text{Dilution Factor}_{\text{(Sample Concentration)}}$$

$$\text{Dilution Factor}_{\text{(Canister Pressurization)}} = \frac{\text{Pressurization for Analysis}}{\text{Receipt Vacuum}} = \frac{14.7\ \text{psig} + \text{Press. for Analysis (psig)}}{14.7\ \text{psig}\left[1 - \frac{\text{Rec. Vac (In Hg)}}{29.9\ \text{In. Hg}}\right]}$$

(Provided by Hayes, 2007)

5.3 Considerations for Sampling with Canisters

Avoid Leaks in the Sampling Train: A leak in any connection will mean that some air will be pulled in through the leak and not through the flow controller. A final pressure reading near ambient is one indication that there may have been a leak.

Verify Initial Vacuum of Canister: See Section 4.2 for detailed instructions on verifying initial canister vacuum.

Monitor Integrated Sampling Progress: It is a good idea to monitor the progress of the sampling during the sampling interval. The volume of air sampled is a linear function of the canister vacuum. For example, halfway (four hours) into an eight-hour sampling interval, the canister should be half filled (2.5 L), and the gauge should read approximately 17 inches Hg. More vacuum than 17 inches Hg indicates that the canister is filling too slowly; less than 17 inches Hg and the canister is filling too quickly. If the canister is filling too quickly because of a leak or incorrect flow controller setting, corrective action can be taken. Ensuring all connections are tight may eliminate a leak. It is possible to take an intermittent sample.

Avoid Contamination: Flow controllers should be cleaned between uses. This is done by returning them to the laboratory.

Caution Against Sampling in Extreme Temperatures: There can be some flow rate drift if the temperature of the controllers is allowed to vary significantly.

5.4 Step-by-Step Procedures for Integrated Sampling

These procedures are for a typical air sampling application and must be documented; actual field conditions and procedures may vary.

Before Arriving at the Field

1. Verify contents of the shipped package (e.g., Chain of Custody, canister, particulate filter, and flow controller)
2. Verify the gauge is working properly
3. Verify the initial vacuum of the canister

It is important to check the vacuum of the canister prior to use. The initial vacuum of the canister should be greater than -26 inches Hg. If the canister vacuum is less than -26 inches Hg, do not use it.

Vacuum Verification

The procedure to verify the initial vacuum of a canister is simple but unforgiving:

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove the brass cap
3. Attach gauge
4. Attach brass cap to side of gauge tee fitting, if one is not already there, to ensure a closed train
5. Open and close valve quickly (a few seconds)
6. Read vacuum on the gauge
7. Record gauge reading on “Initial Vacuum” column of Chain of Custody

8. Verify the canister valve is closed and remove gauge
9. Replace the brass cap

Sample Collection

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove brass cap from canister
3. Attach flow controller to canister
4. Place the brass cap at the end of the flow controller creating an airtight train, and quickly open and close the canister valve in order to check for leaks. If the needle on the gauge drops, your train is not airtight. In this case, try refitting your connections and/or tightening them until the needle holds steady.
5. Once the sample train is airtight, remove the brass cap from the flow controller and open the canister valve, one-half turn.
6. Monitor integrated sampling progress periodically
7. Verify and record final vacuum of canister (simply read built-in gauge)
8. Close valve by hand tightening knob clockwise
9. Replace brass cap
10. Fill out canister sample tag (make sure the sample identification (ID) and date of collection recorded on the sample tag matches what is recorded on the COC exactly).
11. Return canisters in boxes provided
12. Return sample media in packaging provided
13. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody)
14. Place Chain of Custody in box and retain copy
15. Tape box shut and affix custody seal at each opening (if applicable)
16. Ship accordingly to meet method holding times

The final vacuum of a 6 L canister should be between five and ten inches Hg and the final vacuum should be noted on the Chain of Custody. This will enable the laboratory to compare the final vacuum with the receipt vacuum (i.e., the vacuum measured upon arrival at the laboratory).

Important Information for Canister Sampling

- *Do not* use a canister to collect explosive substances, radiological or biological agents, corrosives, extremely toxic substances, or other hazardous materials. Please check applicable regulations and guidance for shipping limitations.
- *Always* use a filter when sampling.
- *Never* allow liquids (including water) or corrosive vapors to enter canister.
- *Do not* attach labels to the surface of the canister or write on the canister.
- *Do not* over-tighten the valve and remember to replace the brass cap.

6.0 REFERENCES

Hayes, H. 2007. Canister and Bag Sampling Guide. *Air Toxics Ltd. Publication, Revision 5,* March 2007, http://www.airtoxics.com/literature/AirToxicsLtdSamplingGuide.pdf.

United States Environmental Protection Agency. 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. Compendium Method TO-15 Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information, Office of Research and Development, United States Environmental Protection Agency. Document No. EPA/625/R-96/010b.

ATTACHMENT 1

INDOOR AIR SAMPLING EVENT INSTRUCTIONS

and

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM

Instructions for Occupants

INDOOR AIR SAMPLING EVENTS

______________________________ will be collecting one or more indoor air samples from your building in the near future. In order to collect an indoor air sample in your structure that is both representative of indoor conditions and avoids the common sources of background air contamination associated with household activities and consumer products, your assistance is requested.

