United States Environmental Protection Agency
Region 5
Superfund Division

Vapor Intrusion Guidebook

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Foreword

The purpose of this Vapor Intrusion (VI) Guidebook is to augment existing United States Environmental Protection Agency (U.S. EPA) guidance by summarizing lessons learned and best practices regarding the process for evaluating the VI pathway at sites in Region 5. This VI Guidebook is intended to (1) assist On-Scene Coordinators (OSC), Remedial Project Managers (RPM), Resource Conservation and Recovery Act (RCRA) Project Managers, and Site Assessment Managers (SAM) as they evaluate and manage VI issues under Superfund Removal, Remedial, and Site Assessment (SA) programs and (2) promote consistency among the approaches used at different VI sites in Region 5.

VI is the migration of volatile chemicals from the subsurface into overlying buildings. A VI exposure pathway is considered complete when people are exposed to vapors originating from site contamination. The VI exposure pathway includes four components: (1) a primary source (such as a spill area, contaminated groundwater, or a landfill), (2) a transport mechanism (such as groundwater flow), (3) vapors in soil (such as soil gas [SG] and sub-slab [SS] vapors), and (4) indoor air (IA) in a building where people are present.

As of the date of this VI Guidebook, U.S. EPA has issued a draft guidance to address the issue of VI entitled “OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils” (Draft Guidance) (U.S. EPA 2002). This VI Guidebook is intended to be consistent with the Draft Guidance and recommends use of the Draft Guidance’s three-tiered screening approach to determine if VI is occurring at a particular site. This approach emphasizes that each component of the pathway, from the source to IA, should be investigated to determine if the VI pathway is complete. This VI Guidebook also makes use of the expansion of this approach as described in the Interstate Technology and Regulatory Council’s (ITRC) “Vapor Intrusion Pathway: A Practical Guideline” (ITRC 2007). This VI Guidebook also uses information in the U.S. EPA Region 3 “Vapor Intrusion Framework” (U.S. EPA 2009) and U.S. EPA Headquarters’ draft answers to frequently asked questions (FAQ) dated August 2009. However, this VI Guidebook expands beyond these source documents by identifying lessons learned from U.S. EPA Region 5 VI sites, including decision-making techniques, sampling techniques, mitigation options, long-term monitoring techniques, and lessons learned at petroleum sites.

This VI Guidebook presents information on different types of VI sites, including sites with chlorinated volatile organic compounds (VOC) in the subsurface and spills of petroleum and petroleum-related chemicals. Petroleum compounds are unique because of their subsurface biodegradation potential and other physical and chemical characteristics. Biodegradation in the subsurface generally occurs if the oxygen level is sufficiently elevated.

Reviewers of this VI Guidebook included OSCs, RPMs, Superfund Division management personnel, U.S. EPA Headquarters personnel, U.S. EPA Environmental Response Team (ERT) personnel, the Ohio Department of Health (ODH), and the Agency for Toxic Substances and Disease Registry (ATSDR).

Key approaches used in this VI Guidebook and contacts for further information are discussed below.

Key Approaches Used in this VI Guidebook

- During the investigation of residential, commercial, or industrial properties for potential VI, it is generally preferred that SS, IA, and outdoor (ambient) air samples be collected at the same time to allow thorough interpretation of all chemical data and interrelationships.
- For residential properties, the Removal Program generally undertakes response actions when IA levels exceed a 1 in 10,000 (10^{-4}) lifetime cancer risk level and is found to be the result of groundwater or soil contamination. Because of temporal and seasonal variations, IA levels exceeding a 1 in 100,000 (10^{-5}) lifetime cancer risk level generally trigger actions to reduce IA levels under the Remedial Program.
- For commercial and industrial properties, removal or remedial actions may be undertaken if IA levels exceed a 1 in 10,000 (10^{-4}) lifetime cancer risk (or result in unacceptable non-cancer risks) and result from site groundwater or soil contamination.
- For U.S. EPA to take action, generally the concentrations of chemicals detected in the SS and IA must exceed site screening levels and be tied to the same chemicals detected in site SG and/or groundwater. Some contaminants may not be soluble in water and may be transported in a light non-aqueous phase liquid (LNAPL) above the groundwater table into off-site areas of concern.

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X Mitigation System Annual Inspection Form

LIST OF ACRONYMS AND ABBREVIATIONS

40 CFR	Title 40 of the *Code of Federal Regulations*
µg/L	Microgram per liter
$\mu g/m^3$	Microgram per cubic meter
AF	Attenuation factor
AOC	Administrative Order on Consent
ARAR	Applicable or relevant and appropriate requirement
ASD	Active soil depressurization
ASTM	ASTM International
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below ground surface
BTEX	Benzene, toluene, ethylbenzene, and xylene
CAG	Community Advisory Group
CalEPA	California EPA
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIC	Community Involvement Coordinator
COC	Chemical of concern
COR	Contracting Officer Representative
CSM	Conceptual site model
DCE	Dichloroethene
DQO	Data quality objective
Draft Guidance	"OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils"
EDD	Electronic data deliverable
EE/CA	Engineering evaluation/cost analyses
EMEG	Environmental Media Evaluation Guide
EP	Explosion-proof
ERRS	Emergency and Rapid Response Services
ERT	Environmental Response Team
FAQ	Frequently asked question
FID	Flame ionization detector
ft^2	Square foot
GC/MS	Gas chromatograph/mass spectrometer
HC	Health consultation
HDPE	High-density polyethylene
HEPA	High-efficiency particulate air

Hg	Mercury
HI	Hazard index
HQ	Hazard quotient
HVAC	Heating, ventilation, and air conditioning
IA	Indoor air
IC	Institutional control
ITRC	Interstate Technology and Regulatory Council
IUR	Inhalation unit risk
L	Liter
LEL	Lower explosive limit
LNAPL	Light non-aqueous phase liquid
MCL	Maximum contaminant level
MMOA	Mutagenic mode of action
MRL	Minimum risk level
NAPL	Nonaqueous-phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NPT	National Pipe Thread
O&M	Operation and maintenance
OD	Outside diameter
ODH	Ohio Department of Health
Ohio EPA	Ohio Environmental Protection Agency
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration
PCE	Tetrachloroethylene
PH	Petroleum hydrocarbon
PID	Photoionization detector
Poly	Polyethylene
ppb	Part per billion
ppbv	Part per billion by volume
ppmv	Part per million by volume
PRP	Potentially responsible party
PSV	Passive soil ventilation
PVC	Polyvinyl chloride
RAGS	“Risk Assessment Guide to Superfund”
RCRA	Resource Conservation and Recovery Act
RfD	Reference dose
REAC	Response Engineering and Analytical Contract
RPM	Remedial Project Manager

SA	Site assessment
SAM	Site Assessment Manager
SERAS	Scientific, Engineering, Response & Analytical Services Contract
SG	Soil gas
SOP	Standard operating procedure
SS	Sub-slab
SSDS	Sub-slab depressurization system
START	Superfund Technical Assessment and Response Team
SVE	Soil vapor extraction
TAGA	Trace Atmospheric Gas Analyzer
TCE	Trichloroethylene
UAO	Unilateral Administrative Order
U.S. EPA	United States Environmental Protection Agency
VI	Vapor intrusion
VOC	Volatile organic compound

Section 1. Introduction

The United States Environmental Protection Agency (U.S. EPA) Region 5 Vapor Intrusion (VI) Workgroup prepared this VI Guidebook in response to the growing number of VI sites in the region. The VI Workgroup recognized a need to establish common procedures for investigating and decision making at VI sites.

As of the date of this VI Guidebook, U.S. EPA has issued the following draft guidance to address the issue of VI: "OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils" (Draft Guidance) (U.S. EPA 2002). In addition, U.S. EPA Headquarters has drafted answers to frequently asked questions (FAQ) about VI. This VI Guidebook is intended to be consistent with and augment current U.S. EPA national guidance. Besides the Draft Guidance, several additional documents present a framework for choosing the appropriate approach based on site-specific conditions, including U.S. EPA's "Brownfields Technology Primer: Vapor Intrusion Considerations for Brownfields Redevelopment" (U.S. EPA 2008) and the Interstate Technical Regulatory Council's (ITRC) guidance document entitled "Vapor Intrusion Pathways: A Practical Guideline" (ITRC 2007). However, this VI Guidebook expands beyond these source documents by identifying lessons learned from U.S. EPA Region 5 VI sites, including decision-making techniques, sampling techniques, mitigation options, long-term monitoring techniques, and lessons learned at petroleum sites.

The VI Guidebook is divided into the sections summarized below.

- **Section 1** provides an introduction to the VI Guidebook.
- **Section 2** discusses VI key concepts and includes a discussion of chemicals of concern (COC) and potential VI migration pathways.
- **Section 3** discusses procedures identifying VI sites in Region 5, removal actions, and cross-program coordination, including an approach for determining how and when sites should be transferred among Region 5 programs. The section's focus is to ensure consistency between the Removal and Remedial Programs.
- **Section 4** discusses the site screening and sampling strategy, including the three-tier approach and sampling strategies.
- **Section 5** discusses community outreach before sampling and methods to obtain access agreements.
- **Section 6** discusses the sampling methodology and procedures, including equipment needed and procedures for SS, IA, and ambient air sampling.
- **Section 7** discusses the communication of sampling results to property owners and tenants.
- **Section 8** discusses decision making at VI sites, including types of actions used at sites and factors to consider when making mitigation choices. The section also presents a simplified decision matrix developed by the Region 5 VI Workgroup.
- **Section 9** discusses mitigation options, including sub-slab depressurization systems (SSDS).

- **Section 10** discusses post-mitigation issues, including proficiency sampling, the operation and maintenance (O&M) manual, and annual inspections.
- **Section 11** lists references used to prepare this VI Guidebook

Section 2. Vapor Intrusion Key Concepts

This section introduces VI key concepts by answering FAQs about VI.

2.1 What is VI?

VI is the migration of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals in buried wastes and contaminated groundwater can emit vapors that may migrate through subsurface soils and into indoor air (IA) spaces of overlying buildings in ways similar to that of radon gas seeping into homes as shown in Figure 1 below. As the figure shows, the VI pathway may be important for buildings both with and without basements (U.S. EPA 2002).

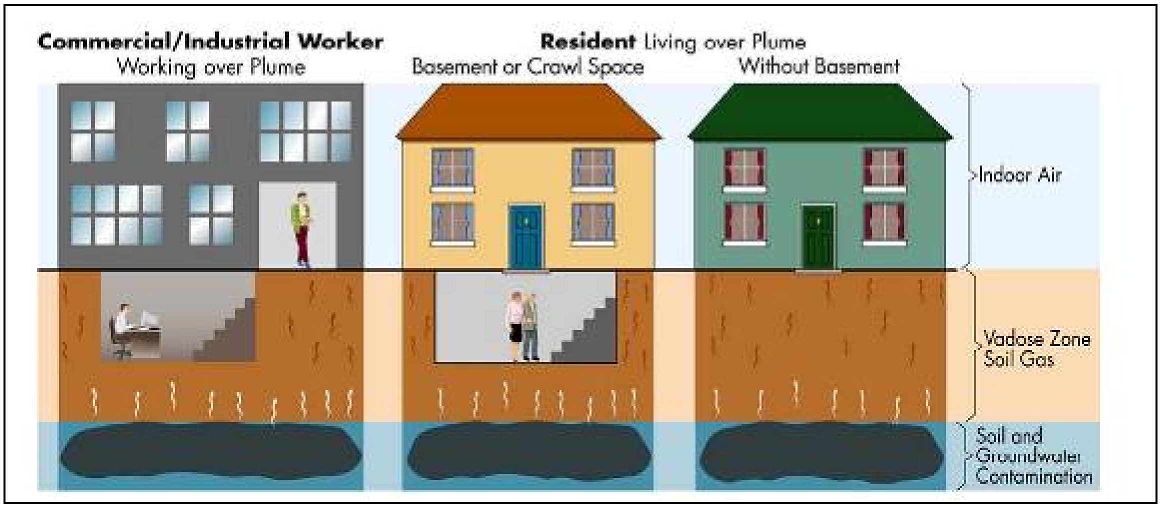


Figure 1 - VI Pathway (ITRC 2007)

As U.S. EPA On-Scene Coordinators (OSC), Remedial Project Managers (RPM), and Site Assessment Managers (SAM) review sites that may be impacted by VI, the conditions summarized below are indicators (or “red flags”) that VI **may be** occurring.

- Groundwater contaminated with chlorinated volatile organic compounds (VOC) or petroleum hydrocarbons is present within 100 feet vertically or horizontally of occupied structures. Common chlorinated VOCs are trichloroethylene (TCE) and tetrachloroethylene (PCE). Common petroleum hydrocarbons are benzene, toluene, ethylbenzene and xylene (BTEX) compounds, light-end petroleum fractions, and biodegradation by-products such as methane.
- Shallow soil gas (SG) samples contain the same chlorinated VOCs or petroleum hydrocarbons observed in the contaminated groundwater plume.
- Permeable soils are present in the vadose zone. The vadose zone is defined as the soil area between the structure and groundwater.
- Older structures above shallow groundwater contamination that, over time, have developed cracks in concrete basement flooring or walls.
- Structures above shallow groundwater contamination that have basements with dirt floors or crawl spaces.

- Older structures above groundwater contamination that may not have a vapor barrier or a “P”-trap in floor drains and sewer laterals.

2.2 Why is VI a Concern?

VI poses potential health risk to residents, workers, and other building occupants who breathe contaminated IA. It has become clear with time and experience that building occupants inhaling chemical vapors resulting from VI is a potential exposure pathway causing unacceptable risk at some Superfund sites.

2.3 Where is VI a Potential Concern?

VI is a potential concern at any building, existing or planned, located near soil or groundwater contaminated with toxic chemicals that can volatilize (ITRC 2007). Relatively low chemical concentrations in soil or groundwater may pose a VI risk. For example, TCE groundwater contamination as low as 200 parts per billion (ppb) in shallow groundwater (20-feet depth) has caused a VI risk at numerous sites in Region 5. Many variables may affect VI, including current or potential site land use, contaminant concentrations, soil type and degree of heterogeneity, building construction and condition, the depth of contamination, and seasonal variations.

U.S. EPA’s Draft Guidance defines “near” as volatile or toxic compounds within 100 feet (laterally or vertically) of buildings unless there is a conduit that intersects the migration route that would allow SG to migrate further than 100 feet (U.S. EPA 2002). The Draft Guidance defines a conduit as any passageway that could facilitate flow of SG, including porous layers such as sand or gravel, buried utility lines, and animal burrows. The 100-foot distance may not be appropriate in all cases. If the contaminant plume is not well defined, it may be necessary to evaluate potential pathways from a distance greater than 100 feet.

2.4 Which Chemicals Pose VI Risks?

Typical sources of VOCs associated with VI include chlorinated solvents and petroleum products. Common chemicals of concern (COC) for VI include TCE, PCE, vinyl chloride, carbon tetrachloride, naphthalene, and BTEX compounds. Landfill gases such as methane can also be associated with the VI pathway for buildings located near current or former landfills and can represent inhalation and explosion risk hazards. Degradation products also should be evaluated for VI.

COCs for potential VI risk generally meet a threshold for volatility and may also exhibit hazardous characteristics. High volatility generally is indicated by high partial pressures and Henry’s Law constants. It is generally accepted that VI COCs have Henry’s Law constants greater than 10^{-5} atmosphere-cubic-meter per mole. COCs can exhibit flammability (such as methane) and acute toxicity (such as hydrogen sulfide).

2.5 How do VOC Vapors Migrate Indoors? What are the Pathways or Conduits for VI Migration?

Once organic compounds are introduced into the subsurface, a complex series of fate and transport mechanisms act upon them, potentially moving them away from the source area. VOCs may be transported beneath buildings as a separate phase nonaqueous-phase liquid (NAPL), dissolved in groundwater, or as a vapor in SG. Vapors typically move from areas of high concentration to areas of low concentration and areas of high pressure to low pressure.

Once volatile contaminants are present near or beneath buildings, they migrate upward as vapor through SG and may accumulate beneath buildings, asphalt, concrete slabs or basements. The vapors migrate inside if there is a crack or opening in the wall or foundation of the building or if there is an opening within a utility corridor that enters the building. Vapors can also migrate laterally along a preferential pathway such as a utility corridor, beneath concrete or asphalt, or within other confined passageways. Figure 2 below shows a conceptual site model (CSM) of vapor intrusion from contaminated groundwater.

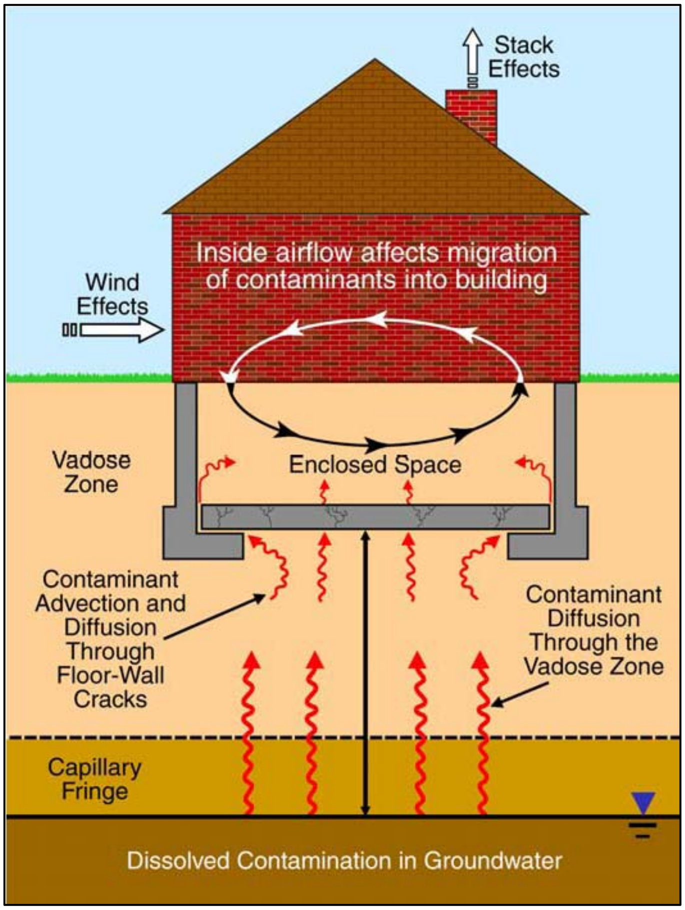


Figure 2 - CSM of VI from Contaminated Groundwater (ITRC 2007)

2.6 Is the VI Pathway Different from Other Exposure Pathways?

The VI pathway presents some unique challenges compared to other exposure pathways. Most other exposure pathways are based on contamination in the outdoor environment. Although actions to characterize and clean up contaminated soil or groundwater may be apparent to the community, they typically are not invasive to the personal lives of individuals, and simple engineering controls often can prevent adverse exposure to contaminated media. VI, on the other hand, may involve the collection of environmental samples inside or immediately outside a building. The process of investigating the VI pathway can be intrusive and often directly affects occupants. In addition, products present inside the property can release VOCs and may therefore complicate the assessment of VI sampling results.

2.7 What is the "Multiple Lines of Evidence Approach," and How is It Useful in Assessing the VI Pathway?

Considerable information primarily based on observation and experience has been generated regarding evaluation of the VI pathway since the pathway emerged as a national issue in the late 1990s and especially since the publication of U.S. EPA's Draft Guidance. VI investigations have indicated that the data set for no single medium (groundwater, SG, sub-slab [SS], or IA) can be reliably used to fully evaluate the potential for risks from VI above health risk-based levels because of the large number of variables affecting the transport of vapors from the subsurface to IA and the confounding influence of indoor sources of common subsurface contaminants.

The current "state-of-the-science" technique is to collect and evaluate multiple lines of evidence to support decision making regarding the VI pathway. Lines of evidence to evaluate the VI pathway can include, but are not limited to, the following:

- Groundwater data: including some level of vertical and spatial profiling as appropriate
- SG data, including some level of vertical and spatial profiling as appropriate
- SS (or crawl-space) SG data
- IA data
- Concurrent outdoor air data
- Background, internal, and external source data
- Information about building construction and current conditions, including utility conduits
- Site geology and history
- Tracer data

By using the "multiple lines of evidence approach," project managers usually have been successful in determining if the VI exposure pathway is complete and if any elevated levels of contaminants in IA likely are caused by subsurface VI, an indoor source (such as a consumer product), or an outdoor source. Generally, site conditions determine the number of lines of evidence that provide enough information for decision making. For example, when groundwater and SS concentrations are low and SS data is non-detect, project managers could determine that the VI exposure pathway is not complete based on relatively few lines of evidence. Coordination with a risk assessor and hydrogeologist generally is very useful in evaluating multiple lines of evidence.

An example project that used the multiple lines of evidence approach is discussed below.

Example Project: Multiple Lines of Evidence Approach
Behr Dayton VOC Removal Site, Dayton, Ohio

VI occurs when there is a direct connection between identified concentrations of chlorinated organic compounds or petroleum hydrocarbons in groundwater, SG, SS, and IA. If specific chlorinated organic compounds or petroleum hydrocarbons are identified in groundwater, SG, SS (at concentrations exceeding site screening levels), and IA (at concentrations exceeding site screening levels and not due to an IA source, resident lifestyle, or ambient air impacts), the VI exposure pathway is complete. Once the pathway has been identified as complete, mitigation or remediation activities should be considered to reduce exposure within the structure.

The four steps summarized below describe how the multiple lines of evidence approach were applied to the Behr Dayton VOC Removal Site, followed by a summary.

First Step – Groundwater Sampling

Groundwater sampling was conducted to determine if there was (1) groundwater contamination within 100 feet of properties and (2) a high probability that groundwater contamination was present beneath the properties. If applicable, existing groundwater sampling data should be examined. If there are no existing data or existing data are inadequate, groundwater sampling may be necessary.

In this site example, the Ohio Environmental Protection Agency (Ohio EPA) conducted the groundwater sampling. The sampling results indicated TCE in groundwater at concentrations as high as 3,900 ppb beneath residential properties. The groundwater depth was approximately 20 feet below ground surface (bgs).

First Step - Geoprobe obtaining a groundwater sample

Second Step – SG Sampling

At the Behr Dayton VOC Removal Site, TCE concentrations as high as 3,900 ppb were detected in groundwater samples. Because TCE was detected in shallow groundwater, Ohio EPA then conducted SG sampling to determine if TCE vapors were migrating vertically from the surface of the contaminated groundwater. Sampling results indicated TCE SG concentrations as high as 160,000 parts per billion by volume (ppbv) (859,877 micrograms per cubic meter [$\mu g/m^3$]) at locations next to residential properties.

Second Step conclusion: TCE groundwater contamination was linked to SG contamination near residential areas. The next step was to obtain residential SS samples.

Second Step - Geoprobe conducting SG sampling approximately 1 foot above groundwater surface (20 feet bgs)

Third Step – SS Sampling

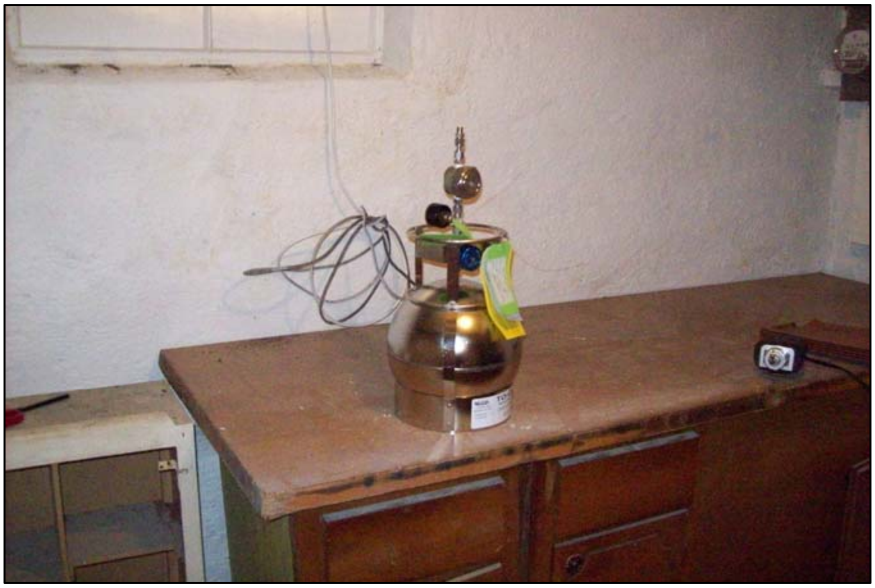
Ohio EPA SG sampling documented TCE concentrations as high as 160,000 ppbv. Because TCE was detected in shallow groundwater and SG at elevated levels, Ohio EPA referred the site to U.S. EPA for a removal action investigation. U.S. EPA then conducted the third step in the multiple lines of evidence approach to VI investigation, the collection of SS samples from properties adjacent to where Ohio EPA collected the SG samples. U.S. EPA documented TCE concentrations as high as 62,000 ppbv (333,202 $\mu g/m^3$) in SS samples. The Ohio Department of Health (ODH) established a TCE site-specific SS screening level of 4 ppbv (21.5 $\mu g/m^3$).

Third Step conclusion: TCE groundwater contamination and SG contamination linked in Steps 1 and 2, was now linked to residential SS contamination above ODH screening levels. The next step was to obtain IA samples.

Third Step - Residential SS sampling using sampling probe and SUMMA canister

Fourth Step – IA Sampling

U.S. EPA documented TCE concentrations as high as 62,000 ppbv in the SS samples. Once U.S. EPA determined that TCE concentrations in the SS samples exceeded the SS screening level, U.S. EPA collected IA samples. The IA samples documented TCE at concentrations as high as 260 ppbv (1,397 µg/m^3). The ODH established a TCE IA screening level of 0.4 ppbv (2.15 µg/m^3).



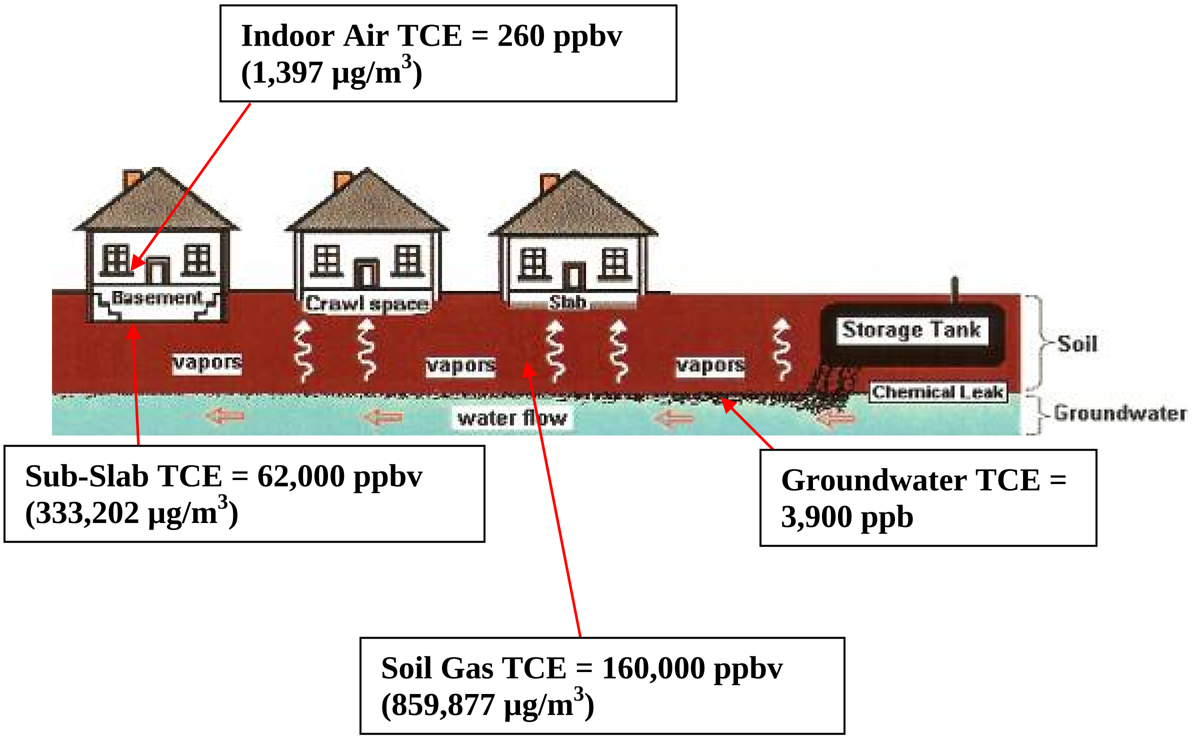
Fourth Step - Residential IA air sampling

Fourth Step conclusion: TCE groundwater contamination linked to SG, SS, and IA contamination above ODH-recommended SS and IA screening levels. Using multiple lines of evidence, a completed exposure pathway was documented and a removal action was initiated.

Note: Simultaneous collection of the SS and IA samples may expedite the decision-making process and reduce the amount of time needed to access a property.

Summary

At the Behr Dayton VOC Removal Site, TCE was the main COC. Groundwater was present at approximately 20 feet bgs in a residential area, extending 0.5 mile from the source. TCE was detected in groundwater samples from a residential neighborhood at concentrations as high as 3,900 ppb. SG samples collected by the Ohio EPA from next to homes within the area of concern contained TCE concentrations as high as 160,000 ppbv. U.S. EPA then collected SS samples from homes within the area of concern and detected TCE concentrations as high as 62,000 ppbv. The ODH (through ATSDR) established a TCE SS screening level of 4 ppbv (21.5 µg/m^3). U.S. EPA then collected IA samples from homes within the area of concern and detected TCE at concentrations as high as 260 ppbv (1,397 µg/m^3). The ODH established a TCE IA screening level of 0.4 ppbv (2.15 µg/m^3). Because TCE was observed in the groundwater, soil gas, SS, and IA and concentrations that exceeded the TCE screening levels, ODH and the Agency for Toxic Substances and Disease Registry (ATSDR) determined that a "completed exposure pathway" existed and that mitigation to reduce TCE exposure was necessary. Figure 3 below illustrates the multiple lines of evidence approach and the completed exposure pathway.


Indoor Air TCE = 260 ppbv (1,397 µg/m^3)

Sub-Slab TCE = 62,000 ppbv (333,202 µg/m^3)

Groundwater TCE = 3,900 ppb

Soil Gas TCE = 160,000 ppbv (859,877 µg/m^3)

Figure 3 - Multiples Lines of Evidence and Completed Exposure Pathway Example

Section 3. Site Identification, Removal Actions, and Cross-Program Coordination

U.S. EPA Region 5 identified the need to establish an approach for addressing VI sites and coordinating among Superfund programs, particularly for National Priorities List (NPL) sites being transferred from the Remedial Program to the Removal Program (and vice versa). To ensure consistency, it is critically important that effective communications are maintained between all Region 5 programs. Additionally, the Superfund Site Assessment (SA) Team should receive guidance on VI site recognition, including cost-effective methods to perform limited investigation of these sites if needed.

This section discusses VI site identification, VI site removal actions, and cross-program coordination for VI sites.

3.1 Site Identification

This section discusses VI site identification programs and recommendations.

3.1.1 Site Identification Programs

As for other risk pathways, the potential for unacceptable VI risks may bring a site to U.S. EPA's attention through a number of programs as summarized below.

- **SA Program** – SA Program staff may identify a possible VI issue at a site based on general environmental program experience and familiarity with VI guidance documents. To date, SA staff have not arranged for VI investigative work because the Hazard Ranking System model does not currently allow for consideration of the VI pathway for the purposes of scoring a site (U.S. EPA 2009). Under the SA Program, a site may pass to the Removal Program if the SAM believes that follow-up VI investigative work is needed. The Removal Program can use experienced Superfund Technical Assessment and Response Team (START) contractor personnel or U.S. EPA Environmental Response Team (ERT) resources to collect SS and IA samples.

  U.S. EPA Region 5 has identified the need to assist SA staff in identifying potential VI sites and performing relatively inexpensive investigative activities (such as Geoprobe sampling) to identify VI sites.

- **Remedial Program** – Generally, sites are identified for potential VI work during the remedial investigation. If the potential for VI is identified after the Record of Decision, then follow-up usually occurs during the 5-year review process. In some cases, sites are investigated earlier if groundwater or SG monitoring results suggests the need for more timely VI activities. The RPM and support staff identify the need to perform a VI investigation and proceed as necessary. Professional knowledge and experience, familiarity with the Draft Guidance (U.S. EPA 2002) and the ITRC guideline (ITRC 2007), and review of supporting technical documents generally provide the basis for the decision to proceed (U.S. EPA 2009).

- **Removal Program** – Sites commonly are identified through referral by other U.S. EPA Region 5 programs, state environmental agencies, or local agencies. Additionally, the Remedial Program may request assistance with potential time-critical components for an NPL site discovered during the 5-year review process. Either the receiving OSC or

Removal Manager (or both) evaluates the incoming request for assistance and determines the need for follow-up. Ohio EPA (for example) has requested U.S. EPA Removal Program assistance after collecting groundwater and SG data. Ohio EPA has then requested U.S. EPA Removal Program assistance in conducting an independent analysis of SS and IA to determine if a completed exposure pathway exists. Based on the results, a site may be assigned to an OSC and, in discussion with Removal Program management, a general course of action is determined. After site investigation, the site may also be transferred from the Removal Program to the Remedial Program for follow-up. For example, levels of contamination may not justify a removal action, but an existing health hazard may need to be addressed under the Remedial Program.

- **Brownfields Program** - Brownfields Program personnel may identify a potential VI issue based on experience and familiarity with VI guidance. If a VI concern is identified, the Brownfields Project Officer may bring the site to the attention of the local entity administering the Brownfields grant. By raising awareness, the Project Officer may be able to identify a potential VI site and actively work with Brownfields Program grant recipients to address the problem through the grant assessment process (U.S. EPA 2009).

  It may be advisable for Brownfields Program staff to review selected guidance documents. U.S. EPA's "Brownfields Technology Primer: Vapor Intrusion Considerations for Brownfields Redevelopment" (U.S. EPA 2008) provides a useful introduction to VI issues.

  Generally, Brownfields Program staff should notify the SA or Removal Program if it becomes aware of a VOC groundwater plume that extends to residential areas beyond the boundaries of a Brownfields development site.

3.1.2 Site Identification Recommendations

Determining if a VI investigation is warranted at a site is not always easy considering factors such as the time and resources likely to be expended, difficulties with residential access, and questions about the relative contribution of residential sources to IA concentrations of volatile chemicals (such as dry-cleaned clothes in the basement or the presence of gas or paint cans in the garage or basement). Despite these constraints, Region 5 staff must decide how to evaluate this potential exposure threat, which may be significant at specific sites.

The general recommendations discussed below apply to the identification of VI sites in Region 5. **U.S. EPA OSCs, RPMs, and SAMs are strongly encouraged to review** one or more of these recommendations and at least be familiar with the 2002 Draft U.S. EPA Guidance and the ITRC 2007 guidance. General recommendations reflecting currently accepted opinions about investigation methods and approaches are presented later in this VI Guidebook. It should be noted that a connection must be made from contaminated groundwater, SG, SS, and IA (the multiple lines of evidence approach). Short-cutting this approach is not recommended.

1. **OSCs, RPMs, and SAMs should use a conservative approach when determining if a VI investigation is warranted at a site.** In general, a VI investigation should be considered if (1) a site has groundwater contamination where concentrations of one or more volatile chemicals exceed the drinking water maximum contaminant level (MCL) or other risk-based concentration values and (2) occupied buildings are located above or

within 100 feet laterally from the surface footprint of the contaminant plume (U.S. EPA 2009). For example, several southwest Ohio VI sites with sand-and-gravel aquifers and shallow (less than 20 feet bgs) groundwater containing VOCs at concentrations exceeding 200 ppb, correlated to a completed exposure pathway to nearby residences. In addition, if a building is located above subsurface soil VOC contamination, a VI investigation may be warranted.

When vacant property at an NPL site lies above VOC-contaminated groundwater or subsurface soil and buildings may be installed under a future-use scenario, Remedial Program personnel should evaluate the need for institutional controls (IC) to control future risk. ICs could include future VI investigation or the incorporation of VI mitigation systems or vapor barriers in design planning for future structures (U.S. EPA 2009).

Note: Homes with existing radon mitigation systems generally will not require a VI evaluation, although (1) SAMs should consider investigating operational factors to ensure that the system is working effectively and (2) RPMs should consider if continued operation of the system should be included in the site remedy.

2. **U.S. EPA OSCs, RPMs, and SAMs should consult ATSDR (or risk assessor) for the latest SS and IA site-specific screening levels.** The Draft Guidance provides screening values for determining the need for a VI investigation based on SG and groundwater concentrations for specific chemicals. However, based on research since the 2002 Draft Guidance was issued, it is now recognized that the use of generic screening levels may inadvertently overlook some VI-related issues. Specifically, research has shown that VI depends not only on chemical concentrations in groundwater or soil but also on the additional site-specific characteristics discussed below (U.S. EPA 2009).

   For any specific site, factors (such as soil type, soil moisture content, subsurface or geologic conduits, building construction, pressure differentials, and other variables) either increase or decrease the likelihood of vapor migration and affect the appropriateness of the use of screening values. Geologic factors (such as the presence of a sand-and-gravel aquifer or a high water table) tend to further reduce confidence in the use of generic screening values (U.S. EPA 2009). The U.S. EPA Region 5 project manager should evaluate these factors and seek the assistance of hydrogeologists, geologists, soil scientists, or other specialists experienced in VI investigations.

3. **OSCs, RPMs, and SAMs should use the nation-wide draft "Vapor Intrusion Database" as appropriate.** U.S. EPA has compiled the draft "Vapor Intrusion Database" for additional information on attenuation when vapors migrate from subsurface sources to IA. The database is intended to help the OSCs, RPMs, and SAMs determine a course of action. The database currently contains IA measurements of VOCs paired with groundwater, SG, and SS measurements for over 913 buildings from more than 41 sites in 15 states. Currently, the database contains over 2,989 paired measurements, of which 35 percent are paired groundwater and IA measurements, 8 percent are paired SG and IA measurements, 53 percent are paired SS and IA measurements, and 4 percent are paired crawl space and IA measurements (U.S. EPA 2009).

   The database was made available in March 2008 and is described in a draft report entitled

"Preliminary Evaluation of Attenuation Factors" (under "Other Documents") at http://iavi.rti.org/login.cfm (obtain a login identification and password in order to gain access to the database) (RTI 2008). The database is intended to (1) provide a tool for users to better understand VI-related attenuation; (2) enable more informed decisions about how to proceed at individual sites; and (3) assist U.S. EPA, states, and other practitioners in evaluating and improving predictive models and screening algorithms for the VI pathway (U.S. EPA 2009).

4. **OSCs, RPMs, or SAMs assigned to a potential VI site should have collective discussions with members of the VI Workgroup**. The U.S. EPA Region 5 VI Workgroup can offer suggestions based on individual experience and knowledge gained from efforts to keep up to date on VI practices and current ideas. The workgroup can also reach out to experts to assist with specific issues. The Foreword of this VI Guidebook lists workgroup contacts.

3.2 Removal Actions

This section discusses removal actions at VI sites, including removal action triggers for VI sites and RPM and OSC removal action roles.

3.2.1 Removal Action Triggers for VI Sites

An OSC or RPM can decide to begin a removal action (such as a mitigation system) based on site-specific conditions in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). **Typically, SS and IA results trigger a removal action** as summarized below.

- **Site-related contaminants are identified in SS and IA that constitute an unacceptable threat to human health:** An unacceptable risk is defined as (1) a cancer risk greater than 10^{-4}, (2) a non-cancer risk resulting in a hazard index (HI) greater than 1.0, or (3) the presences of compounds resulting in a lower explosive limit (LEL) greater than 10 percent. In some cases, cancer risk levels of 10^{-5} will also ultimately require mitigation measures (see Section 8.1).
- **Multiple-lines of evidence indicate that IA contaminants are from VI:** Multiple lines of evidence can include groundwater, SG data, and historical site information that are linked to SS and IA contamination. Concentrations of site-related contaminants in IA must result from VI at and from the site and not from indoor sources or ambient air.

It is important to document groundwater, SG, SS, outdoor ambient air, and IA contamination, in this order. Not "connecting the dots" in this order may lead to the conclusion that VI risks exist when in fact a residential IA contaminant (such as recently dry-cleaned clothes in the basement or the presence of gas or paint cans in the garage) is the source.

In addition, the Removal Program routinely requests SS and IA screening levels from ATSDR, with input from state health departments. For example, in 2009 at the Behr Dayton VOC Removal Site, the residential TCE SS screening level was set at 4 ppbv (21.5 $\mu g/m^3$) and the TCE IA screening level was set at 0.4 ppbv (2.15 $\mu g/m^3$). If the SS TCE screening level was exceeded, then an IA sample was collected. If the residential TCE IA screening level was exceeded and TCE was observed in SG and shallow groundwater, then mitigation was considered warranted.

3.2.2 RPM and OSC Removal Action Roles

This section discusses the roles of the RPM and OSC in VI site removal actions.

Role of the RPM

Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) at Title 42 of the *United States Code,* Sections 9601 *et seq.,* Section 300.5 of the NCP, and Title 40 of the *Code of Federal Regulations* (40 CFR)*,* Part 300 *et seq*., the RPM is defined as “the official designated by the lead agency to coordinate, monitor, or direct remedial or **other response** [emphasis added] actions under Subpart E of the NCP.” The NCP defines “response” as the “remove, removal, remedy, or remedial action, including enforcement activities related thereto” (40 CFR Section 300.5). The RPM assigned to the site has the authority to implement removal actions in accordance with the NCP (U.S. EPA 2009).

An RPM may conclude that a threat to public health exists because of the actual or potential exposure of nearby human populations to hazardous substances based on site-specific information such as groundwater, SG, SS, and IA data; site historical information (location of contamination source areas); and other information (U.S. EPA 2009).

If an RPM in consultation with his or her technical support team concludes that a removal action is warranted at a site to address VI, the RPM should consult with his or her manager about the site-specific situation and recommendations. If the manager concurs that a removal action is warranted, the RPM should coordinate the preparation of one of the two decision-document/funding paths summarized below (U.S. EPA 2009).

- **Potentially Responsible Party (PRP)-lead path:** U.S. EPA generally prefers to have removal actions performed by the PRPs when appropriate. Removal actions can sometimes be required pursuant to an existing Consent Decree (CD), Unilateral Administrative Order (UAO), or Administrative Order on Consent (AOC). In other cases, a separate UAO or AOC may be issued. In this case, the UAO or AOC generally should include an imminent and substantial endangerment finding. The Order also should address the work to be performed, schedules, cost recovery, and other deliverables. Normally, the OSC requests the development of the Order by enforcement support staff in coordination with a technical review team (such as geologists and toxicologists), the Office of Regional Counsel, and U.S. EPA management staff (U.S. EPA 2009).

  Note: For PRP-lead actions at Fund-lead action sites, to maintain consistency, VI standard operating procedures (SOP) should be followed, such as the U.S. EPA ERT SS probe installation procedures, IA sampling procedures, mitigation procedures, and other procedures discussed in this VI Guidebook.

- **Fund-lead path:** At sites where a PRP-lead action is not possible, an appropriate decision document such as an Action Memorandum should be prepared to use U.S. EPA resources to perform removal actions, Coordination between the Remedial and Removal Programs should occur as discussed below.
  - **Funding:** Fund-lead removal actions typically are performed using Removal Program monies. Therefore, for a Fund-lead removal action necessary to address VI at a site undergoing remedial response, coordination likely will be necessary among

the RPM, remedial management staff, and removal management staff to define the scope of the removal action, the anticipated schedule for the work, and resources necessary to implement the removal action (U.S. EPA 2009).

- **Documentation:** Except during an emergency, a signed Action Memorandum is the appropriate U.S. EPA decision document to implement a Fund-lead, time-critical removal action addressing VI. Typically, **the RPM should develop the Action Memorandum** in coordination with the technical review team (geologists, toxicologists, and other personnel), the Office of Regional Counsel, and U.S. EPA remedial and removal management staff. In an emergency (such as liquid chemical migration into basements, VOCs detected at part-per-million levels in IA using hand-held instruments, etc.), an OSC likely will initiate an action using the OSC's emergency authority and contracting capabilities. Emergency authority is granted only to the OSC. After initiation of the action, the OSC typically coordinates future activities with the RPM (U.S. EPA 2009).

Role of the OSC

The role of an OSC during the implementation of removal actions at a site with ongoing remedial response varies based on the site and action. Depending on project needs, the OSC's role may be central (such as direct coordination of a large VI removal action at a non-NPL Fund-lead Site or implementation of an emergency response) or minimal (such as when an RPM acts as the "EPA Project Coordinator" at an NPL site for a PRP-lead removal action addressing VI pursuant to an AOC). The OSC has unique and valuable experience with the removal process, including the mitigation of time-critical threats posed to human health from hazardous substances and the oversight of response contractors in the field. Therefore, RPMs may find it very beneficial to partner and coordinate with an OSC for removal actions to address VI, even though the RPM may directly coordinate the response. Section 3.3.2 discusses coordination between RPMs and OSCs in more detail.

The role of an OSC at a site with ongoing remedial response should be outlined early in the process in coordination with U.S. EPA Remedial and Removal Program management staff. Remedial and Removal Program management staff should periodically and collectively meet with their respective staff to discuss work efforts and work allocations at VI sites where both the Removal and Remedial Programs are actively involved (U.S. EPA 2009).

3.3 Cross-Program Coordination

Site-specific coordination between Region 5 programs has long been standard practice and should continue for VI sites. However, some general guidelines are advisable in light of the expected increase in the number of VI sites, potential resource issues, and the different health threat criteria used by the various programs for implementing mitigation actions. Additionally, standardization of SS and IA screening levels used by state health departments should be a future goal because OSCs (and ATSDR) often rely on these health departments to help establish screening levels.

This section discusses cross-program transfers of VI sites and cross-program coordination recommendations.

3.3.1 Cross-Program Transfers of VI Sites

Within the past several years, a number of NPL sites have been transferred from the Remedial to the Removal Program because VI was identified as a potential exposure pathway. These transfers generally occurred after Remedial Program staff performed SG or SS sampling for VOCs during remedial investigations. The sites generally were transferred to the Removal Program because sampling results indicated levels suspected of warranting IA sampling or mitigation actions by OSCs. At these sites, in the absence of established guidelines or policy, the involved RPMs, OSCs, and respective management staff determined how the work activities would be apportioned between them on a site-by-site basis (U.S. EPA 2009).

Additionally, some Region 5 removal sites (such as the Behr Dayton VOC Removal Site and the East Troy Aquifer Site) have been transferred to the Remedial Program after the OSC conducted extensive residential SS and IA sampling and after the installation of residential vapor abatement mitigation systems. Although these removal activities protect public health in the short term (as long as the vapor abatement mitigation system functions properly), Remedial Program assistance was needed to address the VI source (groundwater contamination).

More recently, the SA Program has recognized potential VI issues at a few sites and has brought these issues to the attention of the Removal Program. This practice may occur more often in the future (U.S. EPA 2009).

3.3.2 Cross-Program Coordination Recommendations

This section discusses coordination recommendations between various personnel in different programs.

Coordination Between RPMs and OSCs

As discussed in Section 3.2.2, because of the OSC's unique and valuable experience with the removal process RPMs may find it very beneficial to partner and coordinate with an OSC for removal actions to address VI, even though the RPM may directly coordinate the response. When a Removal Program ERRS contractor is used for response work, the OSC's involvement may be essential for specific contract purposes, although the RPM can coordinate much of the work as a COR (U.S. EPA 2009). In all cases, the VI site removal approach used (enforcement- or Fund-lead) should first be weighed against the urgency of the threat posed. If the RPM believes that a situation is an emergency, consultation with an OSC should occur immediately to expedite a potential emergency removal action.

Coordination Between SAMs and OSCs

The process of requesting Removal Program assistance at a site should follow normal procedures performed for any site where SAMs believe a removal assessment or action is warranted. Generally, the SAM should discuss his or her evaluation of the need for Removal Program involvement with his or her SA Program manager, who in turn will approach the appropriate Removal Program manager. The Removal Program manager likely will review available information with an OSC and determine if the need for Removal Program follow-up is needed (U.S. EPA 2009).

If requested by SA management staff, the U.S. EPA VI Workgroup can meet with SA Program staff to assist in identifying VI sites, discuss new VI concepts and practices, and present potential investigative techniques for SA sites (U.S. EPA 2009).

When an OSC closes out a VI site after an SA investigation or removal action, the site cannot then be referred back to the SA Program for NPL consideration solely based on the VI pathway. Unlike the situation for removal sites with more common exposure pathways (soil and water ingestion or dermal contact and outside air inhalation), there will be little chance for the Remedial Program to conduct follow-up at a VI site to address residual contamination that could pose longer-term health risk if VI is the only pathway of concern. The OSC should consider this limitation when evaluating health risk criteria at a removal site and the need for mitigation (U.S. EPA 2009).

Coordination Between SAMs and RPMs

For sites identified because of issues other than VI, the SAM assigned to the site may be aware of a potential VI problem and wish to bring the problem to the attention of the Remedial Response Sections. In such cases, the SAM can alert the RPM about the possibility of VI, which the RPM can incorporate into investigative planning for the site.

Coordination Between Brownfields Staff and OSCs

A Brownfields Project Officer should discuss the need for Removal Program involvement at a potential VI site with the Brownfields Program supervisor. If the decision is made to investigate VI issues, the process should closely follow the normal process between SA and Removal Program staff. The Removal Program generally should defer to Brownfields staff for coordination of any field work in light of the partnerships developed by the Brownfields staff with local governments and the possible stigma that Removal Program involvement could bring upon a site. Moreover, the Brownfields Project Officer may independently consult with the Region 5 VI Workgroup, U.S. EPA risk assessors, or the ATSDR for technical advice when evaluating a potential VI site (U.S. EPA 2009).

Section 4. Site Screening and Sampling Strategy

This section discusses the site screening and sampling strategy by answering some FAQs regarding screening and sampling.

4.1 How Should Initial Screening be Conducted?

U.S. EPA's Draft Guidance includes a tiered approach to assessment that involves increasing levels of complexity and specificity to conduct an initial screening analysis. At **sites with no ongoing remedial response action**, state agencies typically conduct a Tier 1 and 2 evaluation before referring the site to U.S. EPA for a removal action. For **sites with ongoing remedial actions,** an RPM typically conducts a Tier 1 and 2 evaluation as part of a remedial investigation or 5-year review. Tier 1, 2, and 3 evaluations are summarized below.

- **Tier 1** – Information from primary, or Tier 1, screening is designed to be used with general knowledge of a site and chemicals known or reasonably suspected to be present in the subsurface. Tier 1 screening does not call for specific media concentration measurements for each COC. Because this level of screening is based on basic physical factors, "screen-outs" in Tier 1 generally remain appropriate throughout the screening process.
- **Tier 2** – Secondary, or Tier 2, screening is designed to be used with limited site-specific information about contamination sources (including media-specific contaminant concentrations) and subsurface conditions (such as depth to groundwater, site geology, and SG information) to estimate IA concentrations resulting from the attenuation of COC concentrations along the vapor migration pathway. U.S. EPA observations and experiences since 2002 have increased awareness of the degree of variability and uncertainty involved with predicting IA concentrations using external measurements and has generally shown the inappropriateness of the single-line-of-evidence "screen-outs" suggested under Tier 2 in the 2002 U.S. EPA Draft Guidance.
- **Tier 3** - Site-specific, or Tier 3, pathway assessment involves collecting more detailed site-specific information and more specifically calls for the collection of building-specific SS and/or IA samples to assess VI. U.S. EPA observations and experiences since 2002 have reinforced the importance of collecting interior and structure samples to assess VI impacts.

4.2 Is There a Generally Accepted VI Investigation Sampling Strategy?

A site-specific VI sampling strategy should be developed in consultation with the site team (such as the OSC, RPM, SAM, risk assessors, hydrogeologists, and geologists) in conjunction with appropriate regional laboratory personnel. This approach ensures that the CSM is used to develop the sampling strategy and that the appropriate data quality objectives (DQO) are incorporated. The investigation of VI sites involves collecting data to support "multiple lines of evidence" as discussed in Section 2.7. A brief summary of the investigation strategy is provided below.

- **Source Investigation** – VI sources can include soil or groundwater contamination but also may include dry wells, underground storage tanks, lagoons, landfills, etc. Source investigation can include the evaluations summarized below.

  - An SG survey can be conducted to quickly locate the source and narrow the areal extent of the impacted area. Field analysis using a mobile laboratory or the U.S. EPA ERT's Trace Atmospheric Gas Analyzer (TAGA) mobile laboratory can provide real-time guidance for determining additional sampling locations. Samples also can be submitted for laboratory analysis.
  - A geophysical survey can be conducted to determine the locations of buried drums, tanks, etc.
  - Soil sampling can be conducted using membrane interface probes, direct-push rods, and multi-incremental sampling.
  - Groundwater observation wells can be installed at strategic locations to assess groundwater flow and contaminant concentrations.

- **<u>SG Sampling</u>** – SG sampling locations should be based on the draft CSM developed during the source investigation. SG concentrations can be measured using permanent soil gas probes complete with manhole covers for multiple sampling rounds or temporary holes installed using a slam-bar or Geoprobe. Sampling can be conducted using absorption tubes or whole-air collectors such as Tedlar bags or SUMMA canisters. Again, field analyses using the TAGA mobile laboratory or an alternate mobile laboratory can provide real-time guidance for determining additional sampling locations.

  Note: Although SG data provides important information, generally SG sampling should not be used to estimate IA levels of contaminants, especially for residences and public buildings.

- **<u>SS Sampling</u>** – SS samples provide strong evidence of a VI threat. Permanent sampling ports allow multiple sampling rounds. Section 6.2 of this VI Guidebook describes the collection of SS samples.
- **<u>IA Sampling</u>** – IA samples provide critical information needed to determine if a complete pathway exists and if a site requires mitigation. Section 6.3 of this VI Guidebook describes the collection of IA samples.
- **<u>Outside or Ambient Air Sampling</u>** – Outside or ambient air samples provide information needed to determine if IA is being impacted by outside ambient air or other sources.

4.3 Which Sample Collection Techniques are Available?

Several types of sample collection techniques are commonly available, including the use of SUMMA canisters, Tedlar bags, and adsorption tubes. Each sample collection technique is briefly discussed below. The selection of the appropriate technique depends on the COCs, the required detection limits, and the project DQOs. Consultation with appropriate sampling, laboratory, ERT, and risk assessment personnel is strongly recommended before the sampling plan is developed. Additional sampling information is presented in Appendix D of the ITRC VI guidance (ITRC 2007), the ERT SOPs (website address http://www.epaosc.org/site_profile.asp?site_id=2107), and U.S. EPA's Forum on Environmental Measures (website address http://www.epa.gov/fem/methcollectns.htm).

4.3.1 SUMMA Canisters

SUMMA canisters are spherical or cylindrical stainless-steel air sampling devices. SUMMA canisters are cleaned and evacuated (i.e., has a negative pressure gauge scale reading) at the laboratory before deployment. The canisters are supplied with a controller to control the flow of air into the canister over the time duration set for the sampling task. Typically, in residential settings, SS and/or IA samples are collected over 24 hours using a 6-liter (L) SUMMA canister. Commercial and industrial settings may have other sampling periods (such 8 hours) to reflect the time of occupancy, requiring the flow controller to be set for a different flow rate. The sampling team must coordinate with the laboratory to ensure that the flow controllers are set at the appropriate flow rate. Sample collection staff must record the initial and final pressure of the canister. Sections 6.2.5 and 6.3.4 discuss SS and IA sampling using SUMMA canisters in detail.

Note: SUMMA is a specific manufacturer, but “SUMMA canister” is a term that has come into common use for any similar air sampling device. U.S. EPA’s use of the term does not imply endorsement of any particular manufacturer.

4.3.2 Tedlar Bags

Tedlar bags are polymeric sampling bags effective for collecting grab samples for the analysis of certain VOCs in SG. The holding times for Tedlar bag samples are considerably more limited than for SUMMA canisters because of surface and permeability issues. Because Tedlar bag samples have limited holding times, the samples should be analyzed on site to reduce the period between sampling and analysis. If the samples are transported to an off-site laboratory, holding times should be considered to ensure that the samples are analyzed within 24 hours of collection. If samples are shipped by air, they must be transported in an air-tight container or with a reduced volume to avoid rupture of the Tedlar bags from in-flight pressure changes. Samples containing compounds with high concentrations or low molecular weights and high vapor pressures may diffuse out of the Tedlar bags and into Tedlar bags containing lower concentrations, resulting in samples with lower and higher concentrations than the initial concentrations.

Before sample collection, Tedlar bags should be baked and flushed with nitrogen by the sampler to lower concentrations of volatile compounds associated with the Tedlar bags themselves (such as dimethyl acid amide, toluene, etc.). Tedlar bag samples should be collected as grab samples and not as time-weighted samples. In addition, the samples should be collected using a vacuum box and not a peristaltic pump.

Note: Tedlar is a specific manufacturer, but “Tedlar bag” is a term that has come into common use for any similar air sampling device. U.S. EPA's use of the term does not imply endorsement of any particular manufacturer.

4.3.3 Adsorption Tubes

Adsorption tubes are cylinders packed with adsorptive material that can be used in active or passive mode. Adsorption tubes can be used to identify the presence of a high-concentration contaminant. In an active mode, air is drawn through the tubes and the target compounds are adsorbed onto the enclosed matrix material. Adsorptive material selection is based on the material to be adsorbed and retained until released for analysis (such as thermal desorption, solvent extraction, and other analysis). Proper selection of sorbent material for sample collection is critical. Sample collection is performed at a designated volumetric flow rate for a prescribed period. Sample collection at flow rates faster than tube rating may result in erroneous results. Similarly, too short of a sampling period may result in insufficient target compound material to analyze using the prescribed method and too long of a sampling period may result in breakthrough in the sampling medium by the target material. Passive adsorption tubes are currently being evaluated but are not recommended at this time for quantitative analysis.

4.4 Which Types of Samples are Collected to Assess for VI, and What are the Sampling Methods?

Sampling options for assessing VI include the following:

- Groundwater sampling
- SG sampling
- Passive SG surveys
- SS sampling beneath buildings,
- Crawl-space sampling
- IA sampling
- Outside ambient air sampling.

The U.S. EPA ERT's SOPs provide details for each sampling method (available to OSCs at website address http://www.epaosc.org/site_profile.asp?site_id=2107). The 2007 ITRC guidance document also discusses sampling methods in detail (ITRC 2007). The VI team (including the OSC, RPM, SAM, hydrogeologists, geologists, and risk assessors) should select the type(s) of samples to be collected from a specific site based on the CSM. Consultation with regional laboratory personnel also is recommended to ensure that (1) the appropriate sampling and analytical methods are selected and (2) the laboratory detection limits allow sample results to be compared to specific VI screening levels.

4.5 What Other Sampling Factors Should be Considered?

Besides sample collection techniques and types, a number of other sampling factors must be considered before sampling is performed. First and most importantly, the COCs must be identified. Many OSCs and RPMs choose to request a specific targeted list of COCs based on site history and known contamination in groundwater, SG, or SS. An extensive list of requested analytes that are not site-related but that may be present in IA because of consumer use creates the potential for confusion in risk communication. For example, if the site history and subsurface data do not include benzene, OSCs and RPMs should exclude benzene as a target analyte because the benzene source could be from a car, lawnmower, or snow blower in the garage or basement. However, targeted analytes should include degradation products. For example, for a PCE or TCE site, an OSC or RPM can choose PCE; TCE; cis-1,2-dichloroethene (DCE); trans-1,2- DCE; and vinyl chloride because these analytes include the primary COCs and their degradation products. The appropriate laboratory personnel should be contacted for questions about specific compound detection and reporting limits.

Second, DQOs must be clearly determined, including specific decisions to be made based on the data collected, detection limits necessary to determine the presence of risk, and other DQO-related factors. The DQOs help ensure that the appropriate sample collection techniques (such as SUMMA canisters, Tedlar bags, and adsorption tubes) and associated analytical methods (such as U.S. EPA Method TO-15 for SUMMA canisters and U.S. EPA Method TO-14 for Tedlar bags) are selected. These methods should be selected carefully to ensure that the appropriate detection limits can be achieved.

Third, it is important to determine the duration of the sampling period. The sampling period should be selected so that the samples are representative of site-specific conditions and useful in risk assessment. A risk assessor can be consulted to assist in making this determination before sampling begins.

Finally, appropriate sampling media and analytical methods should be selected to ensure that the sampling media will properly collect and release the COCs for analysis using an instrumental technique qualitatively and quantitatively capable of achieving the required detection limits.

4.6 What are the Relationships Between Contamination in Various Media?

Results for SG samples collected from nearby residences are very useful along with groundwater data for preliminary indications of a potential problem, but such SG sample results are *not* always representative of SS or IA sample results.

The relationship between SS and IA sampling depends on the following:

- Type of building construction (slab on grade, slab over crawl space, basement, etc)
- Age of the structure
- Foundation conditions (cracked or sound)
- Preferential pathways (such as sand lenses)
- Spatial variations
- Seasonal and temporal variations

A 10-fold (0.10 reduction) attenuation factor (AF) often is applied as worse-case scenario to estimate IA levels based on SS data. Heavy reliance on standard AFs from SS or SG to trigger IA sampling is not recommended and may cause residential properties with an IA problem to be overlooked. For example, ATSDR may recommend a SS screening level of 4 ppbv and an IA screening level of 0.4 ppbv, based on a 10-fold AF.

4.7 Other Questions and Issues

This section discusses answers to other questions related to site screening and sampling.

4.7.1 How Should Very Large Sites be Sampled?

U.S. EPA Region 5 generally recommends sampling all potentially impacted buildings. However, for sites containing a large number of potentially impacted buildings, this approach may not be practical, in part because U.S. EPA may not have been able to attain signed access agreements for sampling at all structures. Unfortunately, there is a great deal of spatial variability in the distribution of contamination in subsurface vapors caused by heterogeneities both in subsurface materials and buildings. Therefore, simple extrapolation from nearby buildings does not appear possible. Large spatial and temporal variations in IA levels are usually two to five times but can be as high as 10-fold as shown in Figure 4 below, which shows individual properties at the Redfield Facility in Denver, Colorado. Also, as Figure 4 shows, tremendous spatial variation even exists between adjacent properties, so it is very difficult to devise methods that do not involve testing of most properties.

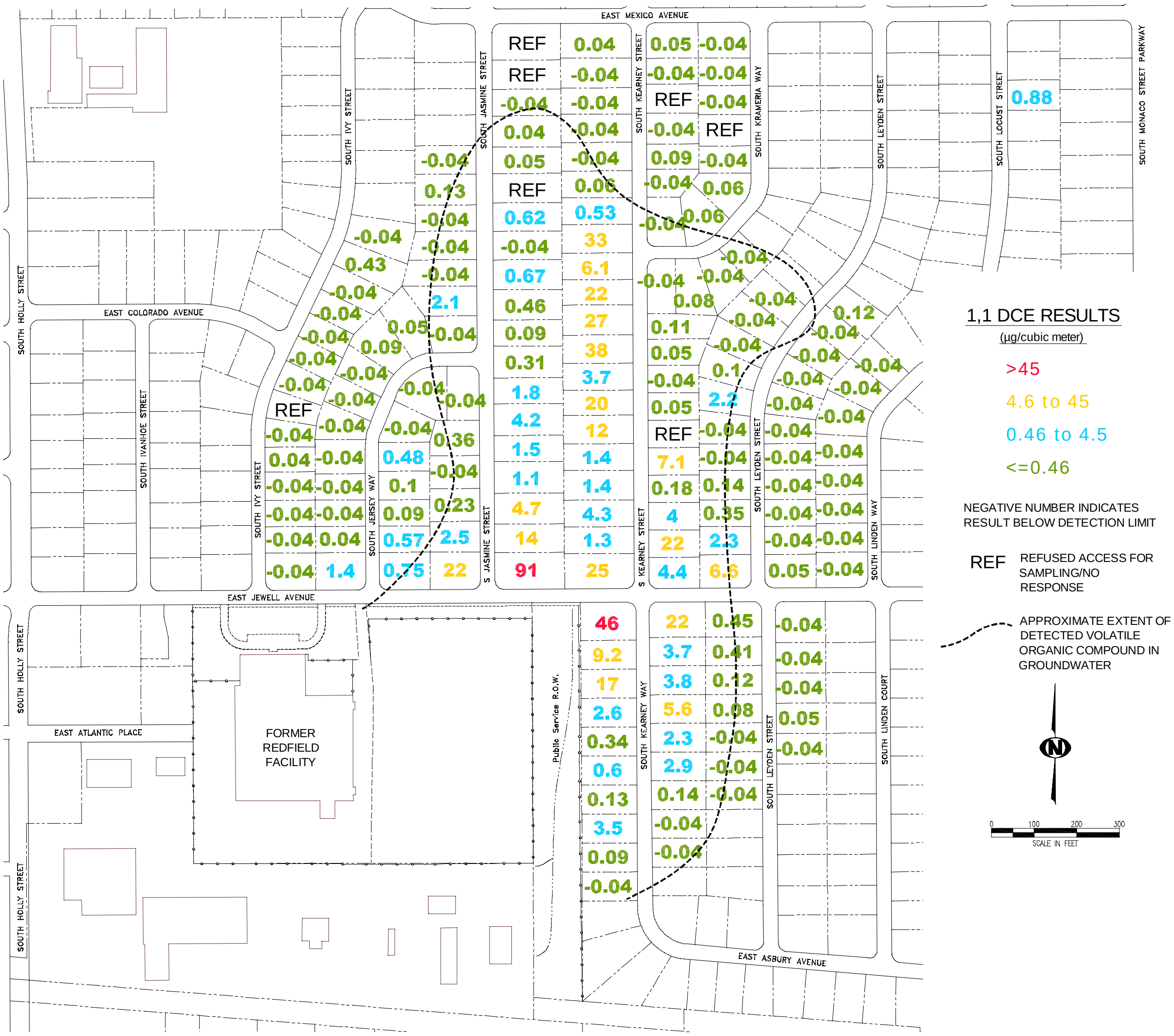


Figure 4 - Temporal and Spatial Variability for 1,1-DCE in IA at the Redfield Facility

In addition, generally identifying a particular building or group of buildings to provide a "worst-case" scenario and determining that surrounding buildings are less likely to be contaminated is not easy. When it is not practical or possible to sample every potentially impacted building, the OSC or RPM should seek the advice of a hydrogeologist familiar with the site geology to help guide the sampling progression. Site team members should work out a defensible investigative approach on a site-specific basis, including a plan for documenting properties where access is not provided.

4.7.2 What Information Should be Gathered Before Sampling IA in Industrial or Commercial Buildings?

U.S. EPA Headquarters may issue new guidance on VI investigation for non-residential settings. Until then, Region 5 recommends the approach summarized below.

- OSCs and RPMs should investigate VI for commercial and public use buildings where the public may be present (such as schools).
- OSCs and RPMs should investigate VI for industrial-use buildings where chemicals forming hazardous vapors generally are NOT a known or well-recognized part of routine operations.
- OSCs and RPMs should be aware that petroleum hydrocarbon (PH) sites have explosive issues (10 percent of the LEL), and biodegradation of PHs may create explosive environments. For these reasons, almost every property needs to be tested when PH could be a problem.
- OSCs and RPMs should place low priority on industrial or commercial non-residential settings if the public generally is NOT expected to be present and if hazardous vapor-forming chemicals that are the same or similar to chemicals in the subsurface are used as part of routine operations.

In the last case, investigators should consider if detailed investigations of the VI pathway would be beneficial. For example, it may not be possible to distinguish between the level of exposure caused by chemical(s) forming hazardous vapors used in industrial or commercial operations and the level of exposure caused by VI-related chemical(s). One possibility for evaluating if a chemical is the same or similar to chemicals in the subsurface is to determine if the chemicals have similar physicochemical properties (such as Henry's Law constants, etc) and toxicological properties (such as cancer and non-cancer effects and similar values for inhalation non-cancer reference concentrations or cancer unit risks).

Industrial and commercial structures have different SS and IA screening levels than residential structures. For most industrial and commercial buildings (except hospitals), the screening levels should be based on an 8-hour-per-day building occupation time.

If a decision has been made to sample an industrial or commercial building, then the factors summarized below should be considered.

- Each building ventilation system and its zone of influence should be identified. The sampling of each zone may be required.

- Any non-ventilated or passively ventilated rooms (such as mechanical rooms where vapors may build up from degreasing agents or other cleaning compounds) should be identified.
- The outdoor air exchange rate for each ventilation system should be evaluated. Subsurface screening levels assume adequate but modest air exchange rates.
- Hours of building occupancy (current and future as appropriate) should be considered. This information should dictate the sampling period needed to represent exposure. For example, at the Behr Dayton VOC Removal Site in Ohio, ATSDR recommended a residential IA TCE screening level of 0.4 ppbv (2.15 $\mu g/m^3$) and a commercial IA TCE screening level of 1.7 ppbv (9.14 $\mu g/m^3$) based on the hours of building occupancy.
- Ventilation system operation should be evaluated. Diurnal fluctuations caused by ventilation system operation may affect VI results.
- Potential pathways for subsurface migration into the building should be determined. Sealing these pathways can be a cost-effective mitigation measure.
- Areas with significant negative pressure should be identified. Negative pressure inside buildings facilitates VI.
- Chemicals and industrial products used in buildings should be identified and screened to determine the presence of potential IA sources of COCs.
- The type(s) of work activities occurring in the building should be determined and could be important in evaluating exposure, interpreting results, and identifying other potential indoor sources of COCs.

4.7.3 How Do I Assess a Site for VI When No Buildings are Present?

Multiple lines of evidence should be used to assess the potential for future VI if buildings or structures may be constructed at a site that currently does not contain buildings or structures. Lines of evidence that should be considered when no buildings currently overlie subsurface contamination include site history, planned future site use, groundwater data, groundwater depth, SG data, soil concentrations, flux chamber data, soil characteristics, subsurface geology, and modeling results. After obtaining several lines of evidence, the RPM can determine the need for ICs or other mechanisms as administrative tools to limit the potential for VI in future buildings.

4.7.4 When Should SG Sample Results be Used to Evaluate a Site for Potential VI?

Sampling of exterior SG immediately outside a structure may be a viable option when supported by knowledge of site geology and subsurface lithology, building conditions, source depths and extents, wind direction, precipitation information, and other site-specific factors. Each RPM and OSC should work with his or her site evaluation team to determine if exterior SG sampling would be useful at their particular site. In addition to evaluating the potential VI pathway, SG sample results also can be used to identify and delineate the source of contamination and to monitor changes in SG concentrations over time. **However, generally SG sampling alone is insufficient for a VI investigation.**

4.7.5 What Are the Issues with Sampling SG in the Rain?

For most sites, measurements made during or immediately after a significant rain event (greater than 1 inch of precipitation) may not be representative of long-term average conditions. For sites where rainfall is very frequent, testing soon after a rainfall event may yield information about representative conditions (ITRC 2007). The effects of weather events on sampling and sampling results are discussed in Section D.11.8 of Appendix D of ITRC's 2007 guidance. In any case, it is useful to collect relevant meteorological data during the sampling event to assist with later data interpretation.

4.7.6 Should Modeling be Used to Assess the VI Pathway?

Modeling can be used to assess the VI pathway. As with all models, high-quality data inputs (such as soil moisture content, representative groundwater and SG concentrations, depth to groundwater, and soil type) and appropriate sensitivity testing are necessary to obtain reliable results. Some models tend to oversimplify site conditions. Therefore, Region 5 generally bases removal and remedial decisions on SS and IA data.

In spite of considerable research, to date, **there is no reliable way to predict IA levels from VI using models.** Although models (such as the Johnson and Ettinger model) may be useful for screening out sites with an additional margin of safety, modeling generally should never substitute for confirmatory SS and IA sampling at a sufficient number of properties to rule out a potential IA problem. Modeling can be used to identify potential problem sites and provide priority rankings for investigation, but only if sufficient and accurate geological, contamination (source concentration), construction and meteorological information are available.

4.7.7 What Are the Units of Measurement for Air and SG Samples, and What are the Conversion Factors?

Air and SG unit conversion is more complicated than soil or water unit conversion. Common units for SG are $\mu g/m^3$, micrograms per liter (µg/L), ppbv, and part per million by volume (ppmv). The easiest way to convert units is to use an on-line calculator. An example on-line calculator is available at website address http://www.airtoxics.com/cclasses/unitcalc.html

Section 5. Community Outreach

VI investigators must be trained to deal with community concerns. Informing residents or business owners that chemicals may have entered their buildings is a delicate situation. Usually, people are just learning that the groundwater or soil near their properties has been contaminated by releases from a nearby site. Communities may be skeptical or unsure of what will happen next. They will wonder how vapors will affect their health and the health of their coworkers and families. It is important to learn from the experience of other investigators facing similar challenges.

Communication is an essential component of any community outreach program. For example, it generally is not good for building occupants to learn about a VI investigation for the first time when someone knocks on their door asking permission to drill holes in their floor or ask about their personal activities (such as smoking and dry-cleaning of clothes).

To be successful, agencies conducting or overseeing VI investigations need to develop a strong community outreach program to educate and reassure the local community about VI in a meaningful, sensitive, and effective manner. Unlike any other contaminant pathway, VI merits effective education of the affected community regarding the risk of SG migration from the subsurface as well as background sources typically found in buildings.

Community Advisory Groups (CAG) can assist in community outreach efforts. CAGs are generally small groups of residents who meet regularly with agencies and responsible parties. They provide an opportunity for the public to gradually gain an understanding of the complexities of VI investigation. In such a setting, initially adversarial relationships usually break down, and community members often come up with constructive advice (ITRC 2007).

This section answers FAQs concerning community outreach issues.

5.1 When and How Should U.S. EPA Inform a Community about VI Concerns and Sampling Plans?

Community outreach activities should be initiated as soon as possible after the determination that VI concerns exist at a particular site. Informing the community about VI concerns and plans to conduct sampling can be resource-intensive. The RPM or OSC should work with a Community Involvement Coordinator to develop a community outreach strategy that ensures the most appropriate means of communication throughout the process. Development of fact sheets, on-line questions and answers, and public availability sessions are recommended to educate the general public and facilitate communication. When choosing the most effective communication strategy, staff should also consider U.S. EPA's previous involvement at the site, the existence of community or neighborhood groups, and which phase of the regulatory process VI is being addressed under.

Because assessment of the VI pathway may involve sampling in homes and workplaces, individual, one-on-one communication with each homeowner or building owner is recommended whenever possible. The one-on-one approach establishes trust and provides an opportunity for the individual to ask questions that may otherwise not happen in a public setting. This communication can occur after meetings with a larger audience to introduce the overall issue of VI. After a community meeting, a letter should be sent to each home and building owner and tenants explaining U.S. EPA's plans to conduct sampling and U.S. EPA's intent to contact the owners and tenants in the near future. U.S. EPA can then begin to contact individual home and building owners and tenants and schedule in-person visits. Building-by-building contact and communication is probably the most effective means of educating the community about VI issues and obtaining access needed to complete sampling activities. Personal contact is recommended to establish a good working relationship with home and building owners and tenants and to build the trust needed for continued access necessary for sampling activities.

The initial visit can be used to further explain U.S. EPA's plans and answer questions, obtain signed access agreements, identifying sample locations, review instructions for the home or building owner or tenant (such as keeping doors and windows closed during sampling, avoiding bringing dry-cleaned clothing indoors during sampling, etc.), and perform a general building survey to determine likely sources of consumer and industrial products. A date and time for sampling also should be scheduled during the initial visit.

Upon identification of a location to be sampled, an access agreement is required. Section 5.2 discusses access agreements in more detail.

5.2 How Do I Obtain a Signed Access Agreement?

The access agreement must be signed by the property owner (and tenants, if necessary) to give U.S. EPA and its contractors permission to access the property for sampling. Attachment A contains an example U.S. EPA access agreement. Once the access agreement is signed, the agreement should be placed in a folder along with all future sampling information and results to organize all information for each property. A separate folder should be used and managed for each property sampled.

A signed access agreement can be obtained in a number of ways, such as by mailing out U.S. EPA sample request letters, holding public meetings and availability sessions, referring the public to the U.S. EPA website, and conducting door-to-door visits. Each method is described below. These methods have been used at Region 5 sites and have resulted in positive community responses.

5.2.1 U.S. EPA Sample Request Letters

Attachment B contains an example of a sampling request packet and letter sent to residents to request access for VI sampling. The letter and packet describe why U.S. EPA is conducting the investigation and contained fact sheets relating to VI and the COCs, an access agreement, and contact information. The sample request letter also contained a postage-paid envelope for the property owner/resident to return the signed access agreement. U.S. EPA used this approach for the Behr Dayton VOC Removal Site in Dayton, Ohio to obtain over 400 signed access agreements for VI sampling. Attachment C contains a second example of a sample request letter sent to residents in the neighborhood of at a project in Cincinnati, Ohio.

Once the access agreement is received, the OSC or RPM can call the resident by telephone to schedule a sampling appointment. For past projects, U.S. EPA has used Community Involvement Coordinators (CIC) to send out the sample request letters. If needed, a second or third mailer can be sent out that could generate additional positive responses.

It is important to track to whom letters have been sent to and how many times letters have been sent in case the property owner questions whether he or she has ever been contacted to request sampling and to document U.S. EPA's attempts in case access never is granted.

5.2.2 Public Meetings and Availability Sessions

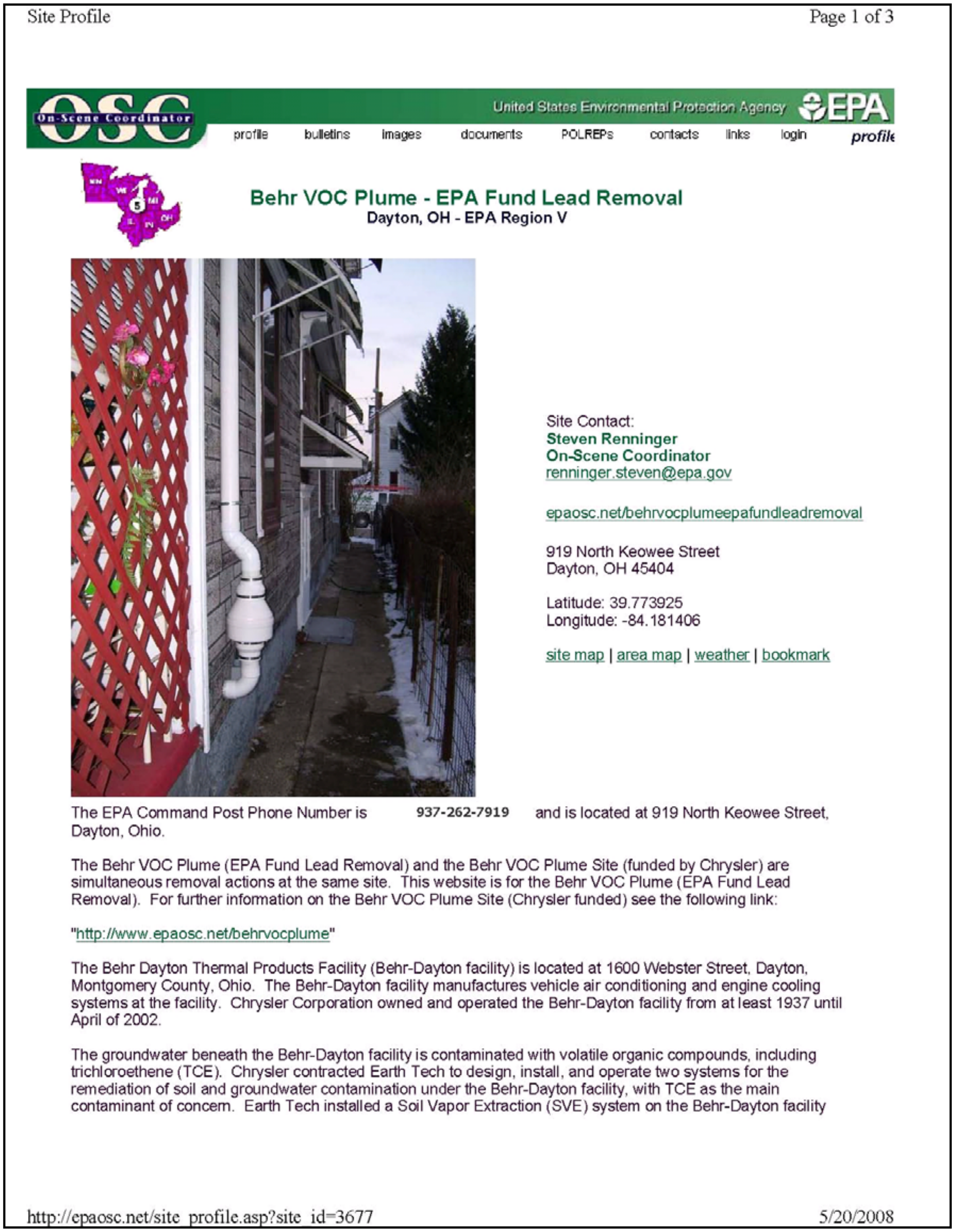
The U.S. EPA OSC or RPM can conduct a public meeting or availability session to gain access to properties for sampling. The public meeting forum allows the OSC or RPM to explain the site history and U.S. EPA's plans. The meeting or availability session allows U.S. EPA to explain VI, the sampling strategy, and how results will be presented to the public, and allows residents to "sign-up" for sampling. Additionally, it is very useful to invite local or state health departments and ATSDR representatives to these events so that they can answer health-related questions.

U.S. EPA OSC and Community Involvement Coordinator conducting public meeting for Behr Dayton VOC Removal Site

For the Behr Dayton VOC Removal Site, U.S. EPA conducted a public meeting and explained the sampling strategy. U.S. EPA tasked its START contractor to have access agreements available at the back of the room for signing after the meeting and to schedule sampling times. This method generated access to more than 50 sampling locations during one public meeting.

5.2.3 U.S. EPA Website

OSCs can utilize http://www.epaosc.org/ to develop a site-specific website that allows the community to see photographs, read about the project status, and sign up for sampling. The next page shows the website used for the Behr Dayton VOC Removal Site. In some circumstances, it may also be possible for RPMs to use this resource.



Site Profile Page 1 of 3

Behr VOC Plume - EPA Fund Lead Removal
Dayton, OH - EPA Region V

Site Contact:
Steven Renninger
On-Scene Coordinator
renninger.steven@epa.gov

epaosc.net/behrvocplumeepafundleadremoval

919 North Keowee Street
Dayton, OH 45404

Latitude: 39.773925
Longitude: -84.181406

site map | area map | weather | bookmark

The EPA Command Post Phone Number is **937-262-7919** and is located at 919 North Keowee Street, Dayton, Ohio.

The Behr VOC Plume (EPA Fund Lead Removal) and the Behr VOC Plume Site (funded by Chrysler) are simultaneous removal actions at the same site. This website is for the Behr VOC Plume (EPA Fund Lead Removal). For further information on the Behr VOC Plume Site (Chrysler funded) see the following link:

"http://www.epaosc.net/behrvocplume"

The Behr Dayton Thermal Products Facility (Behr-Dayton facility) is located at 1600 Webster Street, Dayton, Montgomery County, Ohio. The Behr-Dayton facility manufactures vehicle air conditioning and engine cooling systems at the facility. Chrysler Corporation owned and operated the Behr-Dayton facility from at least 1937 until April of 2002.

The groundwater beneath the Behr-Dayton facility is contaminated with volatile organic compounds, including trichloroethene (TCE). Chrysler contracted Earth Tech to design, install, and operate two systems for the remediation of soil and groundwater contamination under the Behr-Dayton facility, with TCE as the main contaminant of concern. Earth Tech installed a Soil Vapor Extraction (SVE) system on the Behr-Dayton facility

http://epaosc.net/site_profile.asp?site_id=3677 5/20/2008

U.S. EPA Website for Behr Dayton VOC Removal Site

5.2.4 Door-to-Door Visits

Another method to use is to go door-to-door to obtain signed access agreements. Depending on the time of day when one would go door-to-door, the results could vary. At the Behr VOC Plume site, U.S. EPA CIC, the START contractor and the local health department walked door-to-door throughout the area of concern to obtain signed access agreements. This method generated numerous signed access agreements.

5.3 After the Access Agreement Form is Signed, What's Next?

Once the access agreement is signed, a sample date and time should be scheduled. Attachment D provides an example of the Residential Sample Reminder Form. This form should be filled out and either given to or mailed to the location to be sampled to remind residents when the sampling team will visit. Homeowners like this form because they can place it on their refrigerators as a reminder. The form also provides information such as how many samples will be collected, where the samples will be collected from, instructions to ensure the integrity of the air samples, and contact information in case the sampling time needs to be rescheduled.

5.4 How Do I Deal with Reluctant Home and Building Owners?

Access to owner-occupied residences may be handled differently than for commercial buildings or rental properties. Allowing U.S. EPA to sample and install mitigation systems in an owner-occupied residence is a voluntary action. Homeowners who occupy their properties should be encouraged to take advantage of the offered assessment activities or mitigation system. However, U.S. EPA should not continue to pressure reluctant homeowners once sufficient information has been communicated regarding health risks and the benefits of mitigation. U.S. EPA can also request the assistance from the local health department to meet with owners and occupants to explain the need for sampling or the installation of a mitigation system.

For commercial buildings and residential rental properties, property owners may be making sample access decisions for families living in rental properties. For example, if the property owner of a residential rental property refuses access, U.S. EPA may request the assistance of the local health department to write a letter to the property owner to describe why the sampling is necessary and to inform the owner of his or her obligation to ensure that the rental property is safe for occupancy.

Owners who currently occupy their residences should be advised that if they decline an offer for installation of a vapor mitigation system and change their minds in the future, they may be responsible for the costs of installing and maintaining their own systems.

The number of attempts to obtain access to perform a VI assessment or install a mitigation system should be consistent with regional practice. In general, more than one attempt to obtain access is recommended. All attempts should be documented using telephone conversation records or letters sent to home and building owners. All requests for access as well as the provision of access should be in writing to document U.S. EPA's due diligence.

At properties in Region 5 for which initial access could not be obtained, additional access request letters were mailed. At least two to three attempts are sometimes needed to gain access. If access is still not granted after multiple attempts, the property location should be documented and the local health department should be informed that access could not be obtained for VI sampling.

5.5 How Should I Track Ownership Changes for Owner-Occupied Residences that Did Not Provide Access?

For homes and buildings where access was not provided for assessment sampling or installation of a mitigation system, OSCs and RPMs should make reasonable attempts to track ownership changes as long as U.S. EPA is involved at the site. These attempts could include contact on an annual basis, drive-by visits, communication with community representatives, and other approaches. Reasonable attempts could also include an annual site inspection during which nearby homes and buildings for sale are noted. If ownership changes are found, then appropriate follow-up should be conducted with the new home or building owner.

5.6 What Specific Information or Instructions Should be Provided to Residents Before IA Samples are Collected?

Standardized fact sheets should be used to inform home and building owners about potential household sources of IA contamination, steps the home or building owner can take to minimize such sources, and steps the U.S. EPA will take to minimize risks. Some common household sources of background IA contamination include nail polish remover, paints and paint thinner, dry-cleaned items, scented candles, and cleaning fluids. Attachment E provides examples of fact sheets provided by the ODH. Fact sheet information should be reviewed with the home or building owner before sampling begins.

The occupants of the property to be sampled should be informed of the guidelines below.

- Do not to smoke in close proximity to the SUMMA canisters.
- Leave doors and windows closed during sampling.
- Try not to enter the room where sampling is being conducted.
- If possible, do not bring home dry-cleaned items during the sample period.
- Do not touch the SUMMA canisters during sampling.

5.7 How Can I Educate Communities about Consumer and Household Sources of IA Contamination to Minimize Interference with VI Studies?

As discussed in Section 5.6, standardized fact sheets should be used to inform home and building owners about potential household sources of IA contamination, steps the home or building owner can take to minimize such sources, and steps the U.S. EPA will take to minimize risks. This information should be reviewed with the home or building owner, and a plan should be developed to remove consumer and household sources of IA contamination before sampling begins. In addition, the home or building owner should be informed that once a VI system is installed, the system will protect the home or building only against chemicals coming from the ground but will not protect the home against continuing indoor sources because VI mitigation systems are not IA filtration systems. Home or building owners also should be informed that it is in their best interest to minimize consumer and household sources of IA contamination not just during sampling events but over the long term as well.

Section 6. Sampling Methodology and Procedures

Before sampling is conducted at a property, **the property owner or tenant (if the property is a rental property) must sign an access agreement** as discussed in Section 5 above. This section discusses the VI sampling methodology and procedures, including laboratory requirements, SS sampling, IA sampling, co-located IA and duplicate SS air sampling, ambient air sampling, building basement types, use of a mobile laboratory or field-portable gas chromatograph/mass spectrometer (GC/MS), and data management.

6.1 Laboratory Requirements

Once the COCs have been determined, prior to sampling, U.S. EPA OSCs and RPMs can consult with the state health department and/or ATSDR for recommendations on SS and IA screening levels. There will be separate screening criteria for residential and commercial/industrial locations. Once the screening levels are established, the laboratory should be consulted to verify that its reporting limits are lower than the established screening levels. For example, if the IA screening level for TCE is 0.4 ppbv (2.15 $\mu g/m^3$), the laboratory's reporting limit for TCE should be less than this value. For SUMMA canister samples analyzed for VOCs or PHs, U.S. EPA Method TO-15 should be used for sample analysis.

The SUMMA canisters and regulators used to collect IA samples should be individually "certified" cleaned by the laboratory to ensure that low detection limits can be achieved. The SUMMA canisters used for SS samples are cleaned but are typically only "batch" certified, which means that one out of every 10 or 20 SUMMA canisters is "certified" cleaned. For these reasons, IA sampling is generally more expensive than SS sampling. In addition, it is therefore important to make sure that the laboratory properly labels which SUMMA canisters are "certified" cleaned for IA sampling and which canisters have been cleaned but not "certified" for SS sampling. Some laboratories may just "certify" clean both IA and SS SUMMA canisters to avoid confusion in the field.

6.2 SS Sampling

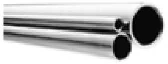
SS samples are collected to confirm the presence of a site-related COC beneath the foundation of a property. Before SS sample collection, SS sampling ports should be installed and sampled in accordance with the U.S. EPA Response Engineering and Analytical Contract (REAC) SOP #2082 (Attachment F). A vacuum (such as a shop-vac) equipped with a high-efficiency particulate air (HEPA) filter should be used during installation activities to minimize the impact of concrete dust on the property and the sampler during drilling activities.

The following sections describe the SS sampling equipment and supplies, temporal considerations, spatial considerations, SS sample collection, and the use of a tracer gas to test for leakage during SS sampling.

6.2.1 SS Sampling Equipment and Supplies

The table on the next page provides an example list of materials and tools usually necessary to install sub-slab sampling ports and generally conduct SS sampling. The list is only an example, and many alternate models or equipment can be purchased from alternative vendors.

Equipment	Example Vendor
Hilti Hammer Drill, SDS-Plus or equivalent 	Hardware store
3/8-inch masonry bit – greater than 16 inches long 	Hardware store
1-inch masonry bit about 6 inches long 	Hardware store
18- to 20-inch tool bag with shoulder strap	Hardware store
Two 9/16-inch wrenches	Hardware store
One ½-inch wrench	Hardware store
One ¾-inch wrench	Hardware store
Needle-nose pliers	Hardware store
DeWalt Portable Shop Vac (Model DC500) or equivalent	Hardware store
HEPA filter for Shop Vac (Model DC500) or equivalent	Hardware store
Pipe cutter (stainless steel tubing cutter)	Hardware store
Pipe thread tape	Hardware store
One 3/8-inch drive ratchet	Hardware store
One ¼-inch Allen socket for a 3/8-inch drive ratchet	Hardware store
Quickcrete or equivalent	Hardware store
Plastic tablespoons	Hardware store
50-foot-long extension chord	Hardware store
Combo ReelCord (or equivalent extension chord with built-in power strip and GFCI)	Hardware store
Three-prong to two-prong adapter	Hardware store
Scissors	Hardware store
Light bulb socket adapter	Hardware store
Work light and a flashlight	Hardware store
Extra light bulbs (for basements that have burned out bulbs)	Hardware store
Dry erase board – letter size	Walmart or equivalent
Dry erase markers	Walmart or equivalent
Small zippered bag to hold small tools	Walmart or equivalent
Water bottle and Ziploc bags	Walmart or equivalent
Paper towels	Walmart or equivalent

Equipment		Example Vendor
Digital manometer (range: 0 to 1 inch water column) Model 475-000-FM (Series 475 Mark III)		Dwyer Instruments, Inc. (or equivalent) www.dwyer-inst.com
¼-inch-outside diameter (OD) Teflon tubing **Note:** Some Teflon tubing may contain elevated levels of perfluorinated hydrocarbons.)		Total Safety or equivalent
Modeling clay (white, gray or colorless)		Craft store
¼-inch-OD stainless-steel tubing (SS-T4-S-035-20) – Chromatographic grade		Swagelok or equivalent http://swagelok.com/
¼-inch compression to ¼-inch female connector (National Pipe Thread [NPT]) (SS-400-7-4)		Swagelok or equivalent
¼-inch compression to ¼-inch male connector (NPT) (SS-400-1-4)		Swagelok or equivalent
¼-inch ferrule sets (SS-400-Set)		Swagelok or equivalent
¼-inch Teflon-coated plug (4534K12) **Note:** Use Teflon tape to wrap threads of plug before installation.		McMaster-Carr or equivalent www.mcmaster.com

6.2.2 Temporal Considerations

Temporal factors can greatly affect SS sample results. Temporal factors affecting SS sampling include seasonal changes in building depressurization due to the use of fireplaces, heaters, open windows, air conditioners, or wind; the movement of subsurface SG from barometric pumping caused by both diurnal and longer-term atmospheric pressure changes; and temperature effects on contaminant partitioning. There have been sites where the timing of the sampling is correlated with the depth of the water table. Ideally, these factors should be considered when developing a sampling and analysis plan and evaluating data.

6.2.3 Spatial Considerations

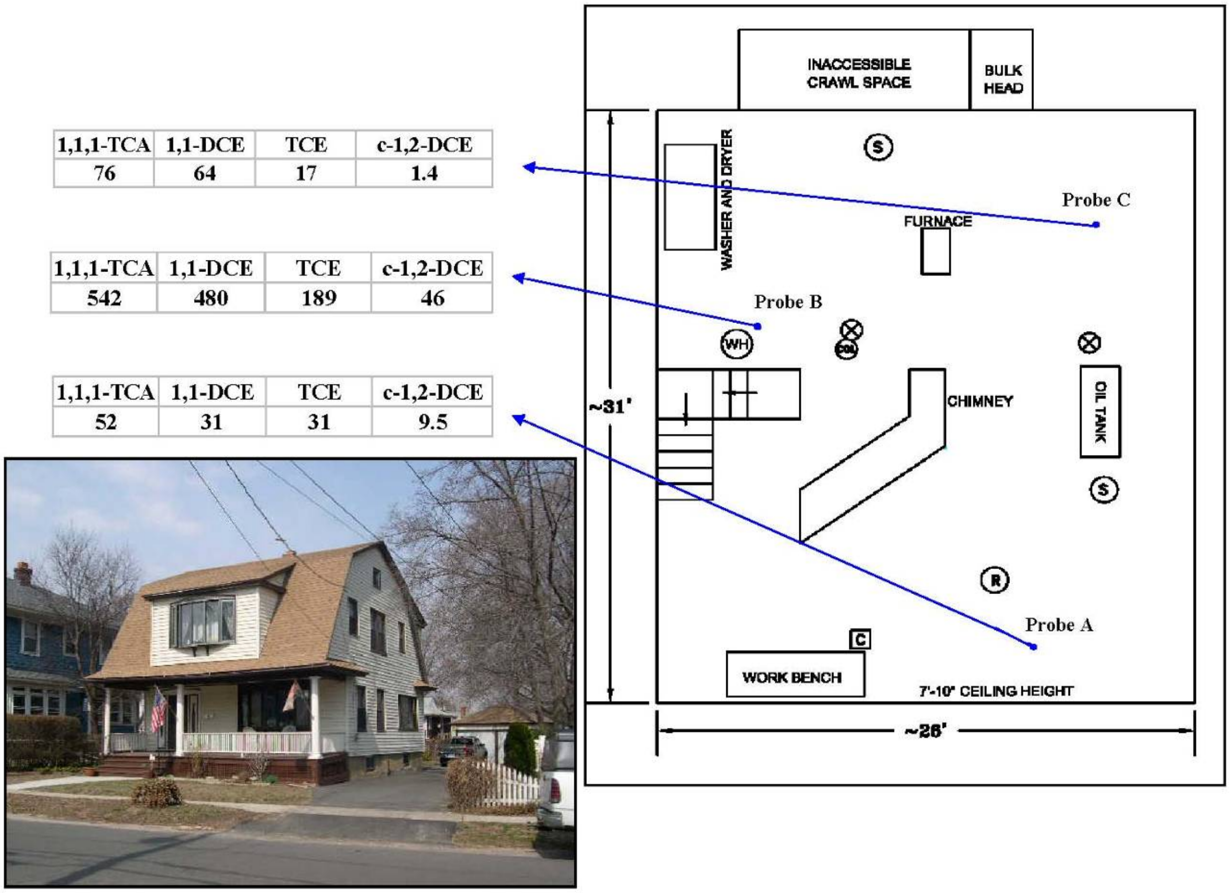
Past sampling results show considerable variation in contaminant levels measured in SS air even when the source is relatively homogenous. Therefore, at least one SS sample should be collected from each property, if possible. If a single sampling location is used, it should be located in the lowest point of the property (such as the basement) and approximately in the middle of the room where concentrations are expected to be highest while potentially having the greatest radius of influence for SS air across the footprint of the basement.

If more than one SS sample is collected, the sampling locations should be spaced to adequately cover the floor space of the basement or lowermost floor. Properties where the collection of more than one SS sample is particularly desirable include schools and multi-family homes, basements where a concrete footer divides the basement into two sections, and when the area of the basement or slab exceeds 1,500 square feet (ft^2).

Based on SS data collected to date, there appears to be significant spatial variability in SS concentrations even over an average-sized basement. Recommendations about how many SS samples to collect vary, ranging from one SS sample for every 330 ft^2 (or two to three samples for every average-sized home) to one SS sample for an average residential dwelling of 1,500 ft^2.

Although it may be desirable to collect several SS from a building in order to gain statistical information, this approach may not be practical because of (1) construction considerations (such as the presence of utilities, floor condition, floor materials, finished basements, post-stressed concrete, etc.), (2) reluctance of the owner to grant permission to install multiple sampling ports, and (3) cost considerations. However, whenever possible, multiple ports should be installed at a percentage (minimum recommended 10 percent) of the sampled buildings in order to allow a check for variability in an area.

Figure 5 on the next page shows an example of spatial variability in SS sample results for one residence.



1,1,1-TCA	1,1-DCE	TCE	c-1,2-DCE
76	64	17	1.4

1,1,1-TCA	1,1-DCE	TCE	c-1,2-DCE
542	480	189	46

1,1,1-TCA	1,1-DCE	TCE	c-1,2-DCE
52	31	31	9.5

Figure 5 - Example of Spatial Variability in SS Sampling

Certain situations should trigger discussions about the need for additional (or possibly fewer) SS sampling locations than those recommended above. Such situations include very large or small homes or buildings, buildings with more than one foundation floor type, subsurface structures or conditions that could facilitate or mitigate VI, multi-use buildings with sensitive populations in segmented areas (such as day care facilities), and areas of buildings directly above the subsurface with constant occupancy (as opposed to occasional occupancy). For larger structures, a statistician can help determine the numbers and placement of sampling ports to ensure that the DQOs are met.

6.2.4 Special Considerations

Considerations for SS sampling are listed in Section D.6 of Appendix D of the ITRC 2007 Guidance and are summarized below.

- SS sampling should be avoided in areas where groundwater could intersect the slab.
- Underground utilities and structures (such as electric, gas, water, tension rods, and sewer lines) should be located and avoided.

- If a vapor barrier already exists under the slab, SS sampling could puncture the barrier, so the hole must be carefully resealed after monitoring is complete.
- For basements, primary entry points for vapors could be through sidewalls rather than from below the floor slab, so SS sampling may require augmentation by collecting samples through basement walls.

6.2.5 SS Sample Collection

SS samples are typically collected using 6-L SUMMA canisters fitted with a flow orifice pre-calibrated to collect a 6-L air sample over a 24-hour period. For commercial properties, the sampling period may or may not be reduced to 8 hours. The 6-L SUMMA canister is connected to a stainless-steel vapor probe using Teflon tubing. Once the 24-hour sampling period is complete, a vacuum check of the SUMMA canister should be conducted and documented, the SUMMA canister brass Swagelok$^{®}$ cap should be installed, and the SUMMA canister should be boxed and shipped to the laboratory for analysis within the sample holding time.

At the start of the sampling event, a pressure gauge vacuum reading should be performed and the value recorded. An initial vacuum reading typically exceeds -28 inches mercury (Hg) (a pressure measurement). Typically, the canister is deployed at approximately -30 inches Hg and should be turned off at a lower negative pressure (between -1 to -10 inches of Hg). The slight negative pressure ensures that the canister fills over the entire planned sampling period. If the canister flow controller shows 0 inch Hg (atmospheric pressure), samplers have no way of knowing if the canister filled over the planned sampling duration or over a shorter timeframe. At the end of the sampling period, a pressure gauge vacuum reading should be performed again and the value recorded. The U.S. EPA ERT recommends that an ending vacuum reading between -1 and -10 inches Hg indicates that a valid sample was collected. If the final vacuum reading exceeds -10 inches Hg or is less than -1 inch Hg, another sample should be collected.

SS air samples should be labeled with a unique sample designation number (for example, 123Main-SS-101510). One may also consider using a unique coded identification number for residential samples to maintain “confidentially” in the event the sampling data will be shared with the public, lawyers, or uploaded onto websites. Both the sample number and the sample identification information should be recorded on the Air Sampling Field Form in Attachment G).

Note: For high-altitude sampling, the pressure reading may differ significantly from measurements performed in the laboratory. Additionally, the flow rates on the flow controller need to be adjusted for the situation. The flow controllers measure a volumetric amount that is flowing, not a mass amount. At high altitudes, there is less mass (fewer molecules) in the same volume.

6.2.6 Use of Tracer Gas to Test for Leakage during SS Sampling

Tracer gas is used to assess the integrity of sampling equipment. A tracer compound can provide quantitative proof of the integrity of a probe seal by demonstrating that breakthrough of air from the surface is not occurring. Immediately before sampling, the tracer compound should be placed around the SS probe tubing at ground surface. The tracer compound selected should not be present in SG and should be detectable with sufficient sensitivity. If the probe has been installed and sealed correctly, little or no tracer compound will be detected in the SG sample. If the tracer compound selected is observed at a concentration approaching or greater than 1 part per million, it is reasonable to assume that the SG probe has a leak and another SG probe should be installed and sampled.

If temporary probes are used for sampling, the use of tracer gas is highly recommended. Experienced personnel should be consulted before sampling procedures are determined, including evaluation of the need for tracer gas. U.S. EPA has developed analytical SOPs (U.S. EPA TO-14, TO-15, and TO-17) for specific requirements for tracer gas and specific tracer gas detection limits that support the selection of the tracer gas for specific sites.

If permanent probes are used for sampling, a leak test still is recommended to verify an adequate seal, at least during the first round of sampling. At some commercial or industrial sites, a leak test may be necessary before each sampling event because the top of the permanent SG sampling point may have been damaged or impacted by daily operations and repair of seal may be needed.

Section D.4.7 of the ITRC 2007 guidance provides additional information on leak testing using tracer gas, including the advantages and disadvantages of various liquid and gas tracer compounds.

Spraying of isopropyl alcohol as a leak check

6.3 IA Sampling

IA samples are collected to confirm the presence of a site-related contaminant in the indoor environment and to allow risk calculation. The following sections discuss the collection of SS samples before IA samples, the VI Resident Questionnaire, IA sampling prescreening, and IA sample collection.

6.3.1 Collection of SS Samples before IA Samples

Until recently, most VI investigation approaches have recommended that SS samples be collected first to determine if IA sampling is required. However, simultaneous SS and IA sampling can be conducted if proper IA screening techniques are followed. Simultaneous collection of SS and IA samples is advantageous because (1) SS and IA sample results can provide a paired set of data, increasing the understanding of the relationship between SS and IA concentrations, (2) environmental sampling contractor re-mobilization costs are reduced or eliminated, and (3) disturbance of property owners and residents is reduced.

6.3.2 VI Resident Questionnaire

Before IA samples are collected, the VI Resident Questionnaire in Attachment H should be filled out. The VI Resident Questionnaire form can be used to record information about sources of chemicals within the residence that could be detected in IA samples. The form also can be used to record site-specific information about household features that can help in the interpretation of analytical data.

For petroleum sites, it is important to consider consumer chemical product impacts and contributions to IA quality. Many household products contain petroleum compounds. Therefore, the questionnaire needs to account for the variety of household products and building construction materials typically used in each household. If sampling is to be conducted at a residence after a gasoline spill, cars must be removed from attached garages for at least 24 hours before sampling is conducted.

6.3.3 IA Sampling Prescreening

IA sampling prescreening includes a physical survey of the structure to be sampled conducted in conjunction with an interview of the occupants of the structure. The purpose of the physical survey is to obtain data to allow qualitative assessment of factors that could influence IA quality. The physical survey includes collecting information on the building configuration, such as layout, attached garages, utility entrances into the building, ventilation system design, foundation conditions, the presence of a foundation sump, building material types (including recent carpeting or linoleum installation and painting), the presence of fireplaces, the location of laundry facilities, and other information.

The physical survey also includes collecting data related to IA quality, such as use of cleaning products, the presence of dry-cleaned items, use of carpet-cleaning services, indoor storage of paints or PH products, use of aerosol products, presence of smokers, occupant hobbies, and other information. The VI Resident Questionnaire form in Attachment H includes questions related to IA quality.

It is also recommended that potential IA sources be removed from the structure at least 24 hours before sampling begins based on an air exchange rate of 0.2 per hour. Potential IA sources include household and consumer product chemicals such as paints, gasoline, dry-cleaned items, and nail polish remover. A secure location for storing the removed products should be identified such as an outside shed. Alternately, the items could be triple-bagged and placed in the garage or outside. If sampling for SS vapors only, it is not necessary to remove potential IA sources. However, if IA by itself is being sampled or IA air together with crawl space or SS is being sampled (an option in U.S. EPA Region 5), potential IA sources should be removed.

An inventory of household or other products in the building that could be sources of volatile chemicals is particularly important if potential sources cannot be removed. Such an inventory often is useful even if the sources can been removed. The inventory should document all sources of volatile chemicals present (or formerly present) in the structure. Section 1.6.1 of ITRC 2007 guidance provides greater detail about this issue.

A residence or building also can be surveyed for VOC contributions to IA from indoor sources. The U.S. EPA ERT's TAGA mobile laboratory or a photoionization detector (PID) that can detect ppb levels can be used. However, the PID may not be sensitive enough for very low-concentration sources. More information about the TAGA laboratory is available by contacting David Mickunas, TAGA Coordinator, at mickunas.dave@epa.gov or (919) 541-4191.

The ppbRAE or equivalent, low-level VOC PID can be used to determine if chemicals are present in the sampling area. The ppbRAE instrument is used because if its capability to analyze VOCs in the ppb-range. The ppbRAE or equivalent must be calibrated and the calibration results documented before it is used. Care should be taken not to fog the lens of the ppbRAE from changes in temperature or humidity.

Note: U.S. EPA's use of the term ppbRAE does not imply endorsement of the ppbRAE manufacturer.

Because of fire and explosion considerations, direct-read instrumentation should also be used in addition to or along with SUMMA canister priority testing for VI investigation for petroleum and petroleum by-products. These instruments can include multi-gas/explosive meters and the TVA-1000 for PID and flame ionization detector (FID) readings along with Tedlar bag sample collection. Direct-read instrumentation also can selectively be used to determine methane concentrations along with total hydrocarbon concentrations.

6.3.4 IA Sample Collection

IA samples typically are collected using 6-L SUMMA canisters equipped with critical-orifice flow regulation device sized to allow the collection of an air sample over a 24-hour sampling period. At least one IA sample should be collected from each property. Larger residential or commercial properties often require that more IA samples be collected as discussed below. IA samples should be collected from the lowest point on the property that has the potential for frequent use (such as the basement). If the property has a basement and only one IA sample is collected, the sampling location should be approximately in the middle of the room and close to the breathing level of a seated person (2 to 3 feet above the floor). If more than one IA sample is collected, the locations should be spread out to adequately cover the floor space of the basement. If the property does not have a basement that can frequently be used, the sampling device should be placed in a bedroom, preferably the master bedroom or the bedroom of the youngest child.

Care should be taken to deploy SUMMA canisters away from the direct influence of any forced air from air conditioning units, central air conditioning vents, furnaces, or heaters. Also, during the sampling period, exterior doors and windows generally should be kept closed. Heating, ventilation, and air conditioning (HVAC) systems should be operated normally to be representative of actual living conditions. HVAC operation should be noted and considered when determining if additional tests are required (such as during different seasons). IA concentrations due to VI will vary over time and are likely (but not necessarily) higher during the winter season. SUMMA canisters should be deployed in areas not subject to disturbances and not at locations that interfere with the occupant's normal activities.

Air samples should be labeled with a unique sample designation number (for example, 123Main-IA-101510). One may also consider using a unique coded identification number for residential samples to maintain "confidentially" in the event the sampling data will be shared with the public, lawyers, or uploaded onto websites. Both the sample number and the sample identification information should be recorded on the Air Sampling Field Form in Attachment G.

The SUMMA canister vacuum should be recorded immediately before canister deployment and recorded on the Air Sampling Field Form. The initial vacuum should be greater than -28 inches of Hg. The critical-orifice flow controller as supplied by the laboratory should then be installed on the canister, and the SUMMA canister should be opened at the beginning of the sample collection period. The sampling start time and initial vacuum should be recorded on the Air Sampling Field Form.

Other information that should be recorded on the Air Sampling Field Form includes temperatures at the start and end of the sampling period, basement depth, equipment serial numbers, sample type (such as baseline, post-mitigation, etc.), the sampler's name, and any comments. Photographs of the sampling event should also be taken, including the inside and outside of the property where the sampling occurred.

The SUMMA canister valve should be closed at the end of the sample period (usually after 24 hours), and the end time should be recorded on the Air Sampling Field Form. If there is evidence of canister disturbance during sample collection, this fact also should be recorded on the Air Sampling Field Form.

The SUMMA canister vacuum should be measured immediately after canister retrieval at the end of the sampling period and recorded on the Air Sampling Field Form. An ending vacuum reading between -1 and -10 inches Hg indicates that a valid sample was collected. If the final vacuum reading is greater than -10 inches of Hg or less than -1 inch of Hg, another indoor air sample should be collected. Once the vacuum is measured, the brass Swagelok® cap should be securely tightened on the inlet of the SUMMA canister.

6.4 Co-Located IA and Co-Located SS Air Sampling

One way to check the integrity of the laboratory IA data is to collect a co-located IA sample adjacent to another IA sample. The sample ports should be placed side by side during the sampling period. U.S. EPA may collect co-located samples during PRP oversight activities to check the integrity of the PRP consultant's laboratory results.

One way to check the integrity of a SS sample is to attach a splitter to the sample tubing to allow two SUMMA canisters to collect an air sample at the same time. This procedure can be used to collect a co-located air sample or when an U.S. EPA OSC or RPM would like to co-locate an air sample along with the PRP consultant's SS air sample.

Co-located (Side-by-Side) IA sample collection (left) and co-located SS air sample collection (right)

6.5 Ambient Air Sampling

It is good general practice to collect at least one ambient air sample on a day that IA samples are collected in order to provide a baseline against which the IA sample results can be compared. Outdoor ambient air samples should be collected from a representative location, preferably upwind and away from any wind obstructions such as trees and buildings. The ambient air sample allows the U.S. EPA OSC or RPM to determine if outside VOC concentrations may contribute to the IA sample results.

Nearby buildings with air emissions from commercial or industrial facilities should be considered as potential interferences. Relevant meteorological data (such as barometric pressure, temperature, wind direction and speed) should be collected and documented during the ambient air sampling event.

Outdoor ambient sampling should begin at least 1 hour and preferably 2 hours before IA sampling begins and continue until at least 30 minutes before IA sampling is complete. This practice is recommended because most buildings have an hourly air exchange rate in the range of 0.25 to 1.0 per hour, which means that air entering a building before IA sampling can remain in the building for a long time (ITRC 2007).

6.6 Building Basement Types

Buildings completed below grade with basements or partial basements may be prone to VI for several reasons. Floors and walls may have small voids and cracks that allow SG to enter the building. Basements with earthen floors are especially susceptible to VI because of the large surface area for SG migration into the overlying structure, especially if ventilation is not present to dilute significant vapors. Finished basements (with living spaces) also can be of concern because of a combination of insufficient ventilation and frequent use. Other "red flag" buildings include those with basements sumps, walls with moisture barriers, and walls that are wet during the rainy season. Evidence of drywells, cisterns, or other voids below basements should be identified because these could be preferential pathways for VI.

This section describes five types of basements. Each type has a unique sampling approach to determine if VI is occurring.

6.6.1 Concrete Floor

Basements with concrete floors can be finished or unfinished. Initially, at least one SS and one IA sample should be collected from a concrete-floor basement, preferably near the middle of the basement.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Finished concrete-floor basement

6.6.2 Concrete Floor with Dirt Crawl Space

Sometimes a section of the basement has a concrete floor and is next to a crawl space lined with dirt or rock. Initially, at least one SS sample should be collected from the concrete-floor section of the basement and one IA sample should be collected from the crawl space area.

Dirt crawl space

6.6.3 Dirt Floor

For basements with dirt floors only, only one IA sample should be collected. No SS sample is required. Some basements may have a partial slab large enough to allow vapors to accumulate and to allow installation of a sampling port. Rock outcrops in basements can potentially create routes for seepage of contaminated groundwater and vapors, and in these cases, IA sampling should be conducted.

Basement with dirt floor

6.6.4 Dirt Crawl Space Only

Structures having only a dirt crawl space beneath the foundation only require an IA sampling within the crawl space area.

Dirt crawl space beneath foundation

6.6.5 No Basement or Slab Foundation

Property on slab foundation with no basement

Initially, at least one SS and one IA air sample should be collected from the main floor in structures with no basements (slab foundations). The samples should be collected from near the middle of the structure.

6.7 Use of Mobile Laboratory or Field-Portable GC/MS

A mobile laboratory can be a faster, more cost effective way to expedite site characterization for VI. However, mobile laboratories may be more operator-dependent than samples analyzed at a fixed laboratory. The mobile laboratory may use U.S. EPA Method 8021B Modified or U.S. EPA Method 8260 Modified. These methods originally were written for water and soil sample analysis and have been modified for SG analysis. Data may be biased high (or low) for an air-specific method such as TO-14A or TO-15. U.S. EPA recommends that results for at least 10 percent of the mobile laboratory samples be confirmed through analysis at a fixed laboratory using U.S. EPA Method TO-14A or TO-15.

U.S. EPA Region 5 has used the ERT's TAGA mobile laboratory to analyze air samples from VI projects. The TAGA mobile laboratory operates under ERT's Scientific, Engineering, Response & Analytical Services Contract (SERAS). At the Highway 7 and Wooddale Avenue Project in St. Louis Park, Minnesota, U.S. EPA's ERT SERAS contractor installed approximately 268 SS sample probes at a combination of residential and commercial/industrial properties. The TAGA unit was used to analyze SS air samples (using a modified U.S. EPA Method TO-15 analysis), and the results were compared to screening levels established by the state health department.

The TAGA unit is self-contained and capable of real-time sampling and analysis at the part-per-trillion-by-volume level for outdoor air, IA, and emissions from various environmental sources. Each TAGA unit is equipped with the TAGA triple-quadruple mass spectrometer, a state-of-the-art Agilent GC/MS for VOC analysis, and an Agilent MicroGC for permanent gas analyses. Three TAGA systems in buses and one TAGA system in a trailer currently are available. Two TAGA buses are located in Edison, New Jersey; one TAGA bus is located in Las Vegas, Nevada; and the TAGA trailer is located in Research Park, North Carolina. More information concerning the TAGA laboratory, its capabilities, and its schedule is available from Dave Mickunas, TAGA Coordinator, at mickunas.dave@epa.gov or (919) 541-4191. Attachment I contains a paper written by Dave Mickunas which explains how the TAGA can be used to resolve VI issues.

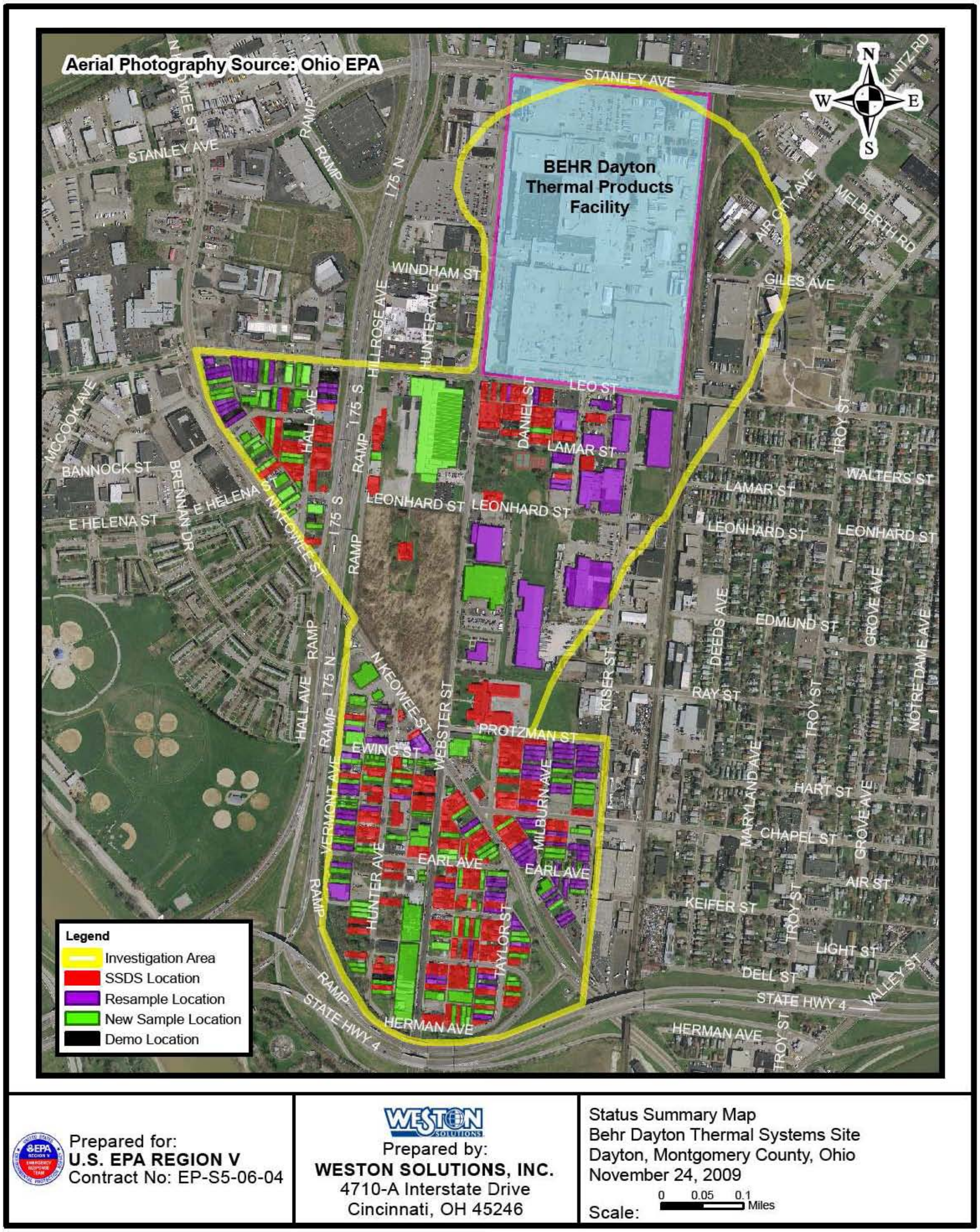
Instrumentation in a TAGA bus

A field GC/MS can be another useful tool for VI investigation. A field GC/MS may be used to identify pathways, such as gaps around utility conduits, transmissive slab cracks, or even migration of VOCs through electrical outlets. The field GC/MS is not a "point-and-shoot" instrument but may be useful for screening purposes at many sites.

6.8 Data Management

Sample data management is required to maintain data organization and tracking. A single person should be tasked with maintaining a spreadsheet or database that organizes sampling location data, contact information, access agreement status, sampling dates, sample identification numbers, sample result mapping, status summary mapping, and all other sample-related information.

As data are reported by the laboratory, results can be managed in different ways. If there are only a few COCs, a spreadsheet can be used to manage the data. Attachment J provides an example Excel spreadsheet used for the Behr Dayton VOC Removal Site to manage sampling results for more than 400 sampling locations. If there are many COCs and many sampling locations, SCRIBE should be used to manage the sample data. SCRIBE is a U.S. EPA data management tool that allows users to import laboratory electronic data deliverables (EDD) into the program. SCRIBE also allows users to query specific data values for efficient data management. More information about SCRIBE is available at website address http://www.ertsupport.org/scribe_home.htm.



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Status Summary Map
Behr Dayton Thermal Systems Site
Dayton, Montgomery County, Ohio
November 24, 2009
Scale: 0 0.05 0.1 Miles

Example of a Color-Coded Status Summary Map

Section 7. Communication of Sampling Results

This section discusses the communication of sampling results by answering some FAQs.

7.1 How Should Building Owners be Notified of Sampling Results and the Need for a VI Mitigation System?

Validated sampling results generally should be provided to property owners and tenants within 30 to 45 days of receipt of the results or sooner if the sampling data can be quickly validated. A transmittal letter should indicate which future actions are necessary, if any, based on the sampling results. It is important for OSCs and RPMs to communicate the fact that the decision to install a VI mitigation system is based on a calculated risk that reflects many conservative and health-protective factors.

The initial notification to residents and owners that their homes and buildings have been selected to receive VI mitigation systems can be delivered in various ways. A primary way is a face-to-face meeting with the building owner or occupant (with health department officials in attendance) to explain the sampling results and next steps, including installation of a system. Another method is a data transmittal letter. However, in many cases, the decision to install a mitigation system will not have been made before the transmittal of sampling results. In these cases, data transmittal letters can be sent to indicate that U.S. EPA is reviewing all data results for the study area and is considering appropriate next steps. Then, once the decision document is signed, a fact sheet can be developed and mailed to all community members in the affected area, and a community meeting should be planned.

An example project discussing the communication of sampling results is presented below.

Example Project: Communication of Sampling Results
Behr Dayton VOC Removal Site, Dayton, Ohio

As sample results were received from the laboratory, the results were summarized in a letter that could be easily understood by property owners and tenants. At the Behr Dayton VOC Removal Site, there were basically two categories of properties: properties requiring no further action and properties requiring mitigation. Each type is discussed below.

Properties Requiring No Further Action

During the U.S. EPA removal action, properties that did not show SS or IA concentrations exceeding site-specific screening levels (10^{-4} risk levels) were mailed letters summarizing sampling results and indicating that “No Further Action” was required by U.S. EPA. Attachment K provides an example of a “No Further Action” letter.

During the removal action at the Behr Dayton VOC Removal Site, U.S. EPA re-sampled properties biennially (during the 2010 remedial investigation) that had already been sampled once (in 2008) and initially provided “No Further Action” letters due to an undefined TCE groundwater plume. U.S. EPA also required re-sampling to include new SS probes at least 20 feet from initial SS probes to account for potential spatial variability in SS gas that may be accumulating beneath the properties.

Properties Requiring Mitigation

For properties that showed SS or IA concentrations exceeding the site-specific screening levels, a meeting was arranged between U.S. EPA, the local health department, and the property owner and tenants as applicable. The property owners and tenants were called and informed about the meeting and informed that the purpose of the meeting was to discuss sample results. Once a meeting date and time were scheduled, a Meeting Reminder Form (Attachment L) was mailed to the property owner and tenants.

At the meeting, a sample result letter was provided to the property owner and any tenants. Attachment M provides an example sample result letter for a property requiring mitigation. U.S. EPA used a short PowerPoint slide presentation (Attachment N) to describe how the SS and IA samples were collected, sample results, U.S. EPA's offer to install an SSDS, and the post-installation SSDS proficiency sampling frequency.

The U.S. EPA OSC then explained that if an SSDS was accepted, the property owner would be required to sign a form called the Residential Vapor Abatement System O&M Agreement (Attachment O). This agreement summarizes the property sample results, explains that U.S. EPA will install an SSDS, explains that the electrical costs to operate the SSDS will be the responsibility of the property owner, and describes the frequency at which U.S. EPA would collect post-installation SSDS proficiency samples.

For properties where SSDS installation was accepted, an ERRS contractor immediately scheduled a site visit with the property owner to determine where SSDS extraction points would be located and to estimate an installation cost to the OSC. The ERRS contractor filled out and provided the property owner with a U.S. EPA Vapor Abatement System Contractor Visit Reminder Form (Attachment P) before leaving the meeting.

After the site visit, the ERRS contractor, the SSDS installation subcontractor, and the property agreed on an SSDS installation date. The ERRS contractor then filled out the U.S. EPA Vapor Abatement System Installation Date Reminder Form (Attachment Q) and provided it to the property owner.

As a reminder, it is critical to maintain constant communication with the property owner (and tenants, if applicable) to ensure that any questions are answered and that the mitigation system is installed timely and efficiently.

7.2 How Should Property Value and Disclosure Concerns be Addressed?

U.S. EPA staff should be very careful about discussing property value and disclosure issues. In general, it is advisable to recommend that prospective buyers or sellers speak to real estate professionals and local-area lenders about questions related to these subjects. However, it is reasonable for U.S. EPA to indicate that a mitigation system is present to reduce exposure to chemicals in IA. It also can be useful to explain that active VI mitigation systems are very similar to radon mitigation systems, which have been widely used and accepted by the public. Homeowners and prospective property owners can also be informed that the VI mitigation system also addresses potential radon problems.

Property disclosure requirements vary depending on location. In general, U.S. EPA should advise property owners that if they decide to sell their homes and buildings, they may be required to disclose information about any VI sample results and the installation of VI mitigation systems. U.S. EPA also should advise property owners to consult with real estate professionals regarding property disclosure requirements in their area.

At the Behr VOC Removal, an O&M Manual was provided to each property owner that received an SSDS. The O&M Manual summarized pre and post mitigation sampling results and information on the SSDS system. More information on the O&M Manual is located in Section 10.3.

7.3 How Should Community Health Concerns Be Addressed?

First of all, OSCs and RPMs should listen to community concerns. U.S. EPA's community involvement coordinators and risk assessors are important resources for OSCs and RPMs in dealing with VI issues. OSCs and RPMs cannot address the health concerns of individual residents, but they can listen to health concerns and respond by providing factual information about a site. If residents have specific questions regarding health concerns, they should be referred to their personal physicians. In addition, ATSDR and state or local health agencies may be able to provide health consultations to community residents.

Section 8. Decision Making at Vapor Intrusion Sites

This section focuses on decision-making at VI sites with respect to risk management and mitigation decisions. This section is designed to assist U.S. EPA OSCs and RPMs in determining how to proceed at VI sites when evaluating the need for a removal or remedial action and for performing additional field work and collecting additional samples.

Superfund investigative and cleanup activities involve the need for careful decision making. It is important to use the “multiple lines of evidence” approach to trace contamination from groundwater to soil vapor to SS to IA (see Section 2.7).

VI sites have a significant potential for inconsistencies in approach because (1) investigative tools and techniques continue to evolve, (2) IA emission sources must be addressed, (3) investigative approaches vary, and (4) different media and exposure pathways (groundwater, SS, and indoor air) are involved. U.S. EPA recognizes that the science is evolving and that approaches may vary based on site-specific circumstances. This section attempts to present a structure and approach for decision making.

It is strongly recommended that the U.S. EPA OSC or RPM form an investigative team for a VI site. At a minimum, the team should include a toxicologist or risk assessor and a hydrogeologist. The OSC or RPM may also add a person within or outside Region 5 with significant VI investigation experience (such as U.S. EPA’s ERT).

This section discusses generic guidelines for the Remedial and Removal Programs, site Categories 1 through 5, commercial versus residential screening values, VI site-specific considerations, mitigation decisions based on SS data – proactive mitigation, and toxicology and risk assessment issues.

8.1 Generic Guidelines for Remedial and Removal Programs

The Superfund Program is responsible for evaluating potential risks and hazards at contaminated sites and for making decisions regarding the need for conducting remedial or removal cleanups of sites to protect human health and the environment. CERCLA and the NCP outline the Superfund Program’s core responsibilities.

The following sections discuss risk levels and VI data used for risk assessment and mitigation decisions.

8.1.1 Risk Levels

Removal actions generally can be initiated when a site presents a carcinogenic risk corresponding to a level of 1 in 10,000 (10^{-4}) or greater (1 in 1,000) or, based on the current 2002 Draft Guidance, when non-cancer hazards exceed an HI or hazard quotient (HQ) of 10 or an ATSDR acute (short-term) risk or screening level is exceeded. The cancer and non-cancer trigger (screening) values are 10 times those recommended for remedial actions at VI sites. In addition, removal actions can be initiated if a fire or explosion hazard exists.

For **remedial actions**, the general policy described in CERCLA and the NCP is that acceptable exposure levels represent an excess, upper-bound lifetime cancer risk level to an individual of between 1 in 10,000 (10^{-4}) and 1 in 1 million (10^{-6}). The 10^{-6} cancer risk level should be used as a point of departure for determining remediation goals (NCP Section 300.430[e][2][A][2]).

Because of variability in VI measurements over time, this VI Guidebook recommends a trigger level of 1 in 100,000 (10^{-5}) cancer risk for combined carcinogens to undertake remedial action.

OSCs and RPMs should request SS and IA screening levels from ATSDR or Superfund risk assessors. Screening levels may differ from state to state because the ATSDR consults with state health departments when developing screening levels. Additionally, OSCs and RPMs should request screening levels specific for the type of property (such as residential versus commercial) and the air space being sampled (such as SS versus IA).

The Removal Program makes use of both short- and long-term screening levels. For example, for VI sites in the State of Ohio, the U.S. EPA OSC or RPM requests a site-specific health consultation (HC) document or Technical Assistance letter from the ATSDR and ODH. The HC document and Technical Assistance letter provide the OSC or RPM with recommended short-term action levels and long-term screening levels for the COCs at residential and commercial properties. Attachment R provides an example of an HC document.

Short-term exposure levels typically are derived from ATSDR's intermediate Environmental Media Evaluation Guide (EMEG). The intermediate EMEG applies to exposure durations of longer than 2 weeks but less than 1 year. Exposure levels exceeding levels derived based on the EMEG will not necessarily result in adverse health effects but should prompt further evaluation of potential public health threats to residents.

Under most circumstances, short-term exposure levels exceeding levels derived based on the EMEG should result in a recommendation to take actions to reduce exposure. The greater the exceedance of levels derived based on the EMEG, the greater the need for a rapid mitigation response and potential relocation of residents. Rapid mitigation may also be undertaken if SS sample results exceed 10 percent of the LEL or if IA sample results exceed 1 percent of the LEL.

Long-term screening or risk levels are those indicated in U.S. EPA's Draft Guidance (available at website address http://epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf). The Draft Guidance levels are based on a 1 in 10,000 (10^{-4}) cancer risk level. Exceedance of the long-term screening values indicates an increased potential for health effects from exposure, and mitigation is warranted.

8.1.2 VI Data Used for Risk Assessment and Mitigation Decisions

CSMs for evaluating the VI pathway are complex because they need to account for migration of contaminants from one medium (such as groundwater or soil) to a vapor phase that can collect underneath building foundations (SS) and finally enter through building foundations into IA. If the OSC or RPM documents the migration of contaminants from groundwater (or soil) to SG to SS to IA, the VI pathway is considered a completed exposure pathway.

Thus, for the VI pathway, multiple media may be involved. Quantitative estimates of risks and hazards as well as levels for IA contaminants that are protective of people can be reliably developed. However, risk assessments and mitigation decisions must also account for several complicating factors, such as (1) the ubiquitous use of products containing VOCs in indoor environments, (2) contributions from ambient air, and (3) site-specific parameters that control contaminant migration from the subsurface to IA.

After receiving the site-specific screening levels, OSCs and RPMs should use existing groundwater and SG vapor data, if available, to determine which buildings are most likely to be impacted by VI at levels that may pose a health hazard. The OSC and RPM also should consider the possibility of preferential pathways for vapor migration, such as sewer and utility lines and the geology of the area. With the property owner's approval (a signed access agreement), SS samples are collected to determine if vapors have migrated to and accumulated at levels of concern below the residence or building. If SS screening levels are exceeded, then IA samples are collected after the property is screened for potential IA sources (such as the presence of recently dry cleaned clothes, paint cans, other solvents, or gas-powered equipment).

The U.S. EPA Region 5 approach recommends that OSCs and RPMs use both SS and IA data before deciding on VI mitigation options for an individual residence. If IA screening levels are exceeded, then mitigation should be considered. For petroleum VI sites, explosion potential should be included in the screening and can be documented in a removal action memorandum as a basis for a removal action.

For VI removal actions in Region 5, to document a health threat, the removal action memorandum must present the results of at least one SS sample exceeding the SS screening levels and the results of the corresponding IA sample also exceeding the IA screening levels (completed exposure pathway). The OSC or RPM should make site-specific decisions, and his or her investigation team should make evaluations on a case-by-case basis, followed by the preparation of appropriate decision documentation for review and concurrence by program management staff. For an emergency, the OSC's delegated warrant authority may be utilized to initiate a removal action.

Based on discussion with removal management staff, OSCs and RPMs should be aware that they **generally** are expected to collect IA analytical data (and document a completed exposure pathway) or have access to IA data collected during a remedial action before they make a health threat determination. The rationale for this approach lies in the Removal Program's focus on addressing exposures at the higher end of the acceptable risk range and the preference for taking mitigation action when a release or threat is of an immediate nature. Exceptions likely will occur, for example, during emergencies when dangerous indoor air readings are recorded with hand-held instruments, extremely high SS readings are measured in the SS probe, or chemical-tainted water or liquid is observed seeping through the walls or floor.

The Superfund Program must address only contamination determined to be site-related. Because the use of VOC-containing products in residences may contribute to the detection of elevated air concentrations during an investigation, the use of IA concentrations **alone** for making cleanup decisions generally is not recommended. In most cases across the country, states and U.S. EPA regions begin a VI investigation **outside** a residence first, preferring to collect groundwater, SG, and SS vapor samples before proceeding to IA sampling.

Although this VI Guidebook does not present a required approach, the OSC should be aware that the decision to take mitigation action at a residence without the collection of IA samples may require a solid, documented supporting rationale. If the OSC believes that mitigation is warranted based on SS data and if an AF other than the standard default factor of 1 to 10 (SS to IA) is used, the OSC should consult with other personnel, such as the ERT.

In light of the Remedial Program's responsibility and authority to address chronic health risks (in contrast to the more time-critical risks addressed under the Removal Program), RPMs may have greater leeway in making mitigation decisions based on SS data without IA data, but again, consultation is advised.

Revisions to the approach outlined above are possible in the future based on advances in VI technical research and on how U.S. EPA Headquarters and Region 5 develop procedural policy regarding VI sites.

8.2 Site Categories 1 through 5

Although multiple decision points can be reached after sampling at a site, ultimately, there are only two choices: no mitigation required or mitigation required. U.S. EPA Region 5 has developed the following categories for sites:

- **Category 1:** No further action site
- **Category 2:** Borderline site (more information needed)
- **Category 3:** Remedial site with removal support
- **Category 4:** High-priority removal site
- **Category 5:** Emergency removal site

Figure 6 below is a general flow chart showing the site categorization and decision-making process for evaluating both SS and IA data. Figure 7 is a general flow chart outlining the decision-making process for evaluating both SS and IA data for the Removal Program. The figures are followed by a table that summarizes actions for sites in each category

When simultaneous SS and IA sampling are conducted or when both SS and IA data are available, the conclusion of the IA sampling becomes the primary determinant for action, even if SS sample results exceed screening levels. However, even when IA risk levels exceed levels of concern, SS screening levels should also exceed levels of concern before action is taken. Furthermore, when SS contamination is the primary source of IA contamination, generally, the IA levels at most are one-tenth the SS levels. If IA levels are higher than one-tenth SS levels, IA may be contaminated with VOC sources other than those found at the site. When IA and SS levels do not represent expected relationships, the Figure 6 and Figure 7 flow charts below rather than the table presented after the flow charts are more useful because of their added detail.

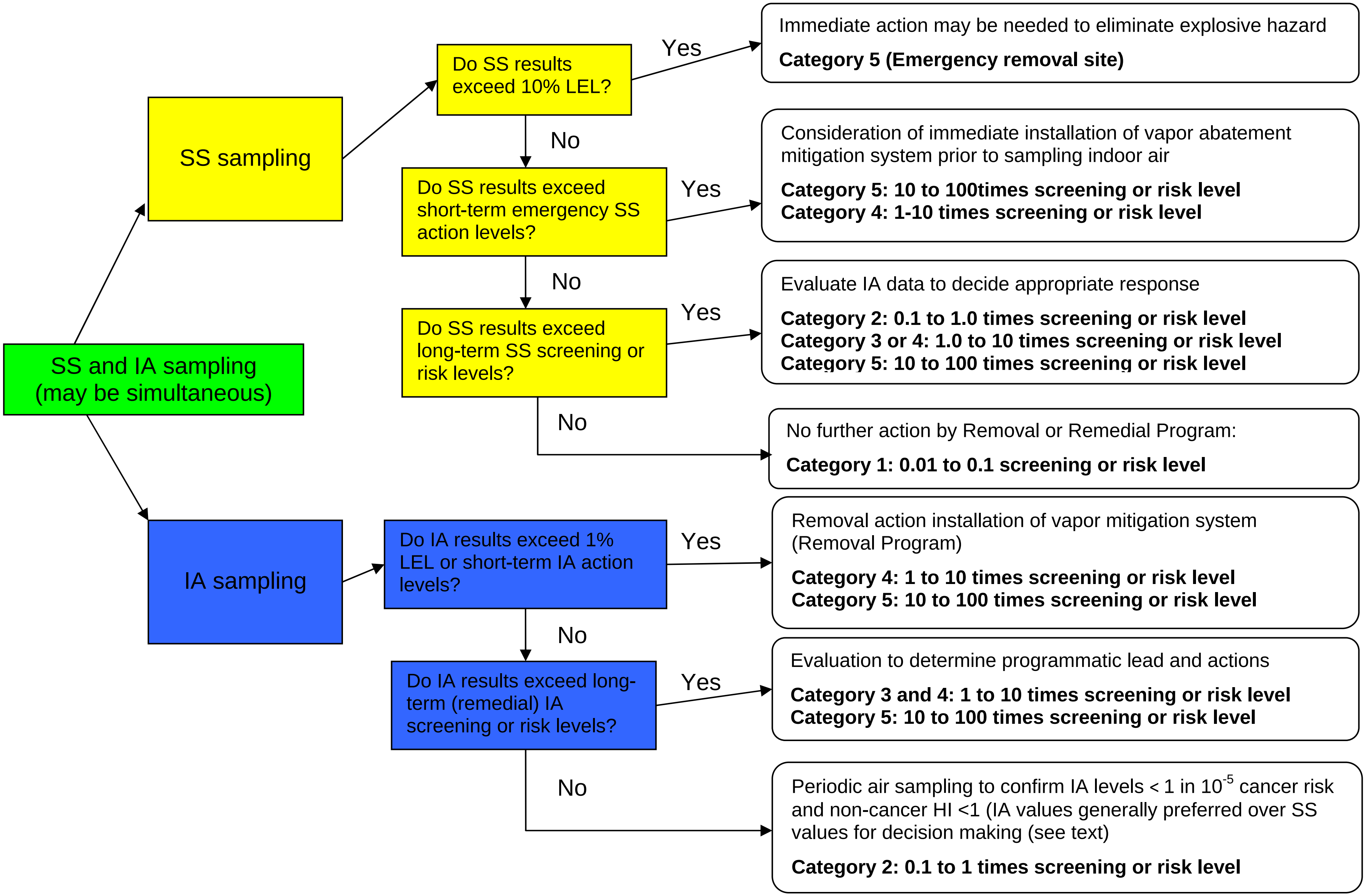


Figure 6 – General Decision-Making Process Flow Chart

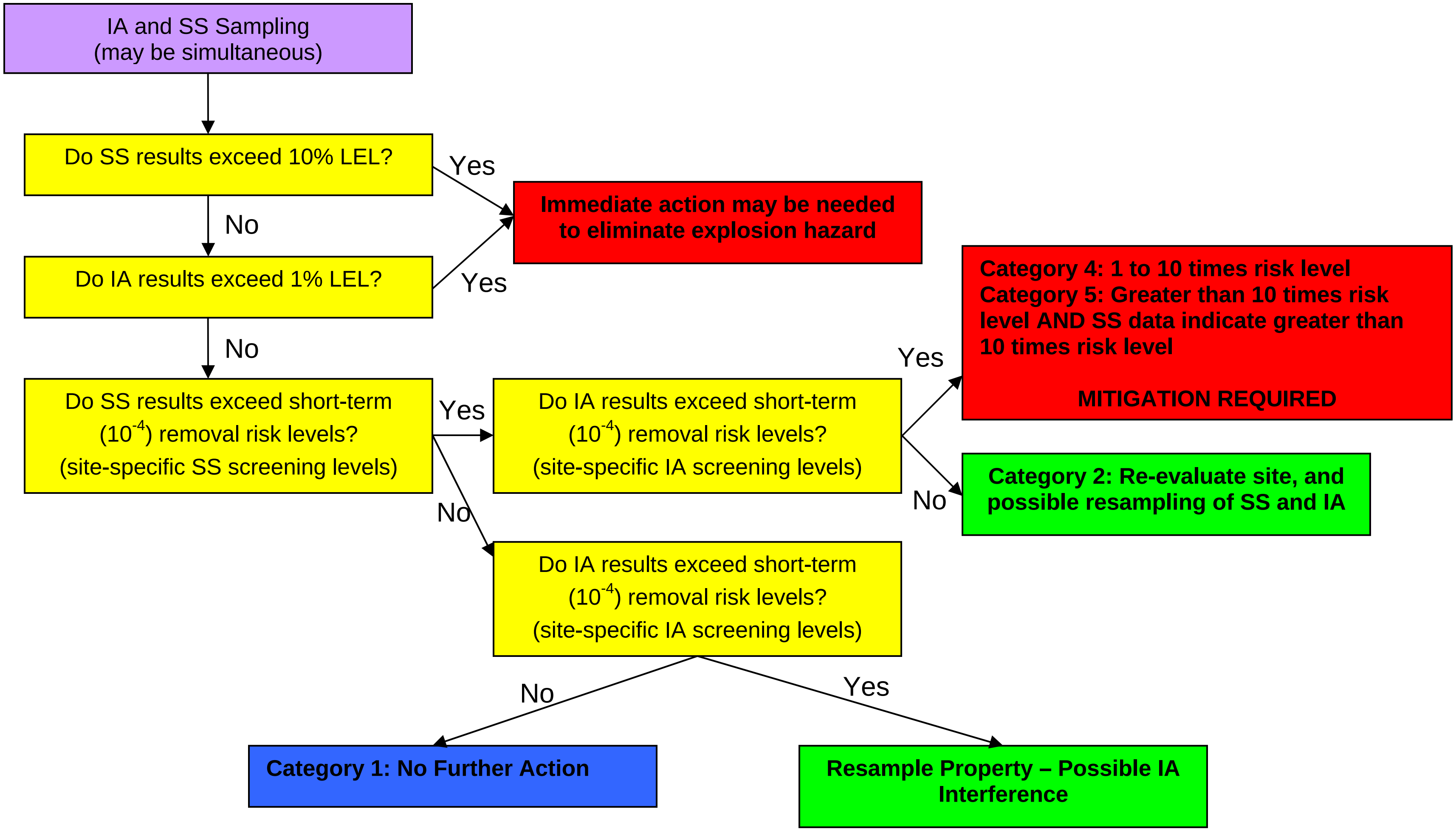


Figure 7 – Decision-Making Process Flow Chart for Removal Program

The table below provides another way to illustrate how sites are categorized based on measured VOC levels in SS and IA and actions to be taken for each category. The categories are **not** intended to be rigid. To show how a VI problem should be categorized, the VOC PCE is used as an example. The current remedial screening or risk level for PCE in IA based on a 1 in 100,000 (10^{-5}) cancer risk is 0.6 ppb, and the current removal screening value for PCE in IA is 6 ppb, which corresponds to a 1 in 10,000 (10^{-4}) cancer risk.

Risk Levels and Actions	**Category 1- No further action site**	**Category 2 - Borderline site**	**Category 3 - Remedial site with removal support**	**Category 4 - High-priority removal site**	**Category 5 - Emergency removal site**
Action or Risk Level[1]	Less than the Risk Levels of concern[2 and 3]	Greater than the SS Risk Level but less than the IA Risk Levels of concern[2 and 3]	1 to 10 times remedial SS and IA Risk Levels of concern[2]	Greater than removal SS Risk Level and between 1 and 10 times removal IA Risk Level of concern[3]	Greater than 10 times both the SS and IA Risk Levels of concern[3]
SS Risk Level[4]	**Remedial Site:** PCE <6 ppb $<10^{-5}$ HI <1 **Removal Site:** PCE <60 ppb $<10^{-4}$ HI <10	**Remedial Site:** PCE >6 ppb $>10^{-5}$ HI>1 **Removal Site:** PCE >60 ppb $>10^{-4}$ HI >10	**Remedial Site:** PCE 6 ppb to 60 ppb 10^{-5} to 10^{-4} HI - 1 to 10	**Removal Site:** PCE > 60 ppb $>10^{-4}$ HI >10	**Removal Site:** PCE > 600 ppb $>10^{-3}$ HI >100
IA Risk Level[4]	**Remedial Site:** PCE <0.6 ppb $<10^{-5}$ HI <1 **Removal Site:** PCE <6 ppb $<10^{-4}$ HI <10	**Remedial Site:** PCE <0.6 ppb $<10^{-5}$ HI <1 **Removal Site:** PCE <6 ppb $<10^{-4}$ HI <10	**Remedial Site:** PCE 0.6 ppb to 6 ppb 10^{-5} to 10^{-4} HI - 1 to 10	**Removal Site:** PCE 6 ppb to 60 ppb 10^{-4} to 10^{-3} HI - 10 to 100	**Removal Site:** PCE > 60 ppb $>10^{-3}$ HI >100
Action	None	Resampling	Mitigation	Removal mitigation	Rapid mitigation

Notes:

1 Action levels are short-term levels of concern (such as ATSDR's EMEG values), including LELs. Risk levels are cancer and non-cancer HI (or HQ) long-term screening levels.