Please follow the instructions below starting at least 48 hours prior to and during the indoor air sampling event:

- Operate your furnace and whole house air conditioner as appropriate for the current weather conditions.
- Do not use wood stoves, fireplaces, or auxiliary heating equipment.
- Avoid using window air conditioners, fans, or vents.
- Do not smoke in the building.
- Do not use air fresheners or odor eliminators.
- Do not use paints or varnishes (up to a week in advance, if possible).
- Do not use cleaning products (e.g., bathroom cleaners, furniture polish, appliance cleaners, all-purpose cleaners, floor cleaners).
- Do not use cosmetics, including hair spray, nail polish remover, perfume, etc.
- Avoid bringing freshly dry-cleaned clothes into the building.
- Do not partake in hobbies indoors that use solvents.
- Do not apply pesticides.
- Do not store containers of gasoline, oil, or petroleum based or other solvents within the building or attached garages (except for fuel oil tanks).
- Do not operate or store automobiles in an attached garage.
- Do not operate gasoline powered equipment within the building, attached garage, or around the immediate perimeter of the building.

You will be asked a series of questions about the structure, consumer products you store in your building, and household activities typically occurring in the building. These questions are designed to help us differentiate chemical vapors from your household products from those related to subsurface contamination. Additionally, the analyte list may include only a select few target analytes and not a "wide variety of chemicals." Various compounds found in common household products (such as paint, new carpeting, nail polish remover), might be found in your sample results.

Your cooperation is greatly appreciated. If you have any questions about these instructions, please feel free to contact: ______________________________

____

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM

Date: ________________ Survey Performed by: ____

1. OCCUPANT:

Rent: _____ Own: _____

Resident Name: ____

Address: ____

Telephone: Home: ______________________ Work: ________________________

How long have you lived at this location? _________________________

List current occupants/occupation below (attach additional pages if necessary):

Age (If under 18)	Sex (M/F)	Occupation

2. OWNER OR LANDLORD: (If same as occupant, check here ___ and go to Item No. 3).

Last Name: ______________________________ First Name: _____________________

Address: ____

City and State: ____

County: __________________________________

Home Phone: ___________________________ Office Phone: ________________________

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

3. SENSITIVE POPULATION:

Daycare/Nursing Home/Hospital/School/Other (specify): ________________________

4. BUILDING CHARACTERISTICS:

Residential/Multi-family Residential/Office/Strip Mall/Commercial/Industrial/School

Describe Building: ___________________________________ Year Constructed: ______

Number of floors at or above grade: ______

Number of floors below grade: _______ (full basement/crawl space/slab on grade)

Depth of structure below grade: _______ ft. Basement size: ________ ft^2

If the property is residential, what type? (Circle all appropriate responses.)

Ranch	2-Family	3-Family	Raised Ranch
Split Level	Colonial	Cape Cod	Contemporary
Mobile Home	Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other: _________________________________	

If multiple units, how many? ________

If the property is commercial:

Business type(s) ____

Does it include residences (i.e., multi-use)? Yes No If yes, how many? _____

5. OCCUPANCY:

Is basement/lowest level occupied? (Circle one)

Full-time Occasionally Seldom Almost Never

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

Level General Use
(e.g., family room, bedroom, laundry, workshop, storage)

Basement ____

1st Floor ____

2nd Floor ____

3rd Floor ____

4th Floor ____

(Use additional page(s) as necessary)

6. CONSTRUCTION CHARACTERISTICS: (Circle all that apply.)

a. Above Grade Construction: (Describe type: wood frame, concrete, stone, brick).

____

b. Basement Type: Full Crawlspace Slab Other: __________

c. Basement Floor: Concrete Dirt Stone Other: __________

d. Finished Basement Floor: Uncovered Covered

If covered, what with? __________________________________

e. Foundation Walls: Poured Block Stone Other: __________

f. Foundation Walls: Unsealed Sealed Sealed with: ______________

g. The Basement is: Wet Damp Dry

h. The Basement is: Finished Unfinished Partially Finished

i. Sump Present (Y / N) If yes, how many? __________________

Where Discharged? ______________________________

Water in Sump? Yes No Not Applicable

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

Identify all potential soil vapor entry points and estimated size (e.g., cracks, utility parts, drains).

____

____

____

____

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? Yes No

Type of ground cover outside of building: Grass Concrete Asphalt Other _________

Is an existing subsurface depressurization (radon) system in place? Yes No

If yes, is it active, or passive?

Is a sub-slab vapor/moisture barrier in place? Yes No

Type of barrier: ____

7. HEATING, VENTING, and AIR CONDITIONING

Type of heating system(s) used in this building: (Circle all that apply: Note the primary).

Hot Air Circulation	Heat Pump	Hot Water Baseboard
Space Heaters	Steam Radiation	Radiant Floor
Electric Baseboard	Wood Stove	Outdoor Wood Boiler

Other: ____

The primary type of fuel used is:

Natural Gas	Fuel Oil	Kerosene
Electric	Propane	Solar
Wood	Coal	

Domestic hot water tank fueled by: ____

Location of Boiler/Furnace: Basement Outdoors Main Floor Other _______________

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

Air Conditioning: Central Air Window Units Open Windows None

Are air distribution ducts present? Yes No

Is there a whole house fan? Yes No

Describe the air intake system (outside air supply, cold air return, ductwork, etc.) and its condition where visible. Indicate the locations on the floor plan diagram.