2 Remedial levels of concern are chemical levels in IA resulting in an additive risk above 1 in 100,000 (10-5) lifetime cancer risk and an HI or HQ greater than 1.0 based on U.S. EPA's reference dose (RfD) or ATSDR's chronic minimum risk levels (MRL).

3 Removal levels of concern are chemical levels in IA resulting in an additive risk above 1 in 10,000 (10-4) lifetime cancer risk and an HI or HQ greater than 10 based on EPA's RfD or ATSDR's

intermediate MRLs. As noted in the table and discussed in text, the Removal Program may take action based on high SS values alone.

4 SS values generally should be 10 or more times greater than IA values. Conversely, IA values are generally expected be one-tenth SS values.

The flow charts in Figures 6 and 7 and table above provide a general illustration of the categorization of sites and the decision-making process. The following sections provide further discussion of the categories (including examples).

8.2.1 Category 1 – No Further Action Site

If SS and IA sample results are below the applicable risk levels, then no further action should be taken at a site by either the Removal or Remedial Programs.

Example

SS data: Cancer risk < 1 in 1 million (10^{-6}) and non-cancer HI < 0.1

IA data: Cancer risk < 1 in 1 million (10^{-6}) and HI < 0.1

In this example, the SS and IA sample results both range from one-tenth to one-one-hundredth the **respective screening levels** of the 1 in 10,000 cancer risk used by the Removal Program and the 1 in 100,000 cancer risk used by the Remedial Program. Non-cancer HI values are one-one-hundredth the trigger of 10 used by the Removal Program and one-tenth the trigger value of 1.0 used by the Remedial Program.

If PCE has a removal screening level (one in 10^{-4} cancer risk) of 6 ppb for IA, and PCE levels are observed near 0.06 ppb (a one in a million cancer risk) or 100 times lower are of no health concern.

Action to be taken: No further action

For Category 1 sites, no further action is taken for the VI pathway and no additional SS or IA sampling is needed because as it is unlikely that a second IA sample would yield potentially unacceptable risk levels, even with a 10-fold increase resulting from temporal or spatial variability. No significant exposure pathway is documented, and no further actions for VI are needed. However, if the site has groundwater contamination, the Remedial Program should conduct a site assessment and determine appropriate subsequent steps.

8.2.2 Category 2 - Borderline Site

If SS sample results are greater than the applicable levels of health concern and the IA sample results are less than the potential levels of health concern, additional rounds of SS and IA sampling are warranted inclusive of worst-case conditions. Worst-case conditions depend on seasonal groundwater level and home heating and cooling factors. Because of seasonal variations, resampling should be conducted by either the Removal or Remedial Program. If the results fall within the values shown below, then an unacceptable IA risk is unlikely and no further action for IA is needed under either the Removal or Remedial Programs.

Example

SS data: Cancer risk between 1 in 1,000,000 (10^{-6}) and 1 in 10,000 (10^{-4}) or non-cancer HI is between 1 and 10.

IA data: Cancer risk < 1 in 100,000 (10^{-5}) [remedial] or < 1 in 10,000 (10^{-4}) [removal] or non-cancer HI is between 0.1 and 1

The SS sample result may approach the SS screening levels (one in 10,000 risk (10^{-4})), but the IA sample result is less than the IA screening levels used by both the Removal and Remedial Programs.

In other words, the chemical is documented below the structure and is present in the IA at low levels. If IA PCE levels were found approaching 0.6 ppb (a one in 100,000 risk (10^{-5})), this might be a potential long-term health concern.

Action to be taken: SS and IA should be resampled under worst-case conditions. If IA levels are below action or risk levels, then no further action is needed.

Although it is recognized that VI issues alone will not drive an NPL listing, the Remedial Program should undertake an SA and determine appropriate subsequent steps, including groundwater monitoring.

8.2.3 Category 3 – Remedial Site with Removal Support

This category represents site with initial SS and IA levels either at or above 10 times short- or long-term screening risk levels used by the Remedial Program. For sites in this category, remediation generally is conducted by the Remedial Program, with removal support. Although the Removal Program generally deals with cancer risks greater than 1 in 10,000 (10^{-4}) or non-cancer HI values of 10 or greater, sites with IA levels resulting in cancer risks greater than 1 in 100,000 or non-cancer HI values of 1.0 or greater may be more appropriately addressed by the Removal Program, especially if the number of sites is small. OSCs and removal managers, in discussion with remedial counterparts (if necessary), should make decisions regarding appropriate actions.

Example

SS data: Cancer risk between 1 in 10,000 (10^{-4}) and 1 in 1,000 (10^{-3}) or non-cancer HI between 10 and 100

IA data: Cancer risk between 1 in 10,000 (10^{-4}) and 1 in 100,000 (10^{-5}) or HI between 1 and 10

Both the SS and IA sample results exceed screening levels. In other words, a chemical is documented below the structure **and** is present at significant levels in IA . A completed exposure pathway is documented.

For example, PCE levels might range from 0.6 ppb to just below 6.0 ppb, which are at or above respective screening levels of one in 100,000 risk and near a one in 10,000 risk.

Action to be taken: Mitigation is warranted by the Remedial Program. Mitigation may include the installation of a residential vapor abatement mitigation system. Section 9 of this VI Guidebook discusses mitigation options.

If the site is referred to the Remedial Program, it should be recognized that individual properties may require several additional rounds of IA sampling. A decision to undertake mitigation may partially be based on the cost of mitigation weighed against the cost of additional future monitoring or sampling to ensure that IA concentrations are not increasing or fluctuating within an unacceptable range.

Unless **at least two rounds of additional sampling** are conducted with results that clearly show risk levels below levels of concern (1 in 10,000 cancer risk and non-cancer HI less than 1.0), then mitigation under the Remedial Program generally is recommended when IA levels exceed a 1 in 100,000 cancer risk and an HI of 1.0. A vapor abatement system is one example of a mitigation system.

Actions for Category 3 sites could include installation of SSDSs, changing the pressurization of the building, increasing ventilation in the building (such as through air exchange), removing source material, and remediating contaminated environmental media. These types of actions could be initiated directly (removal site) or evaluated under an engineering evaluation/cost analyses (EE/CA) (non-time-critical removal or remedial site) or feasibility study (remedial site).

SS vapor concentrations may be so elevated that the future potential for VI (if foundation conditions deteriorate or pressure gradients change) require mitigation to prevent future exposure at levels of concern. In this case, even if IA concentrations do not exceed levels of concern on the date that sampling is conducted, the presence of a significant source may warrant mitigation action (if SS levels are extremely high) or additional sampling at different times of the year. IA concentrations can fluctuate and increase over time as building foundations age and conditions change. Site managers may require additional monitoring and detailed information on (among other things) slab construction and age, the presence of conduits and cracks (and the potential for more), potential modifications that could change the integrity of the slab, and slab covering.

Because a site yields risk levels of concern, the Remedial Program should undertake an SA and consider the next appropriate steps, including groundwater monitoring.

8.2.4 Category 4 – High-Priority Removal Site

This category represents properties with initial SS and IA data for VOC levels equal to or up to 10 times greater than short- or long-term screening risk levels (such as a 1 in 10,000 cancer risk level for IA) used by the Removal Program. Because IA risk levels of heath concern have been exceeded, additional sampling is not required before mitigation.

Example

SS data: Cancer risk 1 in 1,000 or HI between 10 and 100

IA data: Cancer risk 1 in 10,000 or HI >10

The removal action criteria have been exceeded if the PCE SS level is greater than 6 ppb and the IA PCE level is greater than 0.6 ppb. The levels exceed the 1 in 10,000 cancer risk and the properties require mitigation.

Actions to be taken: Mitigation may include installation of a residential vapor abatement system. Section 9 of this VI Guidebook discusses mitigation options.

Because contamination is present at significant levels require mitigation of properties, remediation of groundwater contamination and other actions will also likely be needed.

8.2.5 Category 5: Emergency Removal Site

VOCs may be detected at dangerous levels, especially chemicals at concentrations exceeding LELs or 10 to 100 times greater than ATSDR short-term action levels or long-term screening levels. Under such circumstances, rapid mitigation within weeks is needed.

Example

SS data: LEL > 10% -- emergency actions may be undertaken, ATSDR short-term action level > 10 times, or cancer risk > 1 in 100 or HI > 1,000

IA data: LEL > 1% -- emergency actions may be undertaken, ATSDR short-term action level > 10 times, or cancer risk > 1 in 1,000 or HI > 100

If the SS sample results exceed the LEL by greater than 10 percent or the IA data exceed the LEL by greater than 1 percent, emergency actions may be undertaken. Emergency actions should be taken if SS or IA results exceed the ATSDR short-term action levels by 10-fold.

At a residential site where PCE is observed in the IA at 6 ppb (equal to one in 10,000 cancer risk), an emergency situation would exist if IA levels were found to be more than 60 ppb or 10 times greater than the 10^{-4} screening level. An emergency situation would also exist if SS PCE concentrations were found to be 600 ppb, since it would be possible that 60 ppb IA levels (equal to a 1 in 1,000 cancer risk) could be reached using an attenuation factor of 0.1.

Actions to be taken: Any residences with IA concentrations greater than those discussed above require rapid mitigation within a few weeks of the receipt of sampling results. As previously discussed, early actions may also be undertaken based on elevated SS sample results.

Because contamination is present at significant levels, mitigation is required, including remediation of groundwater contamination and possibly other actions.

8.3 Commercial versus Residential Screening Levels

When determining whether to use the residential or commercial screening or action levels to compare sampling results, OSCs and RPMs should ask, "Is someone currently living or will be living at the site?" If the answer is "yes," then the sample results should be compared to residential screening or action levels.

If a site has a commercial business on the first floor and an apartment on the second floor, then the most conservative action or screening level (residential level) must be used for comparison. Occupational Safety and Health Administration (OSHA) values for VOCs are not appropriate for commercial or industrial facilities when VI is determined to be the source of contamination.

To date in Ohio, for example, for a school, ATSDR and ODH have recommended that sample results be compared to residential screening or action levels because of the sensitive population within the school. These levels may be adjusted to account for the length of the school day and the number of months the school is in session, although it is also acceptable to use residential criteria only.

The use of commercial action and screening levels may also be recommended by the state health department.

8.4 VI Site-Specific Considerations

Contaminant migration from groundwater or soil into buildings may vary greatly, not only from site to site but also from building to building within a site and even from building section to section. These differences are due to site-specific parameters, such as soil type, building foundation type and condition, preferential pathways such as fractures in underlying rock or underground utilities, and differential building pressures. Within a neighborhood, different basement types (such as poured concrete, crawl spaces, cracked concrete, and dirt floors) are the biggest variable in evaluating residences. These characteristics make it extremely difficult if not impossible to extrapolate VI scenarios among sites and generally require the evaluation of multiple lines of evidence to make cleanup decisions, including data from more than one environmental medium (such as groundwater, SS vapor, and IA). In order to address these many variables, sampling plans should be carefully designed to gather data that can best be used to evaluate human exposure. The data collected then should be used to make informed decisions regarding the need for mitigation. Generally, these decisions are made on a case-by-case basis and may involve the use of IA measurements and other environmental measurements.

To provide consistency in the **evaluation** of VI sites, U.S. EPA prepared the Draft Guidance. The 2007 ITRC document follows up on the Draft Guidance with updated procedures. This VI Guidebook was prepared to provide some consistency in Region 5 in the making of mitigation decisions for VI sites. Section 8.5 below provides guidelines to assist OSCs and RPMs in making reasonably consistent cleanup decisions, recognizing that site-specific factors and innovative approaches may result in modifications.

8.5 Mitigation Decisions Based on SS Data – Proactive Mitigation

As discussed previously, to initiate a VI removal action, a complete VI exposure pathway must be documented, meaning that SS and IA screening levels are exceeded based on multiple lines of evidence. A completed exposure pathway documents an actual threat under the NCP. For a large removal action such as that taken at the Behr Dayton VOC Removal Site, over 400 residential samples were collected, and results for more than 75 percent exceeded the IA screening levels. The OSC used a proactive mitigation concept based on SS data and multiple lines of evidence. Proactive mitigation should be considered only when a complete VI exposure pathway is documented.

One approach to making mitigation decisions for VI sites involves the use of the default AFs discussed above or site-specific AFs developed by a project manager. In such cases, the project manager should have SS data for individual homes and should make a mitigation decision based on the SS results. Accompanying IA data may or may not exist. Even if IA data are available, VOC data should not be used to decide if mitigation is conducted but may influence **when** mitigation takes place (the higher the levels and potential IA threat, the higher the priority for action). If the chosen SS-to-IA AF predicts IA levels above acceptable health criteria, mitigation action should be taken. This concept has been termed “proactive mitigation” and could apply to other nearby residences over the groundwater plume or having subsurface soil contamination but no SS data yet.

As noted in ITRC 2007, several states (and possibly some U.S. EPA regional programs) apparently use this approach. The ITRC document even states that “if sub-slab concentrations are more than 1000 to 10,000 times the target indoor air levels, the probability of unacceptable VI is likely sufficient to warrant proactive mitigation without further investigation.” The advantages and disadvantages of proactive mitigation are discussed below.

The largest benefit of proactive mitigation based on SS data is the time and resources saved from not having to conduct several rounds of IA sampling at individual residences. IA sampling can be time-consuming and challenging, especially when multiple residences are to be sampled, because it requires the routine removal of VOC-containing products from residences, inconveniences residents, and presents scheduling difficulties. In many cases, proactive mitigation at residences predicted to have elevated IA readings based on SS results may actually save money when the costs of multiple sampling events and contractor and U.S. EPA personnel labor are considered. Another advantage to proactive mitigation is that the SS environment generally is believed to be more stable than IA, with less fluctuations in concentrations over time. If SS samples are collected properly, the common belief is that SS sample results should not be influenced by extraneous household chemicals.

Risk managers should justify a decision to take mitigation action based on acceptance of the AF approach and the **potential** for IA values to reach unacceptable levels. In theory, risk managers could justify mitigation even if a one or two-time IA sampling event revealed results below levels of concern because the OSC or RPM would be relying on the predictive capability of the AF and a belief that, over time, deteriorating foundation conditions could only result in greater opportunity for vapors to enter a residence.

Alternatively, OSCs and RPMs should evaluate the following factors when considering proactive mitigation: (1) how to rationalize the use of default AFs, (2) the lack of direct exposure data, (3) how to adequately answer resident queries about their potential past exposure to subsurface contaminants that may have migrated to IA, and (4) the likely need to sample IA in any case to determine the effectiveness of a VI mitigation system. Unfortunately, a cursory review of the current "Vapor Intrusion Database" reveals that even site-specific IA-to-SS attenuation ratios can vary widely from building to building and even within the same building at different locations because many variables affect the migration of vapors into residences.

8.6 Toxicology and Risk Assessment Issues

This section addresses toxicology and risk assessment related to VI issues by answering FAQs about these issues.

8.6.1 Are There Updates to Screening Tables in the 2002 Draft Guidance?

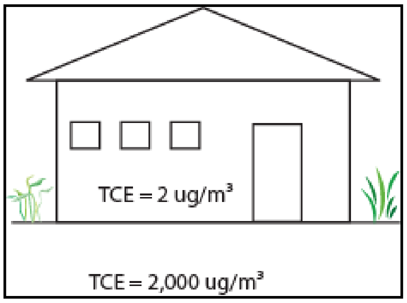
As of the date of this VI Guidebook, the Draft Guidance screening tables have not been updated. Since the release of the Draft Guidance in 2002, the Superfund Program has adopted U.S. EPA's inhalation dosimetry methodology (see "Risk Assessment Guidance for Superfund" [RAGS] F at website address: http://rais.ornl.gov/homepage/RAGS_F_EPA540R070002.pdf). This methodology does not recommend the use of simple route-to-route extrapolation such as those presented in the Draft VI Guidance. The Regional Screening Levels for Chemical Contaminants at Superfund Sites provides a more updated collection of inhalation toxicity values (website address http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm).

8.6.2 What is the Vapor AF (Alpha Value)?

The vapor AF is a unitless empirical ratio of the IA contaminant concentration to the subsurface (SS) contaminant concentration. It is defined as the IA contaminant concentration divided by the contaminant concentration in either SG or groundwater. The SG equation is presented below.

$$(\alpha_{sg}) = C_{indoor}/C_{soil\ gas}$$

For example, a site with soil gas TCE concentration of 2,000 $\mu g/m^3$ in SG and 2 $\mu g/m^3$ in IA would have an AF of (2 / 2,000), or 0.001.



The groundwater equation is presented below.

$$(\alpha_{gw}) = C_{indoor}/(C_{groundwater} \times H \times 1{,}000\ L/m^3)$$

In this equation, H is the compound's unitless Henry's Law constant.

Typically, the alpha factor is calculated based on SG or SS vapor and IA data, but as shown in the equation above, it also can be calculated based on groundwater data. Concentrations for gas samples generally are presented in $\mu g/m^3$, and concentrations for groundwater samples generally are presented in $\mu g/L$.

8.6.3 What are OSWER's Recommended Default AFs?

The default AFs are designed to be conservative and generally are intended to capture ("screen in") approximately 95 percent of the SS AFs in the "Vapor Intrusion Database" as of 2008.

These generic AFs may be used to screen out a site from further investigation or alternatively, to prompt additional characterization and mitigation (if needed). For example, the generic 0.1 SS AF "screens in" approximately 95 percent of the observed SS AFs in the "Vapor Intrusion Database" as of 2008. That is to say, measured or estimated (from groundwater) SS concentrations greater than 10 times the target IA concentrations should be "screened in" for further investigation for possibly unacceptable VI risk. Conversely, SS concentrations measured or reasonably estimated to be below 10 times the target IA concentrations can be "screened out" for VI concerns.

Alternatively, measured or estimated SS concentrations two orders of magnitude (100 times) greater than the target IA concentrations are expected to result in unacceptable VI risk, and exposure mitigation could be considered without further delay. For example, the 2008 "Vapor Intrusion Database" shows that only 7 percent of the observed SS AFs are lower than two orders of magnitude below the generic screening value of 0.1 (that is, have AFs less than 0.001). Therefore, it is reasonable to assume that less attenuation is occurring at any site with an AF greater than 0.001 because approximately 93 percent of the sites in the 2008 "Vapor Intrusion Database" have higher AFs. Therefore, under these conditions, it is reasonable to consider exposure controls before or as part of further studies "confirming" unacceptable VI risk.

A recent evaluation of the paired environmental samples in the "Vapor Intrusion Database" indicates that the default AFs in the 2002 Draft Guidance remain appropriate except for the AFs for deep SG. Screening tables using the toxicity values in the Risk-Based Concentration Tables and the default AFs may be developed. Until this effort is completed, risk assessors can generate screening tables using this same method by looking for the chemical-specific toxicity value on the Risk-Based Concentration Tables and applying the following default AFs from the 2002 Draft Guidance:

- Groundwater to IA = 0.001
- SG to IA = 0.1 (see Note below)
- SS to IA = 0.1
- Crawl space to IA = 1

Note: The 2002 Draft Guidance recommends AFs for both shallow and deep SG, but at this time, use of the shallow SG AF only is recommended. A "Preliminary Evaluation of Attenuation Factors" is available at website address http://iavi.rti.org/OtherDocuments.cfm?PageID=documentDetails&AttachID=369.

8.6.4 What is the Current Approach for Assessing Risk at TCE Sites?

TCE is one of the most prevalent contaminants at Superfund sites. A draft health risk assessment was produced in 2001 and is included in the 2002 Draft Guidance. However, in 2006, the National Research Council issued a report that concludes, "additional studies should be considered and some dose-response models should be revised." In response, U.S. EPA has withdrawn the 2001 draft assessment. In the interim, until the revised TCE assessment is completed, the Superfund Program is implementing its toxicity hierarchy policy (OSWER Directive 9285.7-53) for selecting alternative values. The Superfund Program recommends using the California EPA (CalEPA) cancer slope factor and inhalation unit risk (IUR) values to determine preliminary remediation goals. Using the CalEPA IUR, IA concentrations associated with the 10^{-6} to 10^{-4} risk range are approximately 1.2 to 120 µg/m^3 (0.2 to 22.3 ppbv), with 1 µg/m^3 (0.19 ppbv) being the point of departure (see the Regional Screening Levels for Chemical Contaminants at Superfund Sites at website address http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm).

For further information on appropriate sources and references for TCE, OSCs and RPMs should contact the Superfund Technical Support Center or U.S. EPA Headquarters regarding the use of Tier 3 values.

OSCs and RPMs should consult ATSDR or U.S. EPA risk assessors for recommended site-specific SS and IA screening levels.

It is important that the risk assessor and risk manager consider both the cancer and non-cancer endpoints when evaluating risk and the need to take an action at a site.

8.6.5 How Should Risk Assessors Evaluate Chemicals with No Inhalation Toxicity Values (RfCs and IURs)?

When evaluating IA data and data from other media sampled as part of a VI investigation, risk assessors should quantitatively evaluate the risk for chemicals for which inhalation toxicity values are available as stated in U.S. EPA's Toxicity Hierarchy memorandum (available at website address http://www.epa.gov/oswer/riskassessment/pdf/hhmemo.pdf). In addition, consultations with ATSDR should be conducted as appropriate. If actionable risk has been estimated, risk managers can take appropriate actions to address the risk. If actionable risk has not been estimated, then uncertainty associated with chemicals for which no inhalation toxicity values are available should be discussed as a potential underestimation of risk and communicated to the risk managers.

8.6.6 Should Risks be Calculated for Adults and Children Separately?

If site-related chemicals known to act through a mutagenic mode of action (MMOA) for carcinogenicity are evaluated and no child-specific IUR exists, then it is appropriate to apply age-dependent adjustment factors to the appropriate age ranges for children. No other adjustments to inhalation toxicity values are recommended for assessing risk to children. The list of chemicals that U.S. EPA has identified as acting through a MMOA is available at website address www.epa.gov/osa/spc/cancer_guidelines.htm.

If adults and children are exposed under similar scenarios (that is the exposure time, frequency, and duration are consistent), then no adjustment is necessary to estimate exposure.

8.6.7 Is it Appropriate to use OSHA Standards to Evaluate Worker VI Risk?

OSHA standards should NOT be used to evaluate risk from VI or to establish appropriate IA target levels. The OSHA standards are not fully risk-based. Furthermore, at sites subject to CERCLA, cleanup levels are determined based on applicable or relevant and appropriate requirements (ARAR) or through the risk assessment process. OSHA standards are not ARARs under CERCLA statutes and regulations.

8.6.8 What if VI is a Potential Risk Concern in a Non-residential Setting?

Appropriate steps should be taken to investigate VI exposures and to reduce risks to acceptable levels under all non-residential settings when workplace-related vapors are not expected (because chemicals forming hazardous vapors are not being used as a part of routine operations) or in workplaces where the general public is expected to be present.

Non-residential settings can include, for example, institutional and commercial settings (such as schools, libraries, hospitals, hotels, and retail establishments), places where the public is expected to be present, and occupational-only settings where chemicals forming hazardous vapors generally are not a known or well-recognized part of routine operations (such as for non-industrial settings such as commercial office buildings). In such non-residential settings, it is generally recommend that VI risks be evaluated using existing guidance, with appropriate adjustments for non-residential building and exposure parameters.

Section 9. Mitigation Options

This section discusses mitigation options to reduce VI exposure if SS and IA sample results document a completed exposure pathway, followed by answers to FAQs regarding mitigation options. Additional information regarding mitigation options for VI is available in the Engineering Issue: Indoor Air Vapor Intrusion Mitigation Approaches at website address http://www.epa.gov/nrmrl/pubs/600r08115/600r08115.pdf.

9.1 Sealing Cracks and Holes in Concrete Floors or Walls

The first step in remediating a site should be inspection of the concrete floor or walls for cracks and holes. Chemical vapors tend to migrate through cracks and holes in floors or walls. If cracks or holes are observed, they should be sealed with a tube of concrete filler or hydraulic cement. Also, the use of "Drylock" or epoxy paints should be considered to cover large surface areas and to cover caulked materials previously placed in concrete wall or floor cracks.

Sealed cracks in basement floor

9.2 Installing SSDS on Concrete Basement Floor

SS depressurization involves the creation of an extraction point(s) in a basement floor connected to a high-static extraction fan. The extraction fan should be mounted outdoors directly on the SSDS piping and fastened to a supporting structure by mounting brackets. In Minnesota (a colder climate), extraction fans can be located indoors such as in attics to prevent freezing. On average, the extraction fan provides coverage of approximately 2,000 ft^2 per slab penetration. This coverage may vary depending on the SS material. In general, the tighter the material, the smaller the area covered per slab penetration. The extraction fan should operate continuously to vent the subsurface beneath the basement slab.

The SSDS should be installed by a knowledgeable contractor with experience in installing similar systems. The contractor should follow methods outlined in ASTM International's (ASTM) Standard E 2121-03, "Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings." Before the SSDS is installed, the OSC should meet with the property homeowner and occupants to discuss sampling results, explain what an SSDS is, and the option for installing the SSDS and to set up a time to meet with the owner and occupants to determine the location where the SSDS will be most effective and convenient (see also Section 7.1). All local building codes should to be followed during installation of the SSDS.

If an SSDS is installed to mitigate VI from PH contamination, the equipment must be intrinsically safe because of potential explosive situations. An example of an explosive situation is when vapor concentrations exceed 10 percent of the LEL.

Installation should begin with the determination of an SS extraction point location in the basement. The extraction point location should be agreeable to the homeowner. The extraction system should be documented to be effective across the entire slab. A portion of the basement slab should be cored, and a 3-inch-diameter Schedule 40 polyvinyl chloride (PVC) pipe should be routed from the extraction point through the slab and outside the basement through a wall penetration. The PVC pipe then should be connected to an extraction fan and the exhaust piping routed to the roof-line. Care should be taken to exhaust the air above any nearby intake pipes or building windows.

Any openings around the extraction point penetration, utility penetrations, and other cracks in the concrete foundation floor should be appropriately sealed. Also, the power supply for the fan should be locked to prevent accidental system shut-off. The residents should be supplied with a key to allow the power to be turned off for maintenance purposes. Figure 8 below shows a typical SSDS layout.

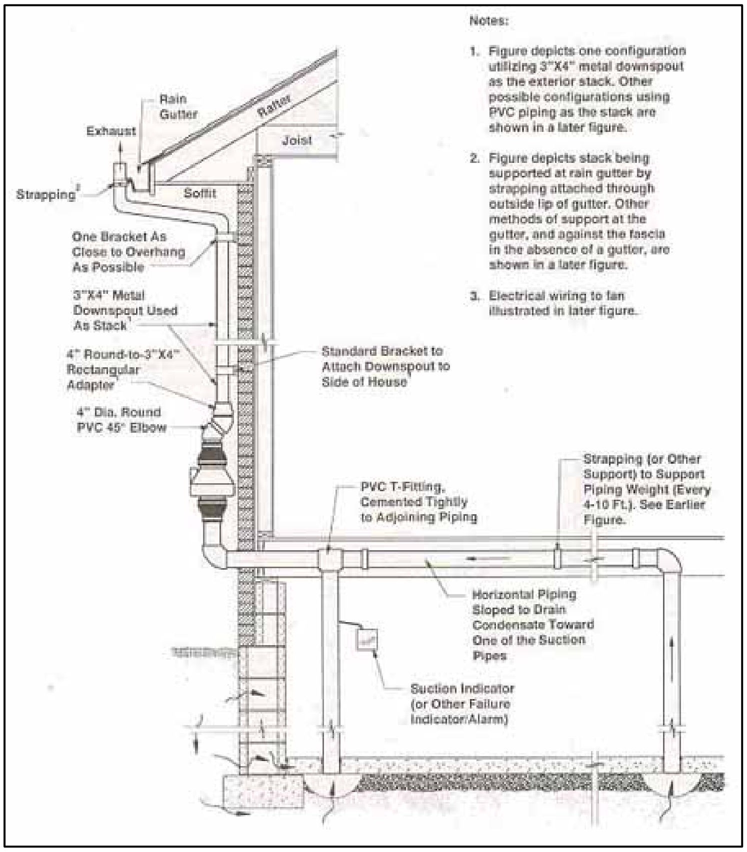


Figure 8 - Typical SSDS Layout

A permanent vacuum gauge should be installed on each system on the extraction side of the fan. The gauge should consist of a “U-tube” manometer with a recommended minimum vacuum of 1 inch of water and a recommended maximum vacuum of 2.5 inches of water. An SSDS vacuum exceeding 4 inches of water may pull “make-up” air (below the house) from the contaminated plume and VOCs toward the residence. The goal is to achieve vacuum under (across) the entire slab, with minimal vacuum draw from the extraction fan.

SSDS extraction fan

SSDS U-tube manometer

Once the SSDS is installed, the radius of influence can be checked using a digital manometer to determine if a vacuum is applied under (across) the entire basement slab. The digital manometer can be used at the initial SS probe location. A second SS probe (if needed) can be installed at the opposite side of the basement, and the vacuum can be checked there. If a vacuum reading is observed at both locations (at least 0.005 inch of water), there is a high probability that the SSDS is working properly and will be successful. If the basement is very large, more than two SS probes may be required to determine if a vacuum is occurring.

If a vacuum is not observed at a SS probe, addition of another extraction point should be considered on another section of the basement and placed as far as possible from the first extraction point.

At the Behr Dayton VOC Removal Site, U.S. EPA developed an SOP to install two extraction points at each property and then to verify the radius of influence. This approach resulted in a success rate of over 95 percent based on first-round post-mitigation proficiency air sample results.

9.3 Installing Slotted PVC Pipe over Dirt Floors and Crawl Spaces

Inhalation exposure in structures having dirt floors or dirt crawl spaces can be reduced by installing line-slotted PVC piping under a 7-millimeter-thick, polyethylene (poly) membrane over the dirt floor or dirt crawl space. The slotted PVC pipe should be routed to an in-line fan and then exhausted just as for a normal SSDS. The poly membrane should be sealed on the walls to ensure a tight seal. This option may be more expensive than a traditional SSDS.

Piping beneath membrane

Piping in crawl space

9.4 Installing Other Mitigation Options for Dirt Floors

Basements with a dirt floor have two mitigation options besides installation of the slotted PVC pipe discussed above. This first is to line the floor with a poly membrane and then install an SSDS. This option may require future maintenance because if the basement is used for storage, the membrane could tear, breaching the vapor seal.

The second option is to install a vapor barrier and pour “flowable fill” concrete into the basement to form a new concrete floor. This option is the most expensive because concrete pouring and forming are labor intensive. In addition, in basements with dirt floors that contain water heaters and furnaces, those items should be raised a few inches and the piping reconfigured to account for the thickness of the new concrete flooring. The OSC or RPM also must coordinate with the owners or occupants to move all belongings out of the basement. This task may not be easy depending on the amount of items requiring removal and the willingness of the owners or occupants to move the items. After the items have been removed and the concrete has been poured and cured, a regular SSDS can be installed.

Basement with dirt floor **Basement with new concrete floor and SSDS**

9.5 Installing SVE Systems

Another mitigation option is the installation of an area-wide soil vapor extraction (SVE) system. At the Behr Dayton VOC Removal Site, an SVE system was installed to enhance vapor abatement within a small residential area where TCE concentrations in SG were very high (up to 160,000 ppbv). SSDSs were installed in residential homes within the small area, but because the TCE concentrations beneath the properties were so elevated, the SSDSs could not completely mitigate IA TCE concentrations within the homes. To enhance TCE vapor mitigation, an SVE system was installed as shown in Figure 9 below. The black dots represent vertical extraction wells piped to a 300-cubic-foot-per-minute blower. The effluent was routed through carbon units to remove TCE.

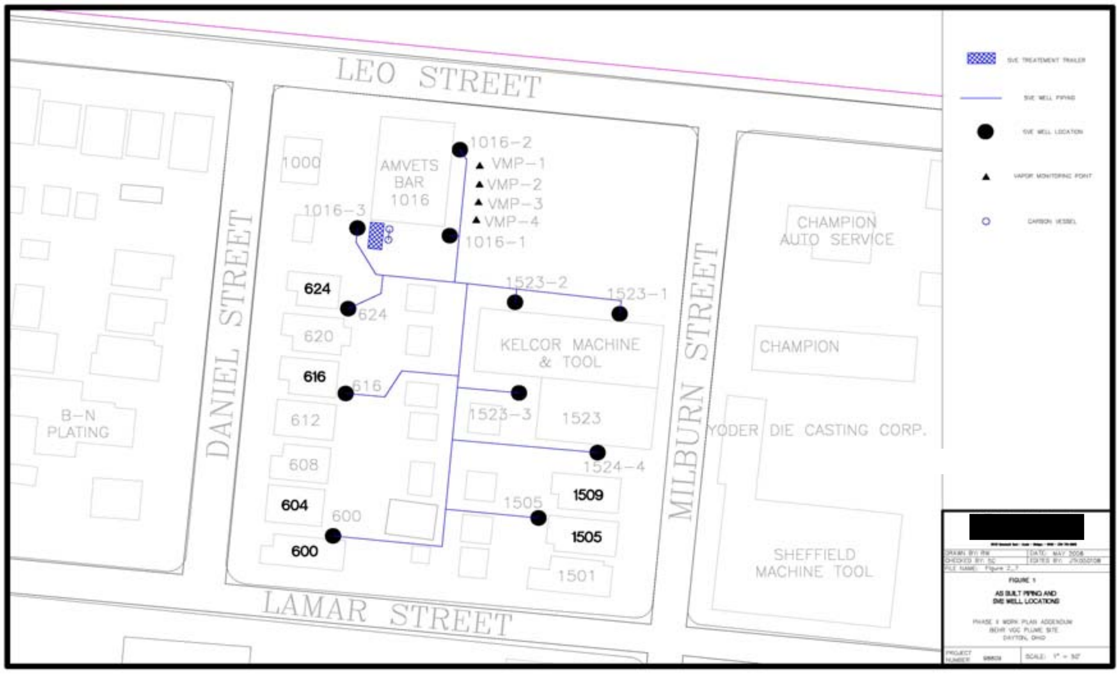


Figure 9 - SVE System Installed at Behr Dayton VOC Removal Site

At a site in Hartford, Illinois, an area-wide SVE system was installed to cover the entire Village of Hartford. Because of explosion concerns associated with petroleum vapors and the biodegradation by-products of petroleum materials, area-wide vapor capture and control was more advantageous than the use of typical, off-the-shelf, radon-type SSDS motors because such motors are not explosion-proof (EP) rated. Area-wide SVE designs require "intrinsically safe" construction because petroleum vapors could generate significant heat, requiring management as part of the ultimate capture, control, and disposal approach.

Obviously, SVE systems cost more than typical radon-type SSDSs. In addition, OSCs should consider how area-wide SVE residential systems extensively involve the public domain for construction installations that could involve public streets, conflict with existing utility systems, and require future ongoing system O&M.

9.6 Frequently Asked Questions

Answers to FAQs about VI mitigation are presented below.

9.6.1 What are the Primary Considerations for Selecting a VI Mitigation Approach?

The first considerations should be if the building already exists or will be a new construction and the likely level of contaminant reduction required. VI mitigation in a new construction is generally more cost-effective. For new construction, the strategy is to prevent openings in the foundation for SG contaminants to enter and to minimize the driving forces for VI by minimizing the stack effect and the effects of wind on the building. Building codes and several manuals address these issues. Passive membranes could be considered for new construction, depending on contaminant reduction requirements.

For existing buildings, applicable mitigation methods are largely dictated by the existing building features, such as the following:

- Type of building foundation: basement, slab-on-grade, slab-below-grade, or crawl space
- Type of heating and air conditioning system

- Tightness of the building (air exchange rate)
- Age or condition of the basement (stone or poured concrete)
- Level of contamination (is more than 60 percent reduction in IA concentration required?)
- Extent of completed floors and walls in the basement and parts of the basement in contact with soil
- Nature of soil under and around the building

9.6.2 Which Mitigation Methods Have Been Demonstrated to Work?

A number of mitigation methods have been used to reduce indoor concentrations of SG contaminants. The most significant body of experience relates to the reduction of indoor radon values (about 1 million houses have undergone radon mitigation). In the case of chemical VI, a few thousand residences have undergone mitigation. The extent to which each mitigation method has been studied and demonstrated varies widely by method. The effectiveness of some mitigation methods is discussed below.

Active soil depressurization (ASD): This method is the most thoroughly studied and demonstrated approach to mitigating VI. This approach consists of a group of methods customized for the different construction features of buildings. The group primarily consists of SSDSs, drain-tile depressurization, wall depressurization, baseboard depressurization, and sub-membrane depressurization. The ASD method can achieve contaminant reductions up to 99.9 percent.

Passive soil ventilation (PSV): This method is similar to the ASD method except that it uses natural driving forces (no active fan) to dilute concentrations through ventilation. This method can achieve contaminant reductions of up to 80 percent. However, performance depends on meteorological conditions, and few systems have been tested for long-term performance.

Positive indoor pressurization: This method is most often used in commercial and industrial buildings where HVAC systems brings in outdoor ventilation air. For energy cost savings, outdoor ventilation frequently is decreased to levels that do not provide adequate positive pressure to prevent VI.

Indoor ventilation (with or without heat recovery): Because many people find it uncomfortable to increase the air exchange rate by more than a factor of three or four, this method usually can achieve contaminant reductions of about 66 to 75 percent.

Sealing cracks and openings in foundations: This method can achieve indoor contaminant reductions of 50 to 80 percent. Sealing major openings also usually helps the performance of other methods.

Passive barriers (impermeable membrane): This method mainly applies to new construction. This method primarily has been applied to sites with explosive gases, such as methane, where the safe level is below about 1 percent or so of the LEL.

9.6.3 What is the Difference between a Construction Vapor Barrier and a VI Barrier?

Construction vapor barriers are not considered robust enough to serve as VI barriers. Construction vapor barriers only consist of a thin plastic sheet laid down below the concrete slab (prior to construction) to serve as a barrier to water vapor. Although these barriers may provide minimal protection, they frequently are ripped during construction and penetrated by utility conduits (such water, sewer, and electrical mains) that are not properly sealed. A VI barrier is specifically designed for VI, and all penetrations are sealed. The VI barrier also is much thicker than a construction vapor barrier. VI sheet barriers typically consist of high-density polyethylene (HDPE) 40 to 60 mils thick or very low-density polyethylene 30 mils thick. The use of thick (60 to 100 mils) sheet barriers or ¼-inch layers of spray-on, rubberized asphalt emulsions may reduce the potential for puncturing or damage during installation (ITRC 2007). The integrity of seals along edges and at penetrations should be inspected and tested during and after construction to ensure proper installation.

9.6.4 Which Diagnostic Measurements are Needed to Select and Design a Mitigation System?

For an existing building, the most important diagnostic is a visual survey to identify any construction features that likely would influence the selection or design of a mitigation system. Some visual survey considerations are summarized below.

- Determine if the building has combinations of basements, slabs on grade, and crawl spaces. Determine if these sections interact and if they require separate mitigation systems.
- Observe major openings that must be closed for any system to function effectively.
- Determine if sumps must be sealed or require special treatment. Sumps sometimes are an excellent place to install a sub-slab system.
- Determine if there are wet basement or crawl-space problems that must be addressed.
- Determine if there are perimeter drain tiles that may be useful in the design of the system.
- Soil depressurization systems (ASD and PSV systems) require that soil under and around the foundation be sufficiently permeable to allow flow or pressure field extension below the entire slab. Standard diagnostic tests for this purpose are sometimes called “sub-slab communication tests.” A sub-slab communication test involves applying suction under the slab at a point suitable for the actual installation. With an appropriate negative pressure applied at this point, the resulting negative pressure is measured at a grid of test points spanning the slab. If a sufficient pressure field can be extended under the slab, a depressurization system should be effective in reducing VI. Sensitive micromanometers are appropriate devices for measuring the pressure field extension.
- For a positive indoor pressurization system, the tightness of the building, especially the basement or ground floor is important. If too much air flow is required to accomplish the required pressurization, the operating costs likely will be too high. In general, a positive pressure of about 5 Pascals is desirable to effectively mitigate VI.

9.6.5 Which Tests are Appropriate to Ensure Proper Installation?

Once a mitigation system has been installed, a series of simple tests should be performed to establish that the system is working as designed. For example, it is notoriously difficult to balance flows properly for air-to-air heat exchange ventilation systems. These systems usually turn out to be not cost-effective.

For soil depressurization systems, it is important to repeat some parts of the sub-slab communication test to establish that the fan actually delivers the designed pressure field extension under the slab. Also, the pressure head established in the exhaust pipe should be checked to ensure that it achieves the design value.

For pressurization systems, the positive pressure in the lowest zones of the building should be monitored over an extended period (at least several days) to establish that the system can maintain adequate pressure over time. It also is important to evaluate the increase in energy consumption necessary to maintain adequate pressure.

These simple tests are intended to establish that the system is operating as designed. However, implementing the procedures does not ensure that a system is performing as designed. Because of uncertainties related to many properties of soil, buildings, and environmental driving factors, IA concentrations cannot be predicted based on these simple measurements. The preferred way to prove the system is performing adequately is to measure IA concentrations for the COCs with and without the system operating.

In many cases, cost-effective tests of preliminary performance can be made using a surrogate system with lower analytical costs, such as a radon mitigation system. A surrogate reduction factor can be established by measuring the surrogate IA concentration with and without the system operating. Once it has been established that the system can reduce the IA concentration of radon or another surrogate by an adequate factor, this factor can be used to estimate the reduction in COC concentrations and should allow a reduced number of measurements of COC concentrations if future measurements are required.

Alternately, measurements of sufficient pressure differentials (for example, 5 Pascals) at a variety of grid locations across the slab can be a strong indication that VI is being minimized.

Measurement of adequate pressure differentials in the system’s exit pipe (for example, 1.0 inch of water or 250 Pascals) can indicate that the system is operating as intended, but these measurements do not measure system performance.

9.6.6 Which ICs Should be Considered to Ensure Long-term Protectiveness of the VI Remedy?

ICs such as non-engineered instruments (administrative or legal controls) may be necessary to ensure the long-term protectiveness of the selected remedy and its compliance. The remedy should be operated and maintained as intended when the remedy was selected.

Depending on the specific situation, ICs that may be helpful include, but are not limited to, government controls, such as zoning laws, public health and safety ordinances, and building permits and codes; proprietary controls, such as covenants; enforcement controls within UAOs and CDs; and informational devices, such as deed notices or public advisories. In some cases, state or local laws or regulations establishing or requiring certain ICs may be considered ARARs.

When the person or entity involved with the day-to-day O&M of a VI remedy is not a liable party, ICs may be even more necessary but also may be more difficult to implement. For a non-NPL site addressed by the Removal Program, the OSC should work with state or local agencies to incorporate ICs and ensure long-term protectiveness of the remedy.

Program staff and attorneys should consider ICs and the steps required to implement these ICs early in the remedy selection process to ensure that the chosen remedy is effective and protective.

The installation of an SSDS is NOT the preferred long-term remedy to solve the VI problem. The installation of an SSDS is a "temporary fix" to the problem. An SSDS reduces the chemical exposure of building occupants. The solution for solving the VI problem is to remediate groundwater contamination. Groundwater remediation could require many years and outlast the life expectancy of an SSDS. Therefore, yearly SSDS inspections should be conducted to ensure that the system is operating property. Section 10 provides more information on annual inspections.

Section 10. Post-Mitigation Issues

This section discusses post-mitigation issues, including post-installation proficiency air sampling, proficiency sample failures requiring mitigation upgrades, the O&M manual, the Quick Guide summary, and annual inspections.

10.1 Post-Installation Proficiency Air Sampling

Post-installation IA proficiency air sampling should be conducted to ensure proper operation of the system. Such sampling may be requested by local or state health departments to prove that residential mitigation systems are achieving site-specific screening levels. Proficiency air sampling should be scheduled with the owner or occupant. Attachment S is an SSDS proficiency sample reminder form that can be mailed to owner or occupant of the property to be sampled as a reminder that the sampling team will be arriving to collect samples. An example of the sampling frequency and proficiency air sample result letters are discussed below.

10.1.1 Sampling Frequency – Removal Actions (Example)

- The first IA sample should be collected 30 days after system installation.
- The second IA sample to be collected 180 days after system installation.
- The third IA sample can be collected 1 year after system installation.
- Annual IA sampling and/or SSDS inspections (described in Section 10.5) can be performed after the first year.

Note: Fund-lead removal actions may have a 1-year time restriction for completing removal activities.

10.1.2 Proficiency Air Sample Result Letters

When sample results are received from the laboratory, a letter should be mailed or given to the property owner and tenants (if applicable) summarizing the sample results. Attachment T provides an example of a proficiency sample result letter. The example letter explains that the sampling results indicate that IA COC concentrations are less than COC screening levels.

If the IA proficiency sample COC concentrations are greater than the COC screening levels, additional mitigation upgrades are necessary to ensure that COC concentrations are less than COC screening levels (see Section 10.2 below).

10.2 Proficiency Sample Failures Requiring Mitigation Upgrades

If IA proficiency sampling results show a COC concentration exceeding the COC's IA screening level, the mitigation upgrades summarized below can be performed.

- **Sealing cracks in the floor with a concrete floor sealer:** Vapors may be entering cracks or holes in the concrete floor if they have not been sealed.
- **Indoor air sources:** Ensure that there are no sources (paint cans, dry cleaning, gas cans, lawn mowers, chemicals) inside the property that may affect the integrity of the proficiency IA samples.

- **Adding an additional extraction point:** Sometimes addition of another extraction point can solve the problem. In some cases, three or four additional extraction points were required in a basement. Additional extraction points may be required because of unknown concrete footers (blocking airflow) under a residence, the soil type beneath the residence, and other factors.
- **Adding an additional fan and extraction point:** In some cases, a second fan was required because of the large size of the structure's footprint. One fan may or may not be strong enough to create the radius of influence needed to solve the VI problem.
- **Increasing the current fan size:** Sometimes increasing the size of the fan solves the VI problem. A larger fan pulls more air through the extraction points.

  Note: A larger fan may pull additional vapors toward the residence. An engineer should be consulted before the fan size is increased.

Mitigation upgrades should be completed within 30 days of observance of an exceedance of a COC IA screening level. Once mitigation upgrades are completed, proficiency sampling should be completed 30 days later.

10.3 O&M Manual

An O&M manual should be supplied to each property owner where an SSDS was installed. The O&M manual should include, but not be limited to, the following information or items:

- Cover letter
- Pictures of the SSDS
- Copy of signed access agreement
- Copy of vapor abatement system O&M agreement
- Copy of baseline sample result letter
- Copy of proficiency sample result letter
- Warranty information for the SSDS fan
- Contact information in case of future questions

In addition, the property owner or occupant should receive keys to the deadbolt that locks the SSDS switch in the "on" position.

Attachment U contains an example of the O&M manual that U.S. EPA supplied to the property owners at the Behr Dayton VOC Removal Site.

After the O&M manual has been given to the property owner, the owner should sign a record that is kept on file to document that the owner received the O&M manual. Attachment V provides a copy of the O&M Manual Acceptance Form.

Deadbolt that locks the SSDS switch in the "on" position

10.4 Quick Guide Summary

A Quick Guide is a two- to three-page summary of why a vapor abatement system was installed at a property. This guide can be placed into a clear protective sleeve and zip-tied to the main extraction pipe of the system. The Quick Guide is especially helpful at rental properties because tenants may move in and out of the property. The Quick Guide is easy to read and informs each new tenant about what the system is and why it was installed. Attachment W provides an example of a Quick Guide.

10.5 Annual Inspections

For projects that extend beyond 1 year, annual inspections of installed vapor abatement mitigation systems should be conducted to ensure that the system is operating properly. In some cases, the local health department can conduct the annual inspections. The inspections should cover the following:

- System vacuum or pressure readings (header and SS probe)
- Confirmation that the extraction fan is operating
- Confirmation that a padlock is attached to the system on/off switch
- Visual inspection of system piping and components
- Inspection of basement floor and wall seals
- Confirmation of system operation with residents
- Confirmation that a copy of the O&M manual is present in the residence and has been updated as necessary
- Depending on the site, collection of annual IA samples to ensure that the system is working

Attachment X provides an example of a Mitigation System Annual Inspection Form.

If an inspection reveals deficiencies (such as an inoperable fan, power switch in the “off” position, or damaged PVC piping), the deficiencies should be corrected as soon as possible. Depending on the type of correction, a post-correction IA sample may be necessary to ensure that the system is operating effectively. If an IA sample is necessary, the sample should be collected approximately 30 days after the correction has been completed.

At the Behr Dayton VOC Removal Site, U.S. EPA required annual inspections of the mitigation systems installed under the removal action. While the remedial investigation was underway, the following mitigation system items were inspected:

- Radius-of-influence testing to ensure a proper vacuum to the footprint of the structure
- Inspection of the extraction fan to ensure that it was in the “on” position
- Inspection of the PVC piping (inside and outside of the structure) to ensure that the piping had not been damaged
- Inspection of the discharge pipe to ensure that it had not been blocked by debris
- Inspection of the U-tube manometer to ensure that it reads at least 1 inch of water
- Inspection of the O&M manual to ensure that is was present at the property and updated with most recent sampling results

Section 11. References

Interstate Technology and Regulatory Council (ITRC). 2007. "Vapor Intrusion Pathway: A Practical Guideline." On-line Address: http://www.itrcweb.org/Documents/VI-1.pdf

RTI International (RTI). 2008. *Indoor Air Vapor Intrusion Database.* "Preliminary Evaluation of Attenuation Factors." Under "Other Documents." March 4. On-line Address: http://iavi.rti.org/login.cfm (obtain a login identification and password in order to gain access to the database and input data).

United States Environmental Protection Agency (EPA). 2002. "OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils." EPA 530-D-02-004. November. On-line Address: http://www.epa.gov/osw/hazard/correctiveaction/eis/vapor.htm

EPA. 2008. "Brownfields Technology Primer: Vapor Intrusion Considerations for Brownfields Redevelopment." EPA 542-R-08-00. March 1.

EPA. 2009. "U.S. EPA Region 3 Vapor Intrusion Framework." June.

ATTACHMENT A

ACCESS AGREEMENT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

Name (please print): ______________________________

Address of property to be sampled ______________________________

____

Home Phone # ______________________

Cell Phone # ______________________

I consent to officers, employees, contractors, and authorized representatives of the United States Environmental Protection Agency (U.S. EPA) entering and having continued access to this property for the following purpose:

- Conducting air monitoring and air sampling activities;

I realize that these actions taken by U.S. EPA are undertaken pursuant to its response and enforcement responsibilities under the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended, 42 U.S.C. Section 9601 et seq.

This written permission is given by me voluntarily, on behalf of myself and all other co-owners of this property, with knowledge of my right to refuse and without threats or promises of any kind.

______________ ______________________________

Date **Signature**

Sample Location Questions:

1. Are you the Owner _____ or the Tenant _____ of the home or building? If you are the owner, go to #3.
2. If you are the Tenant, please write in the owner's name: ______________________ Go to #3 and write in owner's address and phone number.
3. If you are the owner <u>but live at a different address</u>, write your address below (this is the address where the sample results will be mailed to, otherwise, the results will be mailed to the address at the top of the page):

   Owner's Address:______________________________

   ____

   Home Phone # ______________________________

   Cell Phone # ______________________________
4. Does the home or building have a basement? Yes _____ No _____ (If no, you are done)
5. If yes, does the basement have a concrete slab? Yes _____ No _____
6. If no, does the basement have a dirt floor? Yes _____ No ______ Partial _______

<u>I DO NOT authorize access by U.S. EPA at the above-referenced property.</u>

____

Print Name Signature Date

ATTACHMENT B

SAMPLING REQUEST PACKET

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

January 4, 2008

Dear Resident:

As part of an ongoing pollution investigation in your neighborhood, the U.S. Environmental Protection Agency (EPA) is conducting air sampling in residential structures in the McCook Field Neighborhood, located in Dayton, Ohio. If your home has already been sampled or is scheduled to be sampled, please disregard this letter. EPA and its contractor, Weston Solutions Inc., have collected air samples at several locations in the area to date and with your permission, are prepared to collect air samples in your residence. EPA would like permission to test the air at this location.

As part of the pollution investigation, the EPA requires a signed access agreement to enter the residence and collect samples. Completion of the access form is needed for either consent or denial. This air sampling will be completed at no cost to you.

The EPA and Ohio Department of Health are investigating whether dangerous vapors from contaminated groundwater are seeping into residential homes and contaminating indoor air. The EPA conducted a public meeting on November 3rd to explain the nature of this investigation and is offering free sampling until January 31, 2008.

Please contact Weston Solutions at (937) 262-7919 to arrange for a time for your home to be sampled and please fill out the attached access agreement form. If you do not wish to participate in the free sampling event, please sign the bottom of the access agreement form and mark the box “denying access”, and drop off or mail to U.S. EPA Command Post, 919 North Keowee Street, Dayton, Ohio 45404.

As a reminder, please contact Weston Solutions to schedule your sampling before the January 31, 2008 deadline and to mail in the enclosed access agreement to accept or deny EPA’s offer of free sampling in your residence.

Thank you for reviewing this information.

Sincerely,

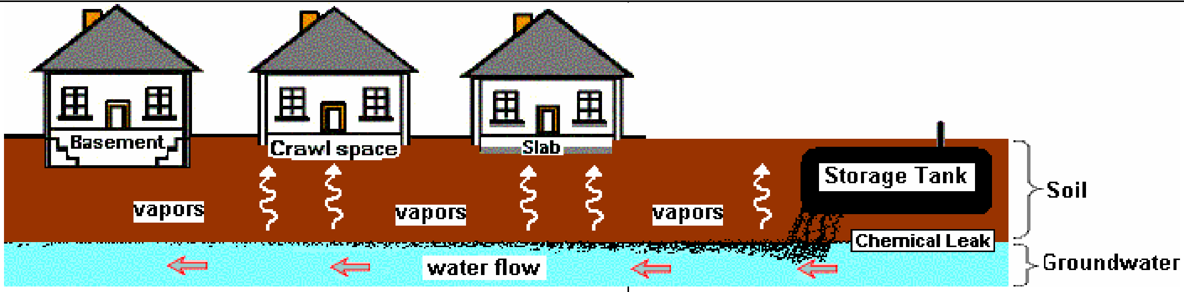
Steven L. Renninger
On-Scene Coordinator
EPA Region 5

Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Vapor Intrusion

Answers to Frequently Asked Health Questions



What is vapor intrusion?

Vapor intrusion refers to the vapors produced by a chemical spill/leak that make their way into indoor air. When chemicals are spilled on the ground or leak from an underground storage tank, they will seep into the soils and will sometimes make their way into the groundwater (underground drinking water). There are a group of chemicals called volatile organic compounds (VOCs) that easily produce vapors. These vapors can travel through soils, especially if the soils are sandy and loose or have a lot of cracks (fissures). These vapors can then enter a home through cracks in the foundation or into a basement with a dirt floor or concrete slab.

VOCs and vapors:

VOCs can be found in petroleum products such as gasoline or diesel fuels, in solvents used for industrial cleaning and are also used in dry cleaning. If there is a large spill or leak resulting in soil or groundwater contamination, vapor intrusion may be possible and should be considered a potential public health concern that may require further investigation.

Although large spills or leaks are a public health concern, other sources of VOCs are found in everyday household products and are a more common source of poor indoor air quality. Common products such as paint, paint strippers and thinners, hobby supplies (glues), solvents, stored fuels (gasoline or home heating fuel), aerosol sprays, new carpeting or furniture, cigarette smoke, moth balls, air fresheners and dry-cleaned clothing all contain VOCs.

Can you get sick from vapor intrusion?

You can get sick from breathing harmful chemical vapors. But getting sick will depend on:
How much you were exposed to (dose).
How long you were exposed (duration).
How often you were exposed (frequency).
How toxic the spill/leak chemicals are.
General Health, age, lifestyle: Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

VOC vapors at high levels can cause a strong petroleum or solvent odor and some persons may experience eye and respiratory irritation, headache and/or nausea (upset stomach). These symptoms are usually temporary and go away when the person is moved to fresh air.

Lower levels of vapors may go unnoticed and a person may feel no health effects. A few individual VOCs are known carcinogens (cause cancer). Health officials are concerned with low-level chemical exposures that happen over many years and may raise a person's lifetime risk for developing cancer.

How is vapor intrusion investigated?

In most cases, collecting soil gas or groundwater samples near the spill site is done first to see if there is on-site contamination. If soil vapors or groundwater contamination are detected at a spill site, environmental protection and public health officials may then ask that soil vapor samples be taken from areas outside the immediate spill site and near any potential affected business or home. The Ohio Department of Health (ODH) does not usually recommend indoor air sampling for vapor intrusion before the on-site contamination is determined.

(continued on next page)

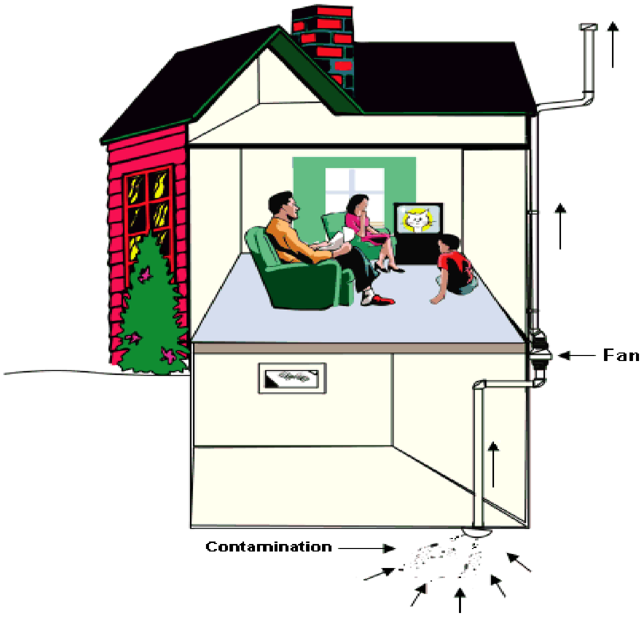
How is vapor intrusion investigated? (continued)

Because a variety of VOC sources are present in most homes, testing will not necessarily confirm VOCs in the indoor air are from VOC contamination in soils at nearby spill site. But if additional sampling is recommended, samples may be taken from beneath the home's foundation (called sub-slab samples), to see if vapors have reached the home. Sub-slab samples are more reliable than indoor air samples and are not as affected by other indoor chemical sources. If there was a need for additional sampling on a private property, homeowners would be contacted by the cleanup contractor or others working on the cleanup site and their cooperation and consent would be requested before any testing/sampling would be done.

What happens if a vapor intrusion problem is found?

If vapor intrusion is having an effect on the air in your home, the most common solution is to install a *radon mitigation system*. A radon mitigation system will prevent gases in the soil from entering the home. A low amount of suction is applied below the foundation and the vapors are vented to the outside. The system uses minimal electricity and should not noticeably affect heating and cooling efficiency. This mitigation system also prevents radon from entering the home, an added health benefit. Usually, the party responsible for cleaning up the contamination is also responsible for paying for the installation of this system. Once the contamination is cleaned up, the system should no longer be needed. In homes with on going radon problems, ODH suggests these systems remain in place permanently.

Radon Mitigation System



What can you do to improve your indoor air quality?

As stated before, the most likely source of VOCs in indoor air comes from the common items that are found in most homes. The following helpful hints will help improve air quality inside your home:

- Do not buy more chemicals than you need and know what products contain VOCs.
- If you have a garage or an out building such as a shed, place the properly stored VOC-containing chemicals outside and away from your family living areas.
- Immediately clean and ventilate any VOC spill area.
- If you smoke, go outside and/or open the windows to ventilate the second-hand, VOC-containing smoke outdoors.
- Make sure all your major appliances and fireplace(s) are in good condition and not leaking harmful VOC vapors. Fix all appliance and fireplace leaks promptly, as well as other leaks that cause moisture problems that encourage mold growth.
- Most VOCs are a fire hazard. Make sure these chemicals are stored in appropriate containers and in a well-ventilated location and away from an open pilot light (flame) of a gas water heater or furnace.
- Fresh air will help prevent both build up of chemical vapors in the air and mold growth. Occasionally open the windows and doors and ventilate.
- Test your home for radon and install a radon detector.

References:

Wisconsin Department of Health and Family Services, Environmental Health Resources, Vapor Intrusion, electronic, 2004.

New York State Department of Health, Center for Environmental Health, April 2003.

Ohio Department of Health, Bureau of Environmental Health, Indoor Environment Program, 2004.

For more information contact:

Ohio Department of Health
Bureau of Environmental Health
Health Assessment Section
246 N. High Street
Columbus, Ohio 43215
Phone: (614) 466-1390
Fax: (614) 466-4556

Created September 2004

Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans

Trichloroethylene (TCE)

(try- klor'oh eth'uh- leen)

Answers to Frequently Asked Health Questions

What is TCE?

TCE is man-made chemical that is not found naturally in the environment. TCE is a non-flammable (does not burn), colorless liquid with a somewhat sweet odor and has a sweet, "burning" taste. It is mainly used as a cleaner to remove grease from metal parts. TCE can also be found in glues, paint removers, typewriter correction fluids and spot removers.

The biggest source of TCE in the environment comes from evaporation (changing from a liquid into a vapor/gas) when industries use TCE to remove grease from metals. But TCE also enters the air when we use common household products that contain TCE. It can also enter the soil and water as the result of spills or improper disposal.

What happens to TCE in the environment?

- TCE will quickly evaporate from the surface waters of rivers, lakes, streams, creeks and puddles.
- If TCE is spilled on the ground, some of it will evaporate and some of it may leak down into the ground. When it rains, TCE can sink through the soils and into the ground (underground drinking) water.
- When TCE is in an oxygen-poor environment and with time, it will break down into different chemicals such as 1,2 Dichloroethene and Vinyl Chloride.
- TCE does not build up in plants and animals.
- The TCE found in foods is believed to come from TCE contaminated water used in food processing or from food processing equipment cleaned with TCE.

How does TCE get into your body?

- TCE can get into your body by breathing (inhalation) air that is polluted with TCE vapors. The vapors can be produced from the manufacturing of TCE, from TCE polluted water evaporating in the shower or by using household products such as spot removers and typewriter correction fluid.
- TCE can get into your body by drinking (ingestion) TCE polluted water.
- Small amounts of TCE can get into your body through skin (dermal) contact. This can take place when using TCE as a cleaner to remove grease from metal parts or by contact with TCE polluted soils.

Can TCE make you sick?

Yes, you can get sick from TCE. But getting sick will depend on the following:

- <u>How much</u> you were exposed to (dose).
- <u>How long</u> you were exposed (duration).
- <u>How often</u> you were exposed (frequency).
- <u>General Health, Age, Lifestyle</u> Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How does TCE affect your health?

<u>Breathing (Inhalation):</u>

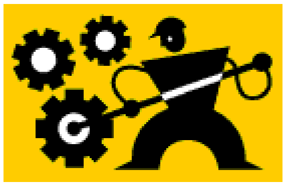
- Breathing <u>high</u> levels of TCE may cause headaches, lung irritation, dizziness, poor coordination (clumsy) and difficulty concentrating.
- Breathing <u>very high</u> levels of TCE for long periods may cause nerve, kidney and liver damage.

<u>Drinking (Ingestion):</u>

- Drinking <u>high</u> concentrations of TCE in the water for long periods may cause liver and kidney damage, harm immune system functions and damage fetal development in pregnant women (although the extent of some of these effects is not yet clear).
- It is uncertain whether drinking low levels of TCE will lead to adverse health effects.

<u>Skin (Dermal) Contact:</u>

- Short periods of skin contact with high levels of TCE may cause skin rashes.



Does TCE cause cancer?

The National Toxicology Program's 11th Report on Carcinogens places chemicals into one of two cancer-causing categories: *Known to be Human Carcinogens* and *Reasonably Anticipated to be Human Carcinogens*.

The11th Report on Carcinogens states TCE is *"Reasonably Anticipated to be Human Carcinogen."*

The category *"Reasonably Anticipated to be Human Carcinogen"* gathers evidence mainly from animal studies. There may be limited human studies or there may be no human or animal study evidence to support carcinogenicity; but the agent, substance or mixture belongs to a well-defined class of substances that are known to be carcinogenic.

There are human studies of communities that were exposed to high levels of TCE in drinking water and they have found evidence of increased leukemia's. But the residents of these communities were also exposed to other solvents and may have had other risk factors associated with this type of cancer.

Animal lab studies in mice and rats have suggested that high levels of TCE may cause liver, lung, kidney and blood (lymphoma) cancers.

As part of the National Exposure Subregistry, the Agency for Toxic Substances and Disease Registry (ATSDR) compiled data on 4,280 residents of three states (Michigan, Illinois, and Indiana) who had environmental exposure to TCE. ATSDR found no definitive evidence for an excess of cancers from these TCE exposures.

The U.S. EPA is currently reviewing the carcinogenicity of TCE.

Is there a medical test to show whether you have been exposed to TCE?

If you have recently been exposed to TCE, it can be detected in your breath, blood, or urine. The breath test, if done soon after exposure, can tell if you have been exposed to even a small amount of TCE.

Exposure to larger amounts is measured in blood and urine tests. These tests detect TCE and many of its breakdown products for up to a week after exposure. However, exposure to other similar chemicals can produce the same breakdown products in the blood and urine so the detection of the breakdown products is not absolute proof of exposure to TCE.

These tests aren't available at most doctors' offices, but can be done at special laboratories that have the right equipment. **Note:** Tests can determine if you have been exposed to TCE but cannot predict if you will experience adverse health effects from the exposure.

Updated 10/12/06

Has the federal government made recommendations to protect human health?

The federal government develops regulations and recommendations to protect public health and these regulations can be enforced by law.

Recommendations and regulations are periodically updated as more information becomes available. Some regulations and recommendations for TCE follow:

- The Environmental Protection Agency (EPA) has set a maximum contaminant level for TCE in drinking water at 0.005 milligrams per liter (0.005 mg/L) or 5 parts of TCE per billion parts water (5 ppb).
- The Occupational Safety and Health Administration (OSHA) have set an exposure limit of 100 ppm (or 100 parts of TCE per million parts of air) for an 8-hour workday, 40-hour workweek.
- The EPA has developed regulations for the handling and disposal of TCE.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for TCE (electronic at http://www.atsdr.cdc.gov/tfacts19.html)

Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2005 (2005 electronic at http://ntp.niehs.nih.gov/ntp/roc/toc11.html)

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

This pamphlet was created by the Ohio Department of Health, Bureau of Environmental Health, Health Assessment Section and supported in whole by funds from the Cooperative Agreement Program grant from the ATSDR.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

Name (please print): ______________________________________

Address of property to be sampled ______________________________

____

Home Phone # ________________________

Cell Phone # ________________________

I consent to officers, employees, contractors, and authorized representatives of the United States Environmental Protection Agency (U.S. EPA) entering and having continued access to this property for the following purpose:

- Conducting air monitoring and air sampling activities;

I realize that these actions taken by U.S. EPA are undertaken pursuant to its response and enforcement responsibilities under the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended, 42 U.S.C. Section 9601 et seq.

This written permission is given by me voluntarily, on behalf of myself and all other co-owners of this property, with knowledge of my right to refuse and without threats or promises of any kind.

______________ ___________________________________

Date **Signature**

Sample Location Questions:

1. Are you the Owner _____ or the Tenant _____ of the home or building? If you are the Tenant, please write in the owner's name, address and phone number: ______________________________________
2. If you are the owner but live at a different address, write your address below (this is the address where the sample results will be mailed to, otherwise, the results will be mailed to the address at the top of the page):

   Owner's Address:__________________________________

   ____

   Home Phone # ____________________________________

   Cell Phone # ______________________________________
3. Does the home or building have a basement? Yes _____ No _____
4. If yes, does the basement have a concrete slab? Yes _____ No _____
5. If no, does the basement have a dirt floor? Yes _____ No _____
6. Is there a heating or ventilation system in the basement? Yes _____ No _____

I do not authorize access by U.S. EPA at the above-referenced property.

____

Signature Date

____

Print Name

EPA
REGION V
EMERGENCY
RESPONSE
TEAM

U.S. EPA FREE INDOOR AIR SAMPLING

CONTACT INFORMATION

TO SCHEDULE A SAMPLE APPOINTMENT, CALL
937-262-7919

OR

STOP BY THE
U.S. EPA COMMAND POST
LOCATED AT:

919 NORTH KEOWEE STREET
DAYTON, OHIO 45404

OFFICE HOURS M-F 9AM – 5PM

ATTACHMENT C

SAMPLE REQUEST LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

July 27, 2009

Dear Property Owner or Resident:

As part of an environmental investigation being conducted in the area of Cincinnati's West End neighborhood, the U.S. Environmental Protection Agency (EPA) needs to test the air in some of the area homes, including your residence.

The EPA, Ohio Department of Health (ODH), Ohio EPA, Cincinnati Health Department and the City of Cincinnati Office of Environmental Quality are investigating whether vapors from a contaminated groundwater plume are entering into homes and contaminating the indoor air. Please note that your drinking water is not contaminated. The drinking water for the West End neighborhood is treated by the City of Cincinnati and is safe to drink.

As part of the investigation, the EPA requires a signed access agreement (written permission) to enter your property and collect samples. EPA and its contractor, Weston Solutions, are prepared to collect air samples at your property and need your permission before we can test your indoor air. If the house is a rental property, the access agreement must be signed by both the property owner and the tenant(s). Completion of the access form is needed for either consent (which allows us to test your home) or denial. This air sampling will be completed at no cost to you.

If you are interested in having free air samples collected at your property, please fill out and mail the attached access agreement form by August 7, 2009. If you do not wish to participate in the free sampling event, please sign the bottom of the access agreement form and mark the box "denying access", and mail using the EPA postage-paid envelope.

As a reminder, please mail in the enclosed access agreement form to accept or deny EPA's offer of free sampling at your property by the August 7, 2009 deadline. If you have any questions, please contact Weston Solutions, at (513) 703-3092.

Sincerely,

Steven L. Renninger
On-Scene Coordinator
U.S. EPA Region 5 - Emergency Response Branch

Enclosures:

1) Access Agreement
2) Postage-Paid envelope

ATTACHMENT D

RESIDENTIAL SAMPLE REMINDER FORM

Residential Sample Reminder Form

SAMPLE TIME:

Date: ___________________

Time: ___________________

PICK-UP TIME:

Date: ___________________

Time: ___________________

Location: _________________________________

U.S. EPA Sampling Notes and Reminders:

1) U.S. EPA will collect at least one sub-slab and one indoor air sample from your property. The duration of the test is approximately 24 hours.
2) The samples will be collected in stainless steel SUMMA canisters. The canister is made of clean stainless steel and does not contain any moving parts or chemicals. Please do not handle or move the canister during the testing.
3) If your basement has a concrete floor or if you have a slab foundation, U.S. EPA will install one sample probe in the house foundation and collect an air sample. The location of the sample probe will be placed in a location that is not that noticeable. This sample is called a sub-slab sample and will test the soil gas beneath your home.
4) If you have a basement with a dirt floor, no sub-slab sample will be collected. Only an indoor air sample will be collected from the basement area.
5) The indoor air sample will be collected in the basement of the house. If there is no basement, the indoor air sample will be collected in the living area of the home.
6) Please do not smoke around the canister and to the extent possible, please leave doors and windows closed during testing.
7) During sampling, do not enter the room where there air samples are being collected. Activity in the room has the potential to alter the air sample results.
8) If possible, do not bring dry cleaning home during the testing.
9) If you have any aggressive pets, please lock them up or place them into a separate room prior to the sample team arriving at your property
10) Analytical results will be submitted to the owner (and tenant(s), if applicable) approximately 4-6 weeks after sampling is completed
11) U.S. EPA will offer to meet with each owner (and tenant(s), if applicable) to discuss the air sample results.
12) As a courtesy, please be on time for your appointment.
13) If you have to reschedule your appointment, please contact U.S. EPA's technical contractor as soon as possible at ______________.