____

____

____

____

____

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

a) Is there an attached garage? Yes No

If yes, does it have a separate heating unit? Yes No

b) Are any petroleum-powered machines or vehicles stored in an attached garage (e.g., lawn mower, ATV, car) Yes No

c) Has the building ever had a fire? Yes No

d) Is there a fuel burning or unvented gas space heater? Yes No

e) Is there a workshop or hobby/craft area? Yes No

If yes, where and what type? ________________________________

f) Is there smoking in the building? Yes No

If yes, how frequently? ________________________________

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

g) Have cleaning products been used recently? Yes No

If yes, when and what type? ____________________

h) Have cosmetic products been used recently? Yes No

If yes, when and what type? ____________________

i) Has there been painting or staining in the last six months? Yes No

If yes, when and where? ____________________

j) Is there new carpet, drapes, or other textiles? Yes No

If yes, when and where? ____________________

k) Have air fresheners been used recently? Yes No

If yes, when and what type? ____________________

l) Is there a kitchen exhaust fan? Yes No

If yes, where is it vented? ____________________

m) Is there a clothes dryer? Yes No

If yes, is it vented outside? Yes No

n) Has there been a pesticide application? Yes No

If yes, when and what type? ____________________

____

o) Are there odors in the building? Yes No

If yes, please describe: ____________________

____

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

p) Do any of the building occupants use solvents at work (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetology)?

Yes No

If yes, what types of solvents are used? ____

____

If yes, are their clothes washed at work? Yes No

q) Do any of the building occupants regularly use or work at a dry-cleaning service? (Circle appropriate response.)

No Unknown

Yes, use dry-cleaning regularly (weekly)

Yes, use dry-cleaning infrequently (monthly or less)

Yes, work at a dry-cleaning service

r) Is there a radon mitigation system for the building/structure? Yes No

If yes, what is date of installation? _________________ Active Passive

s) Additional mitigation system information (fan size, location, operating status, liner installed, etc.):

____

____

____

____

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

9. SAMPLE COLLECTION

This is to be completed by the sample collection team. On a separate sheet(s), provide a sketch of the building (including each floor as applicable), all (nonremovable) potential indoor sources found in the building (including attached garages), the location of the source (floor and room), and each sample location (see below). Any ventilation implemented after removal of potential sources shall be completed at least 24 hours prior to the commencement of the indoor air sampling event.

Photographs should be taken at each sample location, and of any nonremovable source, to supplement the documentation recorded below. The photographs must be of good quality and any labels must be legible.

Location	Sample ID	Sample Container Size	Sample Duration	Flow Rate Verification (Y / N)	Comments

Sampling Information:

Sample Technician: _______________________________ Telephone No.:_________________

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

Laboratory: ____

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

Were "Instructions for Occupants" followed? Yes No

If not, describe modifications:

____

____

____

____

Was field screening performed? Yes No

If yes, describe Make and Model of field instrument used:

____

Meteorological Conditions

Was there significant precipitation within 12 hours prior to (or during) the sampling event? Yes No

Describe the general weather conditions:

____

____

____

____

General Observations:

Provide any information that may be pertinent to the sampling event and may assist in the data interpretation process:

____

____

____

BUILDING: ________________________

FLOOR: __________________________

ATTACH ADDITIONAL DETAIL AS NECESSARY

Remediation and Redevelopment Division

Standard Operating Procedure

DYNAMIC FLUX CHAMBER METHOD FOR MONITORING SOIL SURFACE EMISSION RATES

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

Robert Wagner, Chief
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

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Superfund Section
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. Differences may exist between the procedures referenced in this SOP and what is appropriate under site-specific conditions. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

1.0 INTRODUCTION

This SOP outlines the MDEQ's method and considerations for Dynamic Flux Chamber sampling and is based on the methodology outlined by Radian, 1986, with consideration of issues identified by Eklund, 1992 and Hartman, 2003. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Volatile organic compounds (VOCs) in contaminated soil have the potential to migrate into ambient or indoor air where they may be inhaled by people or animals. The rate at which a vapor-phase chemical crosses the soil-air interface is called the contaminant "flux" rate, which is measured as mass per unit area per unit time (e.g., micrograms of contaminant per square meter of soil surface per minute). Contaminant flux rates can be estimated based on general assumptions about chemical characteristics, partitioning, soil conditions, diffusion rates, and attenuation, among other things (Radian, 1986). However, flux estimates based on mathematical models may not be sufficiently accurate for assessing risks in some circumstances. In such cases, the isolation flux chamber method can be used to directly measure the contaminant's concentration at the soil-air interface as well as the rate at which the compound moves from soil to air.

The isolation flux chamber approach uses an enclosure device, referred to as a flux chamber, to sample gaseous emissions from a defined surface area. The chambers may be used with a flow of sweep gas through the chamber (a "dynamic" test) or without a flow of sweep gas (a "static" test). With the dynamic-chamber method, a clean, dry sweep gas (e.g., high-purity "zero" air) is introduced to the chamber at a fixed, controlled rate (e.g., 0.005 cubic meters per minute (m^3/min)) that is selected based on site conditions. The volumetric flow rate of sweep air through the chamber is recorded, and the concentrations of the VOCs of interest are measured at the exit port of the chamber (Eklund, 1992). As the flux chamber isolates the soil surface from external site conditions, the potential impacts of many meteorological conditions that may be highly variable throughout the day are minimized.

The emission rate of each contaminant can be calculated as:

$$EF_1 = C_1 * Q / A \qquad (1)$$

where:

- EF_1 = emission rate of contaminant 1 (micrograms per square meter per minute (ug/m^2–min))
- C_1 = measured concentration of contaminant 1 (units must be micrograms per cubic meter (ug/$m^{3]}$))
- Q = sweep airflow rate (m^3/min)
- A = surface area (m^2) enclosed by flux chamber

In this method, all parameters in Equation 1 are measured directly through the collection of air samples exiting the chamber. The use of this equation assumes that: (1) the chamber is operating under steady state (i.e., the rate of air flow through the chamber is constant and not a function of time); (2) contaminant flux is uniform over the entire covered surface and relatively constant during the sampling interval of ($t_2 – t_1$); (3) the incoming air stream and the emissions from the soil are well mixed inside the chamber; and (4) the diffusive process is dominant and the advective mass flow from the soil is negligible (Gao et al., 1997).