ATTACHMENT E

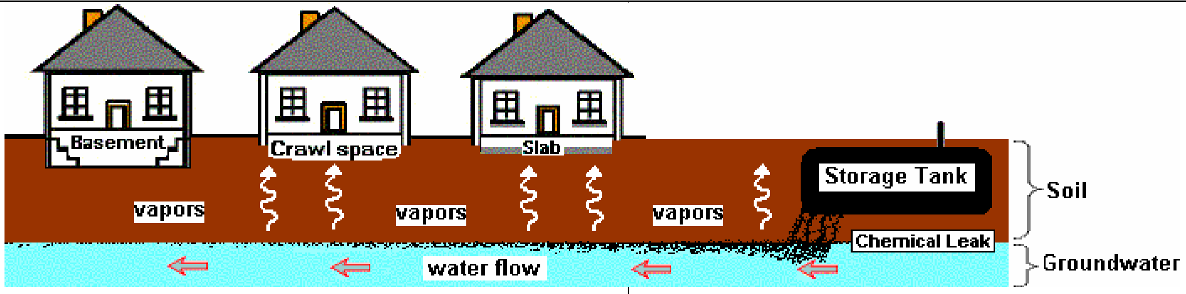
EXAMPLE FACT SHEETS

Bureau of
Environmental Health
Health Assessment Section

“To protect and improve the health of all Ohioans”

Vapor Intrusion

Answers to Frequently Asked Health Questions



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(continued on next page)

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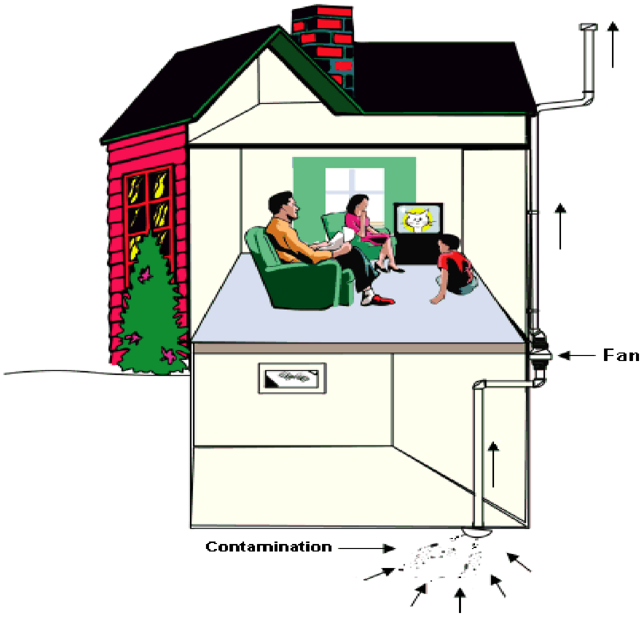

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For more information contact:

Ohio Department of Health
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Created September 2004

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“To protect and improve the health of all Ohioans

Trichloroethylene (TCE)

(try- klor'oh eth'uh- leen)

Answers to Frequently Asked Health Questions

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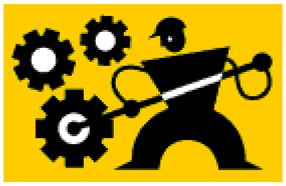
<u>Drinking (Ingestion):</u>

- Drinking <u>high</u> concentrations of TCE in the water for long periods may cause liver and kidney damage, harm immune system functions and damage fetal development in pregnant women (although the extent of some of these effects is not yet clear).
- It is uncertain whether drinking low levels of TCE will lead to adverse health effects.

<u>Skin (Dermal) Contact:</u>

- Short periods of skin contact with high levels of TCE may cause skin rashes.



Does TCE cause cancer?

The National Toxicology Program's 11th Report on Carcinogens places chemicals into one of two cancer-causing categories: *Known to be Human Carcinogens* and *Reasonably Anticipated to be Human Carcinogens*.

The11th Report on Carcinogens states TCE is *"Reasonably Anticipated to be Human Carcinogen."*

The category *"Reasonably Anticipated to be Human Carcinogen"* gathers evidence mainly from animal studies. There may be limited human studies or there may be no human or animal study evidence to support carcinogenicity; but the agent, substance or mixture belongs to a well-defined class of substances that are known to be carcinogenic.

There are human studies of communities that were exposed to high levels of TCE in drinking water and they have found evidence of increased leukemia's. But the residents of these communities were also exposed to other solvents and may have had other risk factors associated with this type of cancer.

Animal lab studies in mice and rats have suggested that high levels of TCE may cause liver, lung, kidney and blood (lymphoma) cancers.

As part of the National Exposure Subregistry, the Agency for Toxic Substances and Disease Registry (ATSDR) compiled data on 4,280 residents of three states (Michigan, Illinois, and Indiana) who had environmental exposure to TCE. ATSDR found no definitive evidence for an excess of cancers from these TCE exposures.

The U.S. EPA is currently reviewing the carcinogenicity of TCE.

Is there a medical test to show whether you have been exposed to TCE?

If you have recently been exposed to TCE, it can be detected in your breath, blood, or urine. The breath test, if done soon after exposure, can tell if you have been exposed to even a small amount of TCE.

Exposure to larger amounts is measured in blood and urine tests. These tests detect TCE and many of its breakdown products for up to a week after exposure. However, exposure to other similar chemicals can produce the same breakdown products in the blood and urine so the detection of the breakdown products is not absolute proof of exposure to TCE.

These tests aren't available at most doctors' offices, but can be done at special laboratories that have the right equipment. **Note:** Tests can determine if you have been exposed to TCE but cannot predict if you will experience adverse health effects from the exposure.

Has the federal government made recommendations to protect human health?

The federal government develops regulations and recommendations to protect public health and these regulations can be enforced by law.

Recommendations and regulations are periodically updated as more information becomes available. Some regulations and recommendations for TCE follow:

- The Environmental Protection Agency (EPA) has set a maximum contaminant level for TCE in drinking water at 0.005 milligrams per liter (0.005 mg/L) or 5 parts of TCE per billion parts water (5 ppb).
- The Occupational Safety and Health Administration (OSHA) have set an exposure limit of 100 ppm (or 100 parts of TCE per million parts of air) for an 8-hour workday, 40-hour workweek.
- The EPA has developed regulations for the handling and disposal of TCE.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for TCE (electronic at **http://www.atsdr.cdc.gov/tfacts19.html**)

Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2005 (2005 electronic at **http://ntp.niehs.nih.gov/ntp/roc/toc11.html**)

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

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ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Updated 10/12/06

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Tetrachloroethylene (PCE)

Other names for tetrachloroethylene include PCE, perchloroethylene, PERC or tetrachloroethene.

What is PCE?

Tetrachloroethylene (also known as PCE, PERC or perchloroethylene) is a man-made chemical that is widely used for dry cleaning clothes and degreasing metal. It is also used to make other chemicals and can be found in some household products such as water repellents, silicone lubricants, spot removers, adhesives and wood cleaners. It easily evaporates (turn from a liquid to a gas) into the air and has a sharp, sweet odor. PCE is a nonflammable (does not burn) liquid at room temperature.

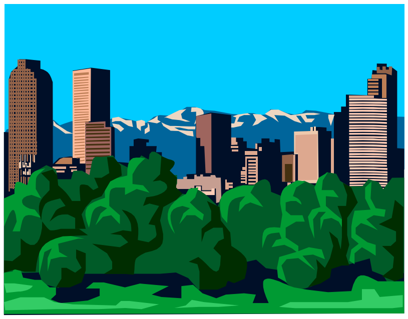
How does PCE get into the environment?

PCE can evaporate into the air during dry cleaning operations and during industrial use. It can also evaporate into the air if it is not properly stored or was spilled. If it was spilled or leaked on the ground, it may find its way into groundwater (underground drinking water).

People can be exposed to PCE from the environment from household products, from dry cleaning products and from their occupation (work). Common environmental levels of PCE (called background levels) can be found in the air we breathe, in the water we drink and in the food we eat. In general, levels in the air are higher in the cities or around industrial areas where it is used more than rural or remote areas.

The people with the greatest chance of exposure to PCE are those who work with it. According to estimates from a survey conducted by the National Institute for Occupational Safety and Health (NIOSH), more than 650,000 U.S. workers may be exposed. However, the air close to dry cleaning business and industrial sites may have levels of PCE higher than background levels. If the dry cleaning business or industry has spilled or leaked PCE on the ground, there may also be contaminated groundwater as well.

What happens to PCE in the environment?



Much of the PCE that gets into surface waters or soil evaporates into the air. However, some of the PCE may make its way to the groundwater. Microorganisms can break down some of the PCE in soil or underground water. In the air, it is broken down by sunlight into other chemicals or brought back to the soil and water by rain. PCE does not appear to collect in fish or other animals that live in water.

How can PCE enter and leave my body?

PCE can enter your body when you breathe contaminated air or when you drink water or eat food contaminated with the chemical. If PCE is trapped against your skin, a small amount of it can pass through into your body. Very little PCE in the air can pass through your skin into your body. Breathing contaminated air and drinking water are the two most likely ways people will be exposed to PCE. How much enters your body depends on how much of the chemical is in the air, how fast and deeply you are breathing, how long you are exposed to it or how much of the chemical you eat or drink.

Most PCE leaves your body from your lungs when you breathe out. This is true whether you take in the chemical by breathing, drinking, eating, or touching it. A small amount is changed by your body (in your liver) into other chemicals that are removed from your body in urine. Most of the changed PCE leaves your body in a few days. Some of it that you take in is found in your blood and other tissues, especially body fat. Part of the PCE that is stored in fat may stay in your body for several days or weeks before it is eliminated.

Can PCE make you sick?

Yes, you can get sick from contact with PCE. But getting sick will depend upon:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- General Health, Age, Lifestyle Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How can PCE affect my health?

Exposure to very high concentrations of PCE (particularly in closed, poorly ventilated areas) can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness and even death. Skin irritation may result from repeated or extended contact with it as well. These symptoms occur almost entirely in work (or hobby) environments when people have been accidentally exposed to high concentrations or have intentionally used PCE to get a "high." Normal background levels (or common environmental levels) will not cause these health affects.

Does PCE cause cancer (carcinogen)?

In the United States, the National Toxicology Program (NTP) releases the *Report on Carcinogens* (RoC) every two years. The *Report on Carcinogens* (RoC) identifies two groups of agents: "Known to be human carcinogens" & "Reasonably anticipated to be human carcinogens."

PCE has been shown to cause liver tumors in mice and kidney tumors in male rats. There is limited evidence for the carcinogenicity of PCE in humans. PCE has been studied by observing laundry and dry-cleaning workers, who may also have been exposed to other solvents, especially trichloroethylene (TCE), but also petroleum solvents.

The *Eleventh Report on Carcinogens* (RoC) has determined that PCE may reasonably be anticipated to be a carcinogen.

Reference:

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological Profile for tetrachloroethylene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service

Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2006. http://ntp.niehs.nih.gov/ntp/roc/toc11.html

Is there a medical test to show whether you have been exposed to PCE?

One way of testing for PCE exposure is to measure the amount of the chemical in the breath, much the same way breath-alcohol measurements are used to determine the amount of alcohol in the blood. Because PCE is stored in the body's fat and slowly released into the bloodstream, it can be detected in the breath for weeks following a heavy exposure. Also, PCE and trichloroacetic acid (TCA), a breakdown product of PCE, can be detected in the blood. These tests are relatively simple to perform but are not available at most doctors' offices and must be done at special laboratories that have the right equipment. Because exposure to other chemicals can produce the same breakdown products in the urine and blood, the tests for breakdown products cannot determine if you have been exposed to PCE or the other chemicals that produce the same breakdown chemicals.

What has the federal government made recommendations to protect human health?

The EPA maximum contaminant level for the amount of PCE that can be in drinking water is 0.005 milligrams PCE per liter of water (0.005 mg/L).

The Occupational Safety and Health Administration (OSHA) have set a limit of 100 ppm for an 8-hour workday over a 40-hour workweek.

The National Institute for Occupational Safety and Health (NIOSH) recommends that PCE be handled as a potential carcinogen and recommends that levels in workplace air should be as low as possible.

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ATSDR
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Revised 08-21-06

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Health Assessment Section

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Exposure to Toxic Chemicals

Answers to Frequently Asked Health Questions

How are we exposed to chemicals?

We come in contact with many different chemicals every day that are non-toxic and normally do not cause health problems. But any chemical could become toxic if a person comes in contact with high enough doses. For example: Aspirin will cure a headache but too much aspirin becomes toxic and can cause serious health problems. You can get sick from contact with chemicals but getting sick will depend on the following:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- General Health, Age, Lifestyle
  Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

Other factors that increase health risks are:

- Current health status (if you are ill or healthy).
- Lifestyle, age, and weight.
- Smoking, drinking alcohol, or taking certain medicines or drugs.
- Allergies to certain chemicals.
- Past chemical exposure.
- Working in an industry/factory that makes or uses chemicals.

What is a completed exposure pathway?

Chemicals must have a way to get into a person's body to cause health problems. This process of those chemicals getting into our bodies is called an exposure pathway. A completed exposure pathway includes all of the following 5 links between a chemical source and the people who are exposed to that chemical.

(1) A Source of the chemical (where the chemical came from);
(2) Environmental Transport (the way the chemical moves from the source to the public. This can take place through the soil, air, underground drinking water or surface water);
(3) Point of Exposure (the place where there is physical contact with the chemical. This could be on-site as well as off-site);
(4) A Route of Exposure (how people came into the physical contact with the chemical. This can take place by drinking, eating, breathing or touching it);
(5) People Who Could be Exposed (people that live near a facility who are most likely to come into physical contact with the site-related chemical).

What are exposure routes?

There are three ways (routes) a person can come in contact with toxic chemicals. They include:

- Breathing (inhalation).
- Eating and drinking (ingestion).
- Skin contact (dermal contact).

Inhalation (breathing)
Chemicals can enter our body through the air we breathe. These chemicals can come in the form of dust, mist, or fumes. Some chemicals may stay in the lungs and damage lung cells. Other chemicals may pass through lung tissue, enter the bloodstream, and affect other parts of our body.

Ingestion (eating or drinking)
The body can absorb chemicals in the stomach from the foods we eat or the liquids we drink. Chemicals may also be in the dust or soil we swallow. These chemicals can enter our blood and affect other parts of our body.

Dermal (skin) Contact
Chemicals can enter our body through our skin. We can come in contact with water polluted by chemicals or touch polluted soil. Some chemicals pass through our skin and enter our bloodstream, affecting other parts of our body.

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Health Assessment Section

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Benzene (ben' zeen)

Answers to Frequently Asked Health Questions

What is benzene?

Benzene, also known as benzol, is a colorless liquid with a sweet odor. It is highly flammable and evaporates in the air quickly.

Where do you find benzene?

Most everyone is exposed to low levels of benzene in their every day activities. People are exposed to small amounts of benzene in the air outside, at work and in the home.

Benzene is a natural part of crude oil, gas and cigarette smoke. Auto exhaust and industrial emissions account for about 20% of the total nationwide exposure to benzene. About 50% of the entire nationwide exposure to benzene results from smoking tobacco or from 2nd hand exposure to tobacco smoke. Other natural sources of benzene include volcanoes and forest fires.

The outdoor air has low levels of benzene that come from the car exhaust, gas fumes and cigarette smoke. Indoor air usually contains higher levels of benzene that can be found in cigarette smoke, glues, paints, furniture wax and detergents.

Benzene is widely used in U.S. industry. Some industries use benzene to make other chemicals which are used to make plastics, resins, nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs and pesticides.

How do you come in contact with unhealthy levels of benzene?

In the air:
- Higher levels of benzene can be released in the air around industries that make or use benzene.

In the underground drinking water:
- If underground storage tanks containing benzene leak, benzene could get into the underground well water and pollute it.

Occupation (job):
- Working in an industry that makes or uses benzene.

Can benzene make you sick?

Yes, you can get sick from benzene. Getting sick will depend on:
- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- General Health, Age, Lifestyle
  Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How does benzene affect health?

Breathing benzene:
Breathing high levels of benzene can cause rapid heart rate, dizziness, headaches, tremors (shaking), confusion, drowsiness (sleepy), and unconsciousness (passing out). Breathing extremely high levels of benzene can result in death.

Eating or drinking benzene:
Eating foods or drinking water containing high levels of benzene can cause an irritated (upset) stomach, vomiting, rapid heart rate, dizziness, convulsions (severe shaking), sleepiness and death.

Long-term exposure to benzene:
Long-term exposure (365 days or longer) to high levels of benzene causes serious problems with the production of blood. Benzene harms the bone marrow which produces the body's red and white blood cells. Red blood cells carry oxygen and white blood cells fight infection. A decrease in red blood cells leads to anemia. A decrease in white blood cells affects the immune system and increases the chance for infection.

Women exposed to benzene:
Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries. It is not known whether benzene exposure affects the developing fetus in pregnant women or fertility in men.

Does benzene cause cancer?

Yes, the Department of Health and Human Services (HHS) has determined that benzene is a known human carcinogen (causes cancer).

Long-term exposure to high levels of benzene in the air can lead to leukemia and cancers of the blood-forming organs.

Is there a medical test to show whether you have been exposed to benzene?

Several tests can show if you have been exposed to benzene. However, all these tests must be done shortly after exposure because benzene leaves the body quickly. These tests include testing the breath, blood and urine. However, the urine test may not be as effective to measures benzene levels.

Note that all these tests will show the amount of benzene in your body but cannot tell you whether you will have any harmful health problems. They also do not tell you where the benzene came from.

What has been done to protect human health?

The Occupational Safety and Health Administration (OSHA) has set a permissible 1 ppm exposure limit of air in the workplace during an 8-hour workday, 40-hour week.

The Environmental Protection Agency (EPA) has set the maximum permissible level of benzene in drinking water at 0.005 parts per million (ppm).

The EPA requires benzene spills or accidental releases into the environment of 10 pounds or more of be reported to the EPA.

Most people can begin to smell benzene in air at 1.5 - 4.7 parts of benzene parts per million (ppm) and smell benzene in water at 2 ppm. Most people can begin to taste benzene in water at 0.5 - 4.5 ppm.

For more information contact:

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Reference:

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for benzene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2006.

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BTEX

Benzene, Toluene, Ethylbenzene, and Xylenes

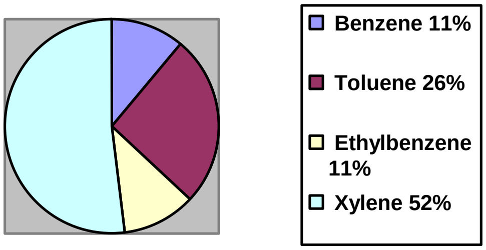
What is BTEX?

BTEX is not one chemical, but are a group of the following chemical compounds:

Benzene, **T**oluene, **E**thylbenzene and **X**ylenes.

BTEX are made up of naturally-occurring chemicals that are found mainly in petroleum products such as gasoline. Refineries will change the amounts of these chemical compounds to meet vapor pressure and octane standards for gasoline. Besides gasoline, BTEX can be found in many of the common household products we use every day.

BTEX Breakdown



BTEX typically make up about 18% of gasoline.

What are some products that contain BTEX?

Benzene can be found in gasoline and in products such as synthetic rubber, plastics, nylon, insecticides, paints, dyes, resins-glues, furniture wax, detergents and cosmetics. Benzene can also be found in cigarette smoke. Auto exhaust and industrial emissions account for about 20% of the total nationwide exposure to benzene. About 50% of the entire nationwide exposure to benzene results from smoking tobacco or from exposure to tobacco smoke.

Toluene occurs naturally as a component of many petroleum products. Toluene is used as a solvent for paints, coatings, gums, oils and resins.

Ethylbenzene is used mostly as a gasoline and aviation fuel additive. It may also be present in consumer products such as paints, inks, plastics and pesticides.

There are three forms of **Xylene:** ortho-, meta-, and para-. Ortho-xylene is the only naturally-occurring form of xylene; the other two forms are man-made. Xylenes are used in gasoline and as a solvent in printing, rubber and leather industries.

BTEX are in a class of chemicals known as volatile organic compounds (VOCs). VOC chemicals easily vaporize or change from a liquid to a vapor (gas). The VOC vapors can travel through the air and/or move through contaminated groundwater and soils as vapors, possibly impacting indoor air quality in nearby homes or businesses.

Where do you find BTEX?

Most people are exposed to small amounts of BTEX compounds in the ambient (outdoor) air, at work and in the home. Most everyone is exposed to low levels of these chemicals in their everyday activities. People who live in urban areas (cities) or by major roads and highways will likely be exposed to more BTEX than someone who lives in a rural setting.

Besides common everyday exposures, larger amounts of BTEX can enter the environment from leaks from underground storage tanks, overfills of storage tanks, fuel spills and landfills. BTEX compounds easily move through soils and can make their way into the groundwater, contaminating public and private water systems and the soils in between.

Can exposure to BTEX make you sick?

Yes, you can get sick from exposure to BTEX. But getting sick will depend on:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- General Health, Age, Lifestyle
  Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How are you exposed to BTEX?

Exposure can occur by either drinking contaminated water (ingestion), by breathing contaminated air from pumping gas or from the water via showering or laundering (inhalation) or from spills on your skin (dermal).

How does BTEX affect health?

Acute (short-term) exposure to gasoline and its components benzene, toluene and xylenes has been associated with skin and sensory irritation, central nervous system-CNS problems (tiredness, dizziness, headache, loss of coordination) and effects on the respiratory system (eye and nose irritation).

On top of skin, sensory and CNS problems, prolonged exposure to these compounds can also affect the kidney, liver and blood systems.

Do BTEX compounds cause cancer?

In the absence of data on the cancer-causing nature of the whole mixture (benzene, toluene, ethylbenzene and xylenes), possible health hazards from exposures to BTEX are assessed using an individual component-based approach of the individual chemicals.

Benzene: According to the U.S. EPA, there is good evidence to believe that benzene is a known human carcinogen (causes cancer). Workers exposed to high levels of benzene in occupational settings were found to have an increase occurrence of leukemia. The Department of Health and Human Services (HHS) has determined that benzene is a known human carcinogen. Long-term exposure to high levels of benzene in the air can lead to leukemia and cancers of the blood-forming organs.

Ethylbenzene: According to the International Agency for Research on Cancer (IARC), ethylbenzene classified as a Group 2B, possibly carcinogenic to humans, based on studies of laboratory animals.

Toluene, and Xylenes have been categorized as not classifiable as to human carcinogenicity by both EPA (IRIS 2001) and IARC (1999a, 1999b), reflecting the lack of evidence for the carcinogenicity of these two chemicals.

Is there a medical test to show whether you have been exposed to BTEX?

Several tests can show if you have been exposed to BTEX. Components of BTEX can be found in the blood, urine, breath and some body tissues of exposed people. However, these tests need to be done within a few hours after exposure because these substances leave the body very quickly. The most common way to test for ethylbenzene is in the urine. However, the urine test may not be as effective to measures benzene levels.

Note these tests will perhaps show the amount of BTEX in your body, but they cannot tell you whether you will have any harmful health problems. They also do not tell you where the benzene came from.

How can families reduce the risk of exposure to BTEX?

- Use adequate ventilation to reduce exposure to BTEX vapors from consumer products such as gasoline, pesticides, varnishes, paints, resins-glues and newly installed carpeting.
- Household chemicals should be stored out of reach of children to prevent accidental poisoning. Always store household chemicals in their original containers; never store them in containers that children would find attractive to eat or drink from, such as old soda bottles. Gasoline should be stored in a gasoline can with a locked cap.
- Volatile chemicals should be stored outside the home if possible – in a separate garage or shed.
- Don't smoke indoors with doors and windows closed.

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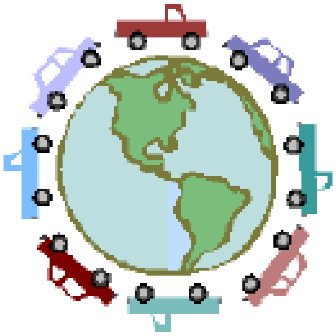

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References:

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for benzene. U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry (ATSDR). 2007. Toxicological profile for ethylbenzene. U.S. Department of Health and Human Services, Public Health Service.

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Agency for Toxic Substances and Disease Registry (ATSDR). 2004. Interaction Profile for Benzene, Toluene, Ethylbenzene and Xylene (BTEX). U.S. Department of Health and Human Services, Public Health Service.

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1,2-Dichloroethene

(also called cis- and trans- 1,2 DCE)

Answers to Frequently Asked Health Questions

What is 1,2 DCE?

1,2-Dichloroethene (1,2 DCE) is a highly-flammable, chlorinated, colorless liquid that has a sharp, harsh odor. There are no known products you can buy that contain 1,2 DCE. 1,2 DCE is used when mixing other chlorinated chemicals and is most often used to produce chemical solvents.

How does 1,2 DCE enter the environment?

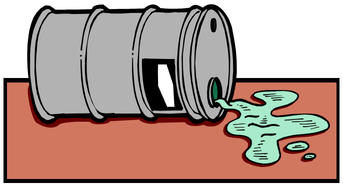
1,2 DCE is released to the environment from chemical factories that make or use this chemical, from landfills and hazardous waste sites that have a spill or leak, from chemical spills, from burning vinyl, and from the chemical breakdown of other chlorinated chemicals in the underground drinking water (groundwater).

What happens to 1,2 DCE when it enters the environment?

Air: When spilled on moist soils or in rivers, lakes and other bodies of water, most of the 1,2 DCE quickly evaporates into the air. 1,2 DCE quickly breaks down by reacting with the sunlight. In the air, it usually takes about 5-12 days for half of any amount spilled to break down.

Water: The 1,2 DCE found below soil surfaces in landfills or hazardous waste sites may dissolve in water during rain events and leak deeper in the soils, possibly contaminating the groundwater. Once in groundwater, it takes about 13-48 weeks for half of any amount spilled to break down.

Soils: Some 1,2 DCE trapped under ground may escape as soil-gas vapors. These vapors can travel through soils, especially if the soils are sandy and loose or have a lot of cracks (fissures). The vapors can then enter a home through cracks in the foundation or into a basement with a dirt floor or concrete slab. 1,2 DCE in groundwater will eventually break down into vinyl chloride and other chemicals, some of which are more hazardous to people than the 1,2 DCE.



How can I be exposed to 1,2 DCE?

People who live in cities or suburbs are more likely to be exposed to 1,2 DCE than people living in rural areas. Most people who are exposed through air or water are exposed to very low levels, in the parts per billion (ppb) range. **Notes: “ppb” is a unit of measurement. Example: 1 part per billion (1 ppb) would be equal to having one bean in a pile of one billion beans or 1 second of time in 32 years.**

Human exposure to 1,2 DCE usually happens where the chemical has been improperly disposed of or spilled. Exposure mainly happens by breathing contaminated air or drinking contaminated water. If the water in your home is contaminated, you could also be breathing 1,2 DCE vapors while cooking, bathing or washing dishes.

The people who are most likely to be exposed to 1,2 DCE are people who work at factories where this chemical is made or used, people who work at a 1,2 DCE contaminated landfill, communities that live near contaminated landfills and hazardous waste sites.

How does 1,2 DCE enter and leave my body?

Most 1,2 DCE enters the body through your lungs when you breathe contaminated air, through your stomach and intestines when you eat contaminated food or water, or through your skin upon contact with the chemical.

Once breathed or swallowed, it enters your blood rapidly. Once in your blood, it travels throughout your body. When it reaches your liver it is changes into several other break-down chemicals. Some of these chemicals are more harmful than 1,2 DCE.

Can 1,2 DCE make me sick?

Yes, you can get sick from exposure to 1,2 DCE. However, getting sick will depend on many factors such as:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- How toxic is the chemical of concern.
- General Health, Age, Lifestyle
  Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How can exposure to 1,2 DCE affect my health?

Most information about exposure to 1,2 DCE is from occupational studies where workers were exposed at very high levels. Most environmental exposures to 1,2 DCE are at much lower than those in the workplace.

The short-term occupational studies of workers exposed to breathing high levels of 1,2 DCE found workers became nauseous (upset stomach), drowsy and tired.

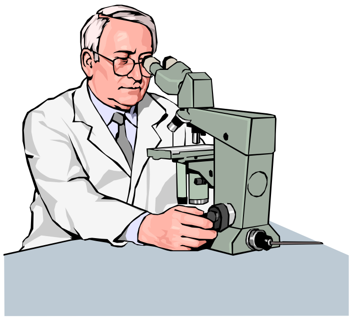
The long-term human health effects after exposure to low concentrations of 1,2 DCE are not known.

Will exposure to 1,2 DCE cause cancer?

The U.S. EPA classifies 1,2 DCE as a Class D carcinogen. The U.S. EPA Class D category is used when the chemical is not classifiable to its human carcinogenicity (ability to cause cancer). This classification is made because there is no solid data that this chemical causes cancer in humans or animals.

Is there a test to find out if I have been exposed to 1,2 DCE?

Tests are available to measure concentrations of 1,2 DCE in blood, urine and tissues. However, these tests aren't normally used to determine whether a person has been exposed to this compound. This is due to the fact that after you are exposed to 1,2 DCE, the breakdown products in your body that are detected with these tests may be the same as those that come from exposure to other chemicals. These tests aren't available in most doctors' offices, but can be done at special laboratories that have the right equipment.



What recommendations has the federal government made to protect human health?

The federal government has developed regulatory standards and guidelines to protect people from possible health effects of 1,2 DCE in water and air.

Water: The EPA has established water quality guidelines to protect both aquatic life and people who eat fish and shellfish. The EPA Office of Drinking Water has set a drinking water regulation that states that water delivered to any user of a public water system shall not exceed 70 ppb for cis-1,2 DCE and 100 ppb trans-1,2 DCE. For very short-term exposures (1 day) for children, EPA advises that concentrations in drinking water should not be more than 4 ppm for cis-1,2 DCE or 20 ppm for trans-1,2 DCE. For 10-day exposures for children, EPA advises that drinking water concentrations should not be more than 3 ppm for cis-1,2 DCE or 2 ppm for trans-1,2 DCE. For industrial or waste disposal sites, any release of 1,000 pounds or more must be reported to the EPA.

Air: The National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) have established guidelines for occupational exposure to cis- or trans-1,2 DCE. Average concentrations should not exceed 200 ppm in the air.

References:

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. Toxicological profile for 1,2-Dichloroethene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. (2006 electronic copy at: http://www.atsdr.cdc.gov/toxprofiles/tp87.html)

U.S. Environmental Protection Agency, Integrated Risk Information System, II.A.1. Weight-of-Evidence Characterization (2006 electronic copy at: http://www.epa.gov/iris/subst/0418.htm#evid)

Where Can I Get More Information?

Ohio Department of Health
Bureau of Environmental Health
Health Assessment Section
246 N. High Street
Columbus, Ohio 43215
Phone: (614) 466-1390

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

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Bureau of
Environmental Health
Health Assessment Section

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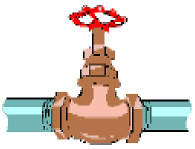
Vinyl Chloride

Answers to Frequently Asked Health Questions

What is vinyl chloride?

Vinyl chloride is a colorless, flammable gas with a mild, sweet odor. It does not occur naturally in the environment but is a man-made product that is used to make polyvinyl chloride (PVC).

Polyvinyl chloride (PVC) is used to make a variety of plastic products including pipes, wire and cable coatings, and packaging materials. Before the mid-1970s, vinyl chloride was used as a coolant, used as a propellant in aerosol spray cans and could be found in some cosmetics.



Vinyl chloride can also be produced as a by-product or when chlorinated solvents such as TCE & PCE chemically break down.

How does vinyl chloride get in your body?

- By breathing (inhalation) vinyl chloride that has leaked from plastics industries, hazardous waste sites, and landfills.
- By breathing (inhalation) vinyl chloride in contaminated workplace air or having skin or eye contact.
- By breathing (inhalation) tobacco smoke from cigarettes or cigars.
- By drinking (ingesting) water from contaminated wells.

Most people begin to smell vinyl chloride in the air at 3,000 parts vinyl chloride parts per million (ppm) of air. However, this is too high a level to prevent adequate warning of exposure. Most people begin to taste vinyl chloride in water at 3.4 parts per million (ppm).

Before government regulations, vinyl chloride could get into food that was stored in materials containing PVC.

How does vinyl chloride affect your health?

It is hard to know what levels of exposure to vinyl chloride can cause health problems. The kinds of health problems and extent of problems that are seen with exposure depend on many factors. These factors include:

- How much vinyl chloride a person is exposed to (dose).
- How long a person is exposed to the vinyl chloride (duration).
- How often a person is exposed to the vinyl chloride (frequency).
- How you were exposed (inhalation or drinking).

Most vinyl chloride you breathe or swallow will quickly enter your blood. When it reaches your liver, the liver will change it into other substances which also travel in your blood. Most of the vinyl chloride leaves your system through the urine within a day after entering your body. But the products made by the liver will take a little longer to leave your body.

Short-term exposure effects:

Breathing high levels of vinyl chloride (much higher than what is normally in the environment) can cause a person to feel dizzy or become sleepy. Studies in animals show that extremely high levels of vinyl chloride can damage the liver, lungs, kidneys, and heart, and prevent blood clotting.

Long-term exposure effects:

People who have breathed high levels (thousands of parts per million-ppm) vinyl chloride for several years under industrial conditions have changes in the structure of their liver. People that have worked with vinyl chloride have nerve damage and others have developed an immune reaction. Some workers exposed to very high levels of vinyl chloride have problems with the blood flow to their hands.

Are there other health problems seen with exposure to vinyl chloride?

Some men who work with vinyl chloride have complained of a lack of libido (sex drive). Women who work with vinyl chloride have reported irregular menstrual periods and have developed high blood pressure during pregnancy. Vinyl chloride has not been shown to cause birth defects.

Is there a test to find out if I have been exposed to vinyl chloride?

There are two tests which can measure vinyl chloride in your body. However, these tests are not routinely available at your doctor’s office and must be done at special laboratories that have the right equipment.

Vinyl chloride can be measured in your breath and vinyl chloride’s chief breakdown product, thiodiglycolic acid, can be measured in your urine. But exposure to other chemicals can also produce the same breakdown products in your urine.

Note that both the breath and urine test must be done shortly after exposure and these tests are not very helpful for measuring low levels of the chemical.

Does vinyl chloride cause cancer?

The Department of Health and Human Services (HHS) has determined that vinyl chloride is a known carcinogen (causes cancer).

The International Agency for Research on Cancer (IARC) has determined that vinyl chloride is carcinogenic (causes cancer) to humans, and the Environmental Protection Agency (EPA) has determined that vinyl chloride causes cancer.

Studies of workers who breathed very high levels vinyl chloride for many years showed an increased risk of cancers of the liver. Also, brain, lung and some cancers of the blood may also be connected with breathing vinyl chloride.

Has the federal government made recommendations to protect human health?

The federal government develops regulations and recommendations to protect public health and these regulations can be enforced by law.

The U.S. EPA requires that the amount of vinyl chloride in drinking water not exceed 0.002 ppm (parts per million).

The Food and Drug Administration (FDA) regulates the vinyl chloride content of plastics, because vinyl chloride may leak from plastic into foods or water.

Reference

The Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for vinyl chloride, September, 1997.

Where can I get more information?

Ohio Department of Health
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Bureau of
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Health Assessment Section

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Polycyclic Aromatic Hydrocarbons (PAHs)

Answers to Frequently Asked Health Questions

What are Polycyclic Aromatic Hydrocarbons (PAHs)?

PAHs are a group of chemicals naturally found in coal, coal tars, oil, wood, tobacco and other organic materials. PAHs are released into the environment as the result of the incomplete burning of these materials.

There are more than 100 different PAHs. PAHs are the waxy solids found in asphalt, crude oil, coal, coal tar pitch, creosote and roofing tar. Some types of PAHs are used in medicines and to make dyes, plastics and pesticides.

PAHs are ubiquitous (are everywhere) throughout the world and can be found in every type of environment. Urban environments (cities) tend to have higher levels of PAHs due to the increased amounts of gas and oil burned as well as the increased use of asphalt and tars on roads and shingles on roofs.

What happens to PAHs when they enter the environment?

PAHs can enter the environment in the air from volcanoes, forest fires, residential wood burning and exhaust from cars and trucks.

In urban (city) environments, PAHs can enter creek and river sediments (soils) from water running off asphalt roads, parking lots and driveways. PAHs are also found in roofing shingles and tars and can run off roofs to be carried to downspouts and drainage systems during rain events.

Some of the PAHs are lighter (or a lower molecular weight) and can volatize (evaporate) into the air. These PAHs break down by reacting with sunlight and other chemicals in the air. This generally takes days to weeks. The more sunlight, the quicker these PAHs will breakdown. These lighter (low molecular weight) PAHs are less toxic to humans and are not carcinogenic (cancer causing).

Heavier (or a higher molecular weight) PAHs do not dissolve in water, but stick to solid particles and settle to the sediments in bottoms of lakes, rivers or streams. These "fat" PAHs stick to soils and sediments and will generally take weeks to months to break down in the environment. Microorganisms in soils and sediments are the main cause of breakdown. These heavy PAHs are carcinogenic (cancer causing) to lab animals and may be carcinogenic to humans.

How might I be exposed to PAHs?

For most of the U.S. population, the primary sources of exposure to PAHs are inhalation of compounds in tobacco smoke, wood smoke and the ambient (outside) air. Smoke may contain both light (vapors) and heavy (soot or ash) PAHs.

You may also be exposed to PAHs by incidental (minor or casual) contact to lake, river or creek sediments or by eating smoked or charbroiled foods.

Overall exposure to PAHs will increase if persons come in contact with PAHs in their workplace. PAHs have been found in industries such as coal tar production plants, smoke houses, coking plants, aluminum production plants, coal tarring facilities and municipal trash incinerators. Also, PAHs can be found in industries such as mining, oil refining, metalworking, chemical production, transportation and the electrical industry. PAHs have also been found in other facilities where petroleum and petroleum products are used or where coal, oil, wood or cellulose is burned.

PAHs are present throughout the environment and you may be exposed to these substances at home, outside or at the workplace. Typically, you will not be exposed to an individual PAH, but to a mixture of PAHs.

How do PAHs enter and leave my body?

PAHs can enter your body through your lungs when you breathe air. However, it is not known how rapidly or completely your lungs absorb PAHs.

PAHs can enter your body through drinking water and swallowing food, soil or dust particles that contain PAHs. But absorption is generally slow when PAHs are swallowed and generally you will not be ingesting (swallowing) large amounts of PAHs.

Under normal conditions of environmental exposure, PAHs could enter your body if your skin comes into contact with soil that contains high levels of PAHs. Studies have shown that low molecular weight (lighter) PAHs can be absorbed through the skin but the absorption of high molecular weight (heavy) PAHs is quite limited.

Once in the human body, PAHs are changed into different substances and stored in tissue and fat cells.

Results from animal studies show that PAHs do not tend to be stored in your body for a long time. Most PAHs that enter the body leave within a few days, primarily in the feces and urine.

Can PAHs make you sick?

Yes, you can get sick from PAHs. But getting sick will depend on:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- Route of exposure: Ingesting (eating) and inhaling (breathing) is more of a risk than dermal (skin) exposure.
- General Health, age, lifestyle: Young children, the elderly and people with chronic (on going) health problems are more at risk to chemical exposures.

PAH's have a low acute toxicity. What this means is that if you were exposed to high levels of PAH's for a short period of time, you will most likely not experience harmful health effects.

Chemicals with high acute toxicity are chemicals that would cause immediate harmful health effects or even death if you came in contact with a high dose. Examples of chemicals with a high acute toxicity are cyanide or arsenic. If you were to come in contact with high levels of arsenic or cyanide, you could die. This is not the case with PAHs.

Do PAHs cause cancer?

It is uncertain if PAHs are carcinogenic (cancer causing) to humans.

Several studies have shown that PAHs have caused tumors in laboratory animals when they breathed these substances in the air, when they ate them or when they had long periods of skin contact with them. Studies in animals have also shown that PAHs can cause harmful effects on skin and the body's system for fighting disease after both short and long-term exposure. But these effects have not been reported in humans.

Studies of people show that individuals exposed by breathing or skin contact for long periods to mixtures that contain PAHs and other compounds may develop cancer. But the studies were uncertain if the cancer was caused by PAHs or the other associated chemicals.

The U.S. Department of Health and Human Services (HHS) has determined some PAHs are known animal carcinogens.

The International Agency for Research on Cancer (IARC) has determined some PAHs are probably carcinogenic to humans, some PAHs are possibly carcinogenic to humans and some PAHs are not classifiable as to their carcinogenicity to humans.

The U.S. Environmental Protection Agency (EPA) has determined some PAHs are probable human carcinogens and some PAHs are not classifiable as to human carcinogenicity.

Is there a medical test to determine whether I have been exposed to PAHs?

Yes. Many PAHs can be measured in the blood or urine soon after exposure. Although these tests can show that you have been exposed to PAHs, these tests cannot be used to predict whether any health effects will occur or to determine the extent or source of your exposure to the PAHs. It is not known how effective or informative the tests are after exposure has stopped. The medical tests used to identify PAHs or their products are not routinely available at a doctor's office because special equipment is required to detect these chemicals. Seek medical advice if you have any symptoms you think may be related to chemical exposure.

What recommendations has the federal government made to protect human health?

Water: Drinking Water MCL (Maximum Contaminant Level) for *Benzo (a) pyrene* is 0.2 ppb (parts per billion). *Benzo (a) pyrene* is a heavy (or a higher molecular weight) PAH.

Air: No standards exist for the amount of PAHs allowed in the air of private homes. However, air standards have been set for occupational (work) settings.

The Occupational Safety and Health Administration (OSHA) has set a limit of 0.2 milligrams of PAHs per cubic meter of air (0.2 mg/m^3). The OSHA Permissible Exposure Limit (PEL) for mineral oil mist that contains PAHs is 5 mg/m^3 averaged over an 8-hour exposure period.

The National Institute for Occupational Safety and Health (NIOSH) recommends that the average workplace air levels for coal tar products not exceed 0.1 mg/m^3 for a 10-hour workday, within a 40-hour workweek. There are other limits for workplace exposure for things that contain PAHs, such as coal, coal tar and mineral oil.

For more information about PAHs:

For detailed information about PAHs, visit the Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile for PAHs.
Web Site: http://www.atsdr.cdc.gov/toxprofiles/tp69.html
E-mail: ATSDRIC@cdc.gov
Toll-free: 1-888-422-8737

References:

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. Toxicological profile for polycyclic aromatic hydrocarbons (PAHs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

ATSDR. 1990. Polynuclear Aromatic Hydrocarbon (PAH) Toxicity. Case Studies in Environmental Health Medicine #13. U.S. Department of Health and Human Services. 19p.

Wisconsin Department of Health and Family Services, Division of Public Health, Bureau of Environmental Health, Chemical Fact Sheet, PAHs, 2004.

Bureau of
Environmental Health
Health Assessment Section

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Landfill Gas

Answers to Frequently Asked Health Questions

Municipal Solid Waste Landfills (MSWLF):

Private homes, business and industry all produce waste. The wastes we create are regulated as either hazardous waste or solid waste. It is the non-hazardous solid wastes that are often sent to a municipal solid waste landfill (MSWLF). Commonly called trash or garbage, the non-hazardous waste accepted at MSWLF include items such as paper products, food items, plastics, metals, glass and household items such as old furniture, appliances and household hazardous wastes. **Note:** For a listing of the common household hazardous wastes that can be taken to your local household hazardous waste collection events, visit the Ohio EPA household hazardous waste web site at: **www.epa.state.oh.us/dhwm/recycpro.aspx**

Ohio Environmental Protection Agency (OEPA) regulations require Ohio landfills to be designed and operated to prevent contamination from moving into the environment. The landfill design and operation system include a liner and a leachate (landfill water) collection systems. Landfills also monitor for methane gas and have gas collection systems.

What are landfill gases?

Landfill gases are colorless vapors that are produced at solid waste landfills and other waste disposal sites where trash and garbage are buried in the ground and covered with dirt. Over time, the bacteria in the soils will break down (decompose) the organic wastes in the landfill. The by-product of these bacteria breaking down the garbage will produce gases, just as humans produce carbon dioxide gas when we breathe out the oxygen we take in. Volatile organic compound (VOC) gases can also be produced in a landfill when common household chemical products vaporize (turn from a solid or liquid into a gas).

The amount and type of gases created by a landfill depends on the amount of garbage buried in the landfill, the type of garbage buried, the age of the landfill, the size and depth of the landfill and the chemical environment within the landfill.

The gases created in a landfill will try to move through the landfill to reach the surface air. Once in the outdoor air, landfill gases will mix with the air and be carried by the surface winds. Wind speed, wind direction and barometric pressure can affect whether residents will come in contact with these landfill gasses. Because wind speed and wind direction change, the degree of the exposure to odors will be different from day to day. At locations near a landfill, landfill gases tend to be most noticeable in the early morning, when winds tend to be most gentle, providing the least mixing of air and dilution of the gas. Landfill gas production tends to be highest when the weather is hot and dry; it decreases with cooling temperatures or frequent rainfall.

Characteristics of landfill gases:

- Landfill gases try to move from higher pressure areas (areas deep within the landfill) to lower pressure areas (areas such as ground surface and off-site areas)
- Landfill gases easily move through loose sand or gravel soils and will be released to the air through any cracks it can find
- Landfill gases will take the path of least resistance, often following buried utility lines (water, electrical, or gas lines)
- At older, unlined landfills, the landfill cover (cap) will often cause gas to move out sideways under ground from the landfill. **Note:** A landfill cover or cap is usually made of clay or some other rainproof (impermeable) material
- Gases will usually move away from the decaying garbage, but it is difficult to predict the specific directions the gas will follow

What kinds of gases are found in a MSWLF?

Landfill gases are typically made up of hundreds of different types of gases. The main gases produced by a MSWLF are usually methane at 40-65% and carbon dioxide (CO_2) at 40-60%. CO_2 and methane are colorless and odorless gasses. Methane, at certain levels, can be flammable or even explosive and can pose a physical hazard. Since methane is lighter than air, it can pose a physical hazard if trapped in confined spaces of buildings, such as basements and crawl spaces

Other landfill gases are produced by bacteria breaking down organic material and are called reduced sulfur gases or sulfides (examples: hydrogen sulfide (H_2S), dimethyl sulfide and mercaptans). These gases _do_ have odors and they give the landfill that familiar "rotting" smell. But hydrogen sulfide (H_2S) and non-methane VOCs make up a much smaller proportion of the landfill gas at less than 1%.

➢ **Methane**	**40-65%**
➢ **Carbon dioxide (CO_2)**	**40-60%**
➢ **Hydrogen sulfide (H_2S) and non-methane VOCs**	**<1%**

How can we detect landfill gas?

Landfill gases are mostly invisible, but they can be detected in the environment by:

- ***Odors:*** Landfill gases commonly contain hydrogen sulfide (H_2S) gas which produces a foul, rotten egg odor. This H_2S odor can be detected at very low levels, levels much lower than those at which this chemical can cause toxic health problems. In contrast, potentially harmful VOCs have a distinctive, sweet, ether-like smell, but you cannot usually smell them in landfill gases because they are present at such low concentrations.
- ***Stressed or dead vegetation:*** Landfill gases will reduce the amount of oxygen in the soils. The lack of oxygen affects deep root growth and often results in the death of deep-rooted plants, especially trees. Soils with high levels of landfill gases will not grow vegetation or the vegetation will be stunted and limited to shallow-rooted plants.
- ***Landfill gas-monitoring probes:*** Landfill gas probes are narrow, hollow tubes inserted in the ground. There are holes in the sides of these tubes that allow gas vapors to flow into the tube. The tubes are then sealed to trap the gas. These sample results can show the type and amount of gas and whether it is at a level that can create a public health threat.

How can landfill gases affect my health and safety?

Under the right set of environmental conditions, landfill gas can be a potential health hazard to residents living close to a landfill. However, a person must be exposed to specific concentrations of chemicals and over a specific period of time before health effects can occur. The two types of health hazards include:

- ***Physical Hazard:*** The methane gas that typically makes up 40-65% of landfill gas is not toxic, but it can ignite and cause an explosion under specific conditions. The specific conditions include the right combination of methane and oxygen, plus a source of ignition (spark-fire). Methane can be explosive at concentrations that range from 5-15% methane per volume of air. At concentrations below 5%, methane levels are too low to ignite. At concentrations above 15%, methane levels are too rich and oxygen levels are too low to combust.
- ***Toxic Chemical Hazard:*** H_2S and VOCs like benzene, perchloroethylene (PCE), trichloroethylene (TCE) and vinyl chloride can be toxic to people if they are inhaled at certain concentrations. If concentrations are high enough, breathing these gases can cause breathing difficulties, nausea (upset stomach), dizziness, headaches and central nervous system problems. Breathing these gases at high concentrations for extended periods of time (years) can cause the development of specific types of cancer and other serious health problems.

How can we reduce landfill gas hazards?

Containment and abatement can reduce the possible health hazards due to the movement of landfill gases off-site into nearby properties. Containment simply means to contain the landfill gasses on-site and not allow them to move off-site. Abatement means to remove, subtract from or completely stop the production of landfill gasses.

- ***Containment:*** Ohio landfills are required to contain the landfill waste and gases through impermeable bottom liners and an engineered cap or cover.
- ***Abatement:*** Landfill gas is vented from the interior of the landfill to the outside. This reduces gas pressure within the landfill and limits the ability of the gas to move off-site. Gas abatement can be done passively or actively, through:
  - Simple vents installed at points around the landfill, or
  - A pipe system that pumps the gas from the landfill to a central collection area.
  - The collected gasses can be simply released to the air, burned off in a flare, or collected to be used as a fuel resource (natural gas).

References:

ATSDR. Landfill Gas Primer, An Overview for Environmental Health Professionals. November, 2000.

Georgia Division of Public Health, Environmental Health and Injury Prevention Branch, Chemical Hazards Program. Landfill Gases and Odors. 2000.

U.S. EPA. Municipal Solid Waste web site. **www.epa.gov/osw/nonhaz/municipal/msw99.htm** Accessed 2009.

For information on Ohio landfills:

Ohio Environmental Protection Agency web site at: **www.epa.state.oh.us/dsiwm**

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

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Bureau of
Environmental Health
Health Assessment Section

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Chloroform

Answers to Frequently Asked Health Questions

What is chloroform?

Chloroform, also called trichloromethane or methyltrichloride, is a colorless liquid with a pleasant, non-irritating odor and a slightly sweet taste. As a volatile organic compound (VOC), chloroform easily vaporizes (turns into a gas) in the air. Chloroform does not easily burn, but it will burn when it reaches very high temperatures. Chloroform was one of the first inhaled anesthetics to be used during surgery, but it is not used as an anesthesia today.

Where do you find chloroform?

In order to destroy the harmful bacteria found in our drinking water and waste waters, the chemical chlorine is added to these water sources. As a by-product of adding chlorine to our drinking and waste waters, small amounts of chloroform are formed. So small amounts of chloroform are likely to be found almost everywhere.

In industry, nearly all the chloroform made in the U.S. is used to make other chemicals. From the factories that make or use this chemical, chloroform can enter the air directly or it can enter the air from the evaporation (changing from liquid to a gas) of chloroform-contaminated waters and soils. Chloroform can also enter the water and soils from industry storage and waste sites spills and leaks.

Not only does chloroform evaporate very quickly when exposed to air, it also dissolves easily in water and does not stick to the soils very well. This means chloroform can easily travel through the soils to groundwater, where it can enter a water supply. Chloroform lasts a long time in both the air and in groundwater. Most of the chloroform in the air eventually breaks down, but it is a slow process. Chloroform does not appear to build up in great amounts in plants and animals, but we may find some small amounts of chloroform in foods.

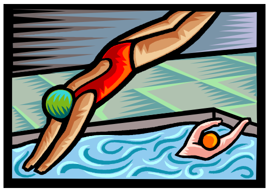
How do you come in contact with chloroform? Who is more at risk?

You are most likely to be exposed to chloroform by drinking contaminated water and/or by breathing contaminated indoor or outdoor air. Chloroform is found in nearly all public drinking water supplies. Chloroform is also found in the air from all areas of the United States. You are probably exposed to small amounts of chloroform in your drinking water and/or in beverages that are made using water that contains chloroform.

People who are at greater risk to be exposed to chloroform at higher-than-normal levels are people who work at or near chemical plants and factories that make or use chloroform. Higher exposures might occur in workers at drinking water treatment plants, waste water treatment plants, and paper and pulp mills. People who operate waste-burning equipment may also be exposed to higher than normal levels. People who swim a lot in swimming pools may also be exposed to higher levels.

How does chloroform enter and leave your body?

- Chloroform can enter your body if you breathe contaminated air (inhalation)
- Chloroform can enter your body if you eat/drink contaminated food or water (ingestion)
- Chloroform can also enter your body through the skin (dermal).



If you take a bath, shower or swim in a pool with chloroform-contaminated water, it can enter your body through inhalation and dermal contact.

Studies in humans and animals show that after you breathe contaminated air or eat contaminated food, the chloroform can quickly enter your bloodstream from your lungs and intestines. Inside your body, chloroform is carried by the blood to all parts of your body, such as the liver, kidneys and fat cells.

Some of the chloroform that enters your body leaves unchanged in the air you breathe out and some of it is broken down into other chemicals. These chemicals are known as breakdown products or metabolites, and some of them can attach to other chemicals inside the cells of your body and may cause harmful effects if they collect in high enough amounts in your body. Some of the metabolites will leave the body in the air you breathe out and small amounts of the breakdown products leave the body in the urine and stool.

How does chloroform affect health?

In humans, large amounts of chloroform can affect the central nervous system (brain), liver and kidneys. Breathing high levels for a short time can cause fatigue, dizziness, and headache. If you breathe air, eat food, or drink water containing elevated levels of chloroform, over a long period, the chloroform may damage your liver and kidneys. Large amounts of chloroform can cause sores (lesions) when the chloroform touches your skin.

Lab studies have shown chloroform caused reproductive problems in animals (mice and rats). However, there is no evidence that show whether chloroform causes harmful reproductive effects or birth defects in humans.

Does chloroform cause cancer?

Based on animal studies, the Department of Health and Human Services (DHHS) has determined that chloroform may reasonably be anticipated to be a carcinogen (a substance that causes cancer). The International Agency for Research on Cancer (IARC) has determined that chloroform is possibly carcinogenic to humans (2B). The EPA has also determined that chloroform is a "probable" human carcinogen.

Results of studies of people who drank chlorinated water showed a possible link between the chloroform in the chlorinated water and the occurrence of cancer of the colon and urinary bladder. Rats and mice that ate food or drank water that had large amounts of chloroform in it for a long period of time developed cancer of the liver and kidneys. However, there is no evidence that shows whether chloroform causes liver and kidney cancer in humans.

Is there a medical test to show whether you have been exposed to chloroform?

Although we can measure the amount of chloroform in the air you breathe out and in blood, urine, and body tissues, we have no reliable test to determine how much chloroform you have been exposed to or whether you will experience any harmful health effects.

The measurement of chloroform in body fluids and tissues may help to determine if you have come into contact with large amounts of chloroform. However, these tests are useful only a short time after you are exposed to chloroform because it leaves the body quickly.

What has been done to protect human health?

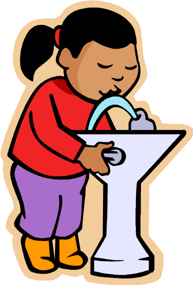
The amount of chloroform normally expected to be in the air ranges from 0.02 to 0.05 parts of chloroform per billion parts (ppb) of air and from 2 to 44 ppb in treated drinking water.

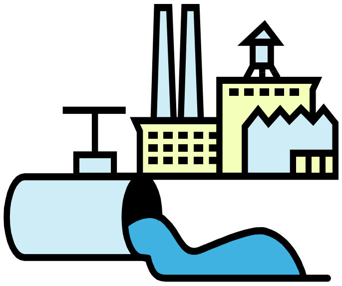
Notes: The below unit of measurement will be found in the ppb (parts per billion) range. Examples: One part per billion (1 ppb) would be equal to having one bean in a pile of one billion beans, or one ppb would be equal to one second of time in 32 years.

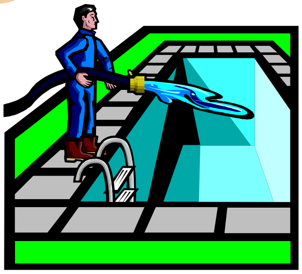
The Environmental Protection Agency (EPA) has set the level of chloroform in drinking water at 80 ppb.

The Occupational Safety and Health Administration (OSHA) has set a permissible 50,000 ppb exposure limit of air in the workplace during an 8-hour workday, 40-hour week.

The EPA requires chloroform spills or accidental releases into the environment of 10 pounds or more of be reported to the EPA.







For more information contact:

Ohio Department of Health
Bureau of Environmental Health
Health Assessment Section
246 N. High Street
Columbus, Ohio 43215
Phone: (614) 466-1390
Fax: (614) 466-4556

Reference:

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for chloroform. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

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Created 04/10/07

Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Chlorobenzene

Answers to Frequently Asked Health Questions

What is Chlorobenzene?

Chlorobenzene is a colorless liquid with an almond-like odor. It is a man-made chemical that you will not find naturally in the environment.

How is Chlorobenzene used?

In the past chlorobenzene was used to make other chemicals, such as phenol and the pesticide DDT. As these chemicals were phased-out, U.S. production of chlorobenzene declined by more than 60% from its peak use in 1960 to 1987. Chlorobenzene is currently used as a solvent for pesticide formulations, a degreaser for automobile parts and to make other chemicals.

How are you exposed to Chlorobenzene?

Humans can be exposed to chlorobenzene by breathing contaminated air, by drinking contaminated water or eating food contaminated with chlorobenzene. We can also be exposed to chlorobenzene through the skin (dermal) by coming into contact with contaminated soils. These exposures are most likely to occur in the workplace where chlorobenzene is used or near a chemical waste site.

What happens to Chlorobenzene in The environment?

Soils: Once spilled onto soils, evaporation and vaporization is the main process chlorobenzene is removed from the surface soils. In deeper soils, chlorobenzene biodegrades (breaks down) rapidly, after one or two weeks.

Air: Chlorobenzene evaporates into the air and quickly breaks down by reacting with the sunlight. In the air, it usually takes about three and a half (3 ½) days to break down.

Water: Chlorobenzene evaporates and biodegrades quickly and takes less than one day to break down in water.

Can Chlorobenzene make you sick?

Yes, you can get sick from exposure to chlorobenzene. However, getting sick will depend on many factors such as:

- How much you were exposed to (dose).
- How long you were exposed (duration).
- How often you were exposed (frequency).
- How toxic is the chemical of concern.
- General Health, Age, Lifestyle
  Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How can exposure to Chlorobenzene affect my health?

Most health information about exposure to chlorobenzene comes from animal studies where lab animals were exposed to very high levels of the chemical. In animals, exposure to high levels of chlorobenzene affects the brain, liver and kidneys. Unconsciousness, tremors and restlessness have also been observed. The chemical can cause severe injury to the liver and kidneys.

Workers exposed to high levels of chlorobenzene complained of headaches, numbness, sleepiness, nausea, and vomiting. However, it is not known if chlorobenzene alone was responsible for these health effects, since the workers were also been exposed to other chemicals at the same time.

It is important to keep in mind that most environmental exposures to chlorobenzene are at much lower levels than those in the workplace or lab studies.

References:

Agency for Toxic Substances and Disease Registry (ATSDR). *Toxicological Profile for Chlorobenzene*. U.S. Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA. December, 1990.

For more information contact:

Ohio Department of Health
Bureau of Environmental Health
Health Assessment Section
(614) 466-1390

Agency for Toxic Substances
and Disease Registry (ATSDR)
Toll-free at 1-888-422-8737

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Created December 2009

ATTACHMENT F

REAC SOP #2082

Response Engineering and Analytical Contract

STANDARD OPERATING PROCEDURES

SOP:	2082
Page:	1 of 14
Rev.	0.0
DATE:	03/29/07

CONSTRUCTION AND INSTALLATION OF PERMANENT SUB-SLAB SOIL GAS WELLS

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1.0 SCOPE AND APPLICATION

2.0 METHOD SUMMARY

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

5.0 EQUIPMENT/APPARATUS

6.0 REAGENTS

7.0 PROCEDURES

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  7.2 Sampling Set-Up
  7.3 Repairing a Loose Probe

8.0 CALCULATIONS

9.0 QUALITY ASSURANCE/QUALITY CONTROL

10.0 DATA VALIDATION

11.0 HEALTH AND SAFETY

12.0 REFERENCES

13.0 APPENDICES

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) outlines the procedure used for the construction and installation of permanent sub-slab soil gas wells. The wells are used to sample the gas contained in the interstitial spaces beneath the concrete floor slab of dwellings and other structures.

Soil gas monitoring provides a quick means of detecting volatile organic compounds (VOCs) in the soil subsurface. Using this method, underground VOC contamination can be identified and the source, extent and movement of pollutants can be traced.

2.0 METHOD SUMMARY

Using an electric Hammer Drill or Rotary Hammer, an inner or pilot hole is drilled into the concrete slab to a depth of approximately 2" with the ⅜" diameter drill bit. Using the pilot hole as the center, an outer hole is drilled to an approximate depth of 1⅜ " using the 1" diameter drill bit. The 1" diameter drill bit is then replaced with the ⅜" drill bit. The pilot hole is drilled through the slab and several inches into the sub-slab material. Once drilling is completed, a stainless steel probe is assembled and inserted into the pre-drilled hole. The probe is mounted flush with the surrounding slab so it will not interfere with pedestrian or vehicular traffic and cemented into place. A length of Teflon® tubing is attached to the probe assembly and to a sample container or system.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

3.1 SUMMA® Canister Sampling

After the sub-slab soil gas sample is collected, the canister valve is closed, an identification tag is attached to the canister and the canister is transported to a laboratory under chain of custody for analysis. Upon receipt at the laboratory, the data documented on the canister tag is recorded. Sample holding times are compound dependent, but most VOCs can be recovered from the canister under normal conditions near the original concentration for up to 30 days. Refer to REAC SOP #1704, *SUMMA Canister Sampling* for more details.

3.2 Tedlar® Bag Sampling

Tedlar® bags most commonly used for sampling have a 1-liter volume capacity. After sampling, the Tedlar® bags are stored in either a clean cooler or an opaque plastic bag at ambient temperature to prevent photodegradation. It is essential that sample analysis be undertaken within 24 to 48 hours following sample collection since VOCs may escape or become altered. Refer to REAC SOP #2102, *Tedlar® Bag Sampling* for more details.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The thickness of a concrete slab may vary from structure to structure. A structure may also have a single slab where the thickness varies. A slab may contain steel reinforcement (REBAR). Drill bits of various sizes and cutting ability will be required to penetrate slabs of varying thicknesses or those that are steel-reinforced.

5.0 EQUIPMENT/APPARATUS

- Hammer Drill or Rotary Hammer
- Alternating current (AC) extension cord
- AC generator, if AC power is not available on site
- Hammer or Rotary Hammer drill bit, ⅜"diameter
- Hammer or Rotary Hammer drill bit, 1"diameter
- Portable vacuum cleaner
- 1 - ¾" open end wrench or 1-medium adjustable wrench
- 2 - 9/16" open end wrenches or 2-small adjustable wrenches
- Hex head wrench, ¼"
- Tubing cutter
- Disposable cups, 5 ounce (oz)
- Disposable mixing device (i.e., popsicle stick, tongue depressor, etc.)
- Swagelok® SS-400-7-4 Female Connector, ¼" National Pipe Thread (NPT) to ¼" Swagelok® connector
- Swagelok® SS-400-1-4 Male Connector, ¼"NPT to ¼" Swagelok® connector
- ¼" NPT flush mount hex socket plug, Teflon®-coated
- ¼" outer diameter (OD) stainless steel tubing, pre-cleaned, instrument grade
- ¼" OD Teflon® tubing
- Teflon® thread tape
- ⅛″OD stainless steel rod, 12″ to 24″ length
- Swagelok Tee, optional (SS-400-3-4TMT or SS-400-3-4TTM)

6.0 REAGENTS

- Tap water, for mixing anchoring cement
- Anchoring cement
- Modeling clay

7.0 PROCEDURES

7.1 Probe Assembly and Installation

1. Drill a ⅜" diameter inner or pilot hole to a depth of 2" (Figure 1, Appendix A).

2. Using the ⅜" pilot hole as your center, drill a 1" diameter outer hole to a depth of 1 ⅜". Vacuum out any cuttings from the hole (Figure 2, Appendix A).

3. Continue drilling the ⅜ inner or pilot hole through the slab and a few inches into the sub-slab material (Figure 3, Appendix A). Vacuum out any cuttings from the outer hole.

4. Determine the length of stainless steel tubing required to reach from the bottom of the outer hole, through the slab and into the open cavity below the slab. To avoid obstruction of the probe tube, ensure that it does not contact the sub-slab material. Using a tube cutter, cut the tubing to the desired length.

5. Attach the measured length (typically 12″) of ¼" OD stainless tubing to the female connector (SS-400-7-4) with the Swagelok® nut. Tighten the nut.

6. Insert the ¼" hex socket plug into the female connector. Tighten the plug. **Do not over tighten**. If excessive force is required to remove the plug during the sample set up phase, the probe may break loose from the anchoring cement.

7. Place a small amount of modeling clay around the stainless steel tubing adjacent to the Swaglok® nut, which connects the stainless steel tubing to the female connector. Use a sufficient amount of modeling clay so that the completed probe, when placed in the outer hole, will create a seal between the outer hole and the inner hole. The clay seal will prevent any anchoring cement from flowing into the inner hole during the final step of probe installation.

8. Place the completed probe into the outer hole. The probe tubing should not contact the sub-slab material and the top of the female connector should be flush with the surface of the slab and centered in the outer hole (Figure 4, Appendix A). If the top of the completed probe is not flush with the surface of the slab, due to the outer hole depth being greater than 1 ⅜", additional modeling clay may be placed around the stainless steel tubing adjacent to the Swaglok® nut, which connects the stainless steel tubing to the female connector. Use a sufficient amount of clay to raise the probe until it is flush with the surface of the slab while ensuring that a portion of the clay will still contact and seal the inner hole.

9. Mix a small amount of the anchoring cement. Fill the space between the probe and the outside of the outer hole. Allow the cement to cure according to manufacturers instructions before sampling.

7.2 Sampling Set-Up

1. Wrap one layer of Teflon® thread tape onto the NPT end of the male connector (SS-400-1-4). Refer to Figure 5, Appendix A.

2. Remove the ¼" hex socket plug from the female connector (SS-400-7-4). Refer to Section 7.3 if the probe breaks loose from the anchoring cement during this step.

3. To ensure that the well has not been blocked by the collapse of the inner hole below the end of the stainless steel tubing, a stainless steel rod, ⅛″diameter, may be passed through the female connector and the stainless steel tubing. The rod should pass freely to a depth greater than the length of the stainless steel tubing, indicating an open space or loosely packed soil below the end of the stainless steel tubing. Either condition should allow a soil gas sample to be collected.

   If the well appears blocked, the stainless steel rod may be used as a ramrod in an attempt to open the well. If the well cannot be opened, the probe should be reinstalled or a new probe installed in an alternate location.

4. Screw and tighten the male connector (SS-400-1-4) into the female connector (SS-400-7-4). **Do not over tighten**. This may cause the probe to break loose from the anchoring cement during this step or when the male connector is removed upon completion of the sampling event. Refer to Section 7.3 if the probe breaks loose from the anchoring cement during this step.

5. If a collocated sub-slab sample or split sample is desired, a stainless steel Swagelok Tee (SS-400-3-4TMT or SS-400-3-4TTM) may be used in place of the Swagelok male connector (SS-400-1-4).

6. Attach a length of ¼"OD Teflon® tubing to the male connector with a Swagelok® nut. The Teflon® tubing is then connected to the sampling container or system to be used for sample collection.

7. After sample collection remove the male connector from the probe and reinstall the hex socket plug. **Do not over tighten** the hex socket plug. If excessive force is required to remove the plug during the next sampling event the probe may break loose from the

anchoring cement. Refer to Section 7.3 if the probe breaks loose from the anchoring cement during this step.

7.3 Repairing a Loose Probe

1. If the probe breaks loose from the anchoring cement while removing or installing the hex head plug or the male connector (SS-400-1-4), lift the probe slightly above the surface of the concrete slab.

2. Hold the female connector (SS-400-7-4) with the ¾" open end wrench.

3. Complete the step being taken during which the probe broke loose, following the instructions contained in this SOP (i.e., **Do not over tighten** the hex socket plug or male connector).

4. Push the probe back down into place and reapply the anchoring cement.

5. Modeling clay may be used as a temporary patch to effect a seal around the probe until the anchoring cement can be reapplied.

8.0 CALCULATIONS

This section is not applicable to this SOP.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

An additional collocated soil gas well is installed with the frequency of 10 percent (%) or as specified in the site-specific Quality Assurance Project Plan (QAPP). The following general Quality Assurance (QA) procedures apply:

1. A rough sketch of the area is drawn where the ports are installed with the major areas noted on the sketch. This information may be transferred to graphing software for incorporation into the final deliverable.

2. A global positioning system (GPS) unit may be used to document coordinates outside of a structure as a reference point.

3. Equipment used for the installation of sampling ports should be cleaned by heating, inspected and tested prior to deployment.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and Lockheed Martin corporate health and safety procedures. All site activities should be documented in the site-specific health and safety plan (HASP).

12.0 REFERENCES

This section is not applicable to this SOP.

13.0 APPENDICES

A - Figures

APPENDIX A
Soil Gas Installation Figures
SOP #2082
March 2007

FIGURE 1

INNER or PILOT HOLE

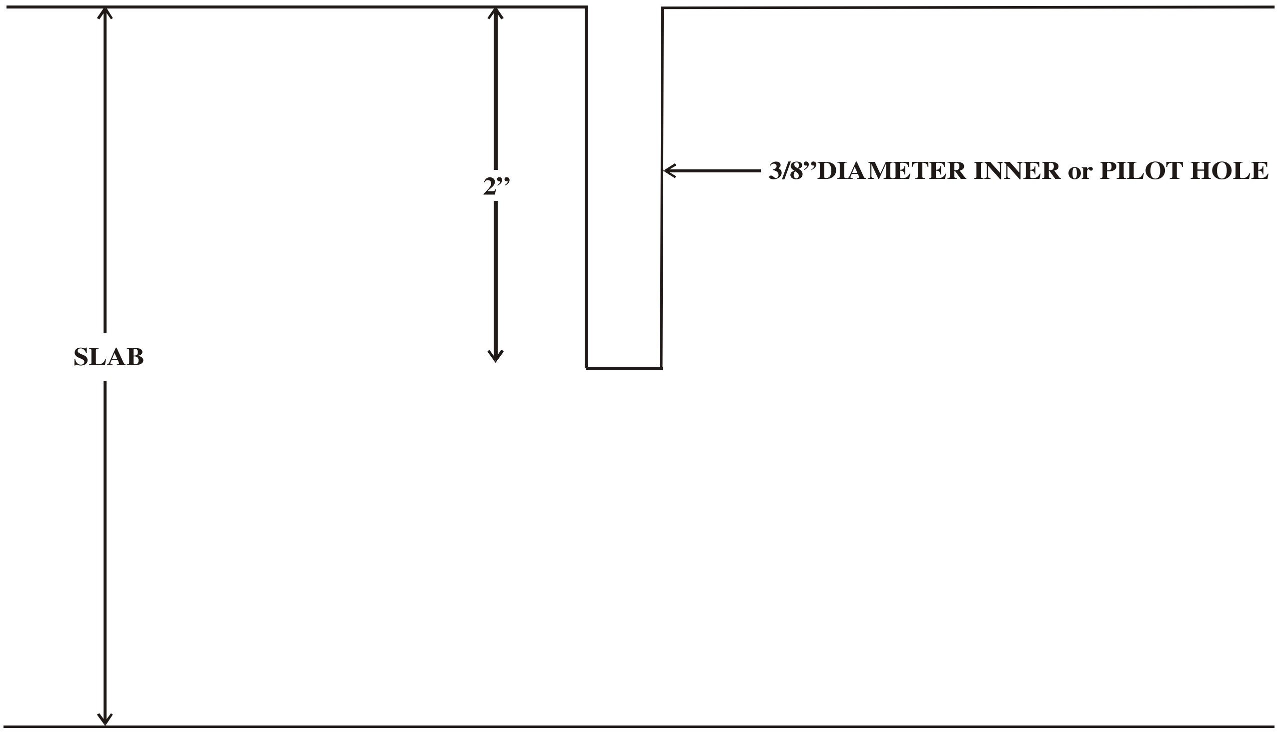


FIGURE 2

OUTER HOLE

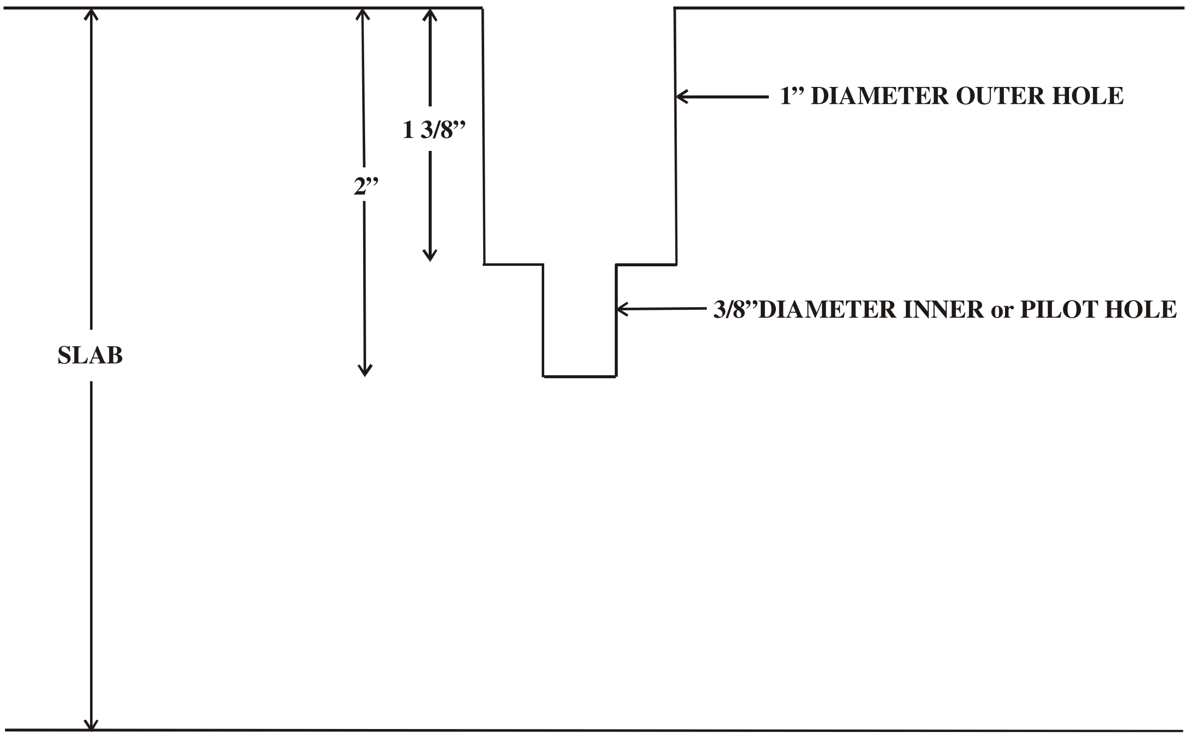


FIGURE 3

COMPLETED HOLE PRIOR to PROBE INSTALLATION

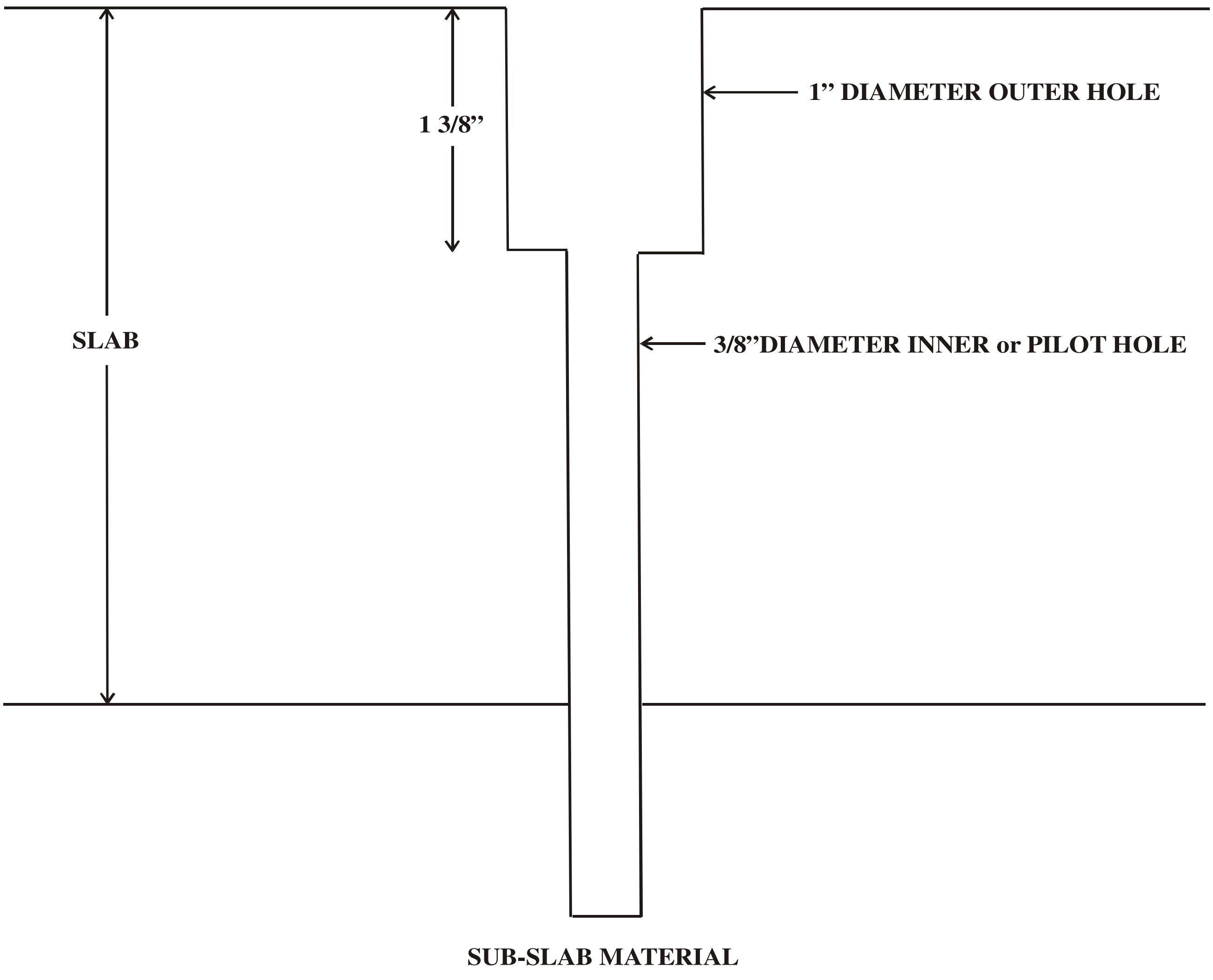


FIGURE 4

SOIL GAS PROBE INSTALLED

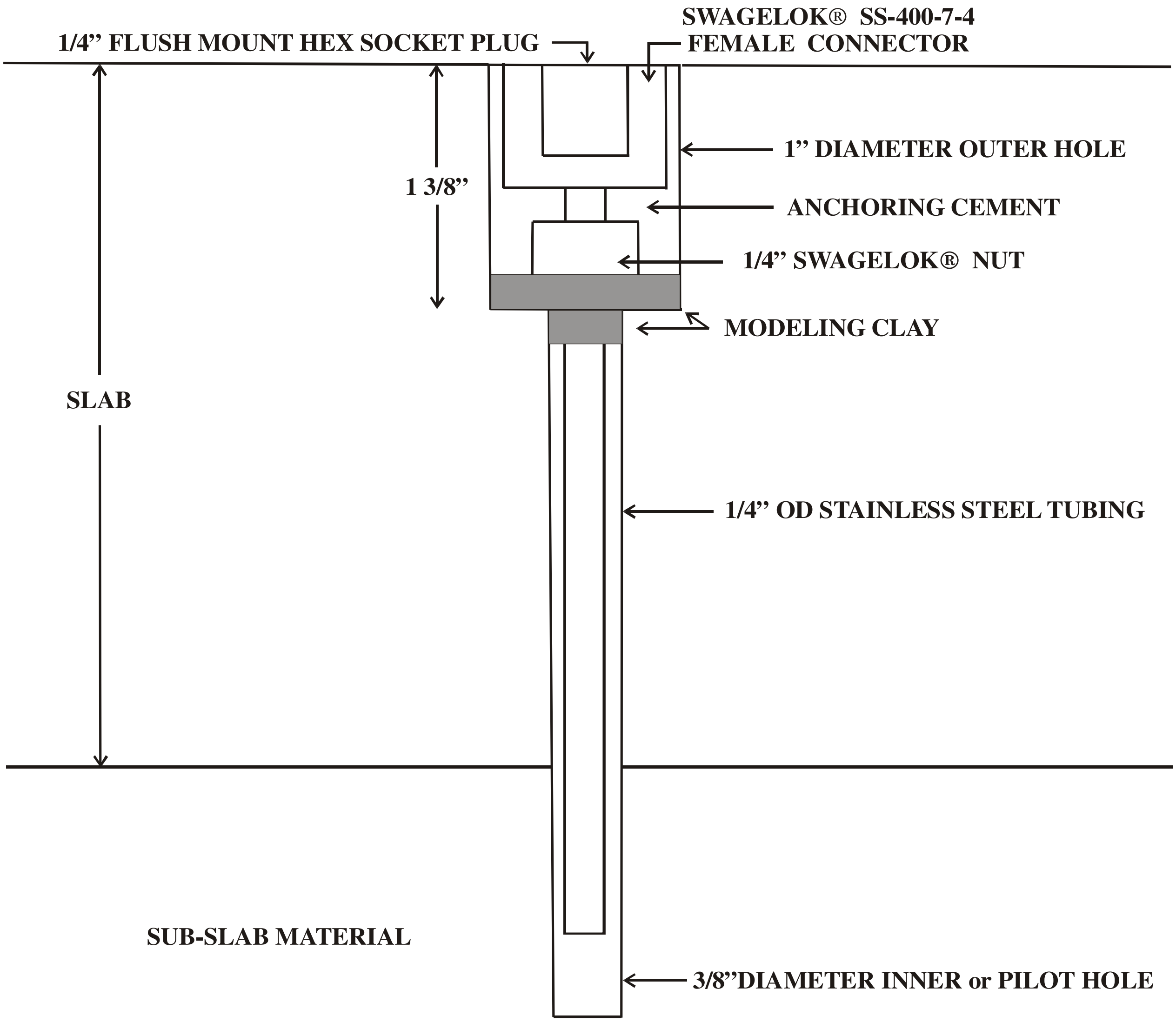


FIGURE 5

SOIL GAS PROBE PREPARED FOR SAMPLING

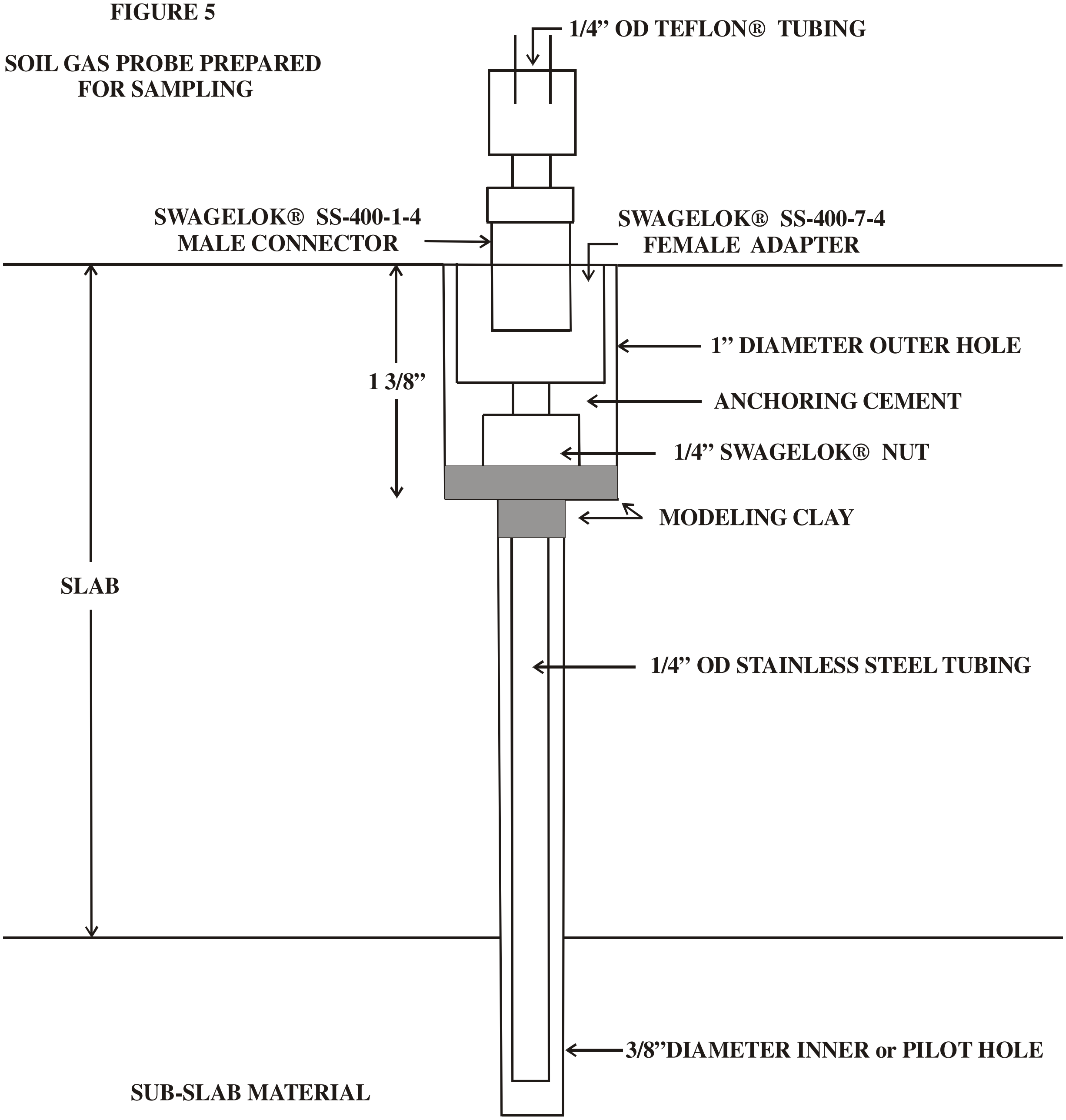
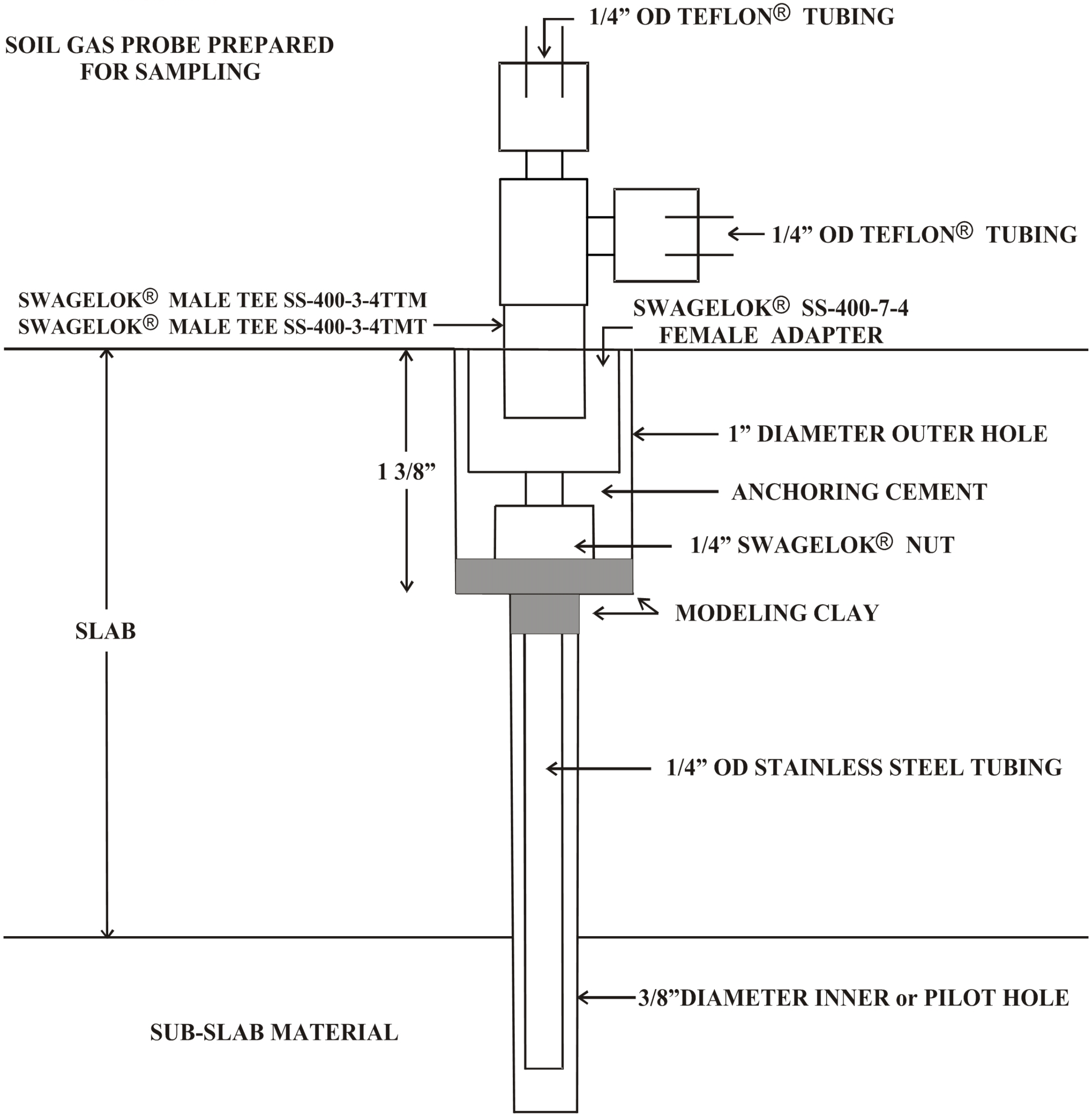


FIGURE 6

SOIL GAS PROBE PREPARED
FOR SAMPLING



ATTACHMENT G

AIR SAMPLING FIELD FORM

Sample Log
[Add Site Name]
[Add City, County, State]

Address: ___________________________________

Owner's Name: ___________________________________

Telephone No: ___________________________________

Occupant's Name (if tenant): ___________________________________

Telephone No: ___________________________________

Is resident living in basement? **YES** ☐ **NO** ☐

Sub-Slab Sample:

Start Date/Time	Barometric Pressure	Outside Temp	Vacuum at Start	Sample ID#	ppbRAE VOC Conc.	SUMMA Canister ID	Regulator ID
/							

End Date/Time	Vacuum at End	Location of Sub-Slab Sample
/		

Indoor Air Sample:

Start Date/Time	Barometric Pressure	Outside Temp	Vacuum at Start	Sample ID#	ppbRAE VOC Conc.	SUMMA Canister ID	Regulator ID
/							

End Date/Time	Vacuum at End	Location of Indoor Air Sample
/		

PICTURES TO BE TAKEN:

Inside basement (all 4 directions)	**YES** ☐	**NO** ☐
Sub-slab sample	**YES** ☐	**NO** ☐
Indoor air sample	**YES** ☐	**NO** ☐
Outside of residence (all 4 directions)	**YES** ☐	**NO** ☐

IF HOUSE HAS A VAPOR ABATEMENT SYSTEM:

U-Tube Manometer (inches water column)	_________	(ideal is greater than 1)
Vacuum Reading (inches water column)	_________	at location _______________
Vacuum Reading (inches water column)	_________	at location _______________
Vacuum Reading (inches water column)	_________	at location _______________

(ideal digital manometer vacuum reading is at least 0.01)

TYPE OF AIR SAMPLING ☐ **Initial** ☐ **__-day post mitigation** ☐ **__-day post mitigation** ☐ **Quarterly Sample**

Other____

Comments:

____

____

____

ATTACHMENT H

VAPOR INTRUSION RESIDENT QUESTIONNAIRE

VAPOR INTRUSION RESIDENT QUESTIONNAIRE

Preparer's Name:______________________________________Date Prepared:_______________

Preparer's Affiliation:____

1. OCCUPANT:

Interviewed: Y / N

Last Name:______________________________ First Name:__________________________

Address:____

City:________________________________ County:____________________ State_________

Home Phone:___________________ Cell Phone:_____________________

Number of Occupants/persons at this location: __________ Age of Occupants______________

2. OWNER OR LANDLORD: (Check if same as occupant _____)

Interviewed: Y / N

Last Name:______________________________ First Name:__________________________

Address:____

City:________________________________ County:____________________ State_________

Home Phone:___________________ Cell Phone:_____________________

Number of Occupants/persons at this location: __________ Age of Occupants______________

3. BUILDING CHARACTERISTICS

Type of Building: (Circle appropriate response)

Residential	School	Commercial
Industrial	Church	Other: ________________________

If the property is residential, type? (Circle appropriate response)

Single Family 2-Family Multi-Family Mobile Home

Apartment House Townhouse/Condo

If multiple units, how many? __________

If the property is commercial, what type?

Business Type(s) ____

Does it include residences (i.e., multi-use)? Y / N If yes, how many? ______

Other characteristics:

Number of Floors __________ Building Age __________

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS (Circle all that apply)

a. Above-grade construction: wood frame concrete stone brick

b. Is there a basement? Yes No

c. Basement type: full crawl space slab Other_______

d. Basement floor: concrete dirt partial Other_______

e. Foundation walls: poured block stone Other_______

f. Integrity of foundation walls: good fair poor

g. The basement is: wet damp dry moldy

h. The basement is: finished unfinished partially finished

i. Integrity of basement floors: good fair poor

j. Sump present? Yes No

NOTE: Include a sketch of the basement and attach to this form.

Does anyone live in the basement? Y / N

If yes, how many people? __________ **What age(s)?** _______________

Approximate square footage of footprint of structure: __________ (ft^2)

Basement/Lowest level depth below grade: __________ (feet)

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

____

____

6. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

a. Is there an attached garage? Y / N

b. Does the garage have a separate heating unit? Y / N / NA

c. Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, ATV, car) Y / N / NA Please specify________________

d. Has the building ever had a fire? Y / N When? _________

e. Is a kerosene or unvented gas space heater present? Y / N Where? _________

f. Is there a workshop or hobby/craft area? Y / N Where and type? ______________

g. Is there smoking in the building? Y / N

h. Are chemicals, paints, etc stored in the basement? Y / N Types? ___________

ANY OTHER COMMENTS

____

____

____

ATTACHMENT I

USING THE TAGA MOBILE LABORATORY TO RESOLVE VAPOR INTRUSION ISSUES

Using the Trace Atmospheric Gas Analyzer (TAGA) Mobile Laboratory to Resolve Vapor Intrusion Issues – Interpretation of Multiple Lines of Evidence for Vapor Intrusion

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Abstract

In recent years, vapor intrusion has been a topic of intense interest in the United States. The number of guidance documents released on this subject has increased dramatically from all sectors, including Environmental Protection Agency and Department of Defense at the federal level, 26 States and several cities at the local levels, and Interstate Technology Regulatory Council and American Petroleum Industry from the public and/or private sector. Published information concerning the vapor intrusion issue addresses this topic in varying degrees.

According to the United States Environmental Protection Agency's Office of Solid Waste and Emergency Response, vapor intrusion is the migration of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals in buried wastes and/or contaminated groundwater can emit vapors that may migrate through subsurface soils and into indoor air spaces of overlying buildings in ways similar to that of radon gas seeping into homes (US EPA, 2002).

The concern that the vapor intrusion pathway poses is whether an unacceptable risk exists for the occupants. To determine the risk associated with chemicals in the vapor intrusion pathway, confounding factors due to the presence of these chemicals from other sources need to be qualitatively and quantitatively identified so that the contributions from the vapor intrusion alone can be assessed. Due to the fact that risk is compound specific and many compounds have unacceptable chronic risk levels at extremely low concentrations, an analytical technique is needed that has high selectivity and sensitivity as well as constant, near real-time analysis updates to accurately and economically assess vapor intrusion sites.

1 Introduction

One of the US Environmental Protection Agency's goals is to reduce or control the risk to human health and the environment. In order to accomplish this task, it is necessary to determine if specific exposure pathways exist and evaluate the site to determine whether contamination is present at levels that may pose a significant risk to human health or the environment. One of the pathways that can contribute to exposure is the vapor intrusion pathway.

The Interstate Technology and Regulatory Council guidance states that to define the vapor intrusion pathway as a complete exposure pathway, a source, migration route, and receptor must be identified. Specifically, this assessment entails the identification of all known or suspected vapor sources of contamination; consideration of the contaminant migration routes (mobility) including an evaluation of methods and manner of access, and identification of those likely to be affected by the contaminants (receptors) (Interstate Technical Regulatory Council, 2007).

Moreover, the general consensus of the members in the regulatory community who evaluate the vapor intrusion pathway is that multiple lines of evidence are needed to ensure that the vapor intrusion pathway is complete. The multiple lines of evidence include but are not limited to:

- groundwater spatial (and vertical profiling, if appropriate) data with modeling;
- soil gas spatial concentrations (and vertical profiling, if appropriate), including subslab, with vertical profiling;
- building construction and conditions;
- constituent ratios; and
- ambient, crawlspace, and inside air concentrations and source determinations.

This paper will focus on the last two elements.

The TAGA mobile laboratories have been used for nearly 25 years by the US Environmental Protection Agency's Environmental Response Team (US EPA's ERT) to monitor for various compounds in the ambient air (Figure 1). The TAGA monitoring has supported enforcement efforts, emergency response activities, natural disaster recovery actions, structure decontamination operations, homeland security requirements, and engineering design testing as well as vapor intrusion studies. Each monitoring operation took advantage of the specificity, sensitivity, and near real-time results that are provided by triple quadrupole technology.

Figure 1 TAGA Mobile Laboratory

During the past 10 years, the TAGA mobile laboratories have been involved with over 70 different vapor intrusion sites involving hundreds of structures with some sites revisited multiple times (US EPA/ERT, 2001), (US EPA/ERT, 2004), (US EPA/ERT 2008), (US EPA/ERT, 2003), (US EPA/ERT, 2001), (US EPA/ERT, 2001), (US EPA/ERT, 2007), (US EPA/ERT, 2004). Most sites investigated had target compounds associated with halogenated hydrocarbons and petroleum compounds, with halogenated hydrocarbon sites being the most prevalent. The TAGA system is a unique technology, which provides extremely low concentration data for targeted compounds with updates to the monitoring results in near real time to afford fine spatial and temporal resolution of the output while transecting inside or outside of the structure. The detailed information gained through the TAGA monitoring offers support for various lines of evidence to suggest that the vapor intrusion pathway exists or not.

2 Procedure

TAGA monitoring requires a fundamental understanding of general theory of tandem mass spectrometry. Additionally, the TAGA monitoring requires certain quality assurance operations to be performed to ensure that the data are scientifically sound. Lastly, TAGA monitoring can be performed remotely by using a Teflon® tube to efficiently transport the sample to the instrumentation or by directly introducing air into the TAGA while the mobile laboratory is operated in either the stationary or mobile mode.

2.1 Mass Spectrometer/Mass Spectrometer General Theory

The ECA TAGA IIe is based upon the Perkin-Elmer API 365 mass spectrometer/mass spectrometer (MS/MS) and is a direct air-monitoring instrument capable of detecting, in real time, trace levels of many inorganic and organic compounds in ambient air. The technique of triple quadrupole MS/MS is used to differentiate and quantitate compounds. The initial step in the MS/MS process involves simultaneous chemical ionization of the compounds present in a sample of ambient air. The ionization can produce both positive and negative ions by donating or removing one or more electrons. The chemical ionization is a "soft" ionization technique, which allows ions to be formed with little or no structural fragmentation. These ions are called parent ions. The parent ions with different mass-to-charge (m/z) ratios are separated by the first quadrupole (the first MS of the MS/MS system). The quadrupole scans selected m/z ratios allowing only the parent ions with these ratios to pass through the quadrupole. Parent ions with m/z ratios different than those selected are discriminated electronically and fail to pass through the quadrupole.

The parent ions selected in the first quadrupole are accelerated through a collision cell containing uncharged nitrogen (N_2) molecules in the second quadrupole. A portion of the parent ions entering the second quadrupole fragments as they collide with the N_2 molecules. These fragment ions are called daughter ions. This process, in the second quadrupole, is called collision-induced dissociation. The daughter ions are separated according to their m/z ratios by the third quadrupole (the second MS of the MS/MS system). The quadrupole scans selected m/z ratios, allowing only the daughter ions with these ratios to pass through the quadrupole. Daughter ions with m/z ratios different than those selected are discriminated electronically and fail to pass through the quadrupole. Daughter ions with the selected m/z ratios are then counted by an electron multiplier. The resulting signals are measured in ion counts per second (icps) for each parent/daughter ion pair selected. The intensity of the icps for each parent/daughter ion pair is directly proportional to the ambient air concentration of the compound that produced the ion pair. All of the ions discussed in this report have a single charge. The m/z ratios of all of the ions discussed are equal to the ion masses in atomic mass units (amu). Therefore, the terms parent and daughter masses are synonymous with parent and daughter ion m/z ratios.

2.2 TAGA Mass Calibration

At the beginning of the sampling day, a gas mixture containing benzene, toluene, xylene, tetrachloroethene, trichloroethene, trans-1,2-dichloroethene and vinyl chloride is introduced by a mass flow controller into the sample air flow, and the tuning parameters for the first quadrupole at 30, 78, 98, 106, 130 and 164 amu, and the third quadrupole at 30, 78, 91, 105, 129 and 166 amu are optimized for sensitivity and mass assignment. The peak widths at half height are limited between 0.55 amu and 0.85 amu. The mass assignments are set to the correct values within 0.15 amu.

2.3 TAGA Response Factor Measurements

The calibration system consists of a regulated gas cylinder with a mass flow controller. The mass flow controller is checked with a National Institute of Standards and Technology (NIST) traceable flow rate meter. The calibration system is used to generate the analytes' response factors (RFs), in units of ion counts per second per part per billion by volume (icps/ppbv), which are then used to quantify trace components in ambient air. The TAGA is calibrated for the target compounds at the beginning and end of the monitoring day. The average of the beginning and end of day RFs are used to generate the intermediate response factor (IRF) used for the final calculations of the target analyte concentrations.

The gas cylinder standard, which contains known mixtures of target compounds, certified by the supplier, is regulated at preset flow rates and diluted with ambient air to give known analyte concentrations. The calibration consists of a zero point and five known concentrations obtained by setting the mass flow controller to 0, 10, 20, 40, 80, and 90 milliliters per minute (mL/min) with the sample air flow at 90 liters per min (L/min). The approximate concentration range of standards introduced into the TAGA is between 1 ppbv and 25 ppbv. The RFs are then determined by using a least-square-fit algorithm to calculate the slopes of the curves. The coefficient of variation is checked for each ion pair's RF to ensure that it is greater than 0.90. The software utilizes the analytes' cylinder concentrations, gas flow rates, air sampling flow rates, and atmospheric pressure to calculate the RFs.

2.4 Transport Efficiency

The transport efficiency and residence time for the target compounds through the 7/8 inch internal diameter, 200-foot length of corrugated Teflon® sampling hose is determined prior to and at the conclusion of indoor air monitoring activities each day. The transport efficiency is determined by introducing a known concentration of the target compounds into the proximal end and then into the distal end of the sampling hose. The signal intensity of each ion pair for each compound is measured in icps and the percent (%) transport efficiency calculated using the equation below:

$$\%\ transport\ \ efficiency\ =\ \frac{signal\ intensity\ at\ the\ distal\ end\ of\ the\ hose}{signal\ intensity\ at\ the\ proximal\ end\ of\ the\ hose}\ x\ 100$$

A transport efficiency of 85% is considered acceptable. The residence time is the interval, in seconds, it takes the air sample to travel the length of the sampling hose. The residence time, which reflects a time difference between the sampling and the instrument response, is incorporated in the offset. The offset, which is the total number of sequences acquired during the residence time, is applied to the monitoring files. Therefore, the observations and instrument responses are temporally coordinated.

2.5 TAGA Air Monitoring

TAGA air monitoring is performed in one of two configurations. The first configuration uses a 200-foot Teflon® tube to transport the air to the instrument from a location inside of a structure and to investigate indoor sources. The second configuration does not require but 3 feet of tubing because the air is introduced directly into the system from the outside through a port in the side of the bus when the TAGA laboratory is driven along the streets and around structures to determine if outdoor ambient air sources are adversely impacting the indoor air of a building.

2.5.1 TAGA Indoor Air Monitoring

TAGA monitoring is performed by continuously drawing air through the 200-foot Teflon® tube at a flowrate of approximately 90 L/min The air is then passed through a glass splitter where the pressure gradient between the mass spectrometer core and the atmosphere causes a sample flow of approximately 10 mL/min into the ionization source through a heated transfer line. The flow into the TAGA source is controlled so that the ionization source pressure is maintained at an optimum value of approximately 3.4 torr. The remaining airflow is drawn through the air pump and vented from the TAGA bus.

Monitoring is performed in the parent/daughter ion-monitoring mode. As monitoring proceeds, the operator presses letter keys (flags), alphabetically on a computer keyboard, to denote events or locations during the monitoring event. This information is also recorded on an event log sheet. Additionally, the sampler, who is moving the distal end of the Teflon® tube and in constant radio communication with the TAGA operator, notes the flags on the schematic of the structure. The intensity of each parent/daughter ion pair monitored by the TAGA is recorded in a permanent file on the computer’s hard drive. One set of recorded measurements of all the ion pairs is called a sequence.

At the beginning of each unit survey or investigation, a one-minute pre-entry ambient data segment is collected. At the operator's signal, the sampler then enters the unit while holding the distal end of the hose at breathing height. The sampler proceeds to each room in the unit where one-minute data segments are collected. After the rooms in the unit are monitored, a one-minute post-exit ambient data segment is collected. Upon completion of the one-minute post-exit ambient air segment, the instrumentation is challenged with the calibration standard, which is introduced at 30 mL/min, approximately 7 ppbv for the target compounds, to verify that the system is functioning properly (Figure 2).

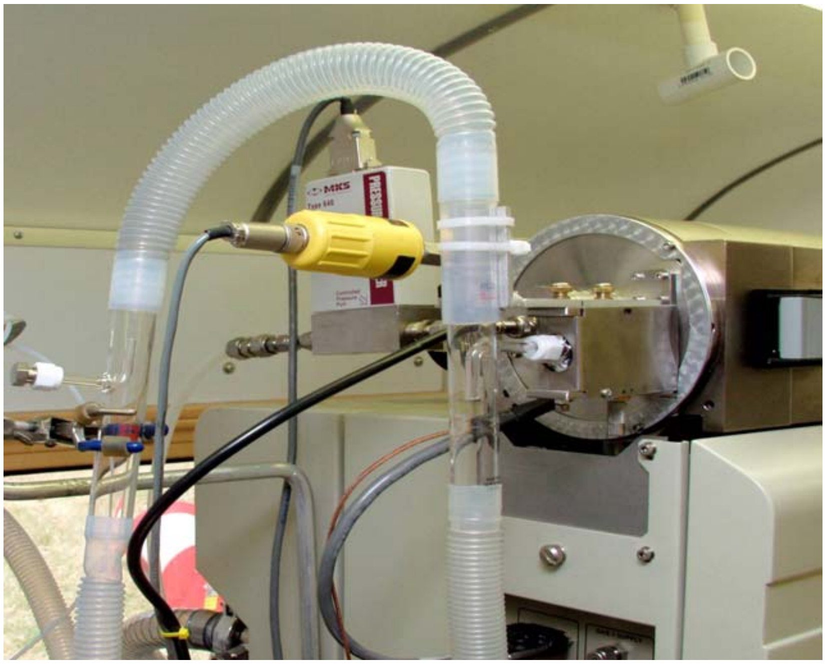


Figure 2. TAGA Source

2.5.2 TAGA Outdoor Mobile Monitoring

The TAGA performs mobile ambient air monitoring using a 3-foot length of corrugated Teflon® sampling hose connected to a glass transfer tube passing through the roof of the TAGA bus. Air is continuously drawn through the Teflon® hose at a flowrate of approximately 90 L/min. The air then passes through a glass splitter where the pressure gradient between the mass spectrometer core and the atmosphere causes a sample flow of approximately 10 mL/min into the ionization source through a heated transfer line. The flow into the TAGA source is controlled so that the ionization source pressure is maintained at an optimum value of approximately 1.6 torr. The remaining air flow is drawn through the air pump and vented from the TAGA.

The TAGA performs air monitoring in the parent/daughter ion monitoring mode. As the air monitoring proceeds, the operator presses the letter keys (flags) sequentially to denote events or locations during the monitoring. This information is also recorded on the operator's log sheet. The intensity of each parent ion/daughter ion monitored by the TAGA, in turn, is recorded by the computer in a file on the hard disk. One set of measurements of all the ions is called a sequence.

3 Results and Discussion

Although vapor intrusion assessments seem very straight forward theoretically, in practical application, they can be very complex due to confounding factors that are not intuitively obvious when investigations are conducted using traditional point sampling and analysis. Typically, in homes that have basements, samples are collected from soil gas beneath the subslab, in the ambient air in basement area, and in the ambient air on the first floor. Additionally, an outside ambient air sample is collected at the residence or in the nearby community to determine the outside ambient air contributions to the indoor air concentrations. Therefore, the indoor air is characterized by two samples.

When the TAGA is utilized for vapor intrusion assessments in a residence, the outside ambient air is monitored prior and subsequent to the indoor investigation for a minimum of three minutes, which represents approximately 200 measurements. Additionally, TAGA monitoring is conducted in every room in the basement and on the first floor for one minute (about 60 measurements) at each location. Lastly, the TAGA monitoring includes focusing on every drain, infrastructure (electric, gas, water, etc.) pass through and openings in the floors and walls below ground surface for one minute at each location. Therefore, at a structure that requires 30 minutes to complete the indoor air monitoring, over 1800 measurements are collected for the assessment using the TAGA.

The following sections will highlight observations that the TAGA monitoring has provided, which helped confirm or deny that vapor intrusion was an issue in a number of structures as well as identifying possible confounding sources.

3.1 Using Compound Signature to Determine Vapor Intrusion

The Raymark Site in Stratford, CT had groundwater contaminated with dichloroethene, 1,1,1-trichloroethane and trichloroethene. During this assignment, a possible vapor intrusion into a children's gymnasium was investigated (schematic shown in Figure 3) (US EPA/ERT, 2001). The concentration profile observed for dichloroethene, 1,1,1-trichloroethane, and trichloroethene rose and lowered in intensity together. Additionally, no chlorobenzene was observed above its detection level as shown in Figure 4. The same letters (flags) are found in the schematic and on the concentration profiles. If these compounds concentrations are found in similar ratios and the concentration ratios of these compounds are nearly the same in other structures, these compounds may be resulting from a common source.

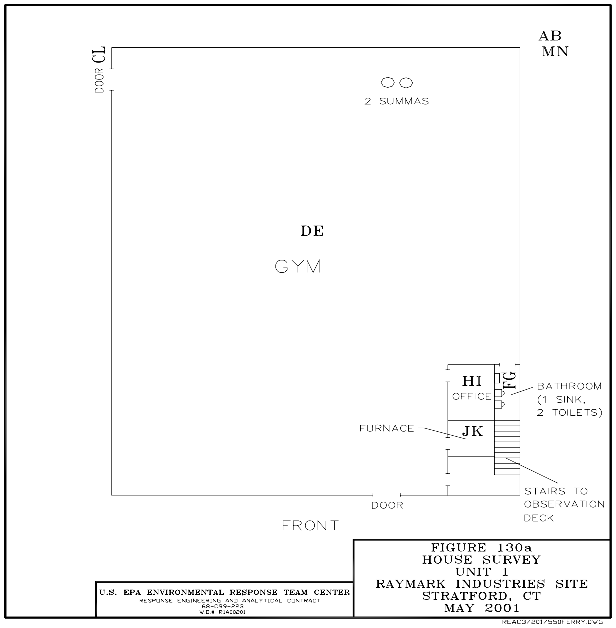


Figure 3 Schematic of the Gymnasium

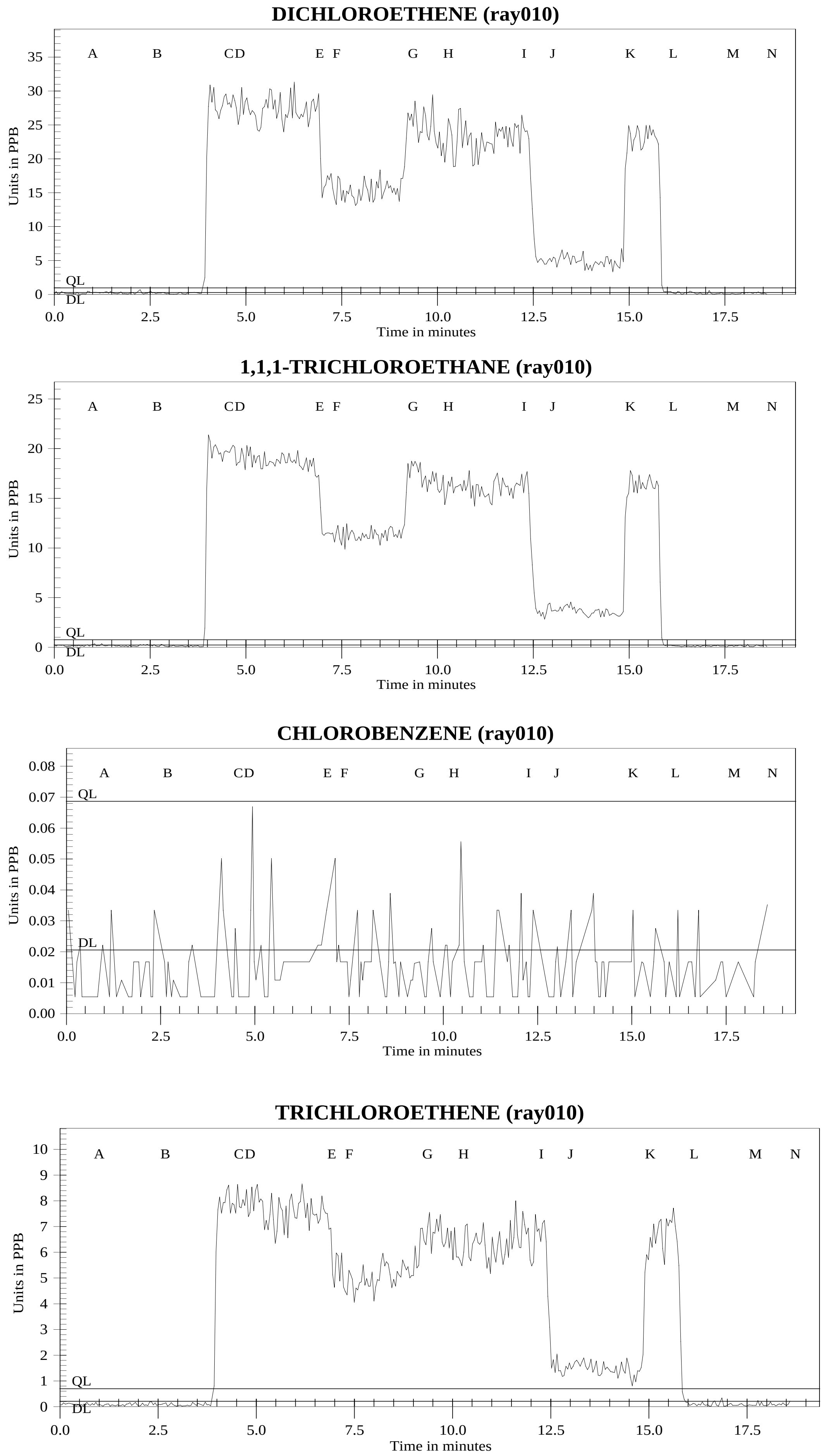


Figure 4 Concentration Profiles for Dichloroethene, 1,1,1-Trichloroethane, Chlorobenzene and Trichloroethene

The residence adjacent to the children's gymnasium was subsequently inspected and a schematic of this residence is shown in Figure 5. Figure 6 shows that the signature compounds are not present at levels at or above the method detection limit in outside ambient air. Figure 6 also shows that the concentrations of the signature compounds are higher in the basement than on the first floor. The fact that the signature compounds are found in the residence and the gymnastic facility, their concentration ratios are similar in both locations, and the concentration levels are higher in the basement of the residence (because the basement is closer to the source of the contamination than on the first floor) suggests that these compounds are emitting from the same vapor intrusion source.

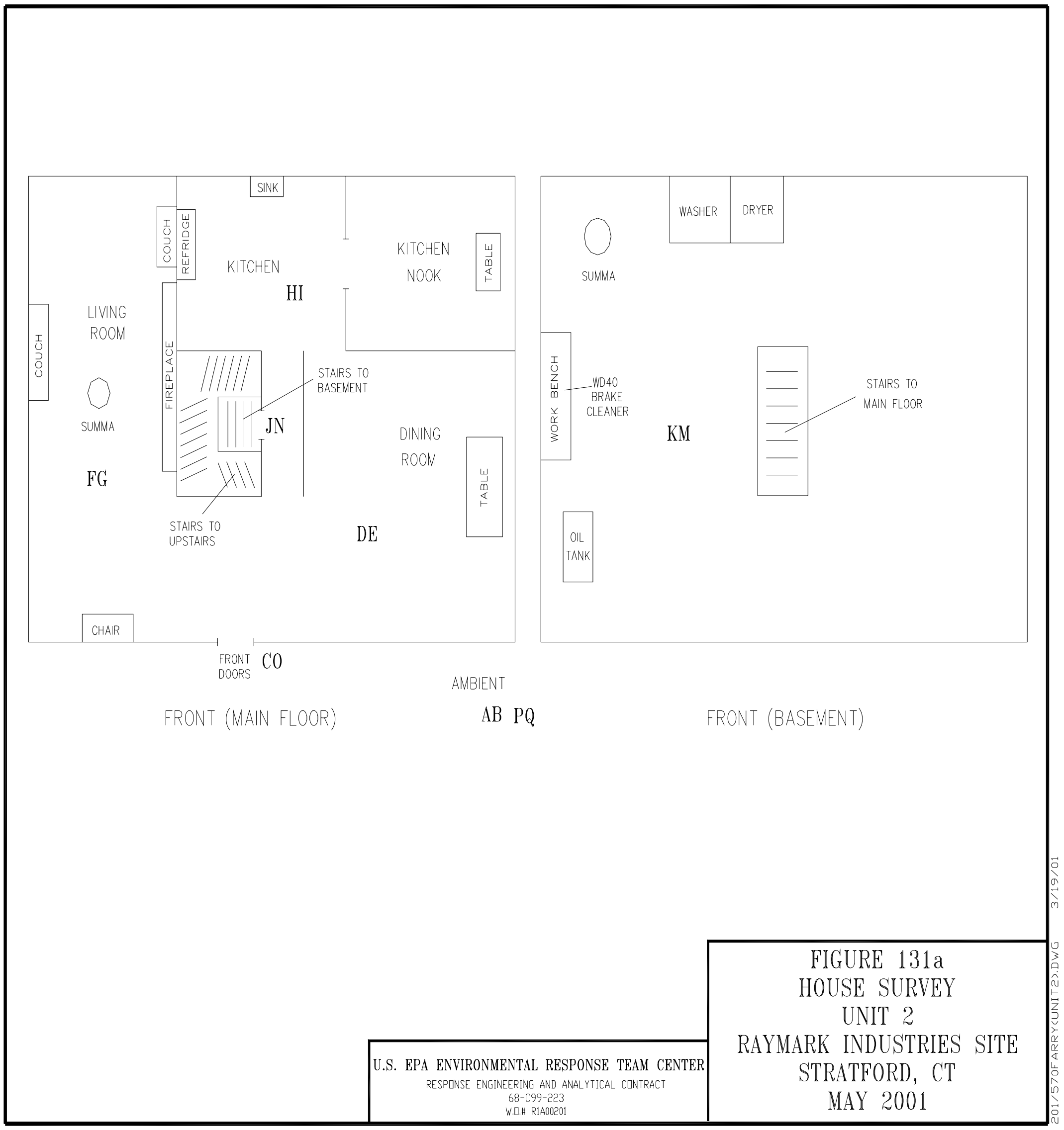


Figure 5 Schematic of the Adjacent Residence

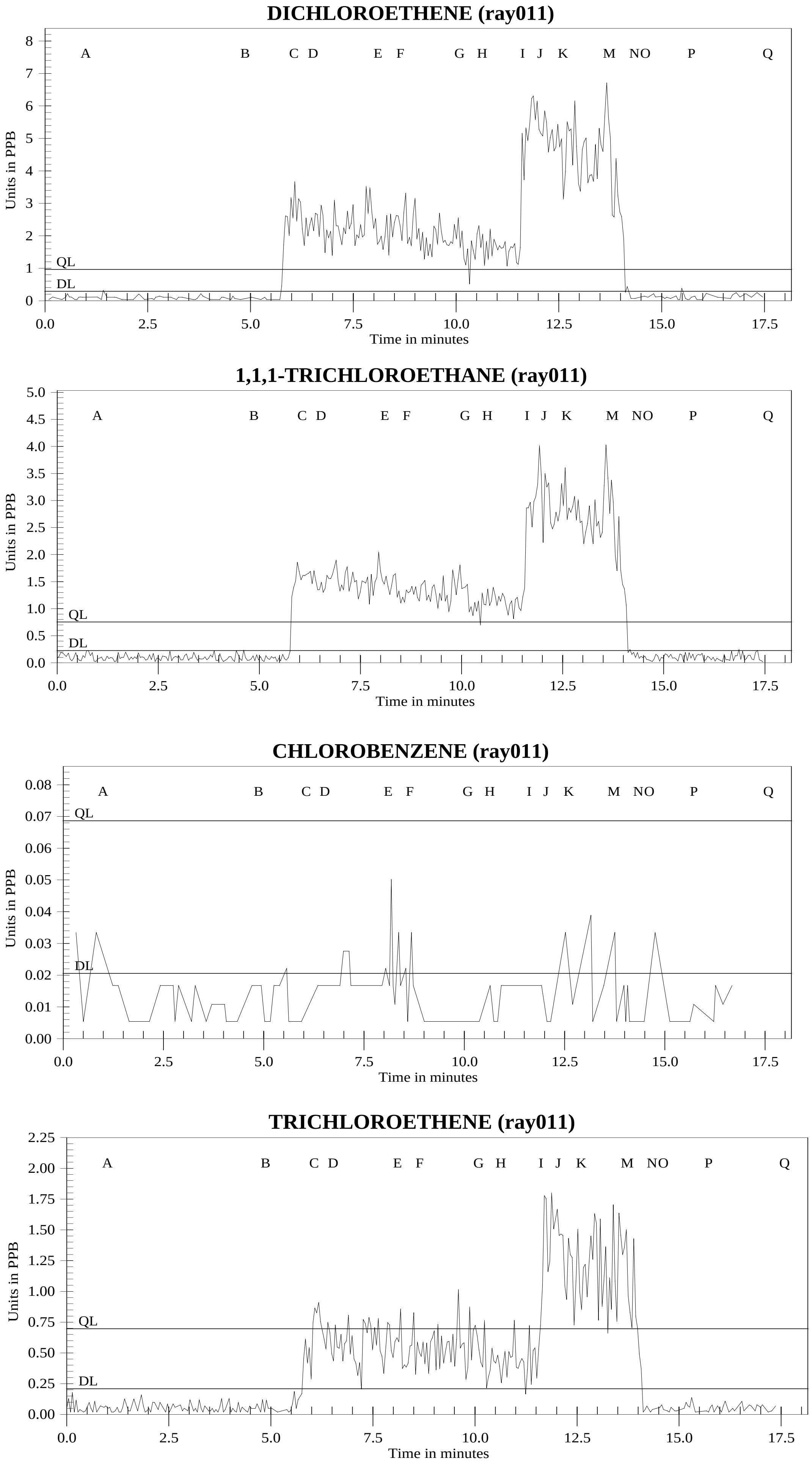


Figure 6 Concentration Profiles for Dichloroethene, 1,1,1-Trichloroethane, Chlorobenzene and Trichloroethene

3.2 Locating Points of Entry for Vapor Intrusion

The Hopewell Precision Site in Hopewell Junction, NY had groundwater contaminated with 1,1,1-trichloroethane and trichloroethene. During this assignment, a bi-level residence was investigated (shown in Figure 7) (US EPA/ERT, 2004). The concentration profiles for 1,1,1-trichloroethane and trichloroethene rose and lowered in intensity together, which indicates a common source. During the monitoring time period, the basement closet door was closed. Inside of this closet is where the outside plumbing enters the residence. The trichloroethene concentration was less outdoors than inside of the residence and reached its maximum concentration in the closet. Additionally, flags Z and AA were associated with the tube handler's first entrance into the closet and flags LL and MM were associated with his second entrance into the closet during which the tube end was moved closer to the wall where the pipe passes through and into the closet. The monitoring data suggests that the vapor intrusion was occurring through these utility passages.

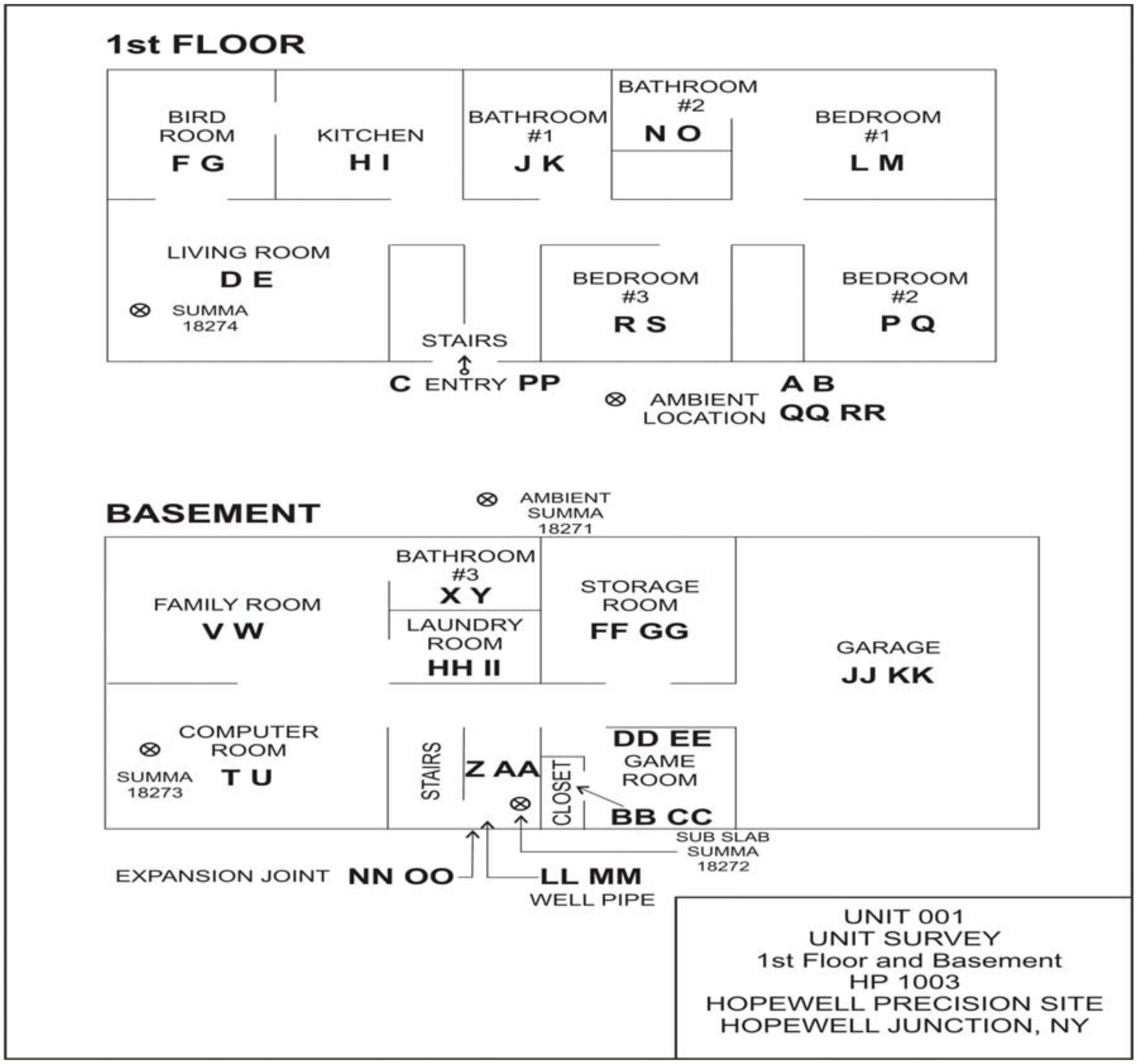
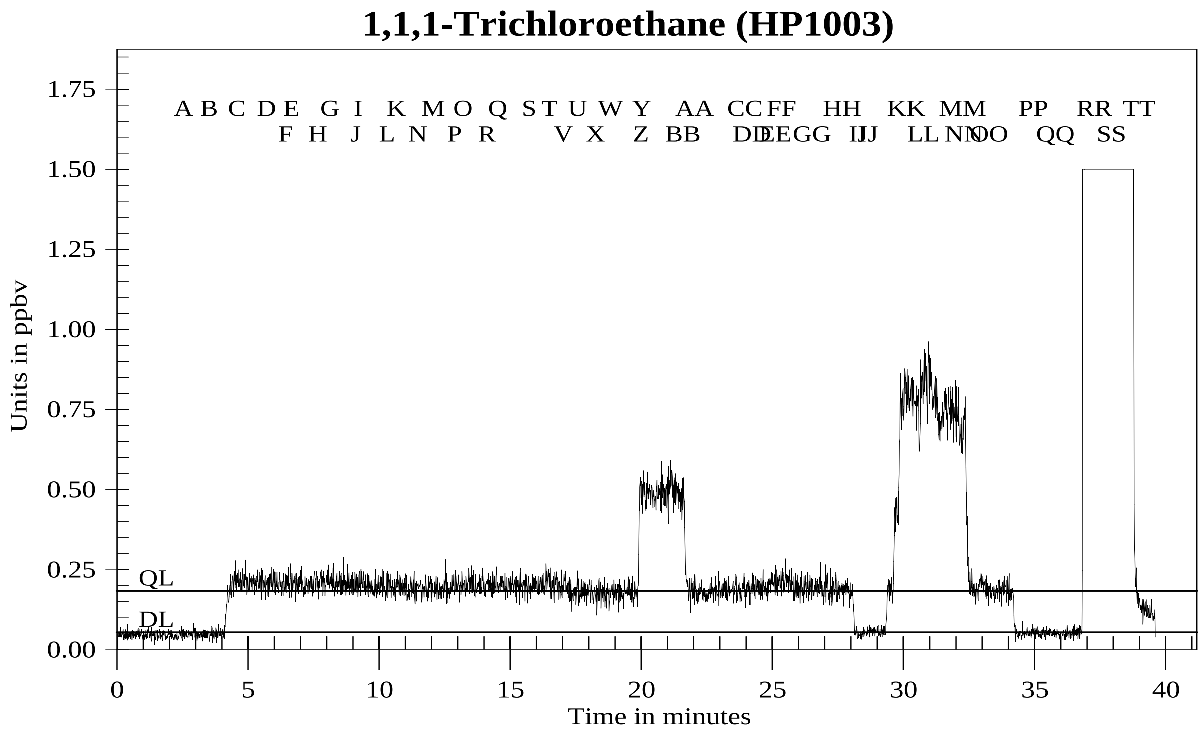


Figure 7 Schematic of the Bi-level Residence



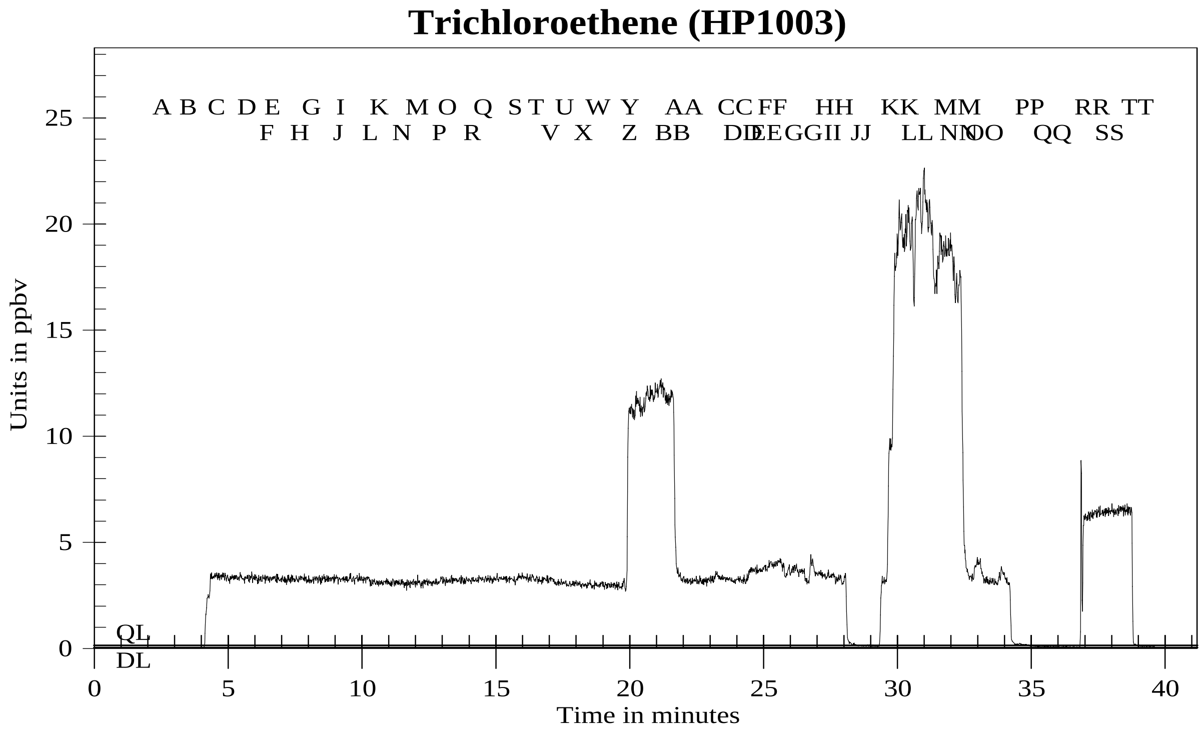


Figure 8 Concentration Profiles for 1.1.1-Trichloroethane and Trichloroethene

3.3 Locating Lifestyle Items that Confound Vapor Intrusion Concentrations

The Hopewell Precision Site in Hopewell Junction, NY had groundwater contaminated with 1,1,1-trichloroethane and trichloroethene. During this assignment, a two-story residence was investigated for possible vapor intrusion and a schematic of this residence is shown in Figure 9 (US EPA/ERT, 2004). The concentration profile observed for 1,1,1-trichloroethane, and trichloroethene rose and lowered in intensity together as the operator moves from location to location, except between flags L and M in the garage where the trichloroethene rose but the 1,1,1-trichloroethene did not as shown in Figure 10.

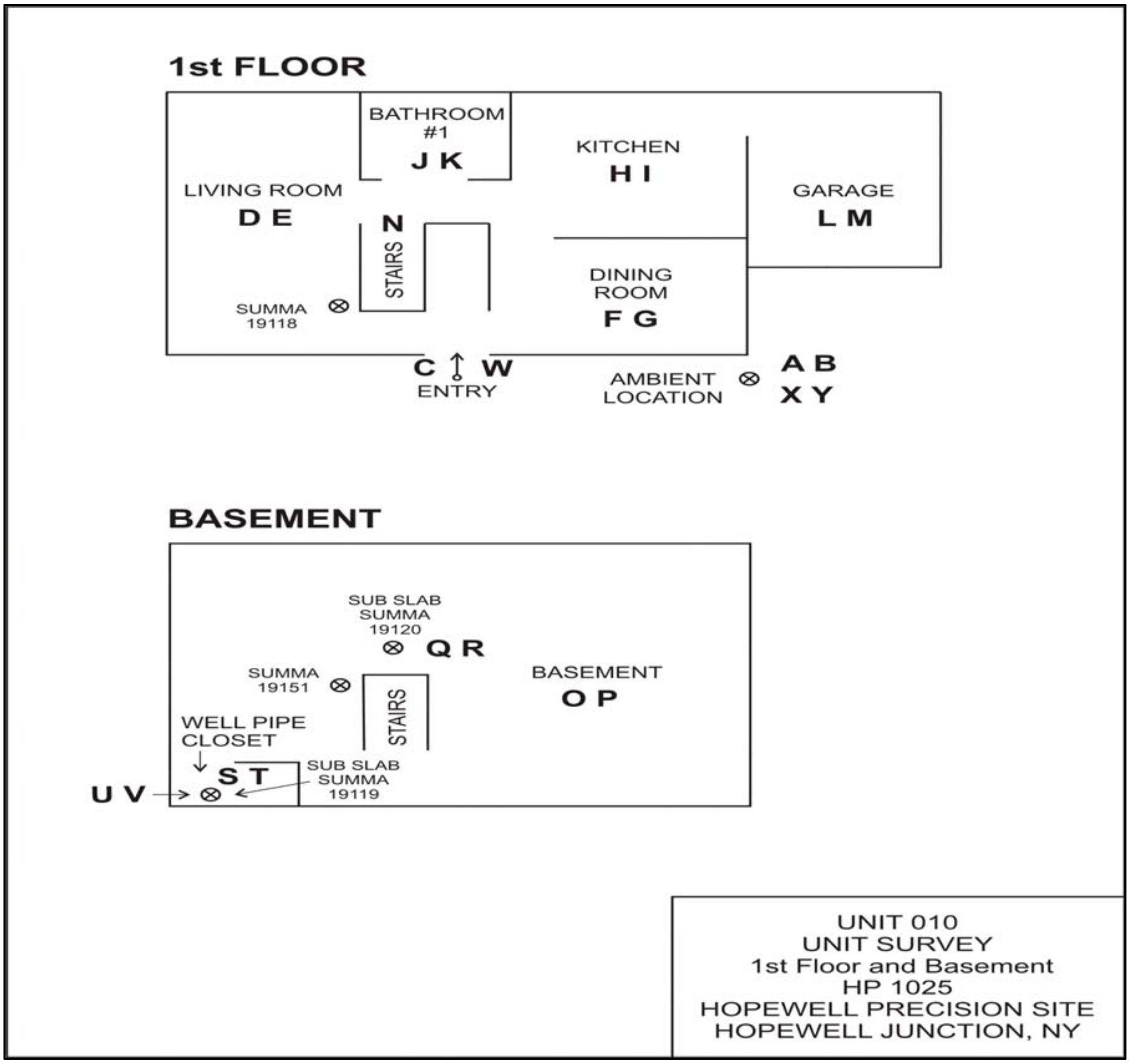
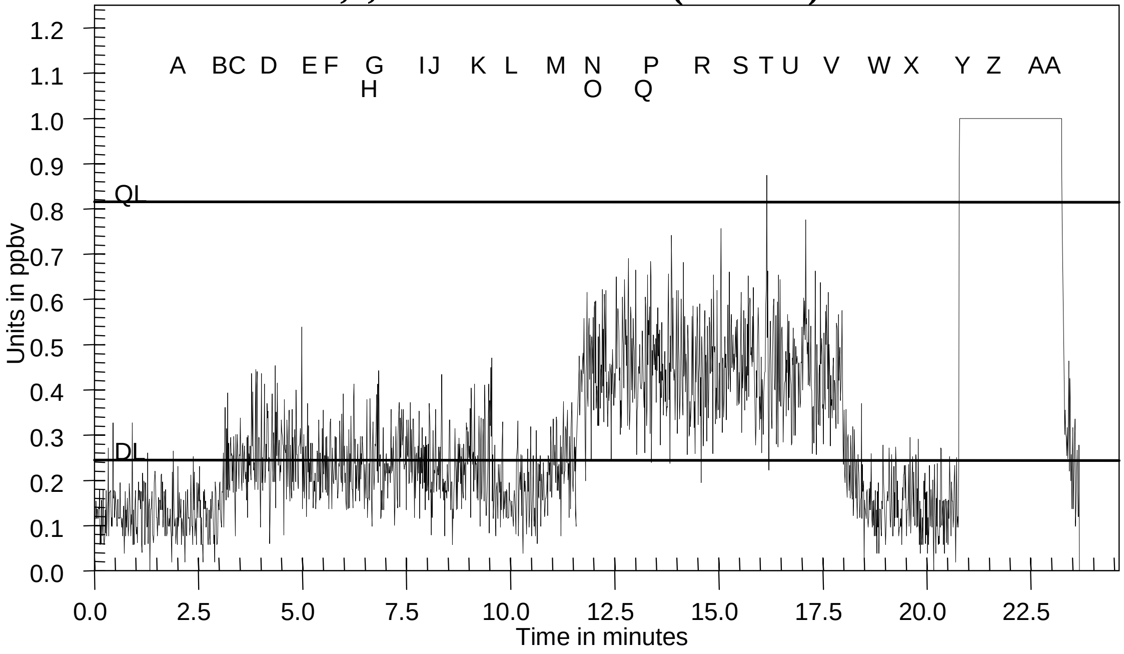


Figure 9 Schematic of the Two Story Residence

1,1,1-Trichloroethane (HP1025)



Trichloroethene (HP1025)

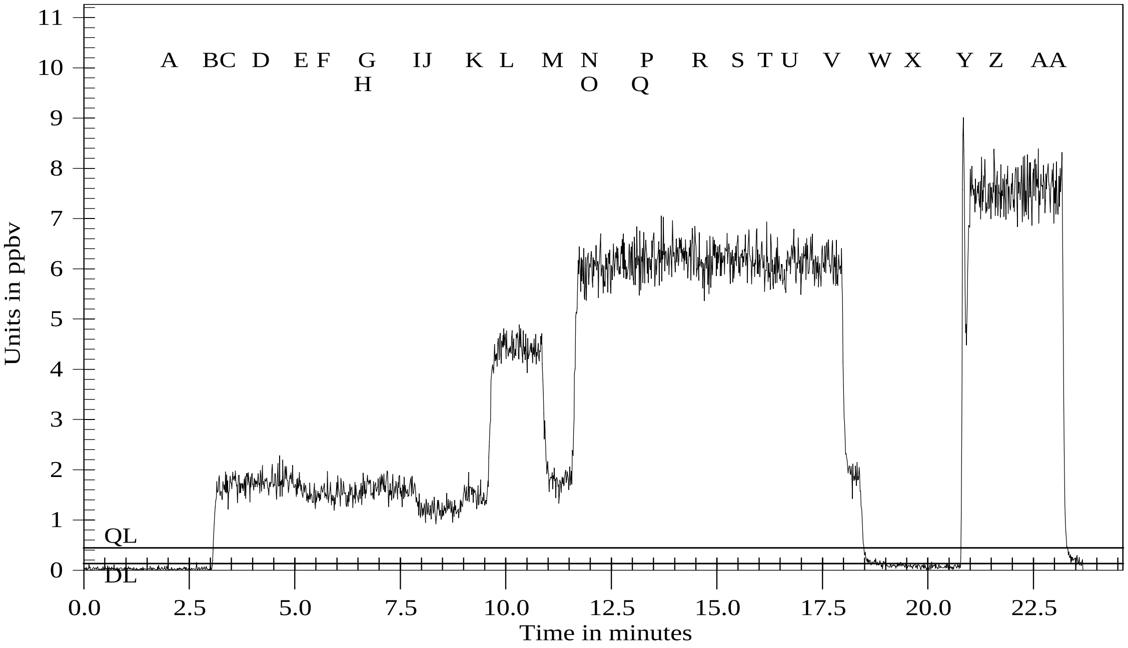


Figure 10 Concentration Profiles for 1,1,1-Trichloroethane and Trichloroethene

The residence's garage was investigated in more detail (schematic shown in Figure 11). The concentration profile observed for 1,1,1-trichloroethane, and trichloroethene show that the 1,1,1-trichloroethane concentration remained nearly constant while that trichloroethene concentration rose sharply as the distal end was passed near certain household items – flags E and F (Figure 12). Although the maximum trichloroethene concentration was approximately 600 ppbv when the end of the tube was near to the lifestyle material, the trichloroethene concentration obtained from monitoring the center of the garage showed that these sources raised the room concentration to about 5 ppbv (Figure 10). The monitoring suggests that elevated levels of trichloroethene were due to lifestyle products.