2.0 GENERAL CONSIDERATIONS FOR FLUX CHAMBER SAMPLING

As with any environmental sampling effort, the overall goal of flux chamber sampling is to obtain representative samples. Care should be taken to avoid cross-contamination or other poor field practices that could bias the analytical data either high or low. Each sampling event must be guided by a sampling and analytical plan prepared in advance and all field conditions and methodology must be documented. The sampling and analytical plan must contain a discussion of the following:

- Equipment – The typical flux chamber is a hemispherical "bowl" or cylinder fitted with a number of small-diameter ports for controlling the flow of gas into and out of the chamber and for measuring the temperature, pressure, or other conditions inside the chamber. See Figure 1. Flux chambers should be constructed from stainless steel or polycarbonate; flexible plastic materials are unacceptable. Various sample trains can be attached to an outlet port to collect samples for analysis in the field or at a fixed laboratory. See Section 3.0 for more information on the construction of a flux chamber.

Figure 1 *Flux chamber before deployment.*

- Sealing the Chamber – When measuring the flux from the soil surface, the edge of the chamber should be pushed approximately two centimeters (cm) into the soil to minimize the entry of ambient air around the edge of the chamber. In compacted soil or similar locations where a reasonably tight seal may be difficult to achieve in this way, hydrated bentonite should be placed around the edge of the chamber to improve the seal and prevent leakage.
- Background Concentrations – To the extent practicable, avoid collecting samples near potential sources of VOCs in ambient air that could enter the flux chamber and affect the results (e.g., motor vehicle exhaust, gasoline and other fuels, aerosol sprays, marking pens, adhesive tape, insect repellent, sunscreen, etc.). Note the presence of such factors in the field documentation.
- Time of Deployment – It is necessary to make a series of flux measurements in several locations to assess the spatial variability in emissions for a given source. It is also important that repeated measurements at a given location are performed to assess the temporal variability (Eklund, 1992). The collection of this data allows an estimation of an emission rate with a known confidence limit.
- Sweep Air – The sweep air carrier gas should be dry, organic-free air, equal to or better than commercial ultrahigh-purity grade (less than 0.01 parts per million by volume total hydrocarbons).

- Sweep Airflow Rate – This is perhaps the single most important operating factor. The sweep airflow rate can be varied to achieve the desired analytical sensitivity. The slower the flow rate, the lower the detection limits, but the longer it will take to reach steady-state concentrations within the chamber. However, the sweep airflow rate must be high enough to ensure that good mixing occurs within the chamber and to create sufficient turbulence to disrupt any laminar film boundary that may form above the soil surface. The sweep air flow should be set based on the results of previous testing; however, it is generally recommended that the sweep airflow rate be established based on a ratio of 25 liters of air per minute per square meter ($L/min/m^2$) of exposed surface area (St. Croix Sensory, Inc., 2010). The sweep gas must be allowed to exit at the same rate at which it is added to prevent a buildup of pressure or the formation of a vacuum inside the chamber, which would alter the flux rate and bias the data.
- Chamber Purging – The residence time (T) is defined as the chamber volume divided by the sweep air flow rate. It typically takes three to four residence times before steady-state concentrations are reached inside the chamber and sampling can be initiated. For example, a 0.030 m^3 chamber with a sweep air flow rate of 0.005 m^3/min has a residence time of six minutes, which means that sample collection can be started 24 minutes after the chamber is placed on the surface.
- Sampling Time – The minimum sampling time necessary is that time required to approach a steady-state concentration within the flux chamber (at least three to four residence times). The maximum acceptable sampling time will depend on the nature of the emission source and the objectives of the monitoring program. In general, whenever possible the sampling duration for soil should be held to 30 to 60 minutes.
- Sampling Rate – The sampling rate (i.e., the rate at which the gas sample is withdrawn from the discharge line) should be less than the flow rate of sweep gas. Otherwise, the outside air would be drawn into the chamber to dilute the sampling gas, which may result in inaccuracy of calculated emissions. Therefore, the sampling rate must be equal to or less than 0.75 times the flow rate of sweep gas.
- Environmental Conditions – Emission rates from soil immediately after a significant rainfall event typically will be lower than from drier soils, as a greater portion of the soil pore space is blocked by water. It is not acceptable for flux chamber sampling to occur for several days after a minor rain event and for up to seven days after 0.3 inches of rain or more has fallen (Radian, 1986). Barometric pressure has also been documented to have an effect on emission rate - higher emission rates are found during periods of lower atmospheric pressure. An effort should be made to avoid flux chamber sampling during periods of unusually high or low barometric pressure. Historical barometric pressure measurements should be reviewed to establish a normal range for the area and weather forecasts should be consulted during the project planning stage.
- Chamber Pressure and Temperature – The pressure and temperature inside the flux chamber should be kept as close to ambient conditions as possible. The temperature inside and outside of the flux chamber must be recorded several times during the sampling event and each time a sample is drawn from the chamber.
- Analytical Techniques – Assessing VOC emissions from soil using flux chambers is done by the USEPA TO-15 Method (USEPA, 1999) via Summa canister or Bottle-Vac®. This method provides the typical reporting limit of 0.1 to 0.001 micrograms per liter.
- Sample Collection Intervals – In addition to the initial (t_0) sample, at least three flux chamber samples should be collected at the same grid coordinates throughout the day to evaluate the daily variation of flux. If a 95 percent upper confidence limit is to be used in future calculations for determining an emission rate, then an appropriate number of samples (e.g., a minimum of nine samples) must be collected from each location.