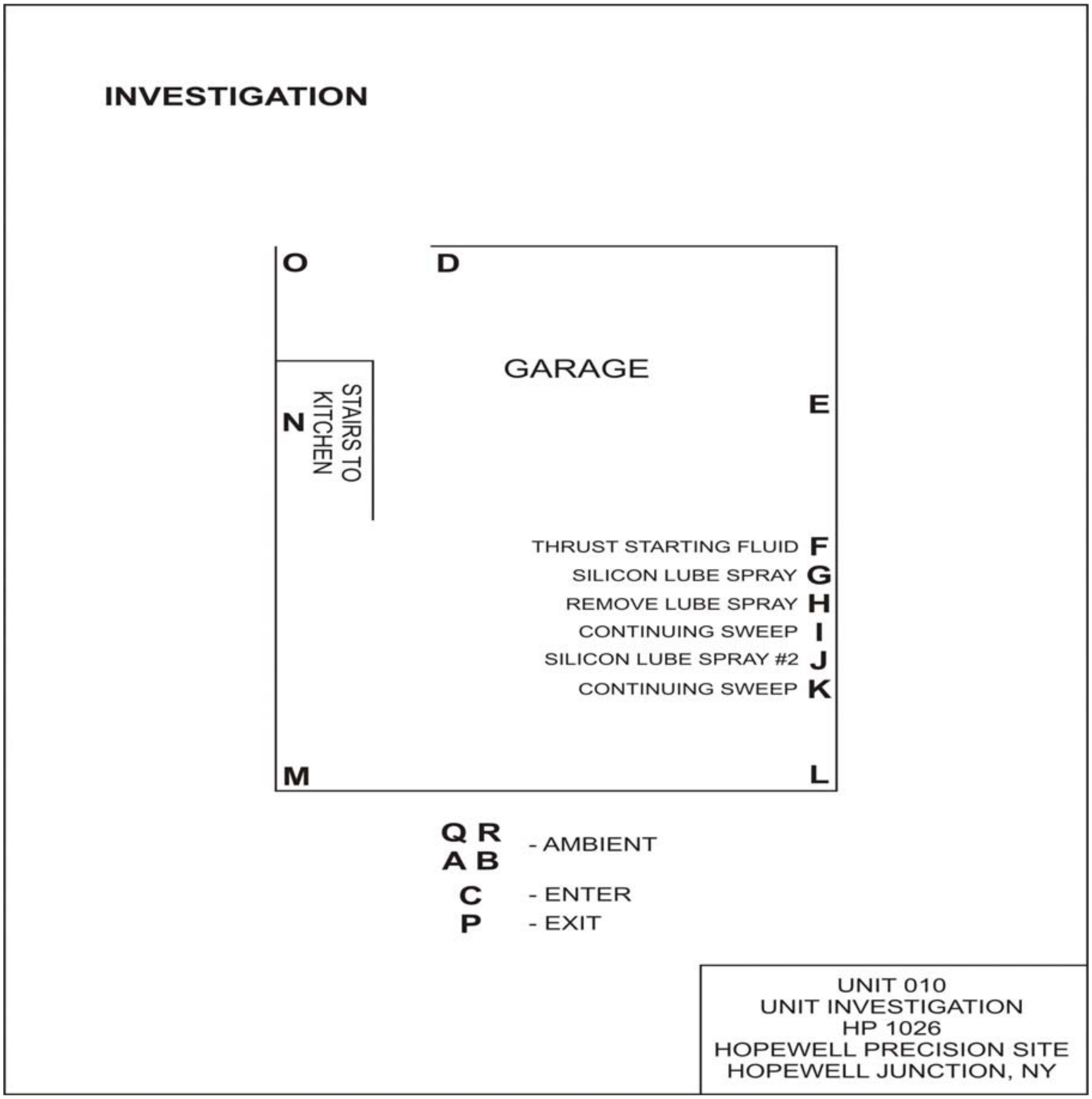
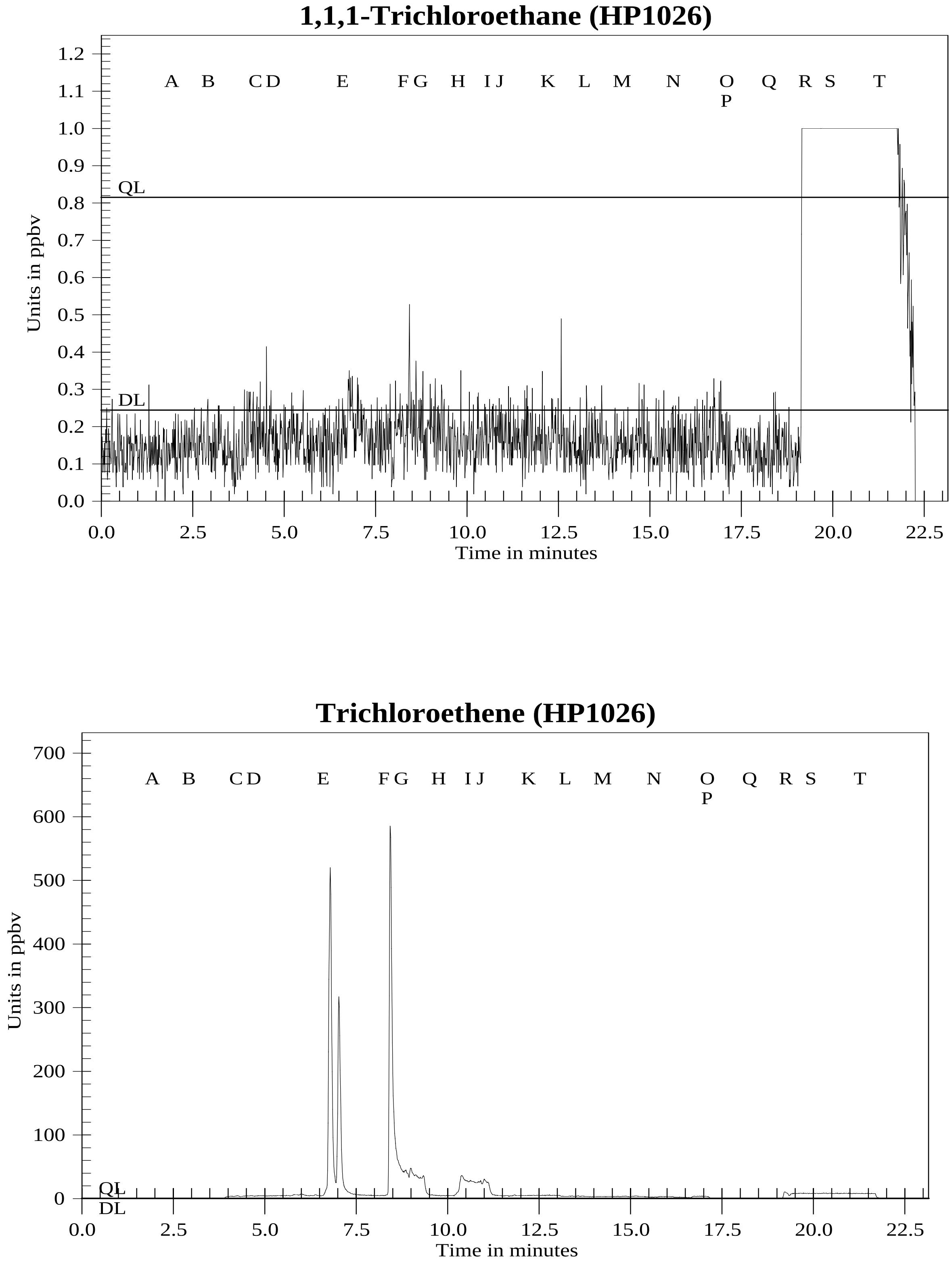


Figure 11 Schematic of the Two Story Residence



1,1,1-Trichloroethane (HP1026)

Trichloroethene (HP1026)

Figure 12 Concentration Profiles for 1,1,1-Trichloroethane and Trichloroethene

3.4 Locating Adjoining Structure Sources that Confound Vapor Intrusion Concentrations

The Parker Solvent Company Site in Little Rock, AR had groundwater contaminated with various solvents. During this assignment, possible vapor intrusion into a government building, which is located across the street from the solvent facility, was investigated (Figure 13) (US EPA/ERT 2008). Initially, the Arkansas Department of Transportation office, which is on the right of the schematic, was examined. The concentration profiles observed for xylene and tetrachloroethene intensity profiles were similar and no detectable concentrations of trichloroethene were observed (Figure 14).

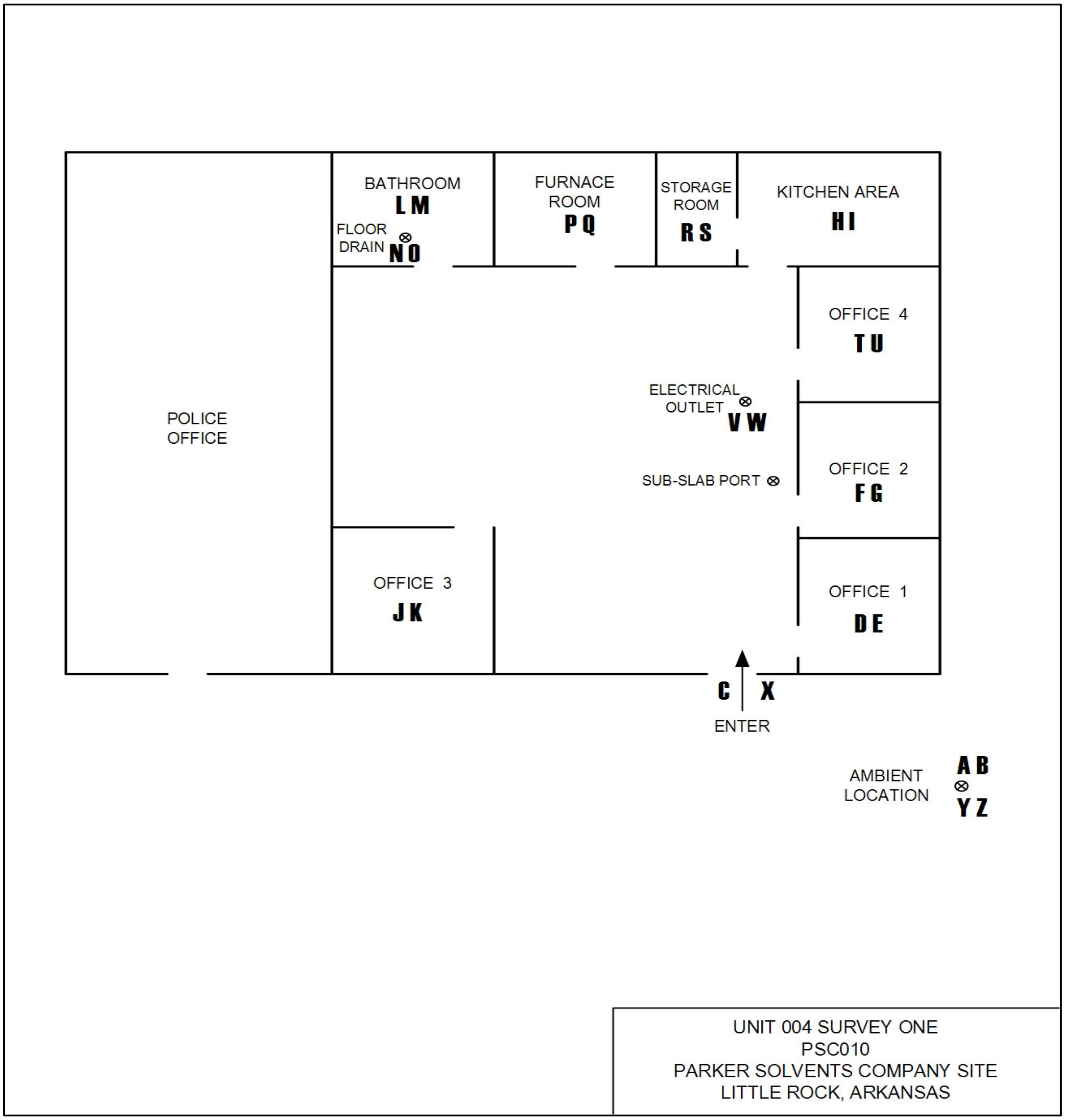
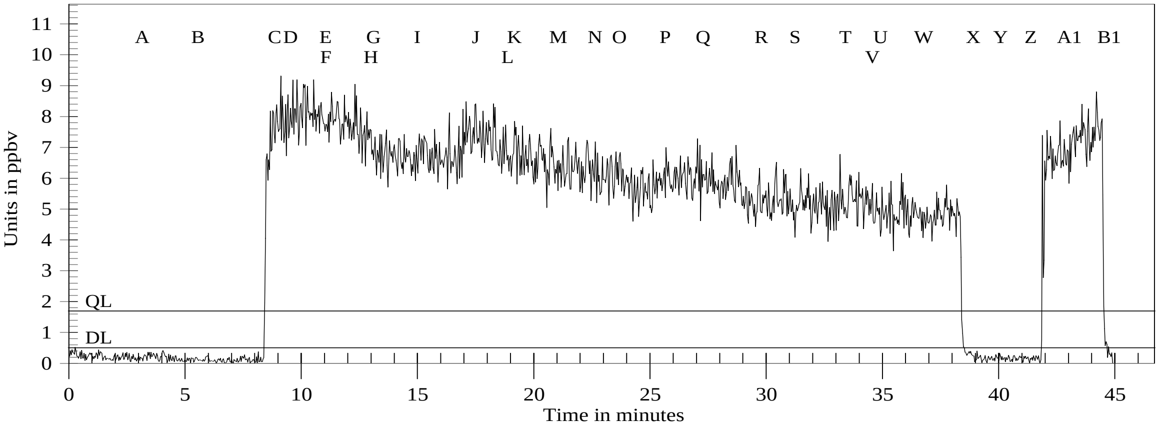
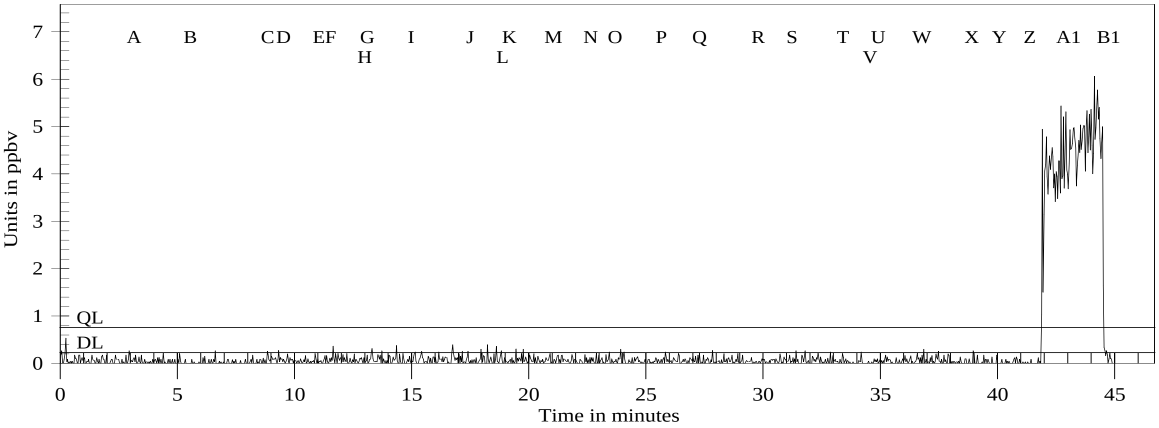


Figure 13 Schematic of the Government Building

Xylene (PSC010)



Trichloroethene (PSC010)



Tetrachloroethene (PSC010)

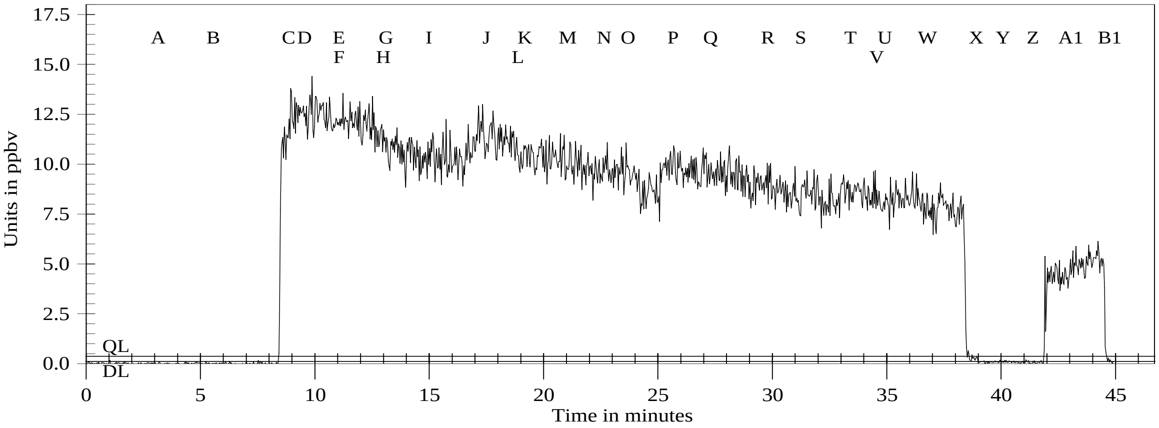


Figure 14 Concentration Profiles for Xylenes, Trichloroethene, Tetrachloroethene

After sampling the government building, the police office space in the same building, which is on the left of the schematic (Figure 15), was examined. As shown in Figure 16, the concentration profiles observed for xylene and tetrachloroethene rose and lowered in intensity together and no detectable concentrations of trichloroethene are present. Notice that the concentrations in Figure 16 are higher than Figure 14. Firearms were frequently cleaned in this police office space. This cleaning operation contaminated the Arkansas Department of Transportation office because vapors from the cleaning operation migrated through the common wall.

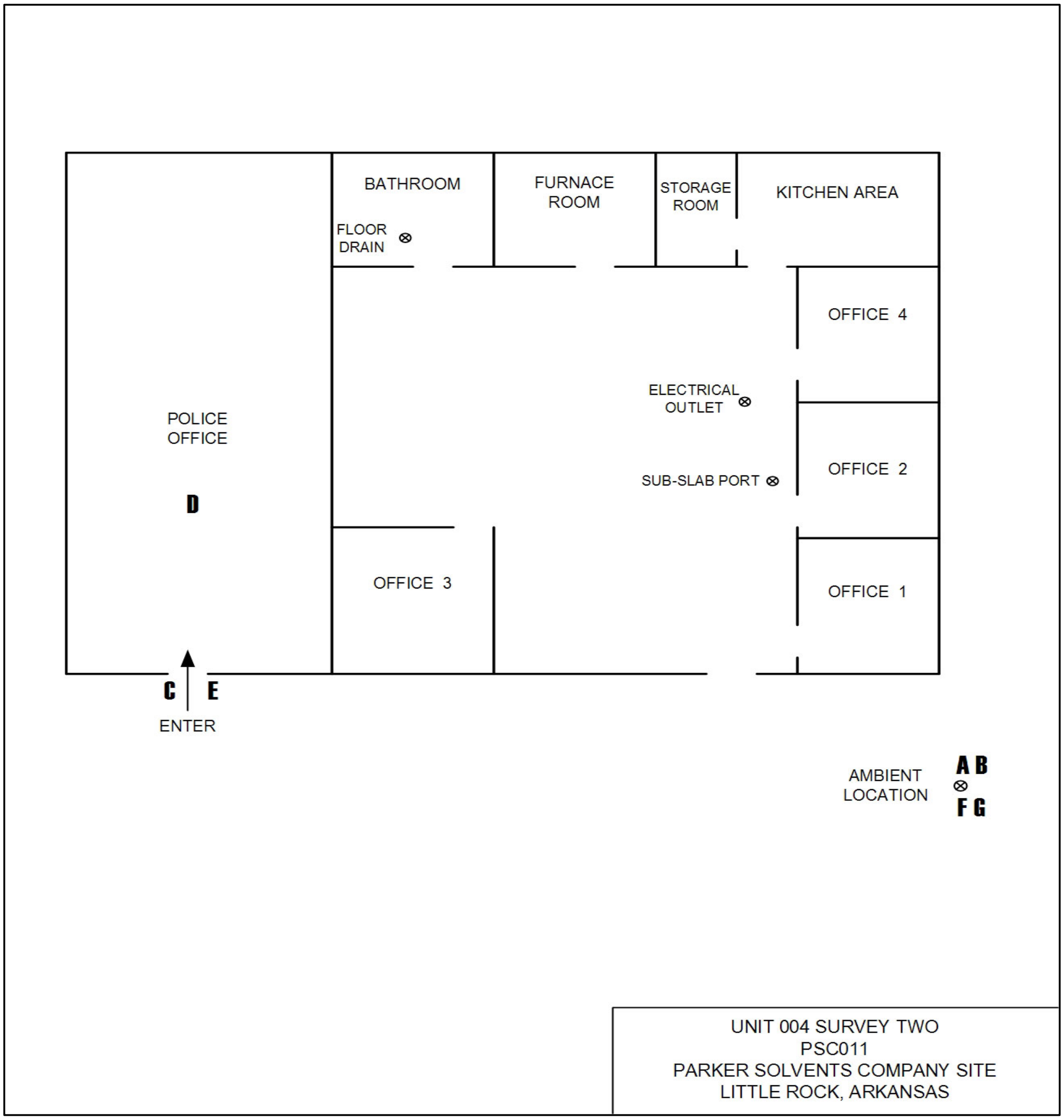
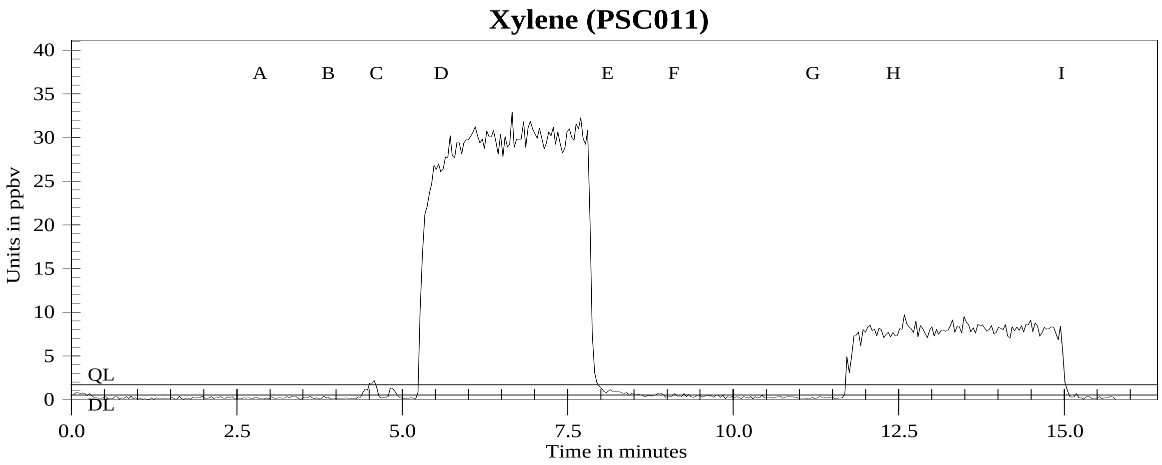
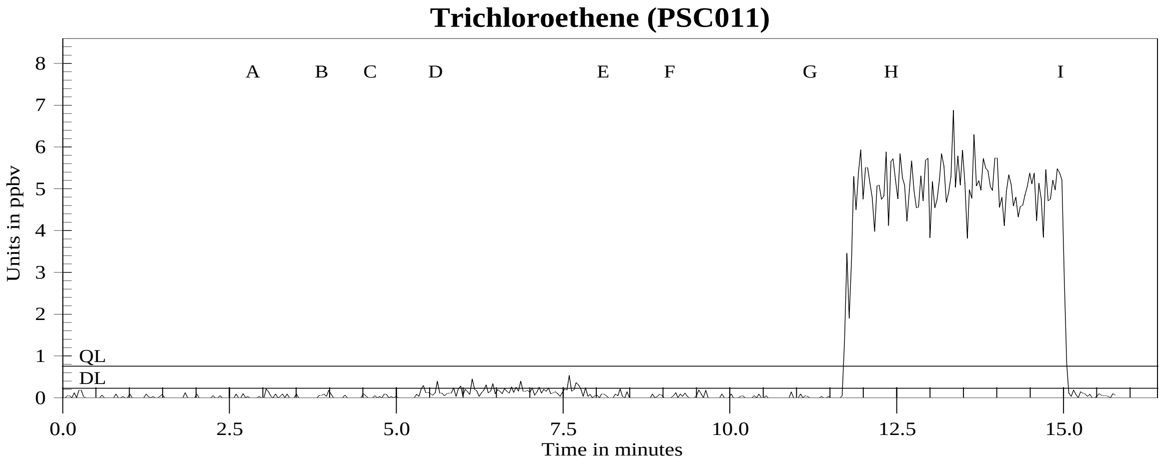


Figure 15 Schematic of the Government Building


Xylene (PSC011)


Trichloroethene (PSC011)

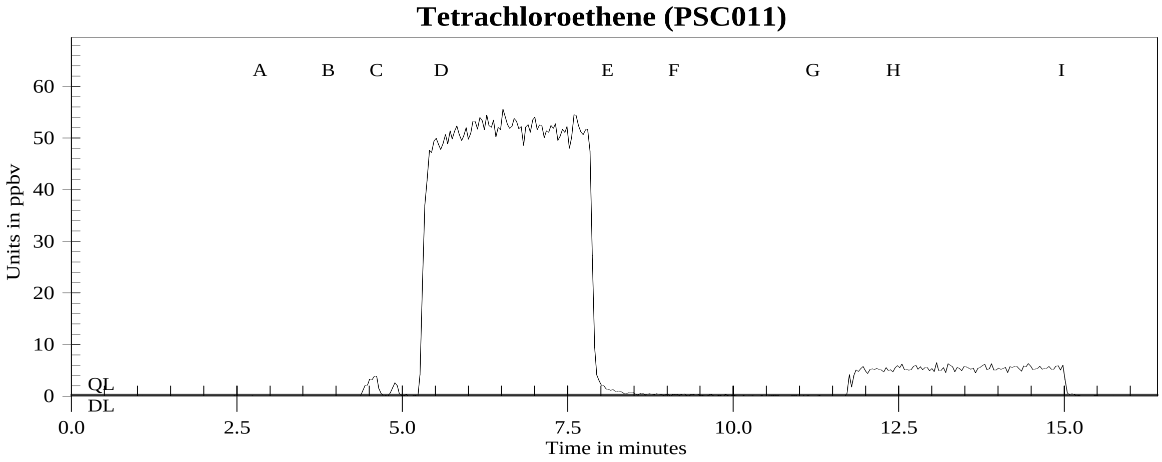

Tetrachloroethene (PSC011)

Figure 16 Concentration Profiles for Xylenes, Trichloroethene, Tetrachloroethene

3.4 Locating Adjacent Structure Sources that Confound Vapor Intrusion Concentrations

The Armen Cleaners Site in Ann Arbor, MI has a dry cleaners in active operations. The cleaners had previously improperly disposed of used tetrachloroethene on the ground in the back lot. It is believed that these disposal practices contaminated the soil and could be a source for vapor intrusion into the adjacent residences. During this assignment, a multi-unit apartment building adjacent to the cleaners was investigated (schematic shown in Figure 17) (US EPA/ERT, 2003).

The TAGA monitoring was performed on two different dates (Figure 17, 18, 19, and 20). On the first day of monitoring, the wind was from the east at 13 miles per hour and the apartment building was directly downwind of the cleaners. During this monitoring period, elevated concentrations of tetrachloroethene were observed as shown in Figure 18. Spikes of tetrachloroethene were observed between the locations denoted by letters B and C, K and L (the tubing was moved outside before entering the basement), and T and U in the concentration profile. This is consistent with the sampler being outside of the apartment building in the ambient air. Therefore, the contamination on the site of the dry cleaners was contaminating the outside ambient air subsequently impacting the indoor air of the apartment building. Therefore the elevated concentrations were not due to vapor intrusion.

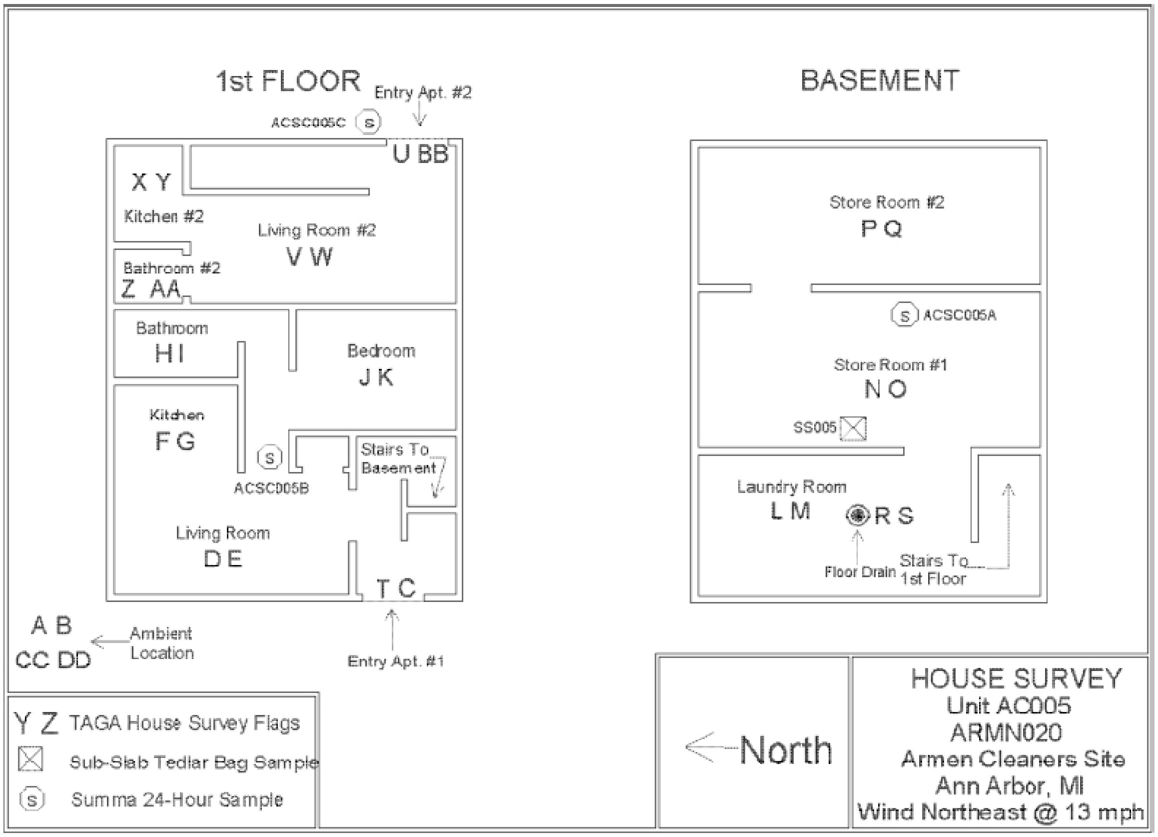
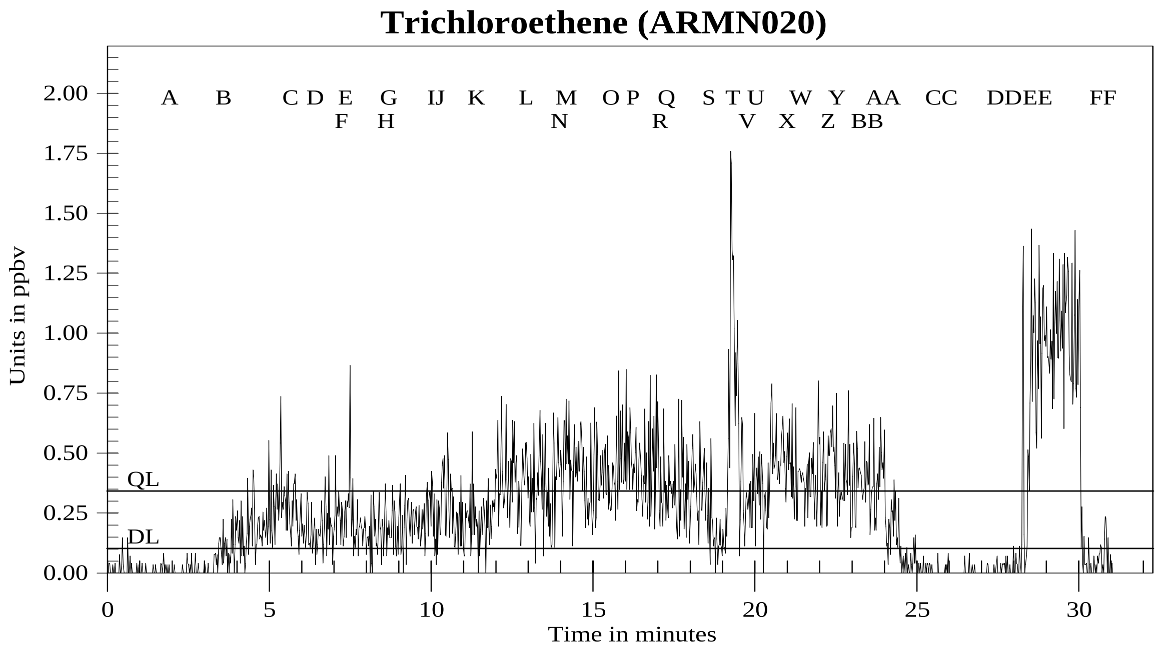


Figure 7a House Survey in Unit AC-005, ARMN020

Figure 17 Schematic of the Apartment Building


Trichloroethene (ARMN020)

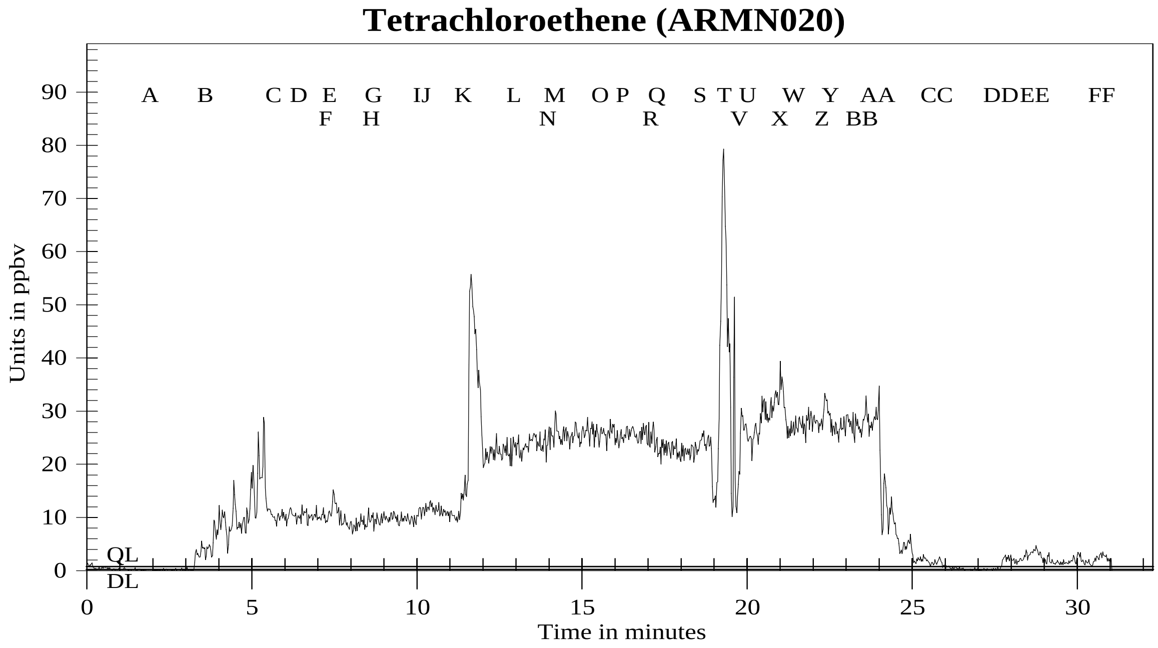

Tetrachloroethene (ARMN020)

Figure 18 Concentration Profiles for Tetrachloroethene and Trichloroethene

On the second day of monitoring, the wind was from the northeast at 12 miles per hour. The apartment building (schematic shown in Figure 19) was off center from being directly downwind of the cleaners but was still being impacted with elevated concentrations of tetrachloroethene, however at a much reduced level. The highest concentrations for tetrachloroethene were observed on the first floor of east apartment nearest to the cleaners between flags X and DD. Although the indoor concentrations are higher than the outside, it is still considered that the outdoor air is responsible for impacting the inside air because the local wind direction were changing, the dry cleaning processes are not always operating at steady state conditions and the apartment air concentration has lag time for the infiltration from outside air to occur. Lastly, vapor intrusion doesn't appear to be the main source of contamination, since the first floor has a considerably greater tetrachloroethene concentration than the basement.

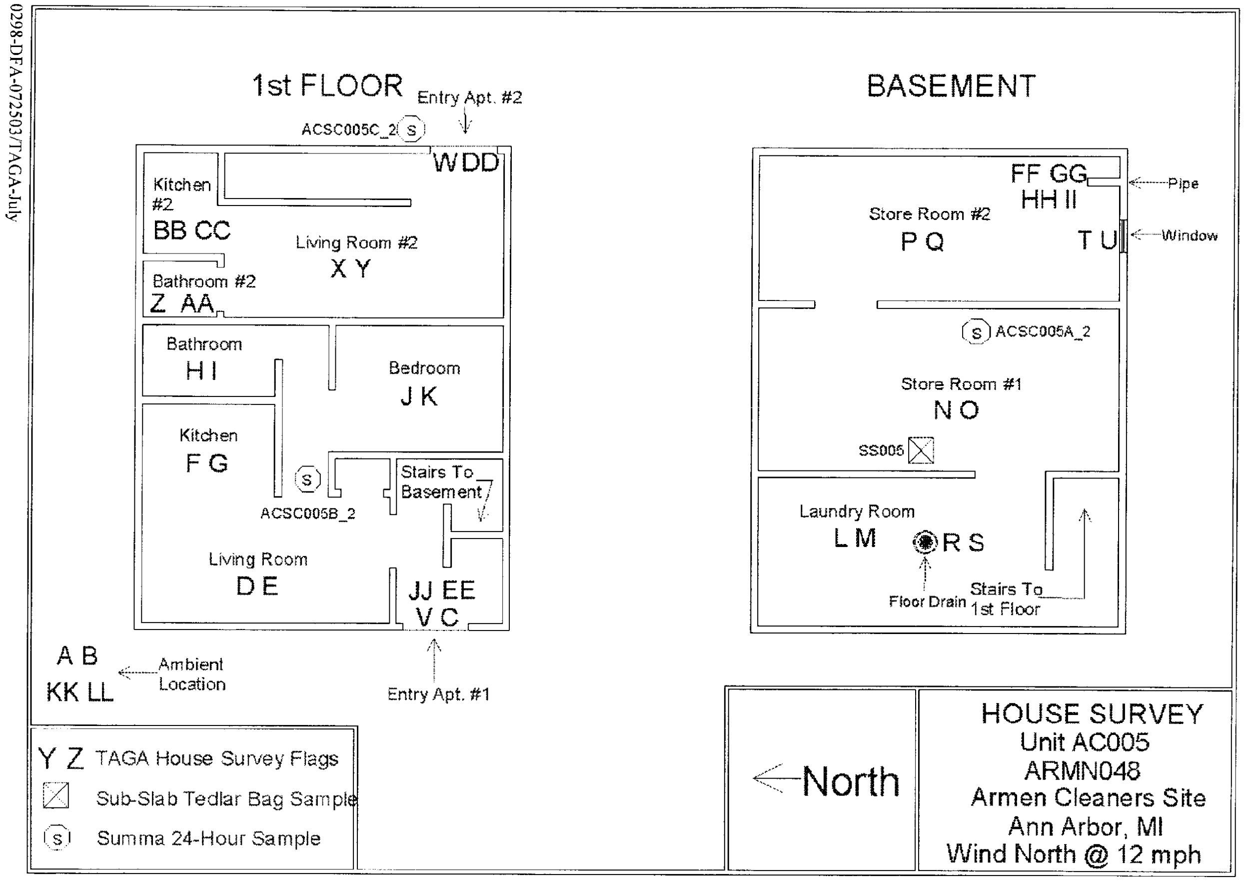


Figure 16a House Survey in Unit AC-005, ARMN048

Figure 19 Schematic of the Apartment Building

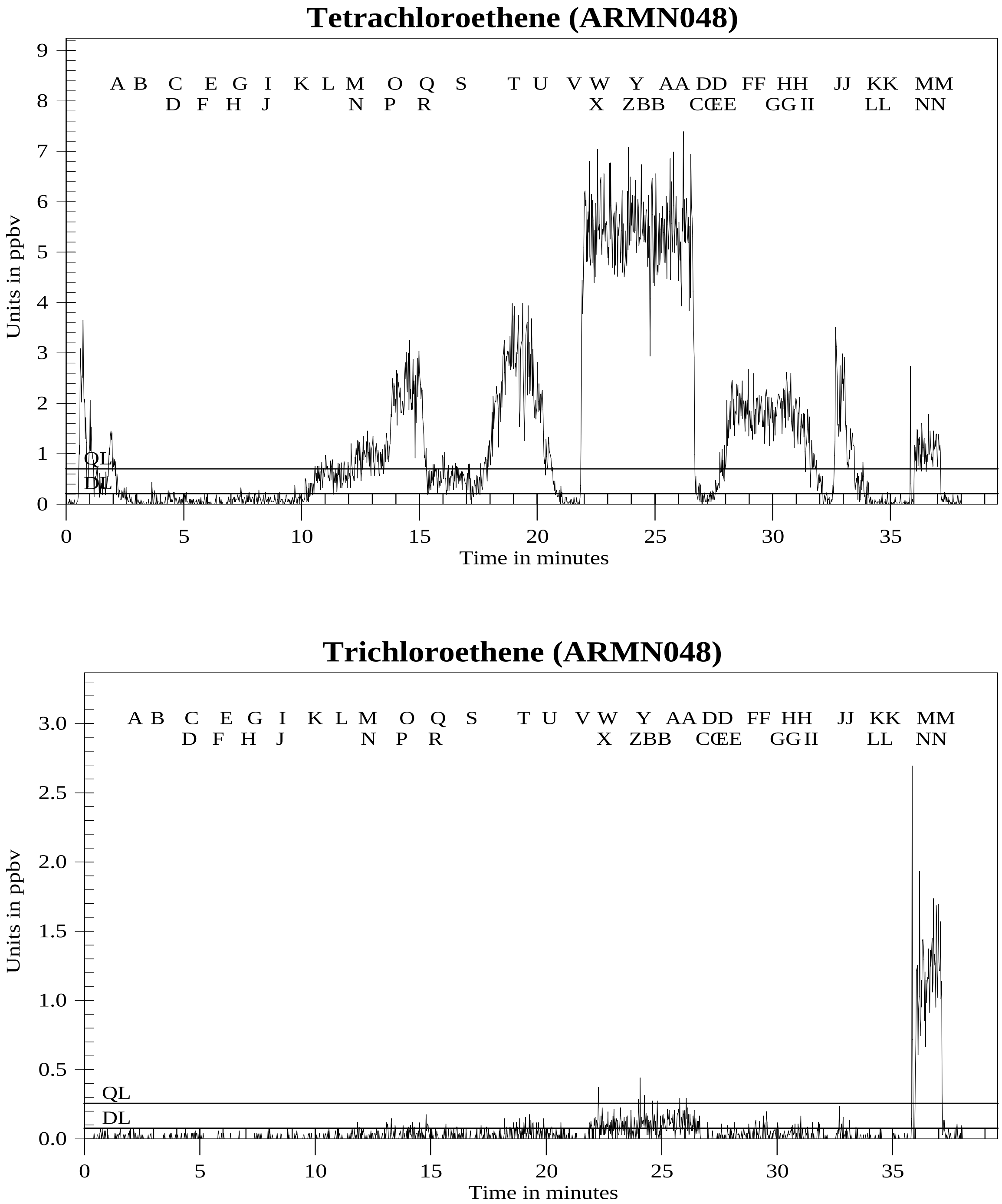


Figure 20 Concentration Profiles for Tetrachloroethene and Trichloroethene

In order to locate the source(s) of the ambient air tetrachloroethene concentration, the TAGA was operated in the mobile mode. The TAGA traveled along the streets adjacent to the cleaners both upwind and downwind (Figure 21). The wind was from the northeast direction at about 10 miles per hour. Tetrachloroethene was observed only when the TAGA was downwind of the cleaners. No other sources were observed during the mobile monitoring. The highest outdoor concentration monitored on the street was about 25 ppbv at flag B on the corner of W. Mosley Street and S. 1st Street.

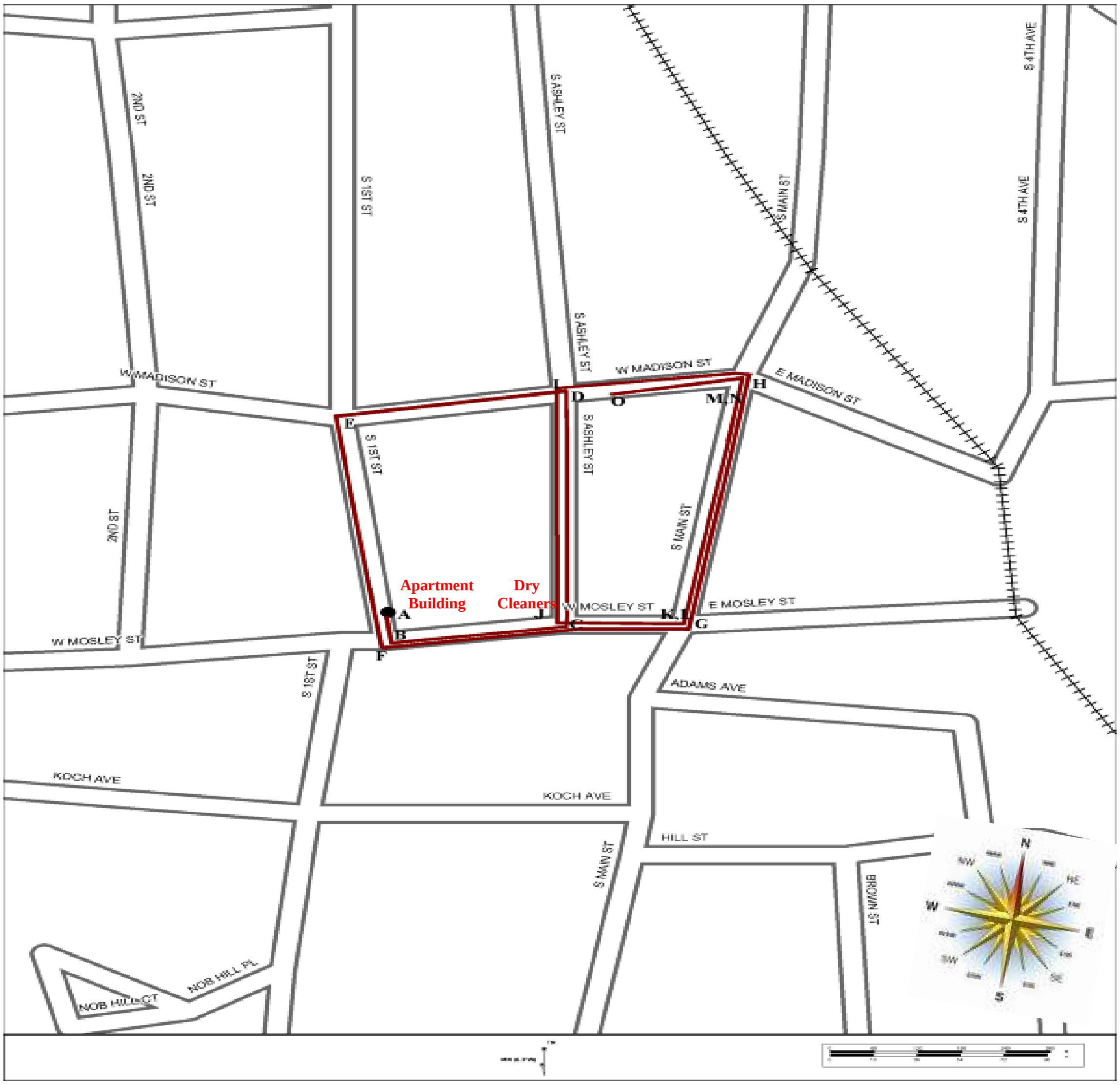


Figure 21 Mobile Monitoring Path around Armen Cleaners

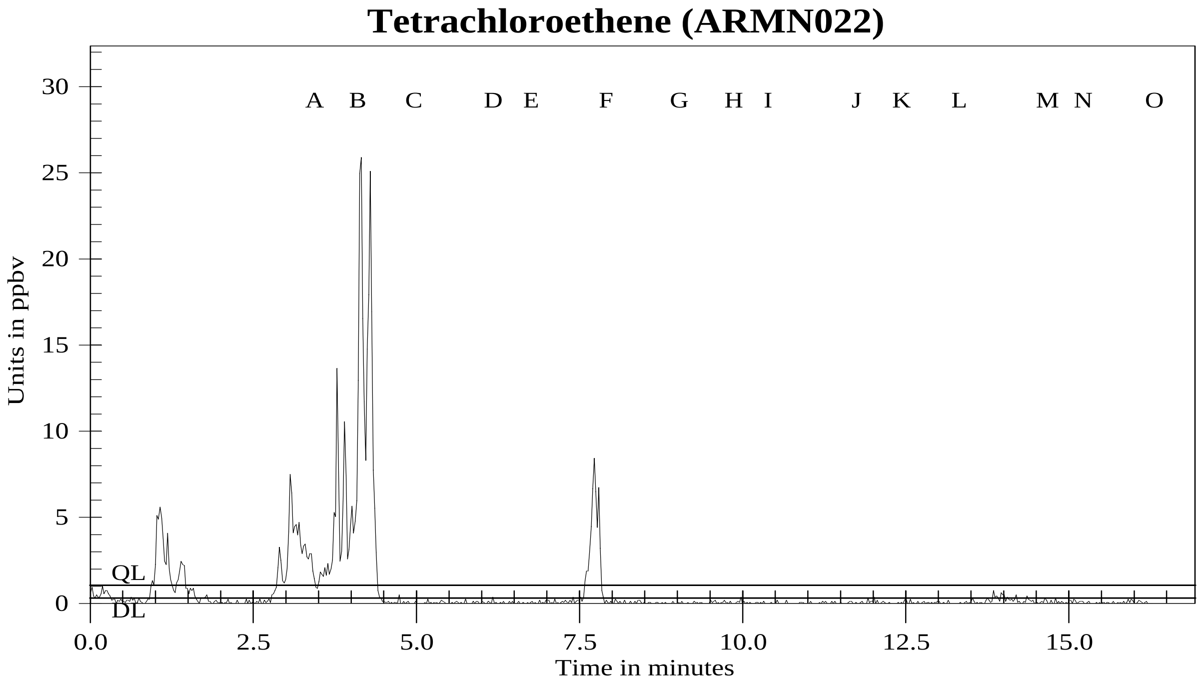


Figure 22 Concentration Profile for Tetrachloroethene

3.5 Locating Accidental/Intentional Released Sources that Confound Vapor Intrusion Concentrations

At the Tranguch Site in Hazleton, PA, a gasoline spill occurred around 1990. Because of the size of the spill and the local geology, there was concern that a completed pathway for vapor intrusion may exist. Numerous residences throughout the potentially affected area were monitored. One of the residences was monitored with the TAGA on four occasions (US EPA/ERT, 2001), (US EPA/ERT, 2001). For the first three TAGA monitoring events, the target compounds, benzene, toluene, and xylene, had very similar concentration profiles. One such set of concentration profiles from the residence is shown with an approximate maximum concentration of 0.5 ppbv for benzene, 5 ppbv for toluene, and 2 ppbv for xylene (Figure 23). However, on the fourth monitoring, all of the target compound concentrations were extremely elevated near the source of contamination with an approximate maximum concentration of 900 ppbv for benzene, 5000 ppbv for toluene, and 2000 ppbv for xylene as shown in Figure 24. The TAGA monitoring found that the source of the target compounds was a floor drain of the main room in the basement. Due to the very high concentrations observed, it was considered that gasoline spill might have gotten into this drain prior to the monitoring with the TAGA. Additionally, the TAGA mobile laboratory has a gas chromatograph with a mass selective detector (GC/MS). A gas sample was collected directly above the liquid in the drain and analyzed. The GC/MS confirmed the presence of the target compounds but also detected lightweight hydrocarbons that are associated with gasoline. However, these lightweight hydrocarbons would not be available in weathered gasoline, which was associated with the 10 year old spill at the site. Therefore, the target compounds measured in the drain were not from vapor intrusion but were from freshly spilled gasoline.

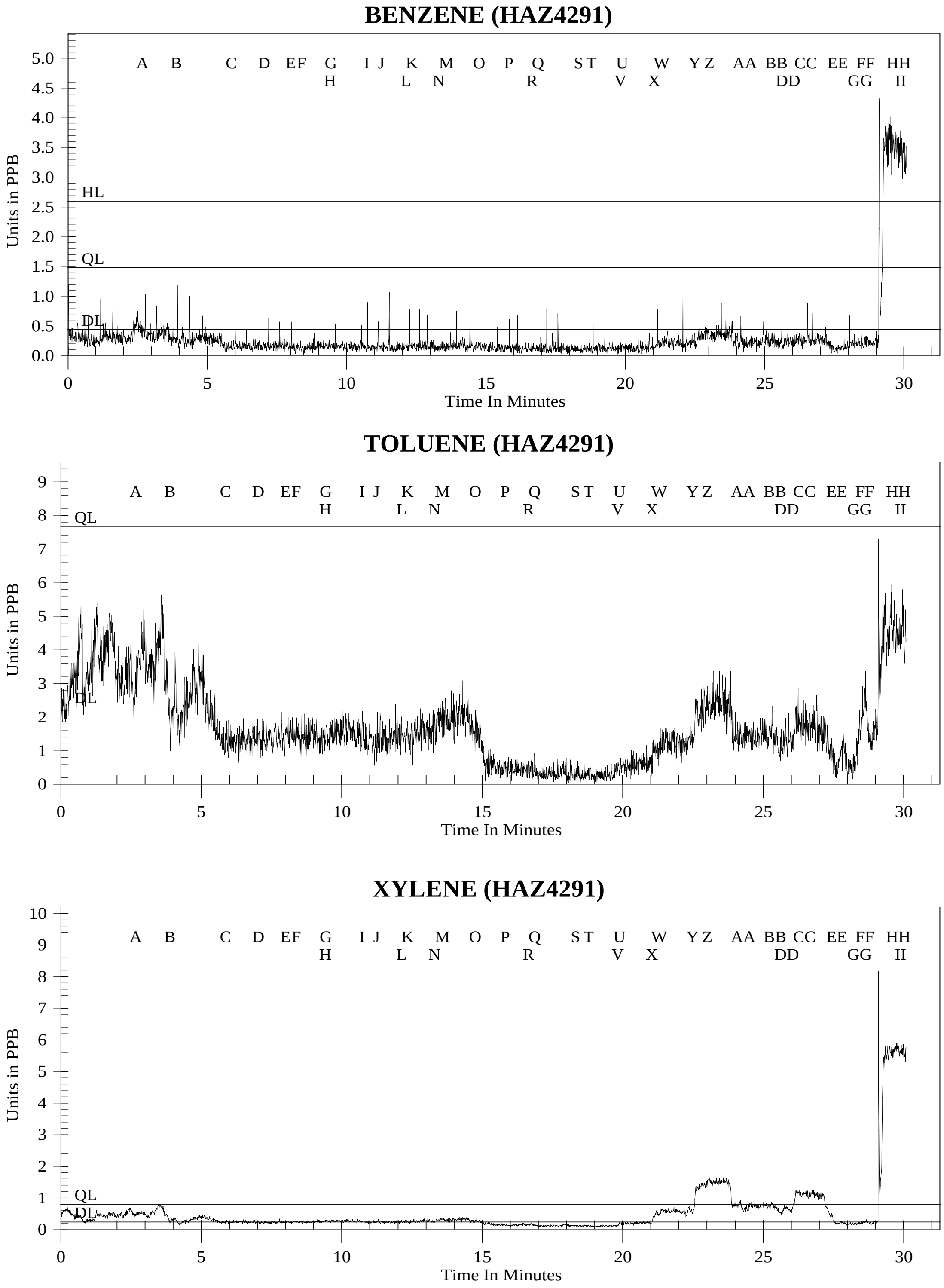


Figure 23 Concentration Profiles for Benzene, Toluene, and Xylene

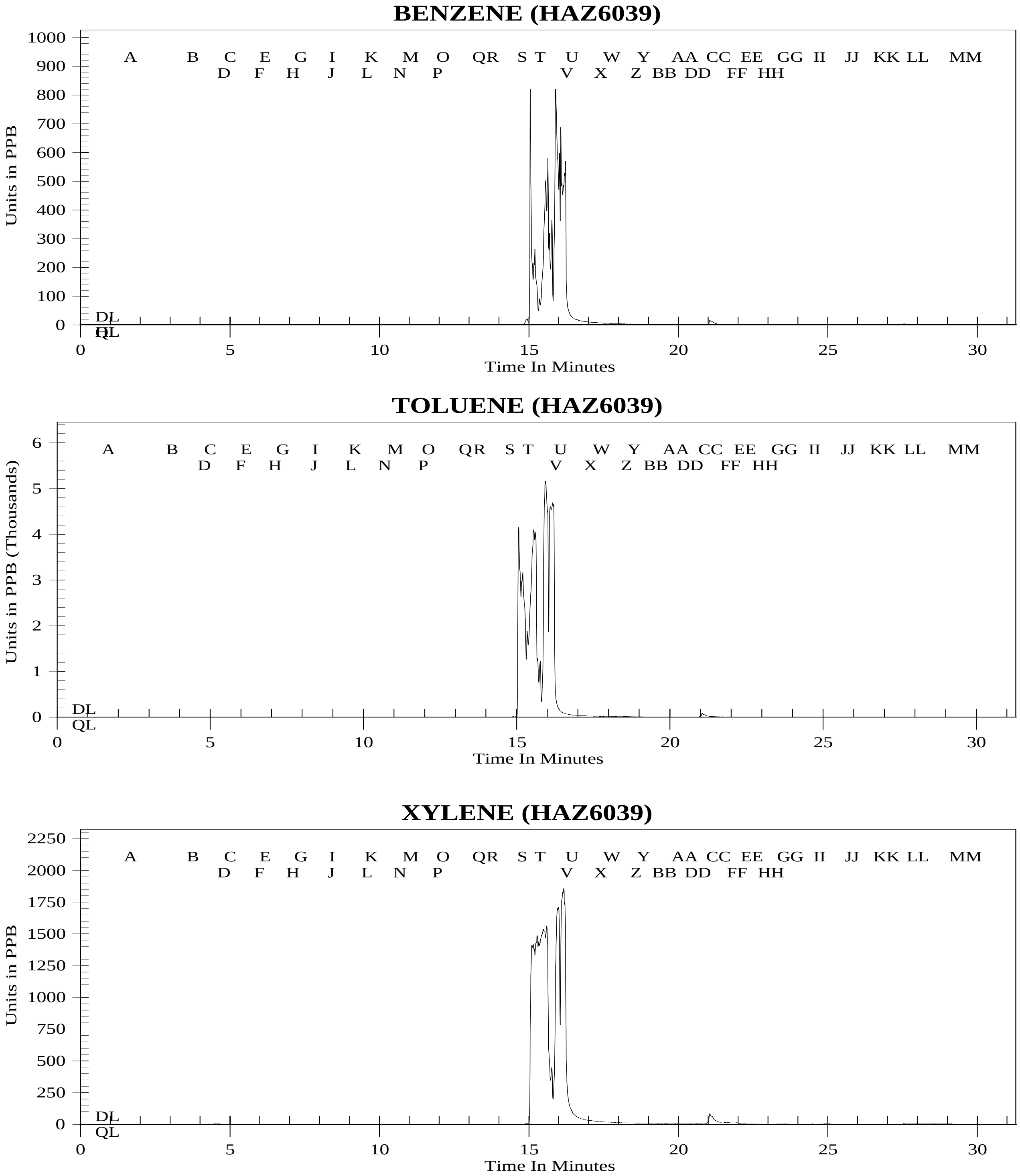


Figure 24 Concentration Profiles for Benzene, Toluene, and Xylene

At the Tarawa Terrace Primary School (US EPA/ERT, 2007) on the Camp Lejeune Marine Corps Base in Jacksonville, NC, there was a concern that vapor intrusion from the ABC Dry Cleaners Site was impacting the school. The distance between the dry cleaners and the school was over 1000 feet. The TAGA monitoring was conducted throughout the school, including the boiler room, during the school's summer recess. On the monitoring day, the school's maintenance staff was performing needed and preventative operations. One of the functions carried out by the workers was to service the boiler room equipment (schematic shown in Figure 25). More specifically, the workers cleaned the electrical contacts on the boiler's control unit. The cleaner contained trichloroethene and no tetrachloroethene. The dry cleaners used tetrachloroethene. Figure 26 shows the concentration profiles from the TAGA monitoring which indicate that the only target compound present was trichloroethene. Therefore, the trichloroethene vapors in the indoor ambient air were the results of the electrical contact cleaner being used and the elevated concentration observed in the sumps were the residuals that were washed down into them.

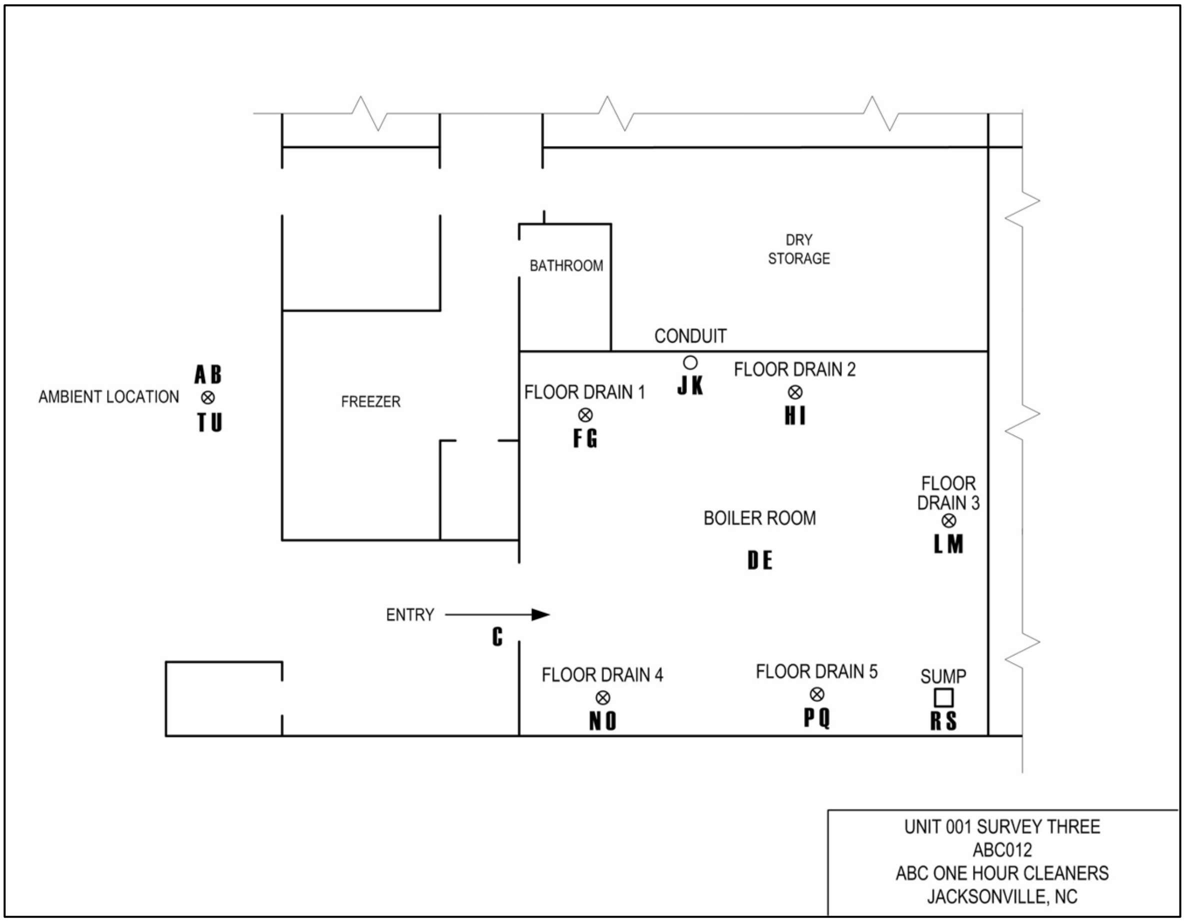


Figure 25 Schematic of the School's Boiler Room

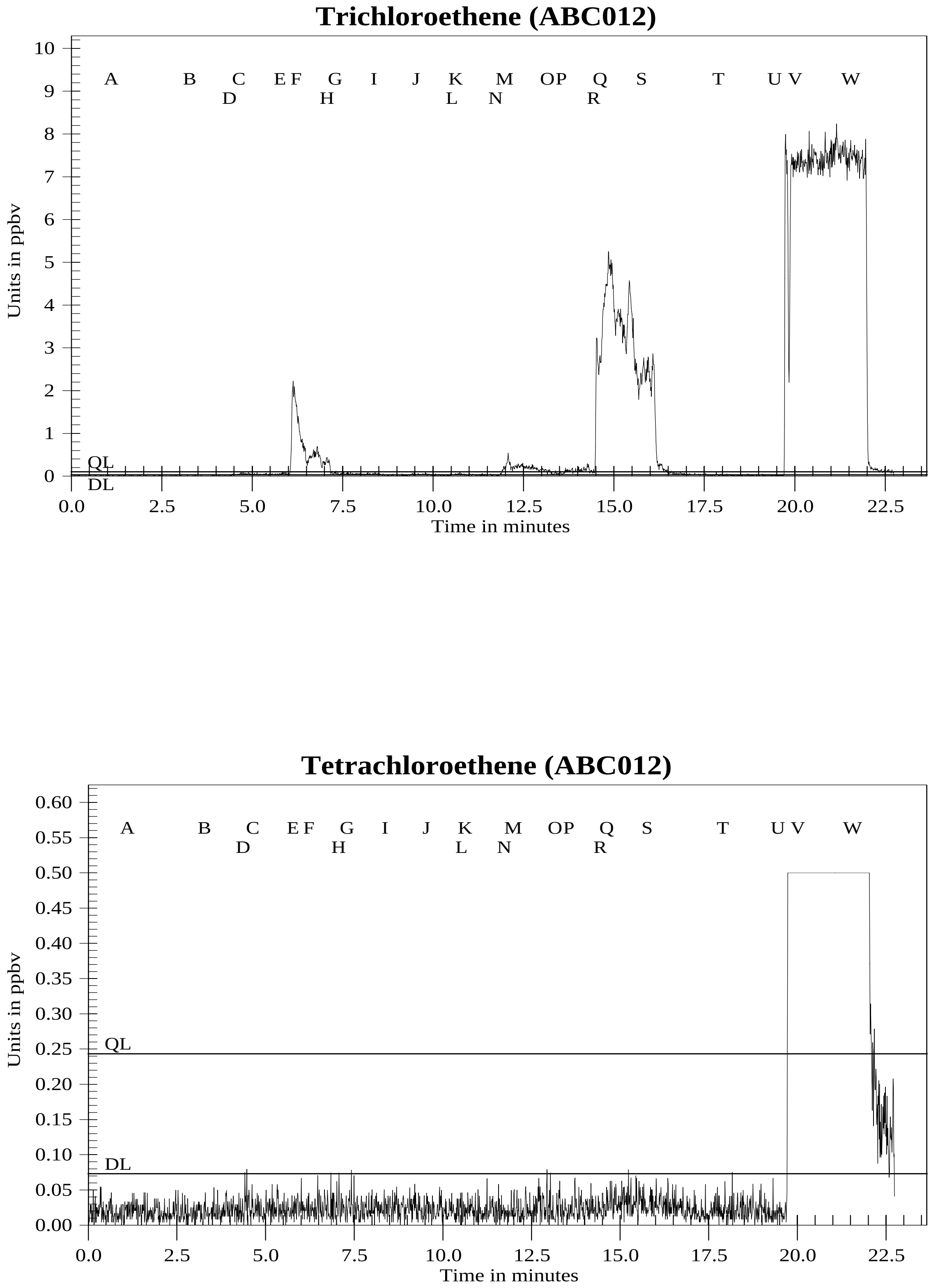


Figure 26 Concentration Profiles for Trichloroethene and Tetrachloroethene

3.5 Contributions from the Presence of Contaminated Groundwater in Indoor Spaces as Sources that Confound Vapor Intrusion Concentrations

At the Valmont Trichloroethene Site in Hazleton, PA, a factory adjacent to a neighborhood had a release of trichloroethene that contaminated the groundwater (US EPA/ERT, 2004). A residence in this neighborhood was monitored twice. During the first monitoring of this residence (schematic shown in Figure 27) the meteorological conditions for the previous 24 hours were a rainfall of 0.9 inches and an average wind speed of about 5 miles per hour. Additionally, the sump in the basement had water in it. When the TAGA monitoring was conducted at the sump, the trichloroethene concentration was nearly 120 ppbv. These concentration profiles are shown in Figure 28. Additionally, the basement trichloroethene concentration was about 1 ppbv.

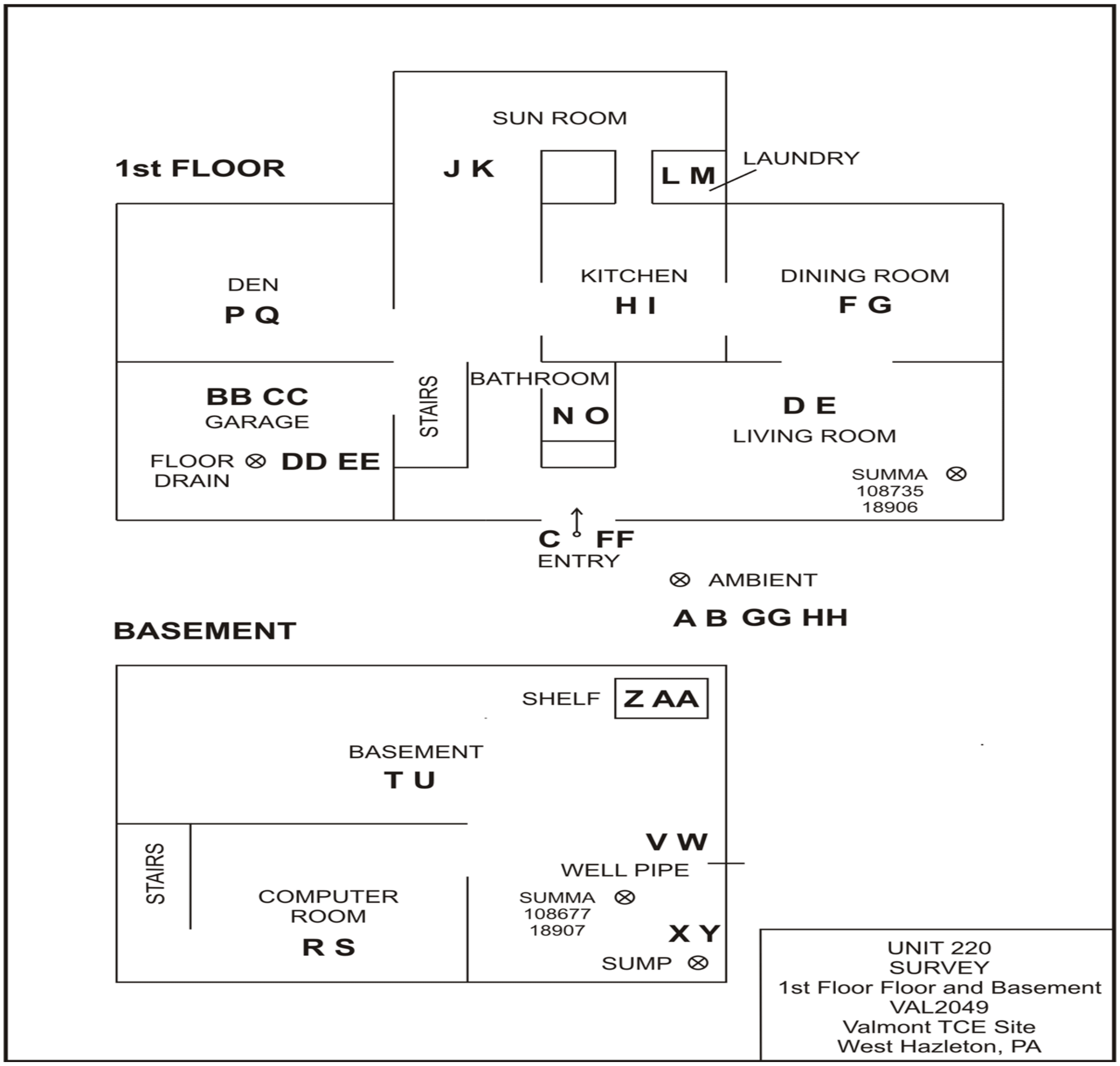


Figure 27 Schematic of the Residence

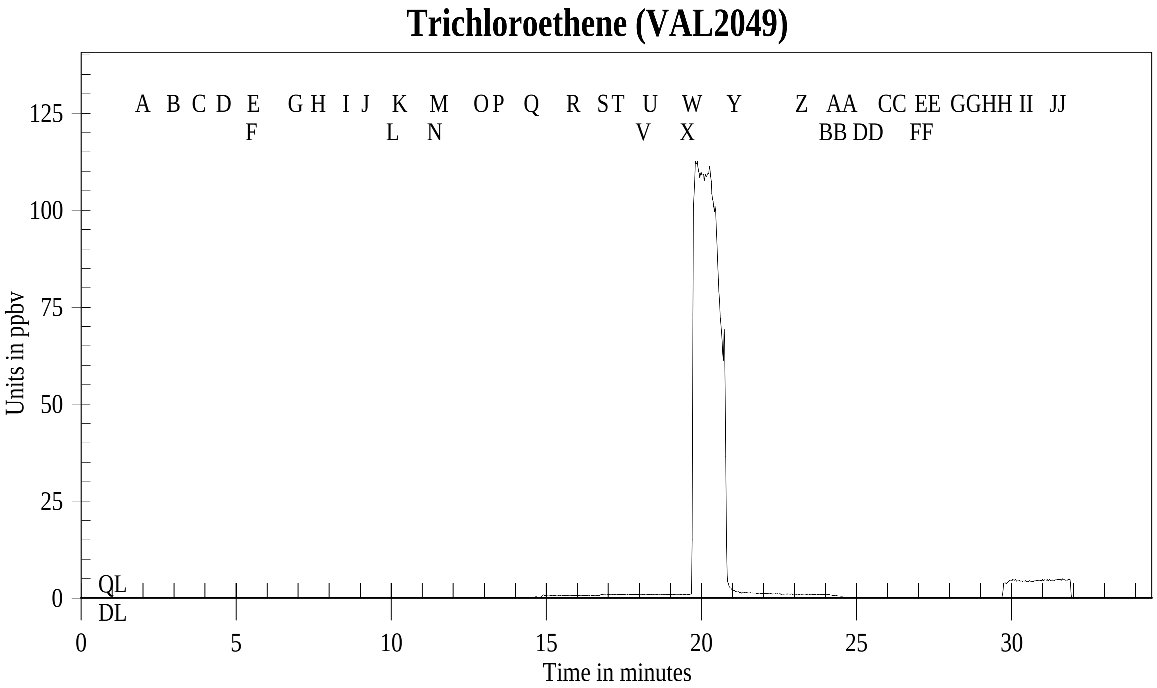


Figure 28 Concentration Profile for Trichloroethene

During the second monitoring of this residence (schematic shown in Figure 29) the meteorological conditions over the previous 24 hours were a rainfall of 1.9 inches and an average wind speed at about 25 miles per hour. The sump in the basement was dry even though it had recently rained. When the TAGA monitoring was conducted at the sump, the trichloroethene concentration was only 20 ppbv as shown in Figure 30. Additionally, the basement trichloroethene concentration was about 0.5 ppbv. The results from these two monitoring events suggest that when contaminated groundwater is in the sump the target compound's indoor air concentration can be elevated. Moreover, this situation is not technically vapor intrusion but volatilization of the target compound from the water in the sump.

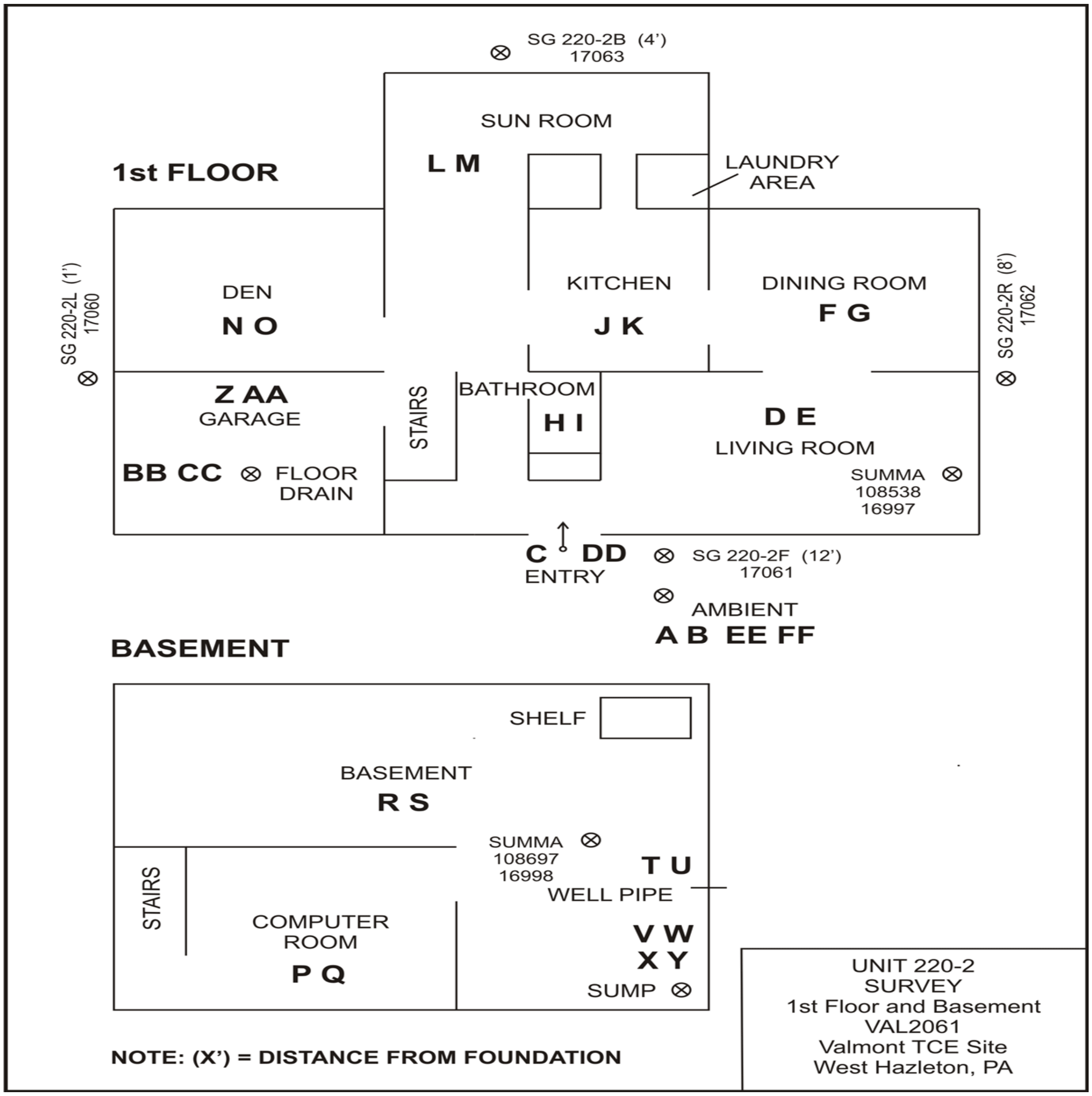


Figure 29 Schematic of the Residence

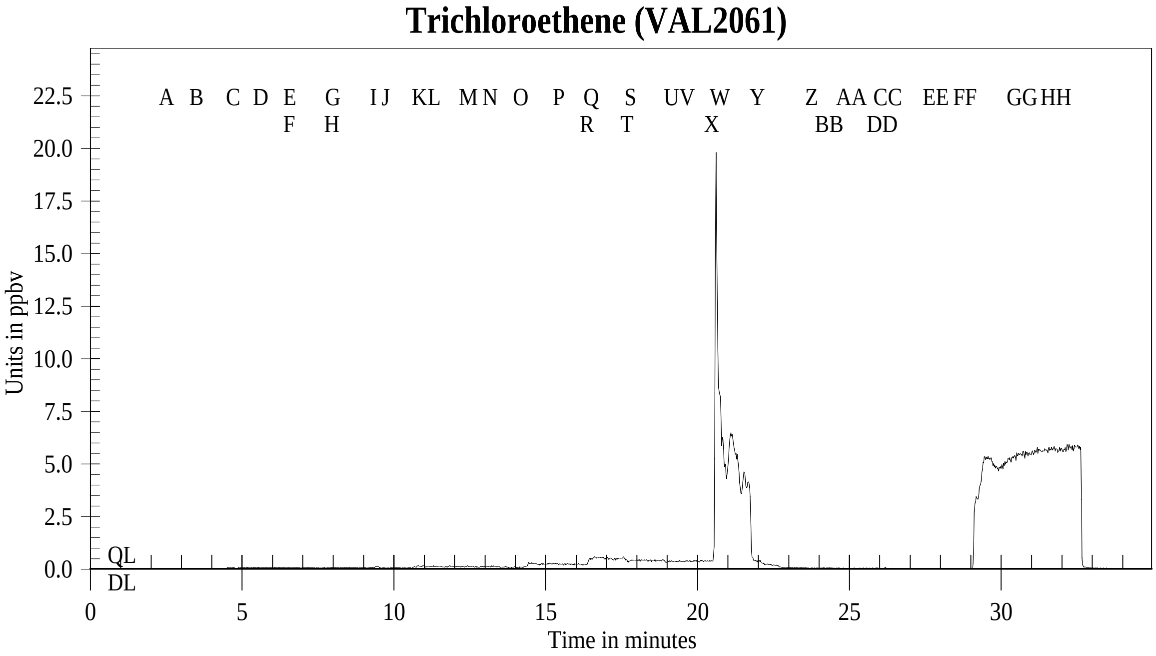


Figure 30 Concentration Profile for Trichloroethene

4 Conclusion

Vapor intrusion assessments can be confounded by a number of factors but the proper evaluation of the matter can be accomplished by employing the proper instruments and techniques that provide good spatial and temporal resolution with the needed sensitivity and selectivity. The TAGA can provide rapid, accurate, reliable, and cost effective analytical information for monitoring indoor and outdoor ambient air. These results can be used to measure current impact and locate source of pollution. These accurate assessments of target chemical concentrations in the vapor intrusion pathway can be used in risk assessment operations to protect human health.

5 Reference

Interstate Technical Regulatory Council (ITRC), “Guidance Vapor Intrusion Pathway: A Practical Guideline,” January 2007.
US EPA/ERT, Final Analytical TAGA Report – 08 February through 30 March 2001, Tranguch Site, Hazleton, PA, August 2001.
US EPA/ERT, Final Analytical TAGA Report – 02 April through 23 May 2001, Tranguch Site, Hazleton, PA, August 2001.
US EPA/ERT, Final Analytical TAGA Report – ABC One Hour Cleaners, Jacksonville, NC, August 2007.
US EPA/ERT, Final Analytical TAGA Report - Hopewell Precision Site, Hopewell Junction, NY, April 2004.
US EPA/ERT, Final Analytical TAGA Report - Parker Solvents Company Site, Little Rock, AR, July 2008.
US EPA/ERT, Final Report – Armen Cleaners Site, 02 June to 05 June 2003, Ann Arbor, MI, July 2003.

US EPA/ERT, Final Report - Raymark Industries Site, Stratford, CT, June 2001.

US EPA/ERT - Final Report – Valmont TCE Site, 03 Through 15 November 2003, West Hazleton, PA, January 2004.

US EPA, “OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance),” EPA530-D-02-004, November 2002.

ATTACHMENT J

EXAMPLE DATA MANAGEMENT EXCEL SPREADSHEET

Sampling Summary
[Site Name]
[City, County, State]

Subject Property	Comments	Owner's Name	Owner's Address	Owner's Phone Number	EPA Access Approved (Y / N)	Tennant Occupied (Y / N)

Sampling Summary
[Site Name]
[City, County, State]

Subject Property	Tenant Name	Tenant Phone Number	EPA Access Approved (Y / N)	Date Collected Sub-Slab Sample	Sample #	Analyte	Sub-Slab Result (ppbv)	Date Collected Indoor Air Sample	Sample #

Sampling Summary
[Site Name]
[City, County, State]

Subject Property	Analyte	Initial Indoor Air Result (ppbv)	Date SSDS System Installed	Date Collected Post Treatment Sub-Slab Sample (30 days)	Sample #	Analyte	Post Treatment Sub-Slab Result (30 days) (ppbv)	Date Collected Post Treatment Indoor Air Sample (30 days)	Sample #

Sampling Summary
[Site Name]
[City, County, State]

Subject Property	Analyte	Post Treatment Indoor Air Sample Result (30 days) (ppbv)	Date Collected Post Treatment Sub-Slab Sample (90 days)	Sample #	Analyte	Post Treatment Sub-Slab Result (90 days) (ppbv)	Date Collected Post Treatment Indoor Air Sample (90 days) (ppbv)	Sample #	Analyte

ATTACHMENT K

SAMPLE RESULT LETTER (NO FURTHER ACTION)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

February 1, 2009

John Smith (owner)
123 Main Street
Dayton, Ohio 45404

Dear Mr. Smith:

The purpose of this letter is to inform you of the results of the sub-slab (the space under your basement floor) and indoor air samples collected from your property on January 15, 2009. As you know, the U.S. EPA collected these samples to see if soil vapors from the ABC Plant are moving through the soils and entering the air inside your property. We are specifically testing for the presence of trichloroethylene (also known as TCE), which has been detected in the groundwater under the neighborhood.

TCE is known as a volatile organic compound (VOC), which means it can easily evaporate (turn from a liquid to a gas) when it is exposed to the soil or air. TCE has the potential, as vapors, to move through the soils and work their way into building substructures, such as basements, where it can accumulate in the indoor air.

The results for the sub-slab and indoor air samples collected at your property are presented below and are identified as “Detected” where TCE was found in the samples. “ND” (no detection) is used when there is a chemical concentration less than the laboratory’s minimum detection limit (the laboratory’s minimum detection limit is written below in parentheses). The air samples are measured in units called parts per billion by volume (ppbv). Following the result for each sample is the “screening level” for the chemical. The Ohio Department of Health (ODH) has recommended the screening levels for sub-slab and indoor air.

Sub-Slab Sampling Results:
TCE: **1.2 ppbv**, ODH recommended screening level: 4 ppbv

The results from the **sub-slab air sample** collected at your property show that the chemical TCE was detected at 1.2 ppbv, which is below the sub-slab screening level recommended by the ODH.

Indoor Air Sampling Results:
TCE: **ND (0.15) ppbv**, ODH recommended screening level: 0.4 ppbv

The results from the **indoor air sample** collected at your property show that the chemical TCE was not detected (ND) greater than 0.15 ppbv, which is below the indoor air screening level recommended by the ODH.

Based on the laboratory results of the sub-slab and indoor air samples collected from your property, the U.S. EPA and ODH conclude that no further action is necessary at your property.

If you have health-related questions concerning this matter, please contact Dr. [Insert Name] at the Ohio Department of Health at 614-123-4567. If you have questions related to the sampling or on-going site investigation, please feel free to contact me at 513-569-7539.

Sincerely,

Steven L. Renninger
On-Scene Coordinator
U.S. EPA Region 5

Attachments: Analytical Results
ODH Fact Sheets (3)

ATTACHMENT L

MEETING REMINDER FORM

Meeting Reminder Form

MEETING TIME:

Date: ___________________

Time: ___________________

Location: EPA Command Post – [add address]

U.S. EPA Notes and Reminders:

1) U.S. EPA will be discussing your property air sampling results
2) The meeting should last 15 minutes.
3) U.S. EPA will be offering to install, at not cost to you, a vapor abatement mitigation system on your property.
4) At the meeting, U.S. EPA will set up a future date for its vapor abatement installation contractor to meet with the owner at the property to assess the basement of the property to determine the layout of the system.
5) At the meeting to determine the layout of the system, U.S. EPA and the owner of the property will agree on the installation date of the vapor abatement mitigation system.
6) As a courtesy, please be on time for your appointment.
7) If you have to reschedule your appointment or have any questions, please contact U.S. EPA's technical contractor as soon as possible at **937-123-4567** OR come to the **U.S. EPA Command Post located at ____________, M-F 9am-5pm**.

ATTACHMENT M

SAMPLE RESULT LETTER (MITIGATION REQUIRED)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

February 1, 2009

John Smith (owner)
123 Main Street
Dayton, Ohio 45404

Dear Mr. Smith:

The purpose of this letter is to inform you of the results of the sub-slab (the space under your basement floor) and indoor air samples collected from your property on January 15, 2009. As you know, the U.S. EPA collected these samples to see if soil vapors from the ABC Plant are moving through the soils and entering the air inside your property. We are specifically testing for the presence of trichloroethylene (also known as TCE), which has been detected in the groundwater under the neighborhood.

TCE is known as a volatile organic compound (VOC), which means it can easily evaporate (turn from a liquid to a gas) when it is exposed to the soil or air. TCE has the potential, as vapors, to move through the soils and work their way into building substructures, such as basements, where it can accumulate in the indoor air.

The results for the sub-slab and indoor air samples collected at your property are presented below and are identified as “Detected” where TCE was found in the samples. The air samples are measured in units called parts per billion by volume (ppbv). Following the result for each sample is the “screening level” for the chemical. The Ohio Department of Health (ODH) has recommended the screening levels for sub-slab and indoor air.

Sub-Slab Sampling Results:
TCE: **12,000 ppbv**, ODH recommended screening level: 4 ppbv

The results from the **sub-slab air sample** collected at your property show that the chemical TCE was detected at 12,000 ppbv, which is greater than the sub-slab screening level recommended by the ODH.

Indoor Air Sampling Results:
TCE: **35 ppbv**, ODH recommended screening level: 0.4 ppbv

The results from the **indoor air sample** collected at your property show that the chemical TCE was detected at 35 ppbv, which is greater than the indoor air screening level recommended by the ODH.

The sub-slab and indoor air exceedances do not necessarily mean that you will experience health effects, only that there is a need for the installation of a vapor abatement mitigation system and additional follow-up proficiency sampling. U.S. EPA will be contacting you in the near future about scheduling the installation of a vapor abatement mitigation system designed to lower the levels of VOCs in the indoor air.

If you have health-related questions concerning this matter, please contact Dr. [enter name] at the Ohio Department of Health at 614-123-4567. If you have questions related to the sampling or on-going site investigation, please feel free to contact me at 513-569-7539.

Sincerely,

Steven L. Renninger
On-Scene Coordinator
U.S. EPA Region 5

Attachments: Analytical Results
ODH Fact Sheets (3)

cc: Site File

ATTACHMENT N

POWERPOINT SLIDES USED TO EXPLAIN SAMPLING AND SSDS

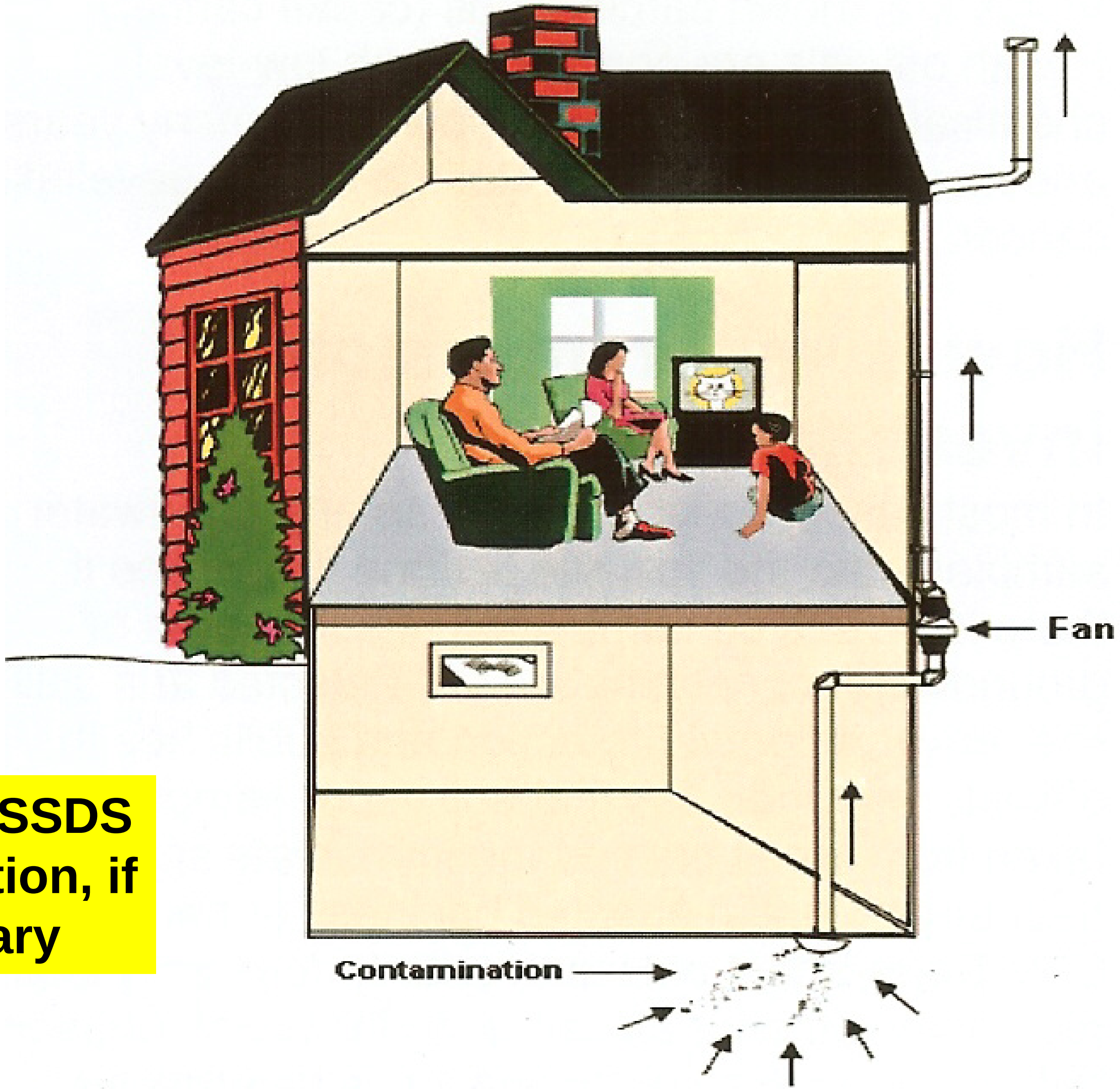
Sub-Slab & Indoor Air Sampling

Step 1- Sub-Slab Sampling

Step 2- Indoor Sampling

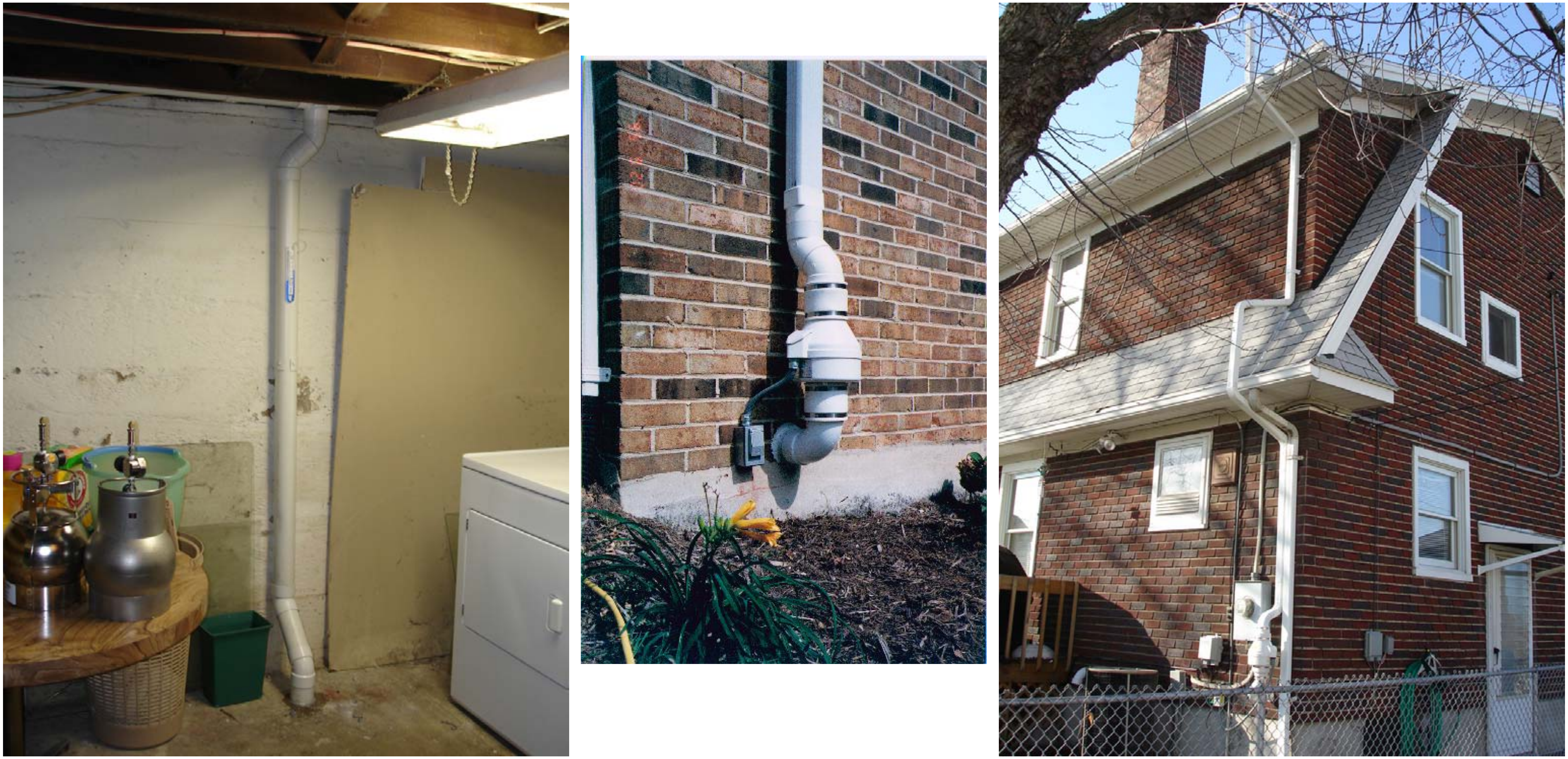
Vapor Abatement Mitigation System

(Sub-Slab Depressurization System or SSDS)



Step 3- SSDS Installation, if necessary

Vapor Abatement System



Post Installation Verification Air Sampling at ___ and ___ days

ATTACHMENT O

RESIDENTIAL VAPOR ABATEMENT SYSTEM O&M AGREEMENT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

NAME: John Smith
ADDRESS: 123 Main Street
Dayton, Ohio 45404

PHONE: 937-123-4567
PROPERTY OWNER: X TENANT__

Re: [Enter Site Name] - Residential Vapor Abatement System O&M Agreement

On April 1, 2009, the U.S. EPA completed sub-slab and indoor air sampling at 123 Main Street as part of the investigation at the [Enter Site Name] located in Dayton, Ohio. The purpose of this letter is to inform you that trichloroethylene (TCE) was observed to be present at a concentration of 12,000 parts per billion by volume (ppbv) and 35 ppbv, respectively, which are greater than the Agency for Toxic Substances and Disease Registry (ATSDR) and Ohio Department of Health (ODH) sub-slab and indoor air TCE screening levels of 4.0 and 0.4 ppbv, respectively.

As part of the U.S. EPA time-critical removal action at the [Enter Site Name], the U.S. EPA proposes to install a vapor abatement system in residences with elevated TCE concentrations in the residential sub-slab and indoor air. If the system is accepted by the property owner, the U.S. EPA will purchase the vapor abatement system and pay for the basic costs of installation[1]. The U.S. EPA has arranged for [Enter ERRS Name] to install a vapor abatement system in your home designed to vent TCE vapors to below the recommended indoor air screening levels established by ATSDR and the ODH. The vapor abatement system includes PVC piping and an inline fan to vent vapors from below the residence foundation to above the roofline.

Following the installation of the residential vapor abatement system, performance sampling will be conducted by the U.S. EPA to ensure that the residential indoor air quality is below the ATSDR and ODH screening level for TCE. Performance sampling will be conducted at __ days and __ days after system installation. The U.S. EPA will provide the property owner a system information binder that will include a description of the vapor abatement system, photographs, sample data, and fan warranty information. Following successful performance sampling of the residential vapor abatement system, operation & maintenance (O&M) of the vapor abatement system will be the property owner's responsibility. Such O&M is estimated to cost an average of $75/year, which basically includes the cost of the electricity to power the inline fan.

---

[1] U.S. EPA will not necessarily pay the costs of associated decorative or cosmetic treatments, or of installation options that are not deemed a "required" installation by the Agency.

If you have health related questions, please contact Dr. [add name] of ODH at 614-123-4567. If you have questions concerning the vapor abatement system or the [Enter Site Name] removal action, please contact me at 513-569-7539.

Sincerely,

Steve Renninger
U.S. EPA On-Scene Coordinator

Please sign below to indicate that you accept the described vapor abatement system and agree to operation & maintenance as described above, or that you decline the described vapor abatement system for your property:

I agree to and **accept** the terms set forth above:

Name Signature Date

I have reviewed the above information and **decline** the described system:

Name Signature Date

ATTACHMENT P

U.S. EPA VAPOR ABATEMENT SYSTEM CONTRACTOR VISIT REMINDER FORM

U.S. EPA Vapor Abatement System Contractor Visit Reminder Form

Date: ___________________

Time: ___________________

Location: _________________________________

1) U.S. EPA and its contractors will be at your residence on the date stated above to determine the type and location of vapor abatement system to install into your residence.

2) The property owner must be present during this meeting.

3) The installation date will be determined during this visit.

4) If you have to reschedule your appointment, please contact [add ERRS RM name and company info], at **937-123-4567** OR come to the **U.S. EPA Command Post located at [add address], M-F 9am-5pm**.

ATTACHMENT Q

U.S. EPA VAPOR ABATEMENT SYSTEM INSTALLATION DATE REMINDER FORM

U.S. EPA Vapor Abatement System Installation Date Reminder Form

Date: ___________________

Time: ___________________

Location: _________________________________

1) U.S. EPA and its contractors will be at your residence on the date stated above to install a vapor abatement system into your residence.

2) If you have to reschedule your appointment, please contact [add ERRS RM Contact Company and Name], at **937-123-4567** OR come to the **U.S. EPA Command Post located at [add address], M-F 9am-5pm**.

ATTACHMENT R

EXAMPLE HEALTH CONSULTATION

Health Consultation

Initial United States Environmental Protection Agency Investigation

Behr VOC Plume Site
Dayton, Montgomery County, Ohio

AUGUST 1, 2008

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR TOLL FREE at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

Initial United States Environmental Protection Agency Investigation

Behr VOC Plume Site
Dayton, Montgomery County, Ohio

Prepared By:

The Health Assessment Section
Of the Ohio Department of Health
Under cooperative agreement with the
Agency for Toxic Substances and Disease Registry

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BEHR VOC PLUME SITE

SUMMARY

In October, 2006, the Health Assessment Section (HAS) was asked to participate in a multi-agency emergency response team to evaluate the potential health impacts to the community posed by elevated levels of trichloroethylene (TCE) in shallow groundwater underlying residential properties in the north Dayton area of Montgomery County, Ohio (Figure 1). The Ohio Environmental Protection Agency (EPA) requested U. S. Environmental Protection Agency (USEPA) and HAS assistance to carry out a time-critical investigation in the neighborhood to address these concerns. The results of groundwater sampling by the Chrysler Corporation for the Behr Dayton facility and deep soil gas sampling by the Ohio EPA showed the presence of TCE in the groundwater and soil gas in the McCook Field residential area that exceeded screening levels established by USEPA's Subsurface Vapor Intrusion Guidance (USEPA, 2002). Exceeding these guidance levels indicates that vapor-phase chlorinated solvents emanating from the underlying groundwater may pose an unacceptable health risk to area residents through the vapor intrusion pathway.

The Health Assessment Section (HAS) at the Ohio Department of Health (ODH) has had a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR) since 1990. This health consultation document evaluates the environmental data collected by Ohio EPA and USEPA as part of the initial vapor intrusion investigation at the Behr VOC Plume site. HAS makes conclusions and recommendations for additional actions that may be necessary to protect the public health.

ATSDR and HAS provided USEPA with health-based screening values for residential and non-residential buildings for trichloroethylene (TCE) and other volatile organic compounds. HAS proposed that interim measures be taken at those properties that exceeded the screening criteria to reduce or eliminate the vapor intrusion route as a pathway of health concern. Initially, indoor air samples were collected by USEPA from eight residences immediately south of the Behr-Dayton facility. This residential area immediately south of the facility was later designated as the Phase I area (See Figure 2) in the USEPA Administrative Order of Consent (USEPA, 2006c).

The Behr VOC Plume site posed an ***Indeterminate Public Health Hazard*** for exposure of nearby residents to contamination via vapor intrusion *in the past.* There are no indoor air data that indicate that nearby residents were breathing site-related contaminants in the air in their homes prior to the Fall, 2006 sampling. There are no soil gas data that indicate that contaminants were at levels in the soil gas that could pose a vapor intrusion hazard to nearby residents. Evidence suggests that area groundwater was contaminated with chlorinated solvents at least since 1999.

Based on the November, 2006 sampling conducted by USEPA Emergency Response Branch, HAS determined that the Behr VOC Plume site poses a ***Public Health Hazard*** to area residents due to potential exposure to chlorinated solvent contamination via vapor intrusion. Indoor air data collected by USEPA and subsequent data collected by the Chrysler Corporation in 2007 and 2008 indicate that, *at the present*, some nearby residents are likely being exposed to trichloroethylene in indoor air via the vapor intrusion route at levels that may pose a long term health threat.

The Behr VOC Plume site may continue to pose a ***Public Health Hazard*** as a result of exposure of nearby residents to contamination via vapor intrusion *in the future* unless the source or sources of the groundwater contamination in the area can be fully identified and cleaned up. The vapor abatement systems proposed for impacted homes are intended to be a temporary solution to prevent or reduce the likelihood of the contaminants entering nearby homes and posing a health threat to the residents. The long term solution to the contaminant exposure issue in the neighborhood is identifying and removing the source of the groundwater contamination underlying the community.

Residents in the Behr VOC Plume Phase I area obtain their water from the City of Dayton public drinking water system which, to date, has not been impacted by contaminants from the Behr VOC Plume site. Although the Dayton public water well field is only about one mile north of the site and the area of influence of the well field approaches the northern edge of the site, there are currently no data that indicate that the contaminants from this site have impacted water quality in the well field.

STATEMENT OF ISSUES

The Behr VOC Plume site is a vapor intrusion site with contaminants that originate from a chlorinated solvent groundwater contaminant plume whose source is the Behr-Dayton Thermal (former Chrysler Air Temp) facility in Dayton, Montgomery County, Ohio. In September 2006, Chrysler notified Ohio EPA that the volatile organic compounds (VOCs) from the Behr-Dayton Thermal facility were migrating off-site in the groundwater under the residential areas south-southwest of the facility (See Figure 3). The high concentrations of contaminants detected in the groundwater migrating off-site led to Ohio EPA concerns that vapor-phase chlorinated solvents could migrate from the groundwater and travel up through the soil and into buildings in the neighborhood south of the Behr-Dayton facility. The concentration of the solvent trichloroethylene (TCE) in the groundwater and soil gas exceeded the USEPA's Office of Solid Waste and Emergency Response (OSWER) Subsurface Vapor Intrusion Guidance (USEPA, 2002) screening levels for this chemical.

In October, 2006, the USEPA Emergency Response Branch On-Scene Coordinator requested the assistance of the Health Assessment Section (HAS) at the Ohio Department of Health to provide indoor air screening and action levels (based in part on ATSDR screening values and hereafter referred to as HAS action levels) for the volatile contaminants found in the plume. The Health Assessment Section of the Ohio Department of Health has a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). Under that agreement, HAS undertook the lead in conducting this public health consultation. This public health consultation document will evaluate the initial environmental data collected at the site and will make conclusions and recommendations for additional actions that may be necessary to protect public health of area residents. This public health consultation will be limited to the initial Ohio EPA and USEPA sampling conducted in the Fall of 2006. Additional public health assessment documents will be completed as on-going investigations into the full extent and nature of this contamination in the north Dayton area continue.

BACKGROUND

Site Location

The Behr VOC Plume Site is located in an older mixed urban industrial/commercial and residential portion of north Dayton, Montgomery County, Ohio (See Figures 1 and 2). The Behr VOC Plume site is a groundwater contamination plume originating from the current Behr-Dayton Thermal facility. Following regional groundwater flow, the groundwater contamination is migrating into the adjacent residential areas south and southwest of the facility. The Behr VOC Plume site is about two miles north of downtown Dayton and one mile north of the confluence of the Great Miami River and the Mad River (Figure 1). The Behr site is about one mile east of the confluence of the Great Miami River and the Stillwater River. The Behr-Dayton Thermal facility is about one mile south of the City of Dayton's wellfield.

Regional Hydrogeology and Groundwater Resources

Natural resources use

There are two major aquifer systems in the area of the Behr VOC Plume, the buried valley aquifer system and the Silurian limestone bedrock aquifer system (Miami Conservancy, 2002). In areas where the sand and gravel deposits are not present, the Silurian limestone bedrock is a suitable source of groundwater (Miami Conservancy, 2002). However, in the area of the Behr VOC Plume, the sand and gravel buried valley aquifer is used exclusively as the source of area drinking water.

The Behr VOC Plume site is located in the Great Miami River valley. The Great Miami River flows across a deep bedrock valley that was cut into the limestone and shale bedrock. Ice Age glaciers back-filled these deep bedrock valleys with sand and gravel deposits and an occasional layer of clay. These valley fill deposits range from 150 to 250 feet thick. The sand and gravel deposits are thickest near the present course of the Great Miami River and taper to 25 feet thick on the edges of the bedrock valley.

Poorly sorted clay tills were deposited as intermittent layers along with the sand and gravel beds in the former river valley. These clay lenses rarely form a continuous, impermeable confining layer. The groundwater that may be perched above these layers is not isolated from the groundwater beneath it. The bulk of the soils under the site are porous and permeable sand and gravels (Ohio Department of Natural Resources well logs). These sand and gravel deposits comprise a prolific buried valley aquifer system. The buried valley aquifer provides most of the region with an abundant supply of water for drinking and industrial use (Miami Conservancy, 2002). Seventy-six percent of the water used in the area is withdrawn via wells from the buried valley sand and gravel aquifer. Most of the water that is withdrawn from the aquifer (67%) is used for public drinking water supplies (Miami Conservancy District [MCD], 2002). This buried valley aquifer has been designated as a “Sole Source Aquifer” (See Figure 1). The USEPA’s Sole Source Aquifer designation is defined as an aquifer that supplies at least 50% of the drinking water consumed in the area overlying the aquifer.

Bedrock is encountered immediately beneath the sand and gravel deposits. Compared to the sand and gravel deposits, the limestone and shale bedrock layers are impermeable and act as a confining unit to the groundwater flow in the overlying sand and gravel aquifer (Miami Conservancy, 2002).

Since 2001, Chrysler has sampled the groundwater from 75 on-site and off-site monitoring wells on an irregular basis. Chrysler reported that groundwater elevations indicated that the flow direction in the vicinity of the facility was from the northwest and turned to the southwest just south of the facility (USEPA, 2006a). Regional groundwater flow in the buried valley aquifer system mimics the regional topographic gradient (Miami Conservancy, 2002). The depth to the water table is commonly relatively shallow, ranging from about 15 to 30 feet below ground surface (ODNR, 1995). The intervening soils consist primarily of unconsolidated permeable, porous sands, gravels, and cobbles (Ohio Department of Natural Resources well logs).

Demographics

The Phase I area lies within the McCook Field Neighborhood Planning District of the City of Dayton. In the 2000 census, there were a total of 2,107 people living in this district with 49 percent white, 47 percent African-American, and 4 percent other. In the McCook District at the time of the 2000 Census, 38 percent of the people were 17 years old or younger, 50 percent were between the ages of 18 and 64, and 12 percent were 65 years old or older. There was a total of 1,141 housing units with 836 households and an average of 2.47 persons per household. At the time of the 2000 census, 15 percent of the housing units were owner occupied, 58 percent were rented and 27 percent were vacant (Dayton, 2003). Also from the 2000 Census, but based on 1999 income, 47 percent of the people (of all ages) living in the McCook District were living with incomes below the poverty level (Dayton, 2000). Since the 2000 Census, the Dayton Metro Housing Parkside Homes project, on the west side of Interstate 75, has been incrementally dismantled and this may have significant impact to the demographics of the McCook Field Neighborhood Planning District.

Land use

The Phase I area (Figure 2) is primarily an area of older, single-family residences interspersed with some small commercial properties. The City of Dayton has zoned this area as a “general industrial district.” There is a small park located on the south side of Lamar Street on the southern border of the Phase I area called Claire Ridge Park. The Behr facility is at the northern edge of the Phase I area on the north side of Leo Street (Figure 2). The areas to the immediate east and west of the Phase I area are occupied by industrial and commercial properties. The surrounding Phase 2 Behr VOC Plume area consists mostly of general and light industrial properties mixed with mature neighborhoods of single-family and commercial properties. Some larger parks can also be found further to the west along the Great Miami River such as Triangle Park and the McCook Field area.

There are a number of industries in addition to the Behr facility near the Phase I area, including, Aramark Uniform Services Inc., DAP Inc., Environmental Processing SVC, Gayston, and GEM City Chemicals Inc. Other than the Aramark facility, existing groundwater data does not indicate that these other facilities are significant sources of contamination in the Phase I area (Ohio EPA; City of Dayton; personal communication, 2007).

Dayton’s drinking water supply wells are about one mile north-northeast of the site. A report prepared for Chrysler in 2002 stated that twelve water wells were located in the Dayton downtown area within one mile of the site (Earth Tech, 2002). Nine of these wells were reported to be domestic wells and two wells were industrial supply wells (Earth Tech, 2002). There is also a public water supply well at the Behr-Dayton Thermal Facility (Earth Tech, 2002).

There are two elementary schools in the Behr VOC Plume area; the Kiser Elementary School and Van Cleve Elementary School. The Kiser Elementary School is immediately east across the railroad tracks from the Behr Facility on Leo Street. Recent indoor air samples detected contaminants at concentrations below the HAS action levels at Kiser Elementary School (USEPA, 2007). The Van Cleve Elementary School was located at 1032 Webster Street, roughly

1,600 feet, south of the Behr facility. However, the school was relocated in August 2007 to 132 Alaska Street after indoor air samples indicated levels of TCE above the HAS action levels in the Webster Street school building in June and July 2007.

The initial residential area investigated by Ohio EPA and USEPA is immediately south of the facility. This area is bordered by Leo Street on the north, Milburn Avenue to the east, Lamar Street to the south, and Webster Street to the west (see Figure 3). Sub-slab and indoor air samples were initially collected by USEPA in eight homes in this area and found to have TCE levels above HAS's indoor air and sub-slab HAS action levels. Under the Administrative Order of Consent signed by USEPA and DaimlerChrysler in December 2006, DaimlerChrysler will resample the homes sampled by USEPA as well as an additional 10 to 12 homes in this residential community.

Site History

Operational history

The Behr-Dayton Thermal facility manufactures vehicle air conditioning and engine cooling systems. Although the operations at the facility have remained consistent through the history of the site, the owners have changed several times. The Chrysler Corporation owned and operated the facility from 1937 until 2002. In 1998 Daimler-Benz and Chrysler Corporation merged forming the DaimlerChrysler Corporation (Chrysler) (USEPA, 2006a). In April 2002, Behr America became the current owner of the Dayton facility. However, DaimlerChrysler Corporation is assuming responsibility for the identification and remediation of the Behr VOC Plume. In the past, TCE was used regularly in the plant's manufacturing processes, primarily as a metal degreaser.

Administrative Order of Consent with Chrysler

Upon obtaining and reviewing the results of initial USEPA Phase I Sampling, USEPA met with Chrysler on November 17, 2006 to discuss the signing of an Administrative Order of Consent (AOC) and the scope of work for a proposed two phase time critical removal action to reduce or eliminate exposure of residents to site related chemicals. The USEPA's proposed a Phase I action that would focus on installing a sub-slab vapor abatement systems in each of the eight residences that USEPA documented had indoor air TCE concentrations greater than 0.4 ppb (USEPA, 2006a). Chrysler expanded the focus of Phase I to include an additional 13 residences in the neighborhood south of facility – bounded by: Leo Street to the north, Lamar Street to the south, Webster Street to the west, and Milburn Street to the east. (Figure 2 and 3). On December 19, 2006 the AOC was signed by USEPA and Chrysler (USEPA, 2006a). On December 21, 2006, USEPA approved Chrysler Phase I Work Plan and by this time Chrysler had already installed vapor abatement systems in three of the residences (USEPA, 2006a). The following actions were approved by USEPA as part of the Phase I Work Plan:

Phase I Actions:

1. Chrysler would install vapor abatement systems in five remaining residences initially sampled by USEPA.

2. Chrysler would install vapor abatement systems in residences with indoor air TCE concentrations that are greater than 0.4 ppb (initial eight plus the additional 14).
3. Chrysler would take periodic confirmatory air samples following the installation of the vapor abatement systems to ensure effectiveness of mitigation systems.
4. USEPA would conduct a public meeting in January, 2007

Previous Site Investigations

In 2002, DaimlerChysler submitted an application for the Voluntary Action Program (VAP) to the Ohio EPA. As part of the VAP application, Chrysler documented groundwater contamination beneath the facility with contaminant levels exceeding VAP cleanup standards. Also in 2002, Chrysler submitted a Human Health Risk Evaluation (HHRA) (Earth Tech, Inc., 2002). The HHRA was the initial screening of human health risk based on the concentration of detected VOCs in the groundwater at off site locations. The main contaminants of potential concern identified in the HHRA were trichloroethylene (TCE) and tetrachloroethylene (PCE). The HHRA evaluated the groundwater below the facility and the groundwater moving off site separately. The HHRA also evaluated the risk to down-gradient residences from vapor intrusion using the Johnson-Ettinger Model (Johnson-Ettinger, 1991). The HHRA concluded that the risks due to vapor intrusion were marginal for non-carcinogenic hazards and carcinogenic risks and concluded “that an imminent and substantial health risk is not present” (Earth Tech, 2002). The report further stated that residences within this plume area south-southwest of the facility are supplied with water from the Dayton’s municipal water supplies and are not at risk of exposure to contaminants through their drinking water.

In response to the groundwater contamination documented in 2002, Chrysler contracted Earth Tech to design, install, and operate two systems for the remediation of on-site contamination, one for the soil cleanup and one for the groundwater contamination under the facility, with TCE as the main contaminant of concern.

On-Site Soil and Groundwater Remediation Systems

Chrysler installed a Soil Vapor Extraction (SVE) system for the removal of contaminants from the soils. The SVE system began operation in October 2003 and continued operating through December 2005. An estimated 900 pounds of VOCs were removed from the soils (Earth Tech, 2006).

In an attempt to remove contaminants from the groundwater, a remediation system consisting of six extraction wells and seven injection wells was installed. The capture zone of the six extraction wells reportedly extends as much as 300 feet to the south and 150 feet east of the Behr facility boundaries. Within this capture zone contaminated groundwater is reportedly recovered and treated by the groundwater remedial system. Sodium lactate solution is injected into this system to break down chlorinated solvents before the groundwater is returned to the aquifer. The remedial groundwater system began operation in June 2004 and an estimated 1,031 pounds of VOCs were removed (Earth Tech, 2006).

Up to 75 monitoring wells, on-site and in the surrounding area, were sampled for VOC analyses on an irregular basis by DaimlerChrysler between 2003 and 2007. DaimlerChrysler summarized the data in a report provided for Ohio EPA in September, 2006. Well MW-010S on-site had concentrations of TCE of 17,000 ppb in 2003 and 10,000 ppb in 2006 (Table 1 and Figure 4). Two monitoring wells in the residential area south of the facility had TCE levels over 100 times the MCL in 2003 that increased in concentration in 2006 to over 700 times the MCL. Off-site monitoring well, MW-029S, in Phase I neighborhood, had TCE levels as high as 16,000 ppb in 2003.

Ohio EPA Discovery

In September, 2006 Chrysler notified Ohio EPA that a chlorinated solvent contaminant plume from the Behr-Dayton Thermal facility was migrating off-site in the groundwater under the residential area south-southwest of the facility. The high concentrations of these VOCs detected in the groundwater migrating off-site led to Ohio EPA concerns that vapor-phase chemical compounds could migrate from the groundwater and travel through the soil and into inhabited buildings near the Behr-Dayton facility. The concentrations of TCE, vinyl chloride, and cis-1,2-dichloroethene in the groundwater exceeded the USEPA Office of Solid Waste and Emergency Response (OSWER) screening levels (USEPA, 2002) (See Table 1).

Exceeding these guidance levels indicated that there was a potential for an unacceptable risk to area residents due to vapor intrusion; vapor intrusion is the migration of vapor-phase volatile organic compounds from contaminated groundwater to soil gas to indoor air of area homes. The OSWER vapor intrusion evaluation process is designed to screen out sites that do not require further investigation or remediation and to focus attention on those sites that need further consideration of the vapor intrusion pathway.

In response to groundwater levels that exceeded the OSWER guidance levels, Ohio EPA sampled the deep soil gas in the Phase I area south of the facility in October, 2006 (Figure 5). These seven soil gas samples were collected approximately one foot above the water table (17 feet below ground surface). Contaminant concentrations in these deep soil gas samples significantly exceeded the OSWER screening levels (USEPA, 2002) for TCE and cis-1,2-dichloroethene in deep soil gas and TCE, cis-1,2-dichloroethene, trans-1,2-dichloroethene, and 1,1-dichloroethene in shallow soil gas. The Ohio EPA soil gas sampling indicated TCE at levels up to 160,000 ppb, cis-1,2-DCE at levels up to 11,000 ppb, and 1,1-DCE up to 1,200 ppb under the north Dayton community (Table 2).

USEPA Referral

ATSDR and HAS were asked to establish short-term HAS action levels and long-term screening values for the contaminants of concern for both residential and commercial sub-slab soil gas and indoor air concentrations at the Behr VOC Plume site (see Appendix A). Short-term HAS action levels and long-term screening values were established for TCE, PCE, cis-1,2-DCE, trans-1,2-DCE, 1,1,1-TCA, and vinyl chloride. Exceeding a short-term action level would warrant immediate action by Chrysler or USEPA to reduce exposure levels. These short term HAS action levels were derived from ATSDR's intermediate EMEGs (Environmental Media Evaluation Guides). Exceeding the EMEGs level will not necessarily result in adverse health effects, but prompted further evaluation to determine potential public health threat to residents. Intermediate EMEGs were developed for exposure durations of longer than two weeks but less than one year. Long-term screening values were taken from the USEPA OSWER Draft Vapor Intrusion Guidance levels at the 10^{-4} cancer risk level. Exceeding the long-term screening values indicates that there is an increased potential to develop health affects due to exposure. Long-term residential indoor air screening level for TCE was set at 0.4 ppb and the short-term action level was set at 100 ppb.

Ohio EPA formally requested assistance from the USEPA Emergency Response Branch on November 6, 2006 to conduct a time-critical removal action at the Behr VOC Plume site (USEPA, 2006a).

USEPA Sampling

USEPA began the vapor intrusion investigation by sampling the sub-slab soil gas and indoor air in eight residents in the Phase I neighborhood in November of 2006. The soil gas can accumulate under basement floors or under cement floors of buildings built on slabs. The soil gas can migrate into the homes through cracks in the floor or through the joints between the floors and the wall. Samples of the sub-slab soil gas can be obtained by drilling a small diameter hole in the concrete and installing sample tubing into the hole. A vacuum canister is attached to the tube through a regulator which facilitates sample collection over a 24 hour period. The indoor air is typically collected in the basement using a vacuum canister connected to a pump which is set up to collect a sample over a 24 hour period. Indoor air samples and sub-slab soil gas samples were collected at the same time in the Phase I neighborhood due to the high concentrations of contaminants found in the deep soil gas samples and the shallow depth to the groundwater. Contaminant concentrations in the sub-slab soil gas samples exceeded the OSWER shallow soil gas screening levels (USEPA, 2002) for TCE in all eight homes (see Table 3). Residential sub-slab screening level was set at 4 ppb for TCE. Sub-slab soil gas levels were exceeded in five homes for cis-1,2-dichloroethene, two homes for trans-1,2-dichloroethene, and one home for 1,1-dichloroethene (USEPA, 2006b).

The indoor air concentrations exceeded the action level of 0.4 ppbv established by ATSDR and HAS in all eight homes (see Table 4). TCE levels in the indoor air exceeded the short-term action level of 100 ppb in three homes USEPA, 2006b).

Community Health Education Activities

HAS staff, in conjunction with the US EPA On-Scene Coordinator and representatives of Public Health of Dayton and Montgomery County (PHDMC), have met repeatedly with residents impacted by the contamination associated with the Behr VOC Plume site. On November 20, 2006, HAS, US EPA, and PHDMC met on a one-on-one basis with the eight residents whose homes were sampled by US EPA in November, 2006. Agencies provided the each resident with their sub-slab and indoor air sampling results, a short history of the site, an explanation of the vapor intrusion route, and discussion of the toxicology and potential health concerns regarding exposure to the primary contaminant of concern, TCE. Agency staff answered questions from the residents and facilitated discussions with representatives from the Chrysler Corporation to sign access agreements to allow Chrysler to conduct additional sampling in and under their homes. HAS provided residents with fact sheets on Exposure to Toxic Chemicals, the Vapor Intrusion Pathway, and Trichloroethylene (See Appendix B).

Agency staff, along with representatives from Chrysler Corporation, met again with residents January 18, 2007 on a one-to-one basis to discuss the results of sub-slab and indoor air sampling conducted by Chrysler in December, 2006 and early in January, 2007. Chrysler offered to install sub-slab vapor abatement systems as a short-term solution to limit or eliminate current exposure to TCE through the vapor intrusion route to residents with indoor air levels of TCE exceeding HAS/ATSDR screening values. Agency and Chrysler staff answered questions from residents and solicited signed agreements from residents for the installation of the abatement systems.

DISCUSSION

Exposure to Toxic Chemicals

For the public *to be exposed* to the elevated levels of chemical contaminants in and around the Behr VOC Plume site, they must first come into contact with the contaminated groundwater, surface water, soils, soil gas, sediment, or air. To come into contact with the contaminated media there must be a *completed exposure pathway*. A completed exposure pathway consists of *five main parts*, which must be present for a chemical exposure to occur. These include:

1) A <u>Source of the Toxic Chemicals</u> of concern;
2) A method of <u>Environmental Transport</u>, which allows the chemical contaminant to move from its source (soil, soil gas, air, groundwater, surface water, sediment);
3) A <u>Point of Exposure</u> where the residents come into direct physical contact with the chemical (on-site, off-site);
4) A <u>Route of Exposure</u>, which is how the residents come into physical contact with the chemical (drinking, breathing, eating, touching); and
5) A <u>Population at Risk</u> which are the people who could possibly come into physical contact with site-related chemicals.

Exposure pathways can also be characterized as to when the exposure occurred or might occur in the *Past, Present, or Future*.

Physical contact with a chemical contaminant, in and by itself, does not necessarily result in adverse health effects. A chemical's ability to affect a resident's health is also controlled by a number of factors, including:

- How much of the chemical a person is exposed to (the *Dose*).
- How long a person is exposed to the chemical (duration of exposure).
- How often a person is exposed to the chemical (frequency).

- The toxicity of chemicals the person is exposed to (how chemicals can make people sick).

Other factors affecting a chemical's likelihood of causing adverse health effects upon contact include the resident's:

- Personal habits
- Diet
- Age and sex
- Current health status
- Past exposures to toxic chemicals (occupational, hobbies, etc.)

The site related chemicals of concern found in the groundwater plume under the Behr VOC Plume site consist primarily of trichloroethylene (TCE) and 1,2-dichloroethene (DCE).

Exposure Pathways

Drinking Water Pathway

Although the Behr VOC Plume site is a known groundwater contamination plume, the focus of this health consultation is on health concerns related to the vapor intrusion pathway resulting from this plume. The residents in the Phase I area obtain water from the Dayton public drinking water supplies. At the present, existing groundwater monitoring data does not indicate that the Behr VOC Plume has directly impacted City of Dayton public drinking water supplies (City of Dayton, person. Comm., 2007).

Vapor Intrusion Pathway

The contaminants of concern, trichloroethylene (TCE) and 1,2-dichloroethene (DCE), are in a class of chemicals known as volatile organic compounds (VOCs). These chemicals are considered sufficiently toxic and sufficiently volatile to pose a threat via the vapor intrusion pathway (USEPA, 2002). Although typically found in the liquid-phase in groundwater, these compounds will readily become a gas on exposure to the air. These vapor-phase contaminants can migrate into the air spaces between soil particles, up through the soils, and then into basements of nearby residences. Once in the basements, these chemical vapors can be distributed throughout the homes and into the breathing air of these residences. Factors that favor this type of transport of these chemicals at the Behr site are; 1) the shallow depth to the groundwater (less than 25 feet below the ground surface), 2) the highly permeable sand and gravel soils in this area, 3) the high concentrations of the contaminants in the shallow aquifer (up to 16,000 ppb TCE), and 4) the short horizontal distance from the source to the nearest residences in the Phase I area. Since the depth to groundwater is shallow, 17 to 25 feet below ground surface at the Behr site, the vertical distance the contaminants will have to travel as a vapor to get into a basement will be minimal. The Behr site is located in the Great Miami River valley and the soils consist of highly porous and permeable sands and gravel. These soils provide an environment where organic compounds can readily volatilize from the groundwater to the vapor-phase in the interstitial spaces in the soil and can then migrate as soil gas to areas of lower vapor pressure at the ground surface.

Groundwater plumes with higher concentrations of volatile contaminants will typically generate higher concentrations of contaminant vapors in the air spaces in the soils above the plume. The concentrations of the contaminants in the shallow groundwater at the Behr VOC Plume site are high as indicated by the levels found in shallow monitoring wells with TCE levels from 94 to 16,000 ppb (11 out of 15 samples with detections); cis-1,2-dichloroethylene levels from 16 to 3,800 ppb (6 out of 15 samples with detections); and vinyl chloride levels from 3 to 730 ppb (5 out 15 samples with detections) (DaimlerChrysler, 2006). Ohio EPA sampling of soil gas over the groundwater contamination plume reflected this relationship, detecting soil gas levels of TCE as high as 160,000 ppb and cis-1,2-DCE as high as 11,000 ppb under the Phase I neighborhood (Table 2). The sub-slab soil gas sampled collected by USEPA from the eight sampled homes had TCE as high as 62,000 ppb and cis-1,2-DCE levels as high as 7,900 ppb (Table 3). The vapor intrusion pathway to the indoor air in these homes was determined to be complete and poses an unacceptable public health concern to nearby residents (USEPA, 2006a).

Past Exposures

No indoor air data are available to determine whether the public has been exposed to contaminants in the air through inhalation in the past. No soil gas or sub-slab soil gas data are available to determine whether there was the potential for vapor intrusion in the past. Available groundwater data indicates that groundwater in the area was impacted by site-related chemicals as least as far back as 1999 (Geoprobe sampling in 1999, monitoring wells installed in 2001).

As indicated above, in 2002, Chrysler submitted a Human Health Risk Evaluation (HHRA) (Earth Tech, Inc., 2002). The HHRA was the initial screening of human health risk based on the concentration of VOCs detected in the groundwater at off site locations. The HHRA evaluated risk from vapor intrusion using the Johnson-Ettinger Model (Johnson-Ettinger, 1991). The HHRA concluded that the risks due to vapor intrusion were marginal for non-carcinogenic hazards and carcinogenic risks and concluded “that an imminent and substantial health risk is not present” (Earth Tech, 2002).

Current Exposures

USEPA collected indoor air samples over a 24 hour period at eight locations in the Phase I area. TCE was detected at concentrations exceeding the HAS screening action level of 0.4 ppb in all eight indoor air samples, with the maximum concentration of 260 ppb at location EPA-05 (See Table 4). HAS’s short term action level of 100 ppb was exceeded at three locations, EPA-2, EPA-03, and EPA-05, along Daniel Street and Milburn Avenue.

Cis-1,2-Dichloroethene was detected at concentrations exceeding the HAS screening action level of 8.8 ppb at sampling locations EPA-02 and EPA-05 with a maximum indoor vapor level of 20 ppb at sample location EPA-05.

Chemicals of Concern

TCE and 1,2-DCE are partially soluble in water and are heavier than water. Significant rainfall events usually flushes these chemicals deeper into the soils and then into the groundwater. TCE tends to sink down through the groundwater and accumulate at the bottom of the aquifer. As it travels deeper in the aquifer, TCE enters low oxygen areas and come in contact with bacteria that break TCE down into other chemicals. Under certain conditions TCE breaks down to DCE and VC (Vogel and McCarty, 1985). DCE, and VC are typically found at the leading edge of a plume where contaminants have been in the ground for the longest period and where bacteria have had more time to break down TCE. Typically the highest concentrations of TCE will be found in that portion of the plume nearest to the source.

Trichloroethylene (TCE)

The primary use of trichloroethylene has been the degreasing of metal parts and its use has been closely associated with the automotive and metal-fabricating industries from the 1950's through the 1970's. It is an excellent solvent for removing greases, oils, fats, waxes, and tars. As a solvent it was used alone or blended with other solvents. These solvents were also added to adhesives, lubricants, paints, varnishes, paint strippers, pesticides, and cold metal cleaners. When in surface soils, TCE will transform from a liquid to a gas faster than many other volatile organic compounds. It has been shown that the majority of the TCE spilled on soils close to the surface will vaporize into the air. When TCE is released into the air, it reacts relatively quickly in the presence of sunlight and oxygen, with about half of it breaking down to simpler compounds in about a week. TCE doesn't stick well to soil particles unless the soils have high organic carbon content. TCE is known to be only slightly soluble in water, but there is ample evidence that dissolved TCE can remain in groundwater for a long time. Studies show that TCE in water will rapidly form a gas when it comes into contact with air. In a sand and gravel aquifer, TCE in the groundwater would rapidly vaporize into the air spaces between adjacent soil grains. Studies indicate that it would then disperse by two primary routes; first, diffusion through the soil air spaces and then be re-adsorbed by groundwater or infiltrating rainwater, or second, it would migrate as a gas to the surface and be released to the atmosphere. The primary means of degradation of trichloroethylene in groundwater is by bacteria, but a breakdown product by this means is vinyl chloride, a known human carcinogen and likely more of a health concern than TCE (Vogel and McCarty, 1985).

Acute Health Effects

Occupational studies of workers who use TCE in their work environments and studies of people intentionally inhaling large amounts of TCE (in excess of 100,000 parts TCE per billion parts of air) indicate the potential for impaired heart function, unconsciousness, and death (ATSDR, 1997). Breathing similarly high levels of TCE for longer periods of time may cause permanent nerve, kidney, and liver damage. Breathing lesser amounts of TCE may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. These latter symptoms are reversible and can be addressed by preventing further exposure of the individual to TCE in the indoor air environment. OSHA has set an occupational indoor air limit of 100,000 ppb TCE for an 8-hour workday over a 40-hour work week. ATSDR has established a 2,000 ppb TCE acute minimum risk level (MRL) for TCE in air (ATSDR, 1997).

Exceeding this latter number in the indoor air of homes in the Behr VOC Plume site area might have triggered temporary removal of residents from their homes. However, the highest indoor air level for TCE detected in the Phase I area at the Behr VOC Plume site is 260 ppb, an order of magnitude less than the ATSDR acute MRL value of 2,000 ppb.

Short-term Non-Cancer Health Effects

ATSDR has established an "intermediate" exposure comparison value for exposures to TCE in the air that may have durations greater than a week but less than a year (15 to 365 days). This 100 ppb level provides protection from possible neurological effects due to TCE exposure over this "intermediate" exposure period (ATSDR, 1997). Three homes sampled by USEPA in November, 2006 had indoor air levels of TCE exceeding this "short term action level". An additional home sampled by Chrysler in January, 2007 also exceeded this value, in addition to the homes already sampled by USEPA. Sub-slab vapor abatement systems were installed in all four homes in February, 2007. Ten-day and 30-day confirmation sampling indicated that levels of TCE in the indoor air in these homes were reduced to single-digit parts per billion levels of TCE (below the 100 ppb "short-term action level") very soon after installation and initial operation of these vapor abatement systems.

Long-term or Chronic Cancer Risk

TCE was most recently classified by USEPA as Class B2 carcinogen – a "probable human cancer-causing chemical". However, the cancer classification of TCE has been withdrawn and is currently under review by USEPA. The National Toxicology Program (NTP), in its 11th Report on Carcinogens (2005), lists TCE as being "reasonably anticipated" to be a human carcinogen based on limited evidence of carcinogenicity from studies of humans and sufficient evidence from studies of lab animals exposed to high levels of the chemical.

Chronic exposure to high levels of TCE in air in the workplace (greater than 100,000 ppb TCE), based on analyses of seven studies of worker populations, was associated with excess incidence of liver cancer, kidney cancer, non-Hodgkin's lymphoma, prostate cancer, and multiple myeloma in these workers. The strongest evidence for linking cancer in these workers to TCE exposure is for the first three of these cancers (NTP, 2005). Agreement between human and animal studies supports the conclusion that TCE exposure may result in the development of kidney cancer. High doses are needed to cause liver toxicity and cancer in lab animals. Differences with regard to how humans and animals process TCE in the liver suggests that humans would be less susceptible to liver cancer from TCE exposures than the lab animals (National Academy of Sciences (NAS), 2006).

The health effects, including increased cancer risks, from chronic exposure to single digit part per billion levels of TCE in air and/or drinking water remain poorly-documented and largely unknown. For the Behr VOC Plume site, HAS and ATSDR recommended a long-term protective screening level of 0.4 ppb TCE in the indoor air, based on a hypothetical cancer risk scenario that assumes a resident lives in the basement of his or her house and breathes in TCE in the air for 30+ years, 24 hours/day for 350 days of the year.

Indoor air levels of TCE in 14 of the 18 homes in the Phase I investigation area sampled by the USEPA and Chrysler exceeded this long-term screening level. Sub-slab vapor abatement systems were installed in all 14 of these homes in February, 2007. As of February, 2008, seven out of these 14 homes still had indoor air levels of TCE above the 0.4 ppb screening level. USEPA is requiring Chrysler to review the effectiveness of their vapor abatement systems in light of these homes still being out of compliance with regard to indoor air levels of TCE. Chrysler recently (February, 2008) has proposed to install an in-ground soil vapor extraction system (SVE) under the entire Phase I neighborhood to try and better address the continuing exposure issues in these homes.

As the duration of the TCE exposures via the vapor intrusion pathway at the Behr VOC Plume site remains largely unknown but may have been going on for at least a decade, the HAS, working with the Chronic Disease and Behavioral Epidemiology Section at the Ohio Department of Health and Public Health of Dayton and Montgomery County Staff, will be conducting a community cancer assessment of the impacted neighborhoods in north Dayton in 2008 to determine cancer incidence in this community.

1,2-Dichloroethene (DCE)

DCE has been manufactured as a chlorinated solvent, but at Behr VOC Plume site it is believed to be primarily a by-product of the breakdown of the solvent TCE in groundwater by bacteria. There are three different forms of DCE of concern at the Behr VOC Plume site; 1,1-DCE, cis-1,2-DCE, and trans-1,2-DCE. TCE breaks down into 1,1-DCE or trans-1,2-DCE forms through minor transformation pathways and these forms are typically found in lower concentrations than the cis-1,2-DCE form. The major portion of the DCE by-product formed in the TCE breakdown is the cis-1,2-DCE form.

Low concentrations of trans-1,2-DCE and 1,1-DCE have been detected in the groundwater, soil gas, and indoor air at Behr VOC Plume site. Trans-1,2-DCE is classified as having evidence that it does not cause cancer in humans and 1,1-DCE has been identified as a chemical that has suggestive evidence of carcinogenic potential. Trans-1,2-DCE and 1,1-DCE have not been found at concentrations in the indoor air at the Behr VOC Plume site Phase I area that pose a health concern (up to 18 ppb for trans-1,2-DCE and 50 ppb for 1,1-DCE).

At the Behr VOC Plume site, cis-1,2-DCE was detected at significantly higher concentrations than 1,1-DCE and trans-1,2-DCE. Cis-1,2-DCE is classified as a Class D Carcinogen because there is no data to indicate that this chemical promotes tumor formation in the body (ATSDR, 1996). Although there is no human non-cancer exposure data for cis-1,2-DCE, non-cancer health effects are expected to be similar to exposure to trans-1,2-DCE. Exposure to high concentrations of trans-1,2-DCE depresses the central nervous system in humans. Inhalation of 1,700,000 to 2,220,000 ppb for 5 minutes or 1,200,000 ppb for 10 minutes of trans-1,2-DCE have caused nausea, drowsiness, fatigue, vertigo, and intracranial pressure in two human subjects (ATSDR, 1996). Slight burning of the eyes was reported by two humans when exposed to 830,000 and 2,220,000 ppb trans-1,2-DCE for 30 minutes (ATSDR, 1996).

The concentrations of cis-1,2-DCE found at the Behr VOC Plume site in the indoor air are unlikely to pose a health concern (at levels at or below 8.8 ppb). Two of the eight residences had levels of cis-1,2-DCE in the indoor air above the levels of concern (11.0 and 20 ppb). Sub-slab vapor abatement systems were installed in these two homes in February, 2007 based on elevated TCE levels. USEPA is requiring Chrysler to review the effectiveness of their vapor abatement systems in light of these homes still being out of compliance with regard to indoor air levels of TCE. TCE was found at higher concentrations in the groundwater, soil gas, sub-slab, and the indoor air than DCE and the screening level for TCE (0.4 ppb) is significantly lower than the screening level for DCE (8.8 ppb). The effectiveness of the vapor abatement systems has focused on the goal of getting indoor air levels below the more conservative screening level for TCE. Chrysler recently (February, 2008) has proposed to install an in-ground soil vapor extraction system (SVE) under the Phase I neighborhood to try and better address the continuing exposure issues in these homes.

CHILD HEALTH CONSIDERATIONS

ATSDR and HAS recognize the unique vulnerabilities of children exposed to environmental contamination and hazards. As part of this health consultation, HAS considered the greater sensitivity of the children who live in the area of the Behr VOC Plume site when drawing conclusions and making recommendations regarding health effects from exposure to chemicals related to the Behr VOC Plume site.

CONCLUSIONS

Exposure of nearby residents to contamination via vapor intrusion associated with the Behr VOC Plume site posed an ***Indeterminate Public Health Hazard*** for *in the past.* There are no indoor air data that indicate that nearby residents were breathing contaminants in the air from the Behr facility. There are no soil gas data that indicate that contaminants were at levels in the soils that could pose a vapor intrusion hazard to nearby residents.

Based on the November 2006 sampling conducted by the USEPA Emergency Response Branch, the Behr VOC Plume site poses a ***Public Health Hazard*** for exposure of nearby residents to contamination via vapor intrusion *at the present time.* The indoor air data collected by the USEPA and subsequent data collected by the Chrysler Corporation in 2007 and 2008 indicate that some nearby residents are breathing TCE in indoor air via the vapor intrusion route *in the present* at levels that may pose a long term health threat.

The Behr VOC Plume site poses a ***Public Health Hazard*** for exposure of nearby residents to contamination via vapor intrusion *in the future.* The source or sources of the groundwater contamination in the neighborhood needs to be fully identified and cleaned up. The installed vapor abatement systems are only intended to be a temporary solution to prevent the contaminants entering nearby homes and posing a health threat to the residents. The long term solution to the contaminant threat to the North Dayton area is identifying and removing the source of the groundwater contamination underlying the community.

RECOMMENDATIONS

1. The nature and extent of the groundwater contamination needs to be more fully investigated. Details of groundwater flow direction and investigation of possible additional sources of contamination are areas that need further investigation. Dayton's well field, one mile to the north, has a cone of influence very close to the northern edge of the Behr facility. Vigilant monitoring of the groundwater in this area is recommended to ensure that contaminants are not entering Dayton's water supply.

2. The full extent of the TCE contamination associated with the Behr VOC Plume site should be determined. Residences and businesses at risk of exposure via vapor intrusion pathway should have their sub-slab and indoor air sampled for TCE.

3. Residences with indoor air levels of TCE exceeding long term screening value for TCE in indoor air should be provided with sub-slab vapor abatement systems.

4. Installed sub-slab vapor abatement systems need to be monitored at regular intervals to ensure that these systems continue to remove vapor-phase chemicals before they can enter the home.

5. Due to the number of mitigation systems installed in the neighborhood and the concentrations of contaminants expelled by these systems, the ambient air should be monitored to ensure that the ambient outdoor air is not at concentrations that pose a health concern.

PUBLIC HEALTH ACTION PLAN

Actions at this site are currently being pursued under USEPA Emergency Response Branch (ERB) authorization to identify and remediate environmental impacts on air, land, and water and evaluate threats to public health in the north Dayton area. Chrysler is conducting an investigations and remediation in a portion of the Phase 2 area and is disputing USEPA claims that the Behr VOC Plume area extends into other neighborhoods further to the southeast and southwest of the Phase I area. In response to concerns from the community, USEPA is currently conducting investigations and remediation in these disputed Phase 2 areas.

HAS will review any additional environmental data collected in Phase I neighborhood. HAS will review indoor air data after the installation of the vapor mitigations systems. HAS will also review environmental data from the Phase 2 area.

At the request of the community, HAS has requested a community cancer assessment from ODH's Chronic Disease and Behavioral Epidemiology Section for the residential area around the Behr facility.

PREPARED BY

Peter J. Ferron – Environmental Specialist
Robert C. Frey Ph. D. – Principal Investigator

CERTIFICATION

The Ohio Department of Health prepared this Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). At the time this Health Consultation was written, it was in accordance with the approved methodologies and procedures. Editorial review was completed by the Cooperative Agreement partner.

Technical Project Officer, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Alan W. Yarbrough

Team Leader, Cooperative Agreement Team, CAPEB, DHAC, ATSDR

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TABLES

Table 1. Behr VOC Plume - Phase I
Shallow Groundwater Monitoring Data

Volatile Organic Compound	MCL	OSWER	MW024S	MW025S	MW027S	MW028S	MW029S	MW030S	MW031S
Sample Date	ug/L	ug/L	3/7/2006	3/7/2006	3/7/2006	3/9/2006	11/18/2003	3/8/2006	3/9/2006
1,1,1-Trichloroethane	200	3,100	0.8U	0.8U	0.8U	46	16U	0.8U	0.8U
1,1-Dichloroethene	7	190	0.8U	0.8U	0.8U	4J	16U	0.8U	0.8U
Cis-1,2-Dichloroethene	70	210	0.8U	1J	0.8U	94	3800	0.8U	0.8U
Tetrachloroethylene	5	110	0.8U	1J	0.8U	4U	16U	0.8U	0.8U
Trans-1,2-Dichloroethene	100	180	0.8U	0.8U	0.8U	4U	29J	0.8U	0.8U
Trichloroethylene	5	5	1U	16	1U	3900	16000	1U	1U
Vinyl Chloride	2	2	1U	1U	1U	5U	730	1U	1U

Volatile Organic Compound	MCL	OSWER	MW032S	MW033S	MW034S	MW035S	MW036S	MW037S	MW038S	MW039S
Sample Date	ug/L	ug/L	11/14/2003	3/9/2006	11/17/2003	11/15/2003	11/16/2003	3/8/2006	3/9/2006	11/9/2005
1,1,1-Trichloroethane	200	3,100	6	18J	0.8U	9	2J	3J	12J	6
1,1-Dichloroethene	7	190	0.8U	4J	0.8U	0.8U	0.8U	0.8U	4U	6
Cis-1,2-Dichloroethene	70	210	7	690	16	62	120	3J	810	190
Tetrachloroethylene	5	110	0.9J	4U	1J	3J	0.8U	2J	4U	0.8U
Trans-1,2-Dichloroethene	100	180	0.8U	19J	0.9J	5J	3J	0.8U	19J	10
Trichloroethylene	5	5	250	3800	220	220	720	120	3900	310
Vinyl Chloride	2	2	1U	36	10	1U	1U	1U	18J	3J

🟦	Samples collected in 2006.
🟨	Concentration exceeds MCL.
🟥	Concentration exceeds MCL and OSWER guidance levels.
🟧	Sample quantitation limit is above the MCL.
J	The associated value is an estimated quantity.
U	The analyte was analyzed for, but was not detected. The associated value is a sample quantitation limit
OSWER	Action levels were derived from the USEPA Draft Vapor Intrusion Guidance Document, 2002, based on target groundwater concentrations at the 10-4 risk level

Table 2. Behr VOC Plume Site - Phase I
Ohio EPA Deep Soil Gas Data, Oct. 2006

Volatile Organic Compound	**OSWER**	**OSWER**	**SG-01**	**SG-02**	**SG-03**	**SG-04**	**SG-05**	**SG-06**	**SG-07**
ppb	Shallow	Deep							
1,1,1-Trichloroethane	4,000	40,000	640	**140***	1300	1500	**160***	310	220
1,1-Dichloroethene	500	5000	**300***	**330***	1200	780	10	12	ND
Cis-1,2-Dichloroethene	88	880	10000	11000	5400	4800	410	1200	**400***
Tetrachloroethylene	120	1200	**33***	5	9	8	2	8	6
Trans-1,2-Dichloroethene	180	1800	770	**390***	**460***	**210***	23	**59***	**34***
Trichloroethylene	4.1	41	120000	70000	160000	140000	13000	16000	12000
Vinyl Chloride	110	1100	**92***	**86***	**45***	9	ND	2	ND

* = Value exceeds calibration range.