FLUX CHAMBER CONSTRUCTION AND DESIGN

Flux chamber data can be significantly affected by chamber design and the rules-of-thumb applicable to one design may or may not be applicable to an alternate design (Eklund, 1992). As a result, widely different design and operating practices can produce significantly different results.

This section is included as a general guide to the construction of flux chambers, additional information can be found in Eklund, 1992. Important design factors include chamber size, volume, geometry, construction materials, length of sampling lines, line construction, and air delivery system, some of which are described further below.

Figure 2 represents a generic construction diagram and its supporting equipment as depicted by Radian, 1986.

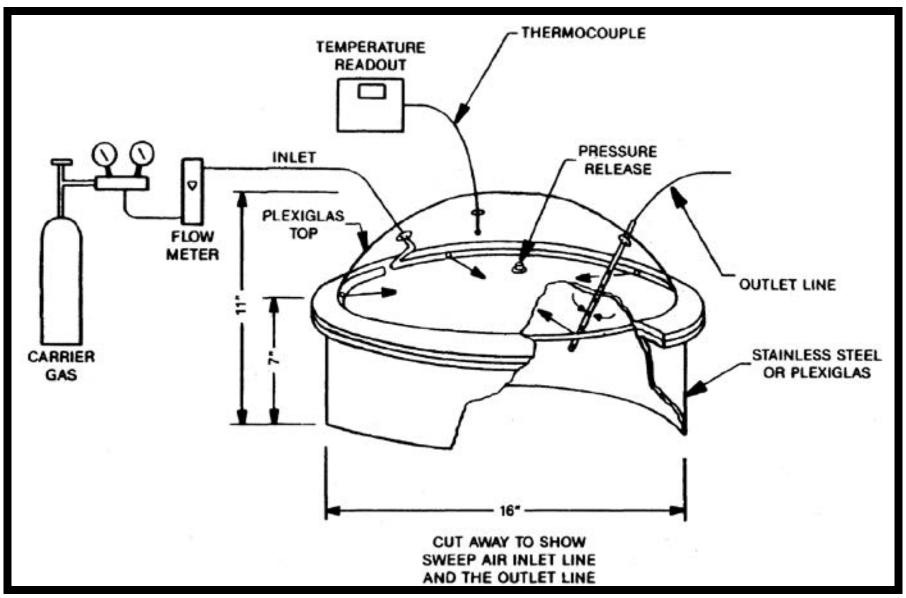

Figure 2 *Flux chamber construction diagram*

3.1. Chamber Size and Volume

In general, flux chamber sampling results are not heavily dependent on the chamber size and volume. The chamber size used is a trade-off among several considerations. The surface area enclosed should be as large as is feasible so that the observed emission flux is not unduly biased by relatively small areas of unrepresentative emissions, the areas perturbed by the chamber edge or seal are a small percentage of the total sampling area, and the wall effects are minimal (Eklund, 1992).

A smaller chamber volume may be advantageous since it minimizes the amount of sweep air used per measurement, is lightweight and easier to transport, and is simpler to fabricate. The volume should be large enough, however, that the volume of gas withdrawn for analysis is a small fraction of the volume in the flux chamber (i.e., the collection of samples from the discharge line does not significantly perturb the chamber atmosphere or pressure). As a general rule of thumb, flux chambers should not be smaller than 0.0074 m^3.

3.2 Materials of Construction

Typically, the flux chamber is constructed with a cylindrical skirt of stainless steel that has the necessary rigidity to be pushed into the soil with a dome made of polycarbonate, acrylic, or stainless steel. Suggested materials are nylon, Teflon®, polyethylene, copper, glass, or stainless steel. The sampling lines used for gas sample collections are typically Teflon® with stainless steel fittings. Based on this construction (and assuming the chamber is cleaned between sampling events), the carry-over of the VOCs from the chamber has never proven to be a problem under field conditions. In addition, sorption of the VOCs has typically not been found to be a problem, although adsorption onto long Teflon® lines (e.g., greater than three meters) is a potential concern, as is adsorption of polar VOCs such as methanol and acetone onto chamber surfaces (Eklund, 1992).

3.3 Air Delivery System

The introduction of sweep air into the flux chamber is perhaps the most important design factor. The air delivery system consists of a cylinder of compressed air fitted with a pressure regulator, small-diameter tubing, a flow meter, and small-diameter tubing inside the chamber to encourage mixing and minimize “short circuiting” between the inlet and outlet ports. Based on a typical sweep airflow rate of 0.005 m^3/min, a standard 149 $foot^3$ tank of gas should be sufficient for one flux chamber over two days of non-continuous sampling.

The USEPA’s approach to the air delivery system (shown on Figure 2) is to place 0.6-cm diameter tubing around the inside of the chamber near the intersection of the cylinder and the dome. The line must contain at least four perforations spaced uniformly around the base of the entire chamber that are parallel to the soil surface to eliminate components of airflow perpendicular to the soil surface (either downward or upward) (Gao et al., 1997).

4.0 SAMPLING METHODOLOGY

4.1 Office Preparation

Prior to departure for the field site, the following supplies should be assembled:

- Log book
- Appropriate field forms such as Soil Surface Flux Log Sheets (Attachment A) and Chain of Custody forms
- Flux chambers
- Sample containers with pressure regulators
- Cylinder of compressed zero-air or nitrogen
- Flow meters
- Ground probe or rod (minimum of three feet in length)
- Clean tubing and fittings
- Ground tarp or plastic
- Weather station for measuring ambient temperature, barometric pressure, and relative humidity
- Temperature probes
- Handheld VOC detector
- Laptop computer with charged internal battery and a sufficient number of charged external batteries to last over the sampling period

In addition, it is important to confirm that the volume of the flux chamber is several times greater than the volume of the container (e.g., Summa canister or "Bottle-Vac®") used to collect the sample. Flux chamber volumes of ten liters or greater are typical. Flux chambers must be cleaned using Alconox (or equivalent) and/or heated and then wrapped in aluminum foil for transport.

4.2 Field Procedures

1. Sample locations must be cleared of all vegetation, gravel, or manmade surfaces (concrete, asphalt) to a depth where the upper soil horizon is visible. Where pavement or asphalt must be cut to access the soil surface, the hole will be sized to allow at least 6 to 12 inches of open area around the chamber. Locations where soil pores are likely to be plugged (e.g., by standing water or extreme compaction) will be recorded in the field notes and avoided.
2. At each location identified in the sampling plan, a probe will be pushed into the ground to a depth of at least two feet to check for the presence of buried foundations or pavement that could limit vapor migration and emissions.
3. Unwrap and inspect the flux chamber. Any residue should be removed using high pressure steam, then rinsed, and dried before use. Wipe the flux chamber clean using a clean cloth.
4. Position the flux chamber on the substrate at the sample location. The rim of the flux chamber should be worked into the surface a minimum of one inch to minimize ambient air intrusion. If a seal between the soil and the chamber cannot be established, hydrated bentonite should be placed around the edge of the chamber.
5. Attach all sampling lines and meters to the flux chamber (and to the sample canister) using a clean, 1/8 or 1/4 inch Teflon® or stainless steel tubing with Swagelok® (or equivalent) valve fittings.
6. Prepare all necessary equipment and supplies. Sample containers, equipment, and supplies should not be placed directly on the ground, on top of waste containers (e.g., drums), or on other potentially contaminated surfaces. Disposable tarps or construction plastic can be spread on the ground downwind from the chamber to provide a clean surface for temporary placement of the sampling equipment.
7. Seal all probes and access points, and/or close off all tubing so that the flux chamber is isolated from the ambient air, with the exception of the exhaust/sampling port, which should remain open. Note that care should be taken to avoid a positive pressure from developing within the chamber.
8. Connect the flux chamber to the sweep air through the inlet port.
9. Record the air temperature inside the flux chamber, the air temperature outside the flux chamber, and the barometric pressure.
10. Open the chamber inlet valve and begin airflow into the chamber at a predetermined rate.
11. For each chamber volume (residence time) record the flow rate, internal temperature, and reading collected with the handheld VOC detector.
12. Monitor emissions and note when steady-state concentrations are reached (approximately 3 to 5 residence times).
13. Record the air temperature inside the flux chamber, the air temperature outside the flux chamber, and the barometric pressure and begin sample collection.

4.3 Sample Collection

1. At the designated sampling time, attach the sampling device to the tubing connected to the exhaust/sampling port.
2. Record the starting canister vacuum and air temperature inside and outside of the flux chamber. The initial pressure of the canister should be between -30 and -27 inches of mercury. However, the canister will be considered acceptable (useable) if the pressure reading is between -30 and -24 inches of mercury.

3. Enter the sample number on the field sample data logging form as provided in Figure 3.
4. Record the start time on the data sheet and open canister inlet valve slowly (in some cases, the canister will begin filling at a predetermined rate as soon as it is connected to the flux chamber). The canister grab samples typically will be collected over a 1 to 3 minute period. A slight hissing sound can be heard during sampling by placing an ear against the canister. Sample containers will remain connected to the flux chamber until the pressure gauge reads zero.
5. After the sample container is filled, close the canister inlet valve and disconnect the sample line from the canister. Some quick-connect fittings will close automatically when they are disconnected from the flux chamber.
6. Record the final pressure reading shown on the gauge attached to the canister (it should be zero). Enter this information along with the stop time on the field sample record and on the sample Chain of Custody form.
7. Enter the sample number, the serial number of the sampling device (canister or sorbent cartridge), and other requisite information on the Chain of Custody form. Label the sampling device with the sample number, date, and time.
8. Ensure that all canister valves are tight and stem nuts are sealed with Swagelok® (or equivalent) plugs before transporting sample containers to the laboratory.

4.4 Quality Assurance/Quality Control Samples

4.4.1 Equipment Blanks

One equipment blank is taken at the beginning of the day and at the conclusion of sampling for each flux chamber. This is done by placing the flux chamber on a contaminant-free stainless steel surface and sealing it around the edge with bentonite or a product like plumber's putty that is determined to be free of potential VOCs. After the chamber is affixed to the stainless steel surface, the chamber is purged with zero-air or nitrogen and a blank sample is collected.

4.4.2 Co-located Samples

Co-located samples should be collected at the frequency indicated by the sampling plan, which for Summa canisters, is typically ten percent.

5.0 FORMS

Sample possession during all testing efforts must be traceable from the time of collection until the results are verified and reported. Sample custody procedures provide a mechanism for documentation of all information related to sample collection and handling to achieve this objective.

5.1 Documentation Procedures

5.1.1 Field Records

In addition to the Field Sample Data Logging Form shown in Figure 3, all field personnel will be required to keep accurate written records of their daily activities in a bound log book. All entries will be legible, written in waterproof ink, and contain accurate and inclusive documentation of an individual's field activities, including field data and observations, any problems encountered, and actions taken to solve the problem. The type of data recorded in the field log book includes field measurements, ambient conditions, and any other information pertinent to the sample collection. Entry errors or changes will be crossed out with a single line, dated, and initialed by the person making the correction. Entries made by individuals other than the person to whom the log book was assigned will be dated and signed by the individual making the entry.