= Indicates not detected at or above the EQL (estimated quantitation limit) value.

🟨 Concentration exceeds OSWER's shallow soil gas value

🟥 Concentration exceeds OSWER's deep soil gas value

ND

Table 3. Behr VOC Plume Site - Phase I
USEPA Sub-Slab Soil Gas Data, Oct./Nov. 2006

Volatile Organic Compound	Screening	Immediate	EPA-01	EPA-02	EPA-03	EPA-04	EPA-05	EPA-06	EPA-07	EPA-08
ppb	**Action Level**	**Action Level**								
1,1,1-Trichloroethane	4,000	7,000	11	260	140	17	140	39	25	900
1,1-Dichloroethene	500	NA	4	52	45	ND	170	ND	ND	540
Cis-1,2-Dichloroethene	88	2000	57	3100	2900	2	7900	170	ND	4200
Tetrachloroethylene	120	2000	ND	37	30	5	23	2.1	0.85	3.8
Trans-1,2-Dichloroethene	180	2000	3	130	130	ND	340	13	0.19	230
Trichloroethylene	4	1000	980	18000	16000	260	62000	3700	49	62000
Vinyl Chloride	110	300	ND	10	14	ND	79	ND	ND	6.7

ND = Indicates not detected at method detection limits.

🟨 Concentration exceeds OSWER's Sub-Slab soil gas Screening Action Level
were derived from the USEPA Draft Vapor Intrusion Guidance Document, 2002,
based on target indoor air concentration at the 10-4 risk level.

🟥 Concentration exceeds ATSDR's Intermediate Sub-Slab soil gas Screening Action Level
derived from the ATSDR Intermediate Environmental Media Evaluation Guide for air.

Table 4. Behr VOC Plume Site - Phase I
USEPA Indoor Air Data, Oct./Nov. 2006

Volatile Organic Compound ppb	Screening Action Level	Immediate Action Level	EPA-01	EPA-02	EPA-03	EPA-04	EPA-05	EPA-06	EPA-07	EPA-08
1,1,1-Trichloroethane	400	700	ND	1.4	0.99	0.5	1	4.9	ND	0.89
1,1-Dichloroethene	190	NA								
Cis-1,2-Dichloroethene	8.8	200	ND	11	8.3	0.19	20	0.21	ND	1.9
Tetrachloroethylene	12	200	ND	0.2	0.13	0.24	0.13	0.12	ND	0.17
Trans-1,2-Dichloroethene	18	200	ND	0.5	0.34	ND	0.97	ND	ND	ND
Trichloroethylene	0.4	100	1.9	180	130	13	260	7.5	0.4	49
Vinyl Chloride	11	30	ND	ND	ND	ND	ND	ND	ND	ND

ND	Indicates not detected at method detection limits.
🟨	Concentration exceeds OSWER's Indoor Air Action Level - derived from the USEPA Draft Vapor Intrusion Guidance Document, 2002, based on target indoor air concentration at the 10-4 risk level.
🟥	Concentration exceeds ATSDR's Intermediate Indoor Air Action Level - derived from the ATSDR Intermediate Environmental Media Guide for air.

FIGURES

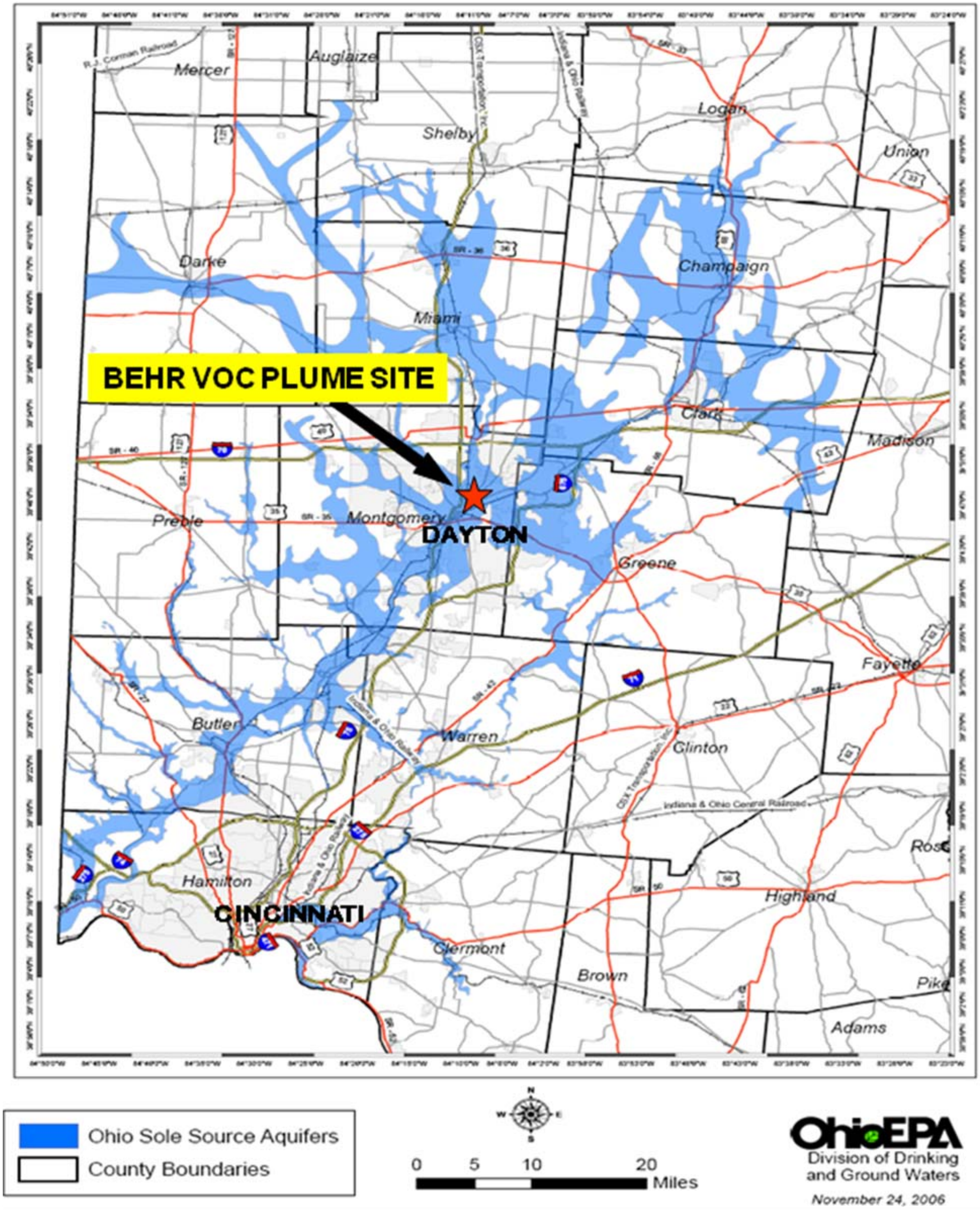

FIGURE 1 –BEHR VOC PLUME LOCATION
AND
GREATER MIAMI SOLE SOURCE AQUIFER

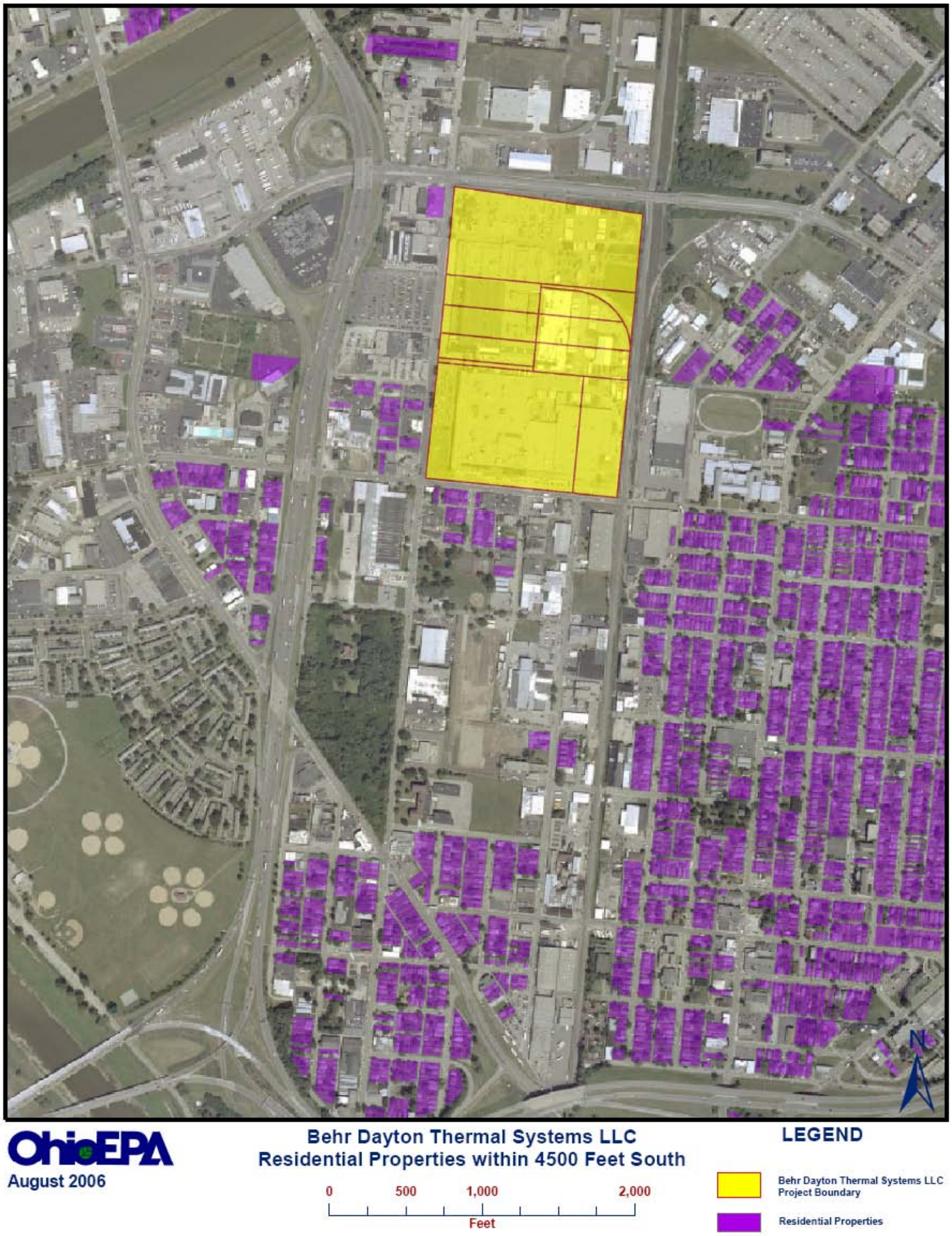

Figure 2 Residential Properties South of the Behr Dayton Facility

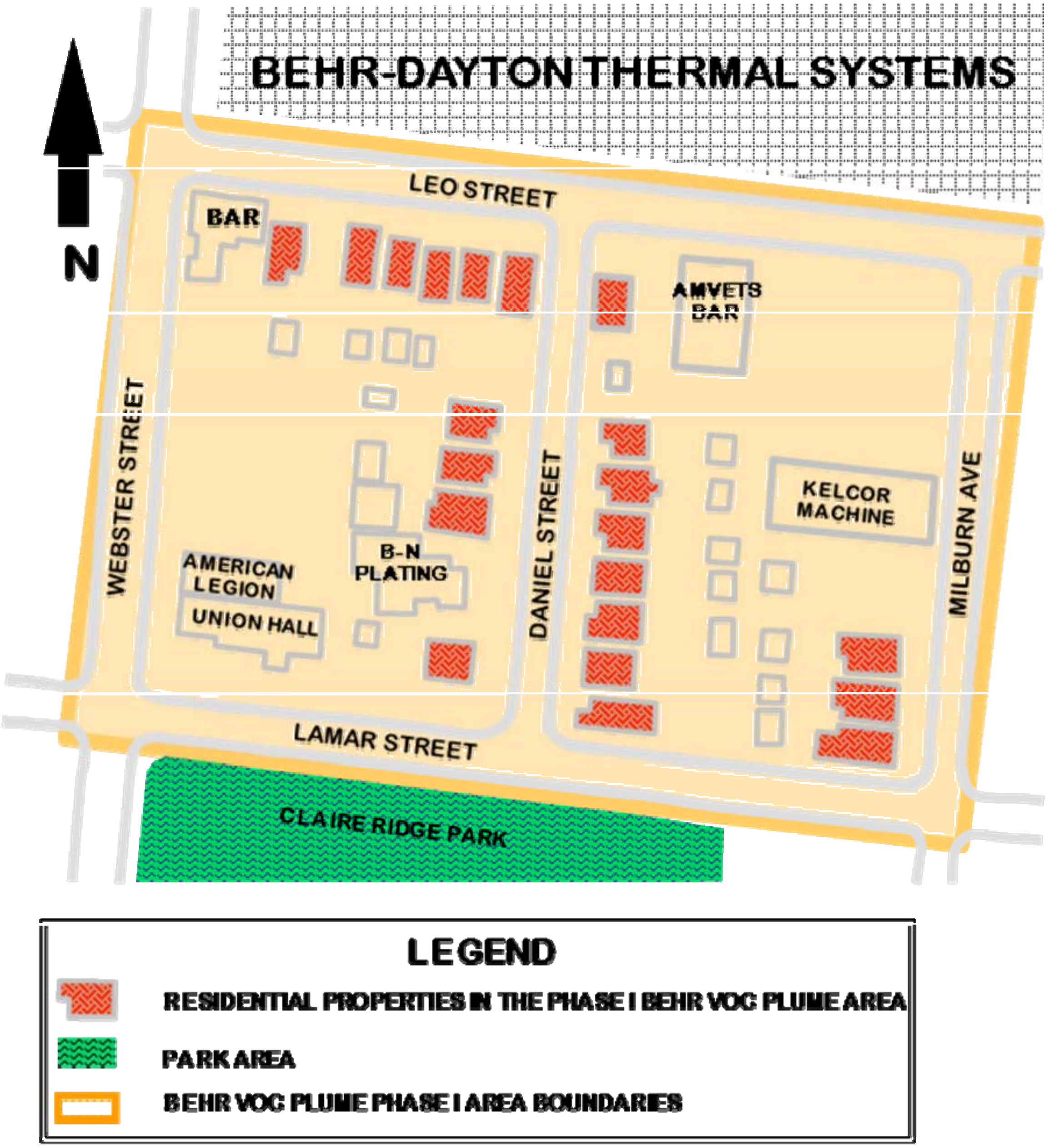

FIGURE 3 – RESIDENTIAL PROPERTIES IN THE BEHR VOC PLUME – PHASE I AREA

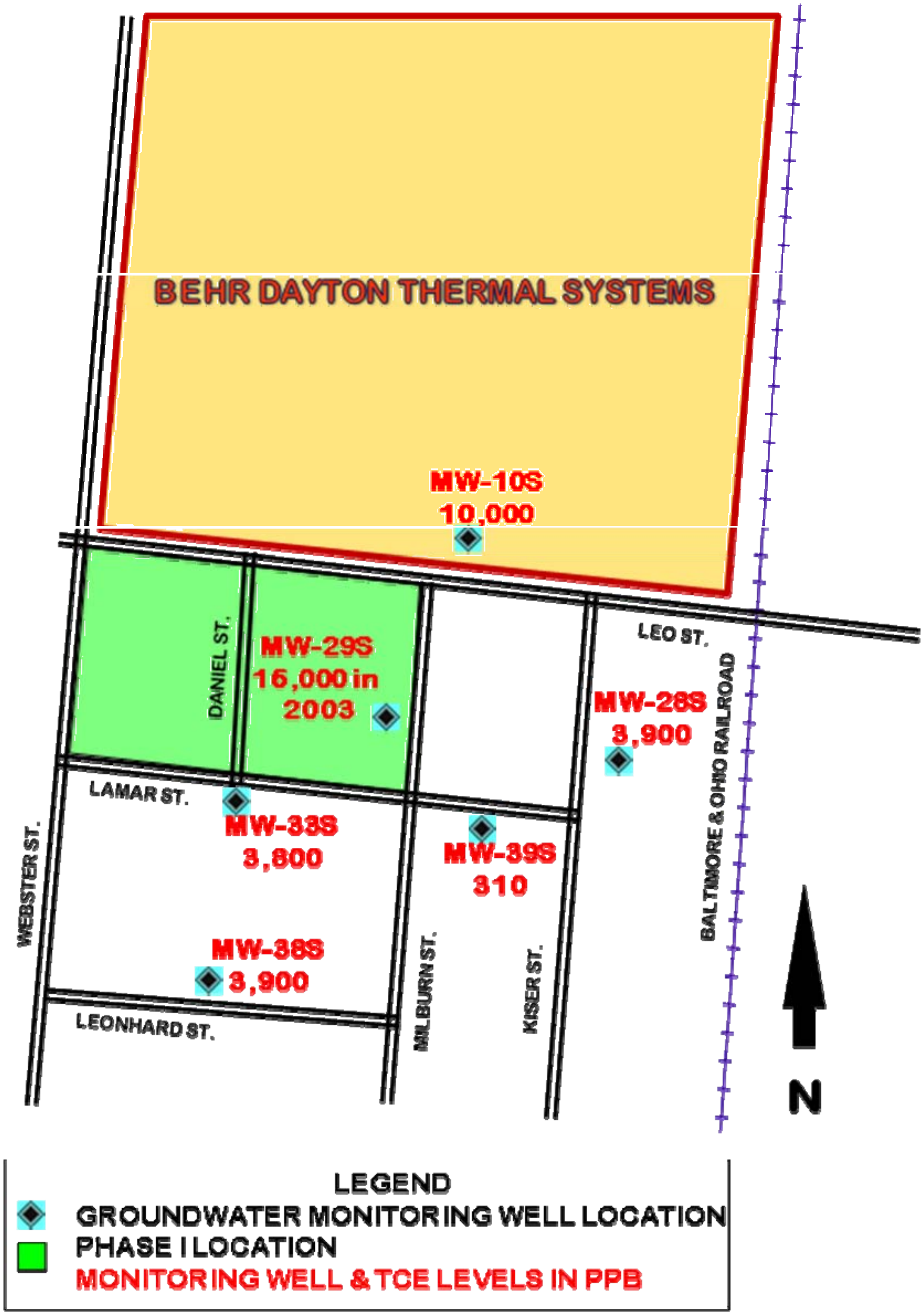

FIGURE 4 – TCE LEVELS IN GROUNDWATER 2006
BEHR VOC PLUME AREA

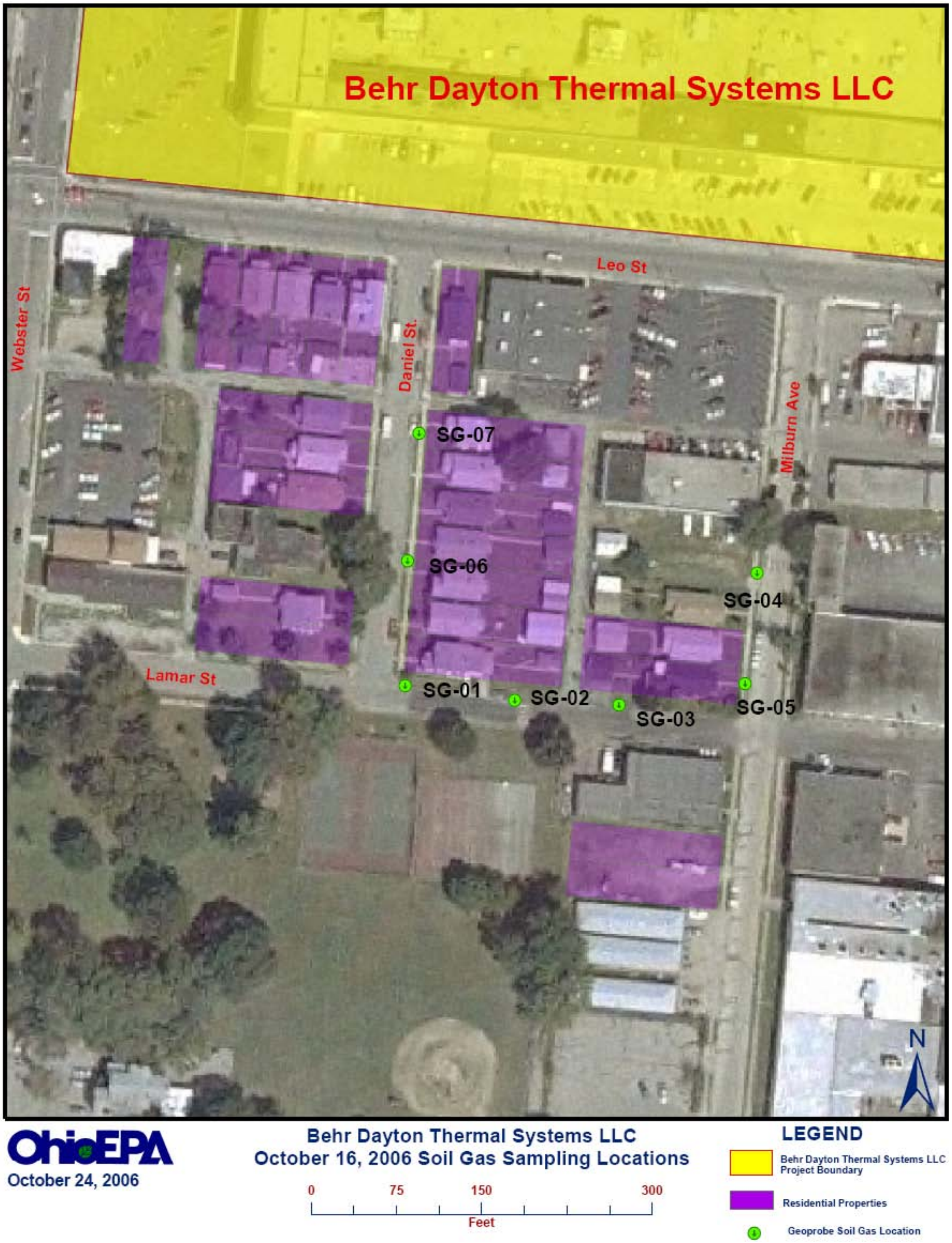

Figure 5 Ohio EPA Soil Gas Sample Locations

APPENDIX A

"ACTION LEVELS" (Parts per billion per volume) FOR CHLORINATED SOLVENTS BEHR-DAYTON SITE, DAYTON, MONTGOMERY COUNTY

Residential	**Short-term Action Level[1]**	**Short-term Action Level**	**Long-term Screening Level[2]**	**Long-term Screening Level**
Chemical	**Indoor Residential**	**Sub-slab Residential**	**Indoor Residential**	**Sub-slab Residential**
Trichloroethylene	100	1,000	0.4	4.0
Perchloroethylene	200	2,000	12	120
cis 1,2 DCE	200	2,000	8.8	88
trans 1,2 DCE	200	2,000	18	180
1,1,1 TCA	700	7,000	400	4,000
Vinyl chloride	30	300	11	110

[1] = ATSDR Intermediate Environmental Media Evaluation Guide (EMEG) for air

[2] = US EPA Draft Vapor Intrusion Guidance document (2002) [Target Indoor air concentration at the 10^{-4} Risk Level]

<u>Note</u>: TCE, PCE, and Vinyl chloride are considered to be human carcinogens and values are based on a 10^{-4} cancer risk number. 1,2 DCE and 1,1,1 TCA are non-carcinogens and risk value based on a chronic hazard index of 1.0

"Short-term Action Level" denotes a level that would trigger immediate action to be taken to reduce exposure levels, either through installation of a sub-slab depressurization system, improved ventilation, or some other action that could be implemented to reduce exposure until the source could be remediated. The "Intermediate" ATSDR EMEG is used instead of the "Acute" EMEG as these exposures would more likely represent something greater than 14 days but less than a lifetime. As such, an exceedence does not necessarily indicate that the home would be unsafe for occupancy, necessitating evacuation of residents. These numbers represent fairly conservative screening criteria.

Evacuation might be a potential course of action if levels of COCs exceeded an Acute EMEG value [2,000 ppb for TCE] or more appropriately a Temporary Emergency Exposure Limit (TEEL) [= 100 ppm for TCE].

Commercial	Short-term Action Level [1]	Short-term Action Level	Long-term Screening Level [2]	Long-term Screening Level
Chemical	**Indoor Commercial**	**Sub-slab Commercial**	**Indoor Commercial**	**Sub-slab Commercial**
Trichloroethylene	420	4,200	1.7	17
Perchloroethylene	840	8,400	50	500
cis 1,2 DCE	840	8,400	37	370
trans 1,2 DCE	840	8,400	76	760
1,1,1 TCA				
Vinyl chloride	126	1,260	46	460

[1] = ATSDR Intermediate Environmental Media Evaluation Guidance (EMEG); adjusted for 8-hr day

[2] = Target Indoor air concentrations US EPA Vapor Intrusion Guidance document (2001); adjusted for 8-hour day

APPENDIX B

The fact sheets for *Exposure to Toxic Chemicals*, the *Vapor Intrusion Pathway*, and *Trichloroethylene* can be found at the Ohio Department of Health web link;

www.odh.ohio.gov/odhPrograms/eh/hlth_as/chemfs1.aspx

ATTACHMENT S

SSDS PROFICIENCY SAMPLE REMINDER FORM

U.S. EPA Sample Reminder Form for Vapor Abatement System Proficiency Samples

SAMPLE TIME:	**PICK-UP TIME:**
Date: ____________________	**Date:** ____________________
Time: ____________________	**Time:** ____________________

Location: ___________________________________

U.S. EPA Sampling Notes and Reminders:

1) U.S. EPA installed a vapor abatement system in your home
2) U.S. EPA will collect one indoor air sample from your property to measure the proficiency of the system. The duration of the test is approximately 24 hours.
3) Analytical results will be submitted to the owner (and tenant(s), if applicable) approximately 4-6 weeks after sampling is completed.
4) The samples will be collected in a stainless steel summa canister. The canister is made of clean stainless steel and does not contain any moving parts or chemicals. Please do not handle or move the canister during the testing.
5) Please do not smoke around the canister and to the extent possible, please leave doors and windows closed during testing.
6) During sampling, do not enter the room where there air samples are being collected. Activity in the room has the potential to alter the air sample results.
7) If possible, do not bring dry cleaning home during the testing.
8) If you have any aggressive pets, please lock them up or place them into a separate room prior to the sample team arriving at your property
9) U.S. EPA will offer to meet with each owner (and tenant(s), if applicable) to discuss the air sample results.
10) As a courtesy, please be on time for your appointment.
11) If you have to reschedule your appointment, please contact U.S. EPA's technical contractor as soon as possible at ______________.

ATTACHMENT T

PROFICIENCY SAMPLE RESULT LETTER – POST-INSTALLATION SAMPLE RESULTS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

February 1, 2009

John Smith (owner)
123 Main Street
Dayton, Ohio 45404

Dear Mr. Smith:

The purpose of this letter is to inform you of the 30-day proficiency sample results of the indoor air sample collected from your property on January 15, 2009. The sample was collected approximately 30 days following U.S. EPA installing a vapor abatement mitigation system at your property. The sample results were reviewed by U.S. EPA to determine the effectiveness of the system. We are specifically testing for the presence of trichloroethylene (also known as TCE), which has been detected in the groundwater under the neighborhood.

TCE is known as a volatile organic compound (VOC), which means it can easily evaporate (turn from a liquid to a gas) when it is exposed to the soil or air. TCE has the potential, as vapors, to move through the soils and work their way into building substructures, such as basements, where it can accumulate in the indoor air.

The result for the indoor air sample collected at your property is presented below and is identified as “Detected” where TCE was found in the samples. “ND” (no detection) is used when there is a chemical concentration less than the laboratory’s minimum detection limit (the laboratory’s minimum detection limit is written below in parentheses). The air sample is measured in units called parts per billion by volume (ppbv). Following the sample result is the “screening level” for the chemical. The Ohio Department of Health (ODH) has recommended the screening level for indoor air.

Indoor Air Sampling Results:
TCE: **ND (0.16) ppbv**, ODH recommended screening level: 0.4 ppbv

The results from the **indoor air sample** collected at your property show that the chemical TCE was not detected (ND) greater than 0.16 ppbv, which is less than the indoor air screening level recommended by the ODH.

The indoor air result is beneath the TCE screening level recommended by the ODH. The results show that the vapor abatement mitigation system is working properly and effectively reducing the vapors beneath your property. U.S. EPA will be contacting you in the near future about scheduling the 180-day proficiency sampling. U.S. EPA would like to take this opportunity to thank you for participating in this mitigation program.

If you have health-related questions concerning this matter, please contact Dr. [Insert Name] at the [insert name of health department] at [insert phone number]. If you have questions related to the sampling or on-going site investigation, please feel free to contact me at 513-569-7539.

Sincerely,

Steven L. Renninger
On-Scene Coordinator
U.S. EPA Region 5

Attachments: Analytical Results

ANALYTICAL RESULTS

ATTACHMENT U

EXAMPLE O&M MANUAL

Vapor Abatement System Manual

for

123 Main Street
Dayton, OH 45404

Compiled by:

U.S. Environmental Protection Agency
Region 5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

September 11, 2008

John Smith (owner)
123 Main Street
Dayton, OH 45404

Dear Mr. Smith:

Based upon the results of sub-slab (the space under your basement floor) and/or indoor air sampling at your property, the U.S. Environmental Protection Agency (EPA) installed a Vapor Abatement System (VAS) as part of the Behr VOC Removal Action. The VAS was installed by U.S. EPA to lower the indoor air trichloroethylene (TCE) level to below levels provided by the Ohio Department of Health (ODH). Elevated levels of TCE in the indoor and/or sub-slab air was the result of the TCE groundwater contamination associated with the Behr VOC Plume Site. Sampling conducted by U.S. EPA at 30 and 90 days following VAS installation has confirmed that the indoor air TCE level is below the ODH indoor air screening level of 0.4 ppbv. U.S. EPA does not plan to conduct additional sampling at your property.

The following manual provides a brief description of the VAS installed in your property. Included in this manual are the air sampling results of all air sampling conducted at your property; photos of each component of your VAS and its function; U.S. EPA project website information; and contact information for any questions you may have regarding the warranty of the VAS. In addition, enclosed with this manual is a key to the system “On/Off” switch located on the exterior of the property. The system is designed to remain in the “On” position at all times to ensure its effectiveness at lowering the indoor air TCE level at the property.

Additional documents in this package include:

1. Access Agreement for Air Sampling
2. Vapor Abatement System Operation and Maintenance (O&M) Agreement
3. Pre-mitigation Sample Results (Baseline Sampling) – Sub-Slab and/or Indoor Air Sampling Letter, Analytical Results and ODH Fact Sheets
4. Vapor Abatement System Proficiency Sample Results – 30 days
5. Vapor Abatement System Proficiency Sample Results – 90 days
6. U.S. EPA Website Information
7. Warranty Information and Contact Information for the Vapor Abatement System

If you have health-related questions concerning this matter, please contact Dr. Bob Frey at the Ohio Department of Health at 614-466-1069. If you have questions related to the sampling or on-going site investigation, please contact me at 513-569-7539.

Sincerely,

Steven L. Renninger
On-Scene Coordinator - U.S. EPA Region 5

Vapor Abatement System – Standard Components

- Photo showing the fan and power-switch portion of the VAS; the fan creates a vacuum under the concrete slab floor or crawlspace. The vacuum draws vapors from under your home and into a PVC pipe system that is vented above the structure. The fan must be “On” and running 24-hours a day to ensure the VAS is operating effectively.

- Photo showing close-up of the locked “On/Off” switch located on the exterior of your structure. The system is designed to run in the “on” position at all times to ensure it is effective.

- Photo showing the sub-slab vapor extraction points; PVC piping extends below the concrete slab or crawlspace liner. PVC piping extends upward to an overhead piping system routed to an “in-line” fan located on the exterior of your structure.

- Photo showing the “U-tube” Manometer (vacuum pressure gauge); the “U-tube” will display a reading greater than zero (0 inches of water column) on the side where the small poly tubing is located when the system is operating effectively.

- Photo showing the effluent vent (exhaust) for the VAS; the vapors are vented above the roof-line of your structure. The vent pipe must be clear of obstructions at all times. This includes caps and covers.

- Photo of sub-slab and indoor air samples being collected.

1. Access Agreement for Sampling

2. Vapor Abatement System O&M Agreement

3. Pre-Mitigation Sample Results (Baseline Sampling)

4. Vapor Abatement System Proficiency Sample Results – 30 days

5. Vapor Abatement System Proficiency Sample Results – 90 days

6. U.S. EPA Website Information

7. Vapor Abatement System Warranty Information

SECTION 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

Name (please print): ____

Address of property to be sampled __________________________________

____

Home Phone # ___________________________

Cell Phone # ___________________________

I consent to officers, employees, contractors, and authorized representatives of the United States Environmental Protection Agency (U.S. EPA) entering and having continued access to this property for the following purpose:

- Conducting air monitoring and air sampling activities;

I realize that these actions taken by U.S. EPA are undertaken pursuant to its response and enforcement responsibilities under the Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended, 42 U.S.C. Section 9601 et seq.

This written permission is given by me voluntarily, on behalf of myself and all other co-owners of this property, with knowledge of my right to refuse and without threats or promises of any kind.

_______________ _______________________________________

Date **Signature**

Sample Location Questions:

1. Are you the Owner _____ or the Tenant _____ of the home or building? If you are the owner, go to #3.

2. If you are the Tenant, please write in the owner's name: _________________________ Go to #3 and write in owner's address and phone number.

3. If you are the owner <u>but live at a different address</u>, write your address below (this is the address where the sample results will be mailed to, otherwise, the results will be mailed to the address at the top of the page):

   Owner's Address:__________________________________

   ____

   Home Phone # ____________________________________

   Cell Phone # ______________________________________
4. Does the home or building have a basement? Yes _____ No _____ (If no, you are done)
5. If yes, does the basement have a concrete slab? Yes _____ No _____
6. If no, does the basement have a dirt floor? Yes _____ No ______

<u>I DO NOT authorize access by U.S. EPA at the above-referenced property.</u>

____

Print Name Signature Date

SECTION 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

NAME: John Smith
ADDRESS: 123 Main Street
Dayton, Ohio 45404

PHONE: 937-555-1234
PROPERTY OWNER: X TENANT__

Re: Behr VOC Plume Site - Residential Vapor Abatement System

On November 27, 2007, the U.S. EPA completed indoor air sampling at 123 Main Street as part of the investigation at the Behr VOC Plume Site located in Dayton, Ohio. The purpose of this letter is to inform you that trichloroethylene (TCE) was observed to be present at a concentration of 12 parts per billion by volume (ppbv), which is greater than the Agency for Toxic Substances and Disease Registry (ATSDR) and Ohio Department of Health (ODH) indoor air TCE screening level of 0.4 ppbv.

As part of the U.S. EPA time-critical removal action at the Behr VOC Plume Site, the U.S. EPA proposes to install a vapor abatement system in residences with elevated TCE concentrations in the residential indoor air. If the system is accepted by the property owner, the U.S. EPA will purchase the vapor abatement system and pay for the basic costs of installation[1]. The U.S. EPA has arranged for Environmental Quality Management to install a vapor abatement system in your home designed to vent TCE vapors to below the recommended indoor air screening levels established by ATSDR and the ODH. The vapor abatement system includes PVC piping and an inline fan to vent vapors from below the residence foundation to above the roofline.

Following the installation of the residential vapor abatement system, performance sampling will be conducted by the U.S. EPA to ensure that the residential indoor air quality is below the ATSDR and ODH screening level for TCE. Performance sampling will be conducted at 30 days and 90 days after system installation. The U.S. EPA will provide the property owner a system information binder that will include a description of the vapor abatement system, photographs, sample data, and fan warranty information. Following successful performance sampling of the residential vapor abatement system, operation & maintenance (O&M) of the vapor abatement system will be the property owner's responsibility. Such O&M is estimated to cost an average of $75/year, which basically includes the cost of the electricity to power the inline fan.

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[1] U.S. EPA will not necessarily pay the costs of associated decorative or cosmetic treatments, or of installation options that are not deemed a "required" installation by the Agency.

If you have health related questions, please contact Dr. Bob Frey of ODH at 614-466-1069. If you have questions concerning the vapor abatement system or the Behr VOC Plume Site removal action, please contact me at 513-569-7539.

Sincerely,

Steve Renninger
U.S. EPA On-Scene Coordinator

Please sign below to indicate that you accept the described vapor abatement system and agree to operation & maintenance as described above, or that you decline the described vapor abatement system for your property:

I agree to and **accept** the terms set forth above:

______________________	________________________	___________
Name	Signature	Date

I have reviewed the above information and **decline** the described system:

______________________	________________________	___________
Name	Signature	Date

SECTION 3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

December 7, 2007

John Smith
123 Main Street
Dayton, Ohio 45404

Dear Mr. Smith:

The purpose of this letter is to inform you of the results of the sub-slab (the space under your basement floor) and indoor air samples collected from your property on November 27, 2007. As you know, the U.S. EPA collected these samples to see if soil vapors from the Behr Dayton Thermal Systems facility (previously owned by Chrysler) are moving through the soils and entering the air inside your property. We are specifically testing for the presence of trichloroethylene (also known as TCE), which has been detected in the groundwater under the neighborhood.

TCE is known as a volatile organic compound (VOC), which means it can easily evaporate (turn from a liquid to a gas) when it is exposed to the soil or air. TCE has the potential, as vapors, to move through the soils and work their way into building substructures, such as basements, where it can accumulate in the indoor air.

The results for the sub-slab and indoor air samples collected at your property are presented below and are identified as “Detected” where TCE was found in the samples. The air samples are measured in units called parts per billion by volume (ppbv). Following the result for each sample is the “screening level” for the chemical. The Ohio Department of Health (ODH) has recommended the screening levels for sub-slab and indoor air.

Sub-Slab Sampling Results:
TCE: **2,400 ppbv**, ODH recommended screening level: 4 ppbv

The results from the **sub-slab air sample** collected at your property show that the chemical TCE was detected at 2,400 ppbv, which is greater than the sub-slab screening level recommended by the ODH.

Indoor Air Sampling Results:
TCE: **12 ppbv**, ODH recommended screening level: 0.4 ppbv

The results from the **indoor air sample** collected at your property show that the chemical TCE was detected at 12 ppbv, which is greater than the indoor air screening level recommended by the ODH.

The sub-slab and indoor exceedances do not necessarily mean that you will experience health effects, only that there is a need for the installation of a vapor abatement mitigation system and additional follow-up proficiency sampling. U.S. EPA will be contacting you in the near future about scheduling the installation of a vapor abatement mitigation system designed to lower the levels of VOCs in the indoor air.

If you have health-related questions concerning this matter, please contact Dr. Bob Frey at the Ohio Department of Health at 614-466-1069. If you have questions related to the sampling or on-going site investigation, please feel free to contact me at 513-569-7539.

Sincerely,

Steven L. Renninger
On-Scene Coordinator
U.S. EPA Region 5

Attachments: Analytical Results
ODH Fact Sheets (3)

cc: Site File

SUB-SLAB AIR SAMPLE RESULTS

Client Sample ID: [redacted]SS 112707

Lab ID#: 0711566B-09A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**5120414**	**Date of Collection: 11/27/07**
Dil. Factor:	**28.2**	**Date of Analysis: 12/4/07 04:39 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	14	Not Detected	70	Not Detected
Freon 114	14	Not Detected	98	Not Detected
Chloromethane	56	Not Detected	120	Not Detected
Vinyl Chloride	14	Not Detected	36	Not Detected
1,3-Butadiene	14	Not Detected	31	Not Detected
Bromomethane	14	Not Detected	55	Not Detected
Chloroethane	14	Not Detected	37	Not Detected
Freon 11	14	Not Detected	79	Not Detected
Ethanol	56	Not Detected	110	Not Detected
Freon 113	14	Not Detected	110	Not Detected
1,1-Dichloroethene	14	Not Detected	56	Not Detected
Acetone	56	Not Detected	130	Not Detected
2-Propanol	56	Not Detected	140	Not Detected
Carbon Disulfide	14	Not Detected	44	Not Detected
3-Chloropropene	56	Not Detected	180	Not Detected
Methylene Chloride	14	Not Detected	49	Not Detected
Methyl tert-butyl ether	14	Not Detected	51	Not Detected
trans-1,2-Dichloroethene	14	Not Detected	56	Not Detected
Hexane	14	Not Detected	50	Not Detected
1,1-Dichloroethane	14	Not Detected	57	Not Detected
2-Butanone (Methyl Ethyl Ketone)	14	Not Detected	42	Not Detected
cis-1,2-Dichloroethene	14	83	56	330
Tetrahydrofuran	14	Not Detected	42	Not Detected
Chloroform	14	Not Detected	69	Not Detected
1,1,1-Trichloroethane	14	Not Detected	77	Not Detected
Cyclohexane	14	Not Detected	48	Not Detected
Carbon Tetrachloride	14	Not Detected	89	Not Detected
2,2,4-Trimethylpentane	14	Not Detected	66	Not Detected
Benzene	14	Not Detected	45	Not Detected
1,2-Dichloroethane	14	Not Detected	57	Not Detected
Heptane	14	Not Detected	58	Not Detected
Trichloroethene	14	2400	76	13000
1,2-Dichloropropane	14	Not Detected	65	Not Detected
1,4-Dioxane	56	Not Detected	200	Not Detected
Bromodichloromethane	14	Not Detected	94	Not Detected
cis-1,3-Dichloropropene	14	Not Detected	64	Not Detected
4-Methyl-2-pentanone	14	Not Detected	58	Not Detected
Toluene	14	Not Detected	53	Not Detected
trans-1,3-Dichloropropene	14	Not Detected	64	Not Detected

Client Sample ID:[redacted]**SS 112707**

Lab ID#: 0711566B-09A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**5120414**	**Date of Collection: 11/27/07**
Dil. Factor:	**28.2**	**Date of Analysis: 12/4/07 04:39 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
1,1,2-Trichloroethane	14	Not Detected	77	Not Detected
Tetrachloroethene	14	300	96	2100
2-Hexanone	56	Not Detected	230	Not Detected
Dibromochloromethane	14	Not Detected	120	Not Detected
1,2-Dibromoethane (EDB)	14	Not Detected	110	Not Detected
Chlorobenzene	14	Not Detected	65	Not Detected
Ethyl Benzene	14	Not Detected	61	Not Detected
m,p-Xylene	14	Not Detected	61	Not Detected
o-Xylene	14	Not Detected	61	Not Detected
Styrene	14	Not Detected	60	Not Detected
Bromoform	14	Not Detected	140	Not Detected
Cumene	14	Not Detected	69	Not Detected
1,1,2,2-Tetrachloroethane	14	Not Detected	97	Not Detected
Propylbenzene	14	Not Detected	69	Not Detected
4-Ethyltoluene	14	Not Detected	69	Not Detected
1,3,5-Trimethylbenzene	14	Not Detected	69	Not Detected
1,2,4-Trimethylbenzene	14	Not Detected	69	Not Detected
1,3-Dichlorobenzene	14	Not Detected	85	Not Detected
1,4-Dichlorobenzene	14	Not Detected	85	Not Detected
alpha-Chlorotoluene	14	Not Detected	73	Not Detected
1,2-Dichlorobenzene	14	Not Detected	85	Not Detected
1,2,4-Trichlorobenzene	56	Not Detected	420	Not Detected
Hexachlorobutadiene	56	Not Detected	600	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	98	70-130
1,2-Dichloroethane-d4	98	70-130
4-Bromofluorobenzene	98	70-130

INDOOR AIR SAMPLE RESULTS

Client Sample ID:[redacted]IA 112707

Lab ID#: 0711566A-11A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**s113016**	**Date of Collection: 11/27/07**
Dil. Factor:	**1.64**	**Date of Analysis: 11/30/07 09:13 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.16	0.40	0.81	2.0
Freon 114	0.16	Not Detected	1.1	Not Detected
Chloromethane	0.16	0.81	0.34	1.7
Vinyl Chloride	0.16	Not Detected	0.42	Not Detected
1,3-Butadiene	0.16	0.28	0.36	0.61
Bromomethane	0.16	Not Detected	0.64	Not Detected
Chloroethane	0.16	Not Detected	0.43	Not Detected
Freon 11	0.16	0.27	0.92	1.5
Ethanol	0.82	160 E	1.5	290 E
Freon 113	0.16	Not Detected	1.2	Not Detected
1,1-Dichloroethene	0.16	Not Detected	0.65	Not Detected
Acetone	0.82	5.9	1.9	14
2-Propanol	0.82	0.87	2.0	2.1
Carbon Disulfide	0.82	Not Detected	2.6	Not Detected
Methylene Chloride	0.33	0.36	1.1	1.2
Methyl tert-butyl ether	0.16	Not Detected	0.59	Not Detected
trans-1,2-Dichloroethene	0.16	Not Detected	0.65	Not Detected
Hexane	0.16	2.0	0.58	6.9
1,1-Dichloroethane	0.16	Not Detected	0.66	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.16	1.8	0.48	5.2
cis-1,2-Dichloroethene	0.16	0.30	0.65	1.2
Tetrahydrofuran	0.82	Not Detected	2.4	Not Detected
Chloroform	0.16	Not Detected	0.80	Not Detected
1,1,1-Trichloroethane	0.16	Not Detected	0.89	Not Detected
Cyclohexane	0.16	0.27	0.56	0.94
Carbon Tetrachloride	0.16	0.18	1.0	1.1
Benzene	0.16	1.4	0.52	4.6
1,2-Dichloroethane	0.16	Not Detected	0.66	Not Detected
Heptane	0.16	0.75	0.67	3.1
Trichloroethene	0.16	12	0.88	66
1,2-Dichloropropane	0.16	Not Detected	0.76	Not Detected
1,4-Dioxane	0.16	Not Detected	0.59	Not Detected
Bromodichloromethane	0.16	Not Detected	1.1	Not Detected
cis-1,3-Dichloropropene	0.16	Not Detected	0.74	Not Detected
4-Methyl-2-pentanone	0.16	Not Detected	0.67	Not Detected
Toluene	0.16	4.8	0.62	18
trans-1,3-Dichloropropene	0.16	Not Detected	0.74	Not Detected
1,1,2-Trichloroethane	0.16	Not Detected	0.89	Not Detected
Tetrachloroethene	0.16	1.6	1.1	11

Client Sample ID:[redacted]IA 112707

Lab ID#: 0711566A-11A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**s113016**	**Date of Collection: 11/27/07**
Dil. Factor:	**1.64**	**Date of Analysis: 11/30/07 09:13 PM**

Compound	**Rpt. Limit (ppbv)**	**Amount (ppbv)**	**Rpt. Limit (uG/m3)**	**Amount (uG/m3)**
2-Hexanone	0.82	Not Detected	3.4	Not Detected
Dibromochloromethane	0.16	Not Detected	1.4	Not Detected
1,2-Dibromoethane (EDB)	0.16	Not Detected	1.3	Not Detected
Chlorobenzene	0.16	Not Detected	0.76	Not Detected
Ethyl Benzene	0.16	0.92	0.71	4.0
m,p-Xylene	0.16	2.9	0.71	13
o-Xylene	0.16	1.0	0.71	4.4
Styrene	0.16	Not Detected	0.70	Not Detected
Bromoform	0.16	Not Detected	1.7	Not Detected
Cumene	0.16	Not Detected	0.81	Not Detected
1,1,2,2-Tetrachloroethane	0.16	Not Detected	1.1	Not Detected
Propylbenzene	0.16	0.24	0.81	1.2
4-Ethyltoluene	0.16	1.0	0.81	5.1
1,3,5-Trimethylbenzene	0.16	0.37	0.81	1.8
1,2,4-Trimethylbenzene	0.16	1.1	0.81	5.6
1,3-Dichlorobenzene	0.16	Not Detected	0.99	Not Detected
1,4-Dichlorobenzene	0.16	Not Detected	0.99	Not Detected
alpha-Chlorotoluene	0.16	Not Detected	0.85	Not Detected
1,2-Dichlorobenzene	0.16	Not Detected	0.99	Not Detected
1,2,4-Trichlorobenzene	0.82	Not Detected	6.1	Not Detected
Hexachlorobutadiene	0.82	Not Detected	8.7	Not Detected

E = Exceeds instrument calibration range.

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	**%Recovery**	**Method Limits**
1,2-Dichloroethane-d4	106	70-130
Toluene-d8	93	70-130
4-Bromofluorobenzene	110	70-130

Bureau of
Environmental Health
Health Assessment Section

“To protect and improve the health of all Ohioans

Trichloroethylene (TCE)

(try- klor'oh eth'uh- leen)

Answers to Frequently Asked Health Questions

What is TCE?

TCE is man-made chemical that is not found naturally in the environment. TCE is a non-flammable (does not burn), colorless liquid with a somewhat sweet odor and has a sweet, “burning” taste. It is mainly used as a cleaner to remove grease from metal parts. TCE can also be found in glues, paint removers, typewriter correction fluids and spot removers.

The biggest source of TCE in the environment comes from evaporation (changing from a liquid into a vapor/gas) when industries use TCE to remove grease from metals. But TCE also enters the air when we use common household products that contain TCE. It can also enter the soil and water as the result of spills or improper disposal.

What happens to TCE in the environment?

- TCE will quickly evaporate from the surface waters of rivers, lakes, streams, creeks and puddles.
- If TCE is spilled on the ground, some of it will evaporate and some of it may leak down into the ground. When it rains, TCE can sink through the soils and into the ground (underground drinking) water.
- When TCE is in an oxygen-poor environment and with time, it will break down into different chemicals such as 1,2 Dichloroethene and Vinyl Chloride.
- TCE does not build up in plants and animals.
- The TCE found in foods is believed to come from TCE contaminated water used in food processing or from food processing equipment cleaned with TCE.

How does TCE get into your body?

- TCE can get into your body by breathing (inhalation) air that is polluted with TCE vapors. The vapors can be produced from the manufacturing of TCE, from TCE polluted water evaporating in the shower or by using household products such as spot removers and typewriter correction fluid.
- TCE can get into your body by drinking (ingestion) TCE polluted water.
- Small amounts of TCE can get into your body through skin (dermal) contact. This can take place when using TCE as a cleaner to remove grease from metal parts or by contact with TCE polluted soils.

Can TCE make you sick?

Yes, you can get sick from TCE. But getting sick will depend on the following:

- <u>How much</u> you were exposed to (dose).
- <u>How long</u> you were exposed (duration).
- <u>How often</u> you were exposed (frequency).
- <u>General Health, Age, Lifestyle</u> Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

How does TCE affect your health?

<u>Breathing (Inhalation):</u>

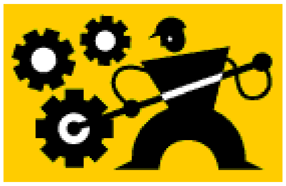
- Breathing <u>high</u> levels of TCE may cause headaches, lung irritation, dizziness, poor coordination (clumsy) and difficulty concentrating.
- Breathing <u>very high</u> levels of TCE for long periods may cause nerve, kidney and liver damage.

<u>Drinking (Ingestion):</u>

- Drinking <u>high</u> concentrations of TCE in the water for long periods may cause liver and kidney damage, harm immune system functions and damage fetal development in pregnant women (although the extent of some of these effects is not yet clear).
- It is uncertain whether drinking low levels of TCE will lead to adverse health effects.

<u>Skin (Dermal) Contact:</u>

- Short periods of skin contact with high levels of TCE may cause skin rashes.



Does TCE cause cancer?

The National Toxicology Program's 11th Report on Carcinogens places chemicals into one of two cancer-causing categories: *Known to be Human Carcinogens* and *Reasonably Anticipated to be Human Carcinogens*.

The11th Report on Carcinogens states TCE is *"Reasonably Anticipated to be Human Carcinogen."*

The category *"Reasonably Anticipated to be Human Carcinogen"* gathers evidence mainly from animal studies. There may be limited human studies or there may be no human or animal study evidence to support carcinogenicity; but the agent, substance or mixture belongs to a well-defined class of substances that are known to be carcinogenic.

There are human studies of communities that were exposed to high levels of TCE in drinking water and they have found evidence of increased leukemia's. But the residents of these communities were also exposed to other solvents and may have had other risk factors associated with this type of cancer.

Animal lab studies in mice and rats have suggested that high levels of TCE may cause liver, lung, kidney and blood (lymphoma) cancers.

As part of the National Exposure Subregistry, the Agency for Toxic Substances and Disease Registry (ATSDR) compiled data on 4,280 residents of three states (Michigan, Illinois, and Indiana) who had environmental exposure to TCE. ATSDR found no definitive evidence for an excess of cancers from these TCE exposures.

The U.S. EPA is currently reviewing the carcinogenicity of TCE.

Is there a medical test to show whether you have been exposed to TCE?

If you have recently been exposed to TCE, it can be detected in your breath, blood, or urine. The breath test, if done soon after exposure, can tell if you have been exposed to even a small amount of TCE.

Exposure to larger amounts is measured in blood and urine tests. These tests detect TCE and many of its breakdown products for up to a week after exposure. However, exposure to other similar chemicals can produce the same breakdown products in the blood and urine so the detection of the breakdown products is not absolute proof of exposure to TCE.

These tests aren't available at most doctors' offices, but can be done at special laboratories that have the right equipment. **Note:** Tests can determine if you have been exposed to TCE but cannot predict if you will experience adverse health effects from the exposure.

Has the federal government made recommendations to protect human health?

The federal government develops regulations and recommendations to protect public health and these regulations can be enforced by law.

Recommendations and regulations are periodically updated as more information becomes available. Some regulations and recommendations for TCE follow:

- The Environmental Protection Agency (EPA) has set a maximum contaminant level for TCE in drinking water at 0.005 milligrams per liter (0.005 mg/L) or 5 parts of TCE per billion parts water (5 ppb).
- The Occupational Safety and Health Administration (OSHA) have set an exposure limit of 100 ppm (or 100 parts of TCE per million parts of air) for an 8-hour workday, 40-hour workweek.
- The EPA has developed regulations for the handling and disposal of TCE.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1997. Toxicological profile for TCE (electronic at http://www.atsdr.cdc.gov/tfacts19.html)

Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2005 (2005 electronic at http://ntp.niehs.nih.gov/ntp/roc/toc11.html)

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

This pamphlet was created by the Ohio Department of Health, Bureau of Environmental Health, Health Assessment Section and supported in whole by funds from the Cooperative Agreement Program grant from the ATSDR.

Updated 10/12/06

Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Exposure to Toxic Chemicals

Answers to Frequently Asked Health Questions

How are we exposed to chemicals?

We come in contact with many different chemicals every day that are non-toxic and normally do not cause health problems. But any chemical could become toxic if a person comes in contact with high enough doses. For example: Aspirin will cure a headache but too much aspirin becomes toxic and can cause serious health problems. You can get sick from contact with chemicals but getting sick will depend on the following:

- <u>How much</u> you were exposed to (dose).
- <u>How long</u> you were exposed (duration).
- <u>How often</u> you were exposed (frequency).
- <u>General Health, Age, Lifestyle</u>
  Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

Other factors that increase health risks are:

- Current health status (if you are ill or healthy).
- Lifestyle, age, and weight.
- Smoking, drinking alcohol, or taking certain medicines or drugs.
- Allergies to certain chemicals.
- Past chemical exposure.
- Working in an industry/factory that makes or uses chemicals.

What is a completed exposure pathway?

Chemicals must have a way to get into a person's body to cause health problems. This process of those chemicals getting into our bodies is called an exposure pathway. A <u>completed</u> exposure pathway includes all of the following 5 links between a chemical source and the people who are exposed to that chemical.

(1) A <u>Source</u> of the chemical (where the chemical came from);
(2) <u>Environmental Transport</u> (the way the chemical moves from the source to the public. This can take place through the soil, air, underground drinking water or surface water);
(3) <u>Point of Exposure</u> (the place where there is physical contact with the chemical. This could be on-site as well as off-site);
(4) A <u>Route of Exposure</u> (how people came into the physical contact with the chemical. This can take place by drinking, eating, breathing or touching it);
(5) <u>People Who Could be Exposed</u> (people that live near a facility who are most likely to come into physical contact with the site-related chemical).

What are exposure routes?

There are three ways (routes) a person can come in contact with toxic chemicals. They include:

- Breathing (inhalation).
- Eating and drinking (ingestion).
- Skin contact (dermal contact).

<u>Inhalation (breathing)</u>
Chemicals can enter our body through the air we breathe. These chemicals can come in the form of dust, mist, or fumes. Some chemicals may stay in the lungs and damage lung cells. Other chemicals may pass through lung tissue, enter the bloodstream, and affect other parts of our body.

<u>Ingestion (eating or drinking)</u>
The body can absorb chemicals in the stomach from the foods we eat or the liquids we drink. Chemicals may also be in the dust or soil we swallow. These chemicals can enter our blood and affect other parts of our body.

<u>Dermal (skin) Contact</u>
Chemicals can enter our body through our skin. We can come in contact with water polluted by chemicals or touch polluted soil. Some chemicals pass through our skin and enter our bloodstream, affecting other parts of our body.

For more information contact:

Ohio Department of Health
Health Assessment Section
246 North High Street, 5th Floor
Columbus OH 43215
Phone: 614-466-1390
Fax: 614-644-4556

The Ohio Department of Health is in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), Public Health Service, U.S. Department of Health and Human Services.

This pamphlet was created by the Ohio Department of Health, Health Assessment Section and supported in whole by funds from the Comprehensive Environmental Response, Compensation and Liability Act trust fund.

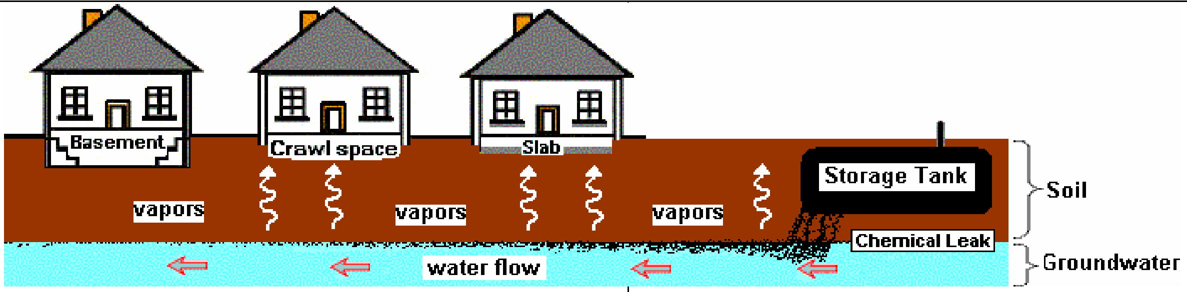
Revised 10/28/03

Bureau of
Environmental Health
Health Assessment Section

"To protect and improve the health of all Ohioans"

Vapor Intrusion

Answers to Frequently Asked Health Questions



What is vapor intrusion?

Vapor intrusion refers to the vapors produced by a chemical spill/leak that make their way into indoor air. When chemicals are spilled on the ground or leak from an underground storage tank, they will seep into the soils and will sometimes make their way into the groundwater (underground drinking water). There are a group of chemicals called volatile organic compounds (VOCs) that easily produce vapors. These vapors can travel through soils, especially if the soils are sandy and loose or have a lot of cracks (fissures). These vapors can then enter a home through cracks in the foundation or into a basement with a dirt floor or concrete slab.

VOCs and vapors:

VOCs can be found in petroleum products such as gasoline or diesel fuels, in solvents used for industrial cleaning and are also used in dry cleaning. If there is a large spill or leak resulting in soil or groundwater contamination, vapor intrusion may be possible and should be considered a potential public health concern that may require further investigation.

Although large spills or leaks are a public health concern, other sources of VOCs are found in everyday household products and are a more common source of poor indoor air quality. Common products such as paint, paint strippers and thinners, hobby supplies (glues), solvents, stored fuels (gasoline or home heating fuel), aerosol sprays, new carpeting or furniture, cigarette smoke, moth balls, air fresheners and dry-cleaned clothing all contain VOCs.

Can you get sick from vapor intrusion?

You can get sick from breathing harmful chemical vapors. But getting sick will depend on:
<u>How much</u> you were exposed to (dose).
<u>How long</u> you were exposed (duration).
<u>How often</u> you were exposed (frequency).
<u>How toxic</u> the spill/leak chemicals are.
<u>General Health, age, lifestyle:</u> Young children, the elderly and people with chronic (on-going) health problems are more at risk to chemical exposures.

VOC vapors at high levels can cause a strong petroleum or solvent odor and some persons may experience eye and respiratory irritation, headache and/or nausea (upset stomach). These symptoms are usually temporary and go away when the person is moved to fresh air.

Lower levels of vapors may go unnoticed and a person may feel no health effects. A few individual VOCs are known carcinogens (cause cancer). Health officials are concerned with low-level chemical exposures that happen over many years and may raise a person's lifetime risk for developing cancer.

How is vapor intrusion investigated?

In most cases, collecting soil gas or groundwater samples near the spill site is done <u>first</u> to see if there is on-site contamination. If soil vapors or groundwater contamination are detected at a spill site, environmental protection and public health officials may then ask that soil vapor samples be taken from areas outside the immediate spill site and near any potential affected business or home. The Ohio Department of Health (ODH) does not usually recommend indoor air sampling for vapor intrusion before the on-site contamination is determined.

(continued on next page)

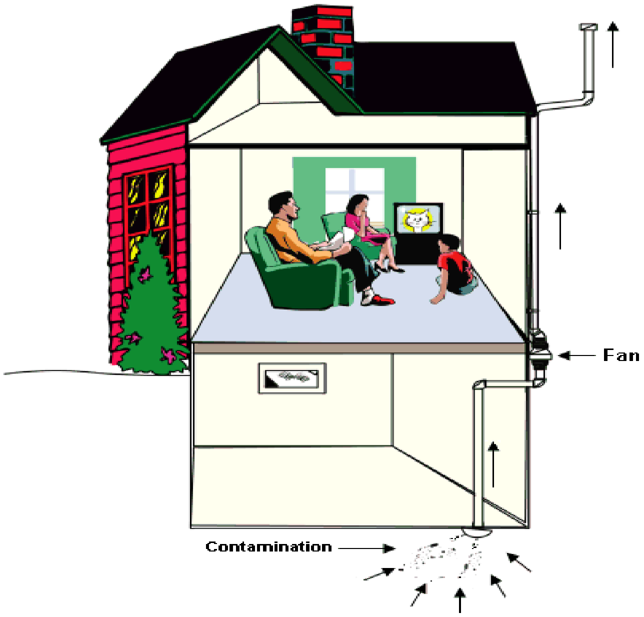
How is vapor intrusion investigated? (continued)

Because a variety of VOC sources are present in most homes, testing will not necessarily confirm VOCs in the indoor air are from VOC contamination in soils at nearby spill site. But if additional sampling is recommended, samples may be taken from beneath the home's foundation (called sub-slab samples), to see if vapors have reached the home. Sub-slab samples are more reliable than indoor air samples and are not as affected by other indoor chemical sources. If there was a need for additional sampling on a private property, homeowners would be contacted by the cleanup contractor or others working on the cleanup site and their cooperation and consent would be requested before any testing/sampling would be done.

What happens if a vapor intrusion problem is found?

If vapor intrusion is having an effect on the air in your home, the most common solution is to install a *radon mitigation system*. A radon mitigation system will prevent gases in the soil from entering the home. A low amount of suction is applied below the foundation and the vapors are vented to the outside. The system uses minimal electricity and should not noticeably affect heating and cooling efficiency. This mitigation system also prevents radon from entering the home, an added health benefit. Usually, the party responsible for cleaning up the contamination is also responsible for paying for the installation of this system. Once the contamination is cleaned up, the system should no longer be needed. In homes with on going radon problems, ODH suggests these systems remain in place permanently.

Radon Mitigation System



What can you do to improve your indoor air quality?

As stated before, the most likely source of VOCs in indoor air comes from the common items that are found in most homes. The following helpful hints will help improve air quality inside your home:

- Do not buy more chemicals than you need and know what products contain VOCs.
- If you have a garage or an out building such as a shed, place the properly stored VOC-containing chemicals outside and away from your family living areas.
- Immediately clean and ventilate any VOC spill area.
- If you smoke, go outside and/or open the windows to ventilate the second-hand, VOC-containing smoke outdoors.
- Make sure all your major appliances and fireplace(s) are in good condition and not leaking harmful VOC vapors. Fix all appliance and fireplace leaks promptly, as well as other leaks that cause moisture problems that encourage mold growth.
- Most VOCs are a fire hazard. Make sure these chemicals are stored in appropriate containers and in a well-ventilated location and away from an open pilot light (flame) of a gas water heater or furnace.
- Fresh air will help prevent both build up of chemical vapors in the air and mold growth. Occasionally open the windows and doors and ventilate.
- Test your home for radon and install a radon detector.

References:

Wisconsin Department of Health and Family Services, Environmental Health Resources, Vapor Intrusion, electronic, 2004.

New York State Department of Health, Center for Environmental Health, April 2003.

Ohio Department of Health, Bureau of Environmental Health, Indoor Environment Program, 2004.

For more information contact:

Ohio Department of Health
Bureau of Environmental Health
Health Assessment Section
246 N. High Street
Columbus, Ohio 43215
Phone: (614) 466-1390
Fax: (614) 466-4556

Created September 2004

SECTION 4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

January 31, 2008

John Smith
123 Main Street
Dayton, Ohio 45404

Dear Mr. Smith:

The purpose of this letter is to inform you of the 30-day proficiency sample results of the sub-slab (the space under your basement floor) and indoor air samples collected from your property on January 21, 2008. The samples were collected approximately 30 days following U.S. EPA installing a vapor abatement mitigation system at your property. The sample results are reviewed by U.S. EPA to determine the effectiveness of the system. We are specifically testing for the presence of trichloroethylene (also known as TCE), which has been detected in the groundwater under the neighborhood.

TCE is known as a volatile organic compound (VOC), which means it can easily evaporate (turn from a liquid to a gas) when it is exposed to the soil or air. TCE has the potential, as vapors, to move through the soils and work their way into building substructures, such as basements, where it can accumulate in the indoor air.

The results for the sub-slab and indoor air samples collected at your property are presented below and are identified as "Detected" where TCE was found in the samples. "ND" (no detection) is used when there is a chemical concentration less than the laboratory's minimum detection limit (the laboratory's minimum detection limit is written below in parentheses). The air samples are measured in units called parts per billion by volume (ppbv). Following the result for each sample is the "screening level" for the chemical. The Ohio Department of Health (ODH) has recommended the screening levels for sub-slab and indoor air.

Sub-Slab Sampling Results:
TCE: **12 ppbv**, ODH recommended screening level: 4 ppbv

The results from the **sub-slab air sample** collected at your property show that the chemical TCE was detected at 12 ppbv, which is greater than the sub-slab screening level recommended by the ODH.

Indoor Air Sampling Results:
TCE: **ND (0.16) ppbv**, ODH recommended screening level: 0.4 ppbv

The results from the **indoor air sample** collected at your property show that the chemical TCE was not detected (ND) greater than 0.16 ppbv, which is less than the indoor air screening level recommended by the ODH.

The TCE level in the sub-slab does not necessarily mean that you will experience health effects, only that the vapor abatement system is working properly and effectively reducing the vapors beneath your property. U.S. EPA will be contacting you in the near future about scheduling the 90-day proficiency sampling. U.S. EPA would like to take this opportunity to thank you for participating in this mitigation program.

If you have health-related questions concerning this matter, please contact Dr. Bob Frey at the Ohio Department of Health at 614-466-1069. If you have questions related to the sampling or on-going site investigation, please feel free to contact me at 513-569-7539.

Sincerely,

Steven L. Renninger
On-Scene Coordinator
U.S. EPA Region 5

Attachments: Analytical Results

cc: Site File

SUB-SLAB AIR SAMPLE RESULTS

Client Sample ID: [redacted]S011708

Lab ID#: 0801322A-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**5012232**	**Date of Collection: 1/17/08**
Dil. Factor:	**1.83**	**Date of Analysis: 1/23/08 08:05 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.92	Not Detected	4.5	Not Detected
Freon 114	0.92	Not Detected	6.4	Not Detected
Chloromethane	3.7	Not Detected	7.6	Not Detected
Vinyl Chloride	0.92	Not Detected	2.3	Not Detected
1,3-Butadiene	0.92	Not Detected	2.0	Not Detected
Bromomethane	0.92	Not Detected	3.6	Not Detected
Chloroethane	0.92	Not Detected	2.4	Not Detected
Freon 11	0.92	Not Detected	5.1	Not Detected
Ethanol	3.7	Not Detected	6.9	Not Detected
Freon 113	0.92	Not Detected	7.0	Not Detected
1,1-Dichloroethene	0.92	Not Detected	3.6	Not Detected
Acetone	3.7	Not Detected	8.7	Not Detected
2-Propanol	3.7	Not Detected	9.0	Not Detected
Carbon Disulfide	0.92	Not Detected	2.8	Not Detected
3-Chloropropene	3.7	Not Detected	11	Not Detected
Methylene Chloride	0.92	Not Detected	3.2	Not Detected
Methyl tert-butyl ether	0.92	Not Detected	3.3	Not Detected
trans-1,2-Dichloroethene	0.92	Not Detected	3.6	Not Detected
Hexane	0.92	Not Detected	3.2	Not Detected
1,1-Dichloroethane	0.92	Not Detected	3.7	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.92	Not Detected	2.7	Not Detected
cis-1,2-Dichloroethene	0.92	Not Detected	3.6	Not Detected
Tetrahydrofuran	0.92	Not Detected	2.7	Not Detected
Chloroform	0.92	Not Detected	4.5	Not Detected
1,1,1-Trichloroethane	0.92	Not Detected	5.0	Not Detected
Cyclohexane	0.92	Not Detected	3.1	Not Detected
Carbon Tetrachloride	0.92	Not Detected	5.8	Not Detected
2,2,4-Trimethylpentane	0.92	Not Detected	4.3	Not Detected
Benzene	0.92	Not Detected	2.9	Not Detected
1,2-Dichloroethane	0.92	Not Detected	3.7	Not Detected
Heptane	0.92	Not Detected	3.7	Not Detected
Trichloroethene	0.92	12	4.9	66
1,2-Dichloropropane	0.92	Not Detected	4.2	Not Detected
1,4-Dioxane	3.7	Not Detected	13	Not Detected
Bromodichloromethane	0.92	Not Detected	6.1	Not Detected
cis-1,3-Dichloropropene	0.92	Not Detected	4.2	Not Detected
4-Methyl-2-pentanone	0.92	Not Detected	3.7	Not Detected
Toluene	0.92	Not Detected	3.4	Not Detected
trans-1,3-Dichloropropene	0.92	Not Detected	4.2	Not Detected

Client Sample ID: [redacted]S011708

Lab ID#: 0801322A-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**5012232**	**Date of Collection: 1/17/08**
Dil. Factor:	**1.83**	**Date of Analysis: 1/23/08 08:05 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
1,1,2-Trichloroethane	0.92	Not Detected	5.0	Not Detected
Tetrachloroethene	0.92	5.5	6.2	38
2-Hexanone	3.7	Not Detected	15	Not Detected
Dibromochloromethane	0.92	Not Detected	7.8	Not Detected
1,2-Dibromoethane (EDB)	0.92	Not Detected	7.0	Not Detected
Chlorobenzene	0.92	Not Detected	4.2	Not Detected
Ethyl Benzene	0.92	Not Detected	4.0	Not Detected
m,p-Xylene	0.92	Not Detected	4.0	Not Detected
o-Xylene	0.92	Not Detected	4.0	Not Detected
Styrene	0.92	Not Detected	3.9	Not Detected
Bromoform	0.92	Not Detected	9.4	Not Detected
Cumene	0.92	Not Detected	4.5	Not Detected
1,1,2,2-Tetrachloroethane	0.92	Not Detected	6.3	Not Detected
Propylbenzene	0.92	Not Detected	4.5	Not Detected
4-Ethyltoluene	0.92	Not Detected	4.5	Not Detected
1,3,5-Trimethylbenzene	0.92	Not Detected	4.5	Not Detected
1,2,4-Trimethylbenzene	0.92	Not Detected	4.5	Not Detected
1,3-Dichlorobenzene	0.92	Not Detected	5.5	Not Detected
1,4-Dichlorobenzene	0.92	Not Detected	5.5	Not Detected
alpha-Chlorotoluene	0.92	Not Detected	4.7	Not Detected
1,2-Dichlorobenzene	0.92	Not Detected	5.5	Not Detected
1,2,4-Trichlorobenzene	3.7	Not Detected	27	Not Detected
Hexachlorobutadiene	3.7	Not Detected	39	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	95	70-130
1,2-Dichloroethane-d4	99	70-130
4-Bromofluorobenzene	99	70-130

INDOOR AIR SAMPLE RESULTS

Client Sample ID: [redacted]A012108

Lab ID#: 0801377B-05A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**s012416**	**Date of Collection: 1/21/08**
Dil. Factor:	**1.58**	**Date of Analysis: 1/24/08 07:06 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.16	0.31	0.78	1.5
Freon 114	0.16	Not Detected	1.1	Not Detected
Chloromethane	0.16	1.0	0.33	2.1
Vinyl Chloride