FLUX CHAMBER EMISSIONS MEASUREMENT DATA

Date____________________ Sampler(s)____________________

Location ____________________ Zone/Grid Point ____________________

Surface Description ____

Concurrent Activity ____

Time	Sweep Air Rate, Q (L/Min)	Residence No. (Q/V)	Gas Conc. (ppmv)	Air Temperature Chamber (C)	Ambient (C)	Sample Type/No.	Comments:	
		0						
		1						
		2						
		3						
		4						
		5						

Comments:____

____

____

7-86-24843

Figure 3. Field Sample Data Logging Form

5.1.2 Sample Labels

Each sample will receive a sample label that identifies the sample by a unique sample identification number. These labels are affixed to the sample container prior to the sample collection.

5.1.3 Sample Log Book

A sample master log will be maintained for all samples collected. Each sample will be assigned a unique identification number, a full description of the sample, its origin, and disposition will be included in the log entry.

5.1.4 Chain of Custody Procedures

Team members collecting the samples are responsible for the care and custody of the samples until they are transferred or dispatched to the appropriate laboratory. When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the record.

This record documents sample possession from the time of collection to the time the sample is dropped off at the laboratory. When the samples are received by the laboratory, the sample control officer will verify the Chain of Custody form against the samples received. If any discrepancies are observed, they will be recorded on the Chain of Custody Form and the project manager will be notified.

5.2 Shipment

All sample shipments will be accompanied by the Chain of Custody form, which identifies the contents of each crate. The person relinquishing the samples to the laboratory will request the signature of a laboratory representative to acknowledge receipt of the samples. Sample collection and shipment will be coordinated to ensure that the receiving laboratory has staff available to process the samples according to the method specifications.

All shipping containers will be secured for safe transportation to the laboratory. The method of shipment, courier name(s), and other pertinent information is entered in the “Remarks” section when the samples are to be shipped (i.e., FedEx, Express Mail, etc.) instead of hand delivered.

5.2.1 Sample Handling Procedures

The objective of the sample handling procedures is to ensure that samples arrive at the laboratory intact, at the proper temperature, and free of external contamination. Sample packaging requirements for hazardous materials requiring interstate transport are defined in Title 40 of the Code of Federal Regulations (CFR), Chapter 1, Part 171. These requirements outline in detail the proper classification and transportation procedures for hazardous materials that will be used in the transporting of samples.

5.2.2 Sample Preservation

Sample preservation, storage requirements, and holding time limitations are specified in the standard analytical methods. In general, soil gas samples should be placed in a container without ice and stored at room temperature in an area away from direct sunlight.

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Remediation and Redevelopment Division

Standard Operating Procedure

VAPOR POINT NAMING CONVENTION

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

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Remediation and Redevelopment Division
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The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

Vapor Point Naming Convention

1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for the naming convention for the sampling points that are installed as a vapor intrusion investigation. The naming convention is utilized to provide vital information for future sampling as most vapor points are not constructed in a manner to confirm the depth of installation. In all instances, the ultimate procedures employed must be documented. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

This SOP does not cover, nor is it intended to provide, a justification or rationale for when this sampling is conducted. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work.

2.0 NAMING CONVENTION

A vapor point must be named using a minimal of three unique number/letter designations to provide clarification and vital information for field sampling and inspection personal. Each boring has a unique number regardless of the horizontal distance between sampling points. Multiple points installed within the same boring will carry an identical numerical identification (see C below). Each of the designations are detailed below.

Format:

A	B	C	D

A (optional) – Two digit number representing the year the vapor point was installed may be utilized.
B – The code VP must be utilized to represent that the point is installed as a vapor point.
C – The sequential number of the point that has been installed. No numbers must be skipped or repeated even if a point is intended to replace a point that had been previously installed in the same area.
D – Depth of the installed sampling point. Sub-slab or foundation samples may be designated with the optional use of an SS.

Please Note: Items B, C, and D must be included in the name of each vapor point.

Examples of naming designations:

(1) 11VP7SS
Description: Vapor Point installed in 2011, the 7th Vapor Point installed in the series, and the point is installed within one foot of the floor

(2) VP2 -16
Description: Vapor Point installed as the 2nd in the series, installed 16 feet below the ground surface

(3) 09VP11-10
Description: Vapor Point installed in 2009, the 11th in the series, installed 10 feet below the ground surface

Remediation and Redevelopment Division

Standard Operating Procedure

INSTALLATION OF A VAPOR PIN™
TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

Robert Wagner, Chief
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

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Superfund Section
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

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1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for installing a sub-slab soil gas probe/vapor monitoring point using a Vapor Pin™. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Sub-slab soil gas samples are vapor samples collected within two feet of the floor of the lowest point of the structure and must be referenced as sub-slab soil gas samples. Though these samples may provide beneficial information to support various lines of evidence, the effects due to barometric pressure, temperature, and the potential breakthrough of ambient air from the surface have the potential to cause these samples to be less reliable than soil gas samples collected at greater depths.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. For example, considerations must be given to the types of chemicals of concern, lithology encountered, surrounding buildings and underground structures, and the depth of the vapor source.

2.0 SAMPLING POINT INSTALLATION

2.1 Boring Advancement

Borings should be through the use of a rotary hammer drill. The specific drill utilized must be capable of utilizing the drill and coring bits identified by the SOP (see below) as well as sufficient size to penetrate the expected thickness of the concrete present.

2.2 Soil Gas Well Materials (General List of Materials)

This SOP utilizes products available from Cox-Colvin & Associates, Inc. The materials list is given below:

Equipment needed for installation	Equipment needed for abandonment:
• Vapor Pin™ • Silicone sleeve • Hammer drill • 5/8 inch diameter hammer bit (Hilti™ TEYX 5/8" x 22" #00206514 or equivalent) • 1½ inch diameter hammer bit (Hilti™ TEYX 1½" x 23" #00293032 or equivalent) for flush mount applications • 3/4 inch diameter bottle brush • Wet/dry vacuum with HEPA filter (optional) • Vapor Pin™ installation/extraction tool • Dead blow hammer • Vapor Pin™ flush mount cover, as necessary • Vapor Pin™ protective cap	• Vapor Pin™ installation/extraction tool • Dead blow hammer • Volatile organic compound-free hole patching material (hydraulic cement) and putty knife or trowel

2.3 Flush mount Vapor Pin™ Installation Protocol

Figure 1. Hammer Drill

1. Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.

2. Prior to fabrication of the sub-slab vapor probes, use the rotary drill and the 1-1/2 inch diameter drill bit to create an outer hole that partially penetrates the slab and is at least 1-3/4 inches in depth (Figure 1). This outer hole will allow the protective cap to be flush with the concrete surface.

3. Brush the hole with a bottle brush and use a small portable vacuum cleaner to remove cuttings from the outer hole.

Figure 2. Inner & Outer Holes

4. Use the rotary hammer drill and the 5/8 inch drill bit to create a smaller diameter “inner” hole through the remainder of the slab and at least 6 inches into the underlying soil to form a void. Figure 2 illustrates the appearance of the “inner” and “outer” holes. Drilling into the sub-slab material will create an open cavity which will prevent obstruction of probes during sampling by small pieces of gravel.

5. Brush the hole with a bottle brush and use a small portable vacuum cleaner to remove cuttings from the hole. Cuttings should be removed prior to advancing completely through the cement as much as possible. Once through the slab, care should be taken to minimize the amount of vacuum applied beneath the slab.

Figure 3. Vapor Pin™ assembly with silicone sleeve over the barbed end

6. Determine the thickness of the slab and record the measurement.

7. Assemble the Vapor Pin™ assembly (Figure 3) by threading the Vapor Pin™ into the extraction/installation tool and placing the silicone sleeve over the barbed end.

Figure 4. Place Vapor Pin™ in hole.

Figure 5. Tap Vapor Pin™ into place.

8. Place the lower end of the Vapor Pin™ assembly into the drilled hole (Figure 4).

9. Place the small hole located in the handle of the extraction/installation tool over the Vapor Pin™ to protect the barb fitting and cap, and tap the Vapor Pin™ into place using a dead blow hammer (Figure 5). Make sure the extraction/ installation tool is aligned parallel to the Vapor Pin™ to avoid damaging the barb fitting.

10. Unscrew the threaded coupling from the installation/extraction handle and use the hole in the end of the tool to assist with the installation. During installation, the silicone sleeve will form a slight bulge between the slab and the Vapor Pin™ shoulder. Installed Vapor Pin™ is shown in Figure 6.

11. Place the protective cap on the Vapor Pin™ (Figure 7).

12. Cover the Vapor Pin™ with a flush mount cover (Figure 8).

Figure 6. Installed Vapor Pin™.

Figure 7. Place Protective Cap.

Figure 8. Flush mount cover.

2.4 Temporary Vapor Pin™ Installation Protocol

Follow the protocol outlined in Section 2.3 Flush mount Vapor Pin™, above with the exception of Steps 2 and 3. These steps are omitted as it is not necessary to drill an outer hole for a temporary installation. An example of a temporary installation is shown in Figure 9.

Figure 9. Temporary Vapor Pin™ Installation.

2.5 Abandonment

All vapor monitoring wells, including those used for soil gas monitoring, must be abandoned upon completion of site activities.

Vapor wells constructed in the manner identified by this SOP may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout and returned as close as possible to the original site conditions. The Vapor Pin™ is designed to be used repeatedly; however, replacement parts and supplies will be required periodically. If the tubing cannot be removed, the tubing should be cemented in place. All surface protective covers must be removed and returned to as close as possible to the original site conditions.

Extraction procedure:

1. Remove the protective cap and thread the installation/ extraction tool onto the barrel of the Vapor Pin™ (Figure 10). Continue turning the tool to assist in extraction, then pull the Vapor Pin™ from the hole.

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

3. Prior to reuse, remove the silicone sleeve and discard.

4. Decontaminate the Vapor Pin™ in a hot water and Alconox® wash, then heat in an oven to a temperature of 130° Celsius.

Figure 10. Removing the Vapor Pin™

3.0 SOIL BORING LOGS AND VAPOR COMPLETION DIAGRAM

Boring logs and diagrams may be completed utilizing a variety of programs. The following information must be included for every sub-slab vapor point installed:

- Project information
- Boring location
- Date installed
- Total depth
- Thickness of concrete
- Project personnel including drilling contractor, driller, and geologist
- Boring diameter
- Soil description (if identified)
- Field screening performed
- A diagram representing installed sampling point that includes:
    - Surface completion
    - Seal used
    - Probe and screen construction materials and specifications
    - Depth of all installed materials including screen, bottom of screen, sand pack, and tubing

4.0 REFERENCES

Though not specifically referenced, the SOP is based upon the SOP by Cox-Colvin & Associates, Inc. with some modifications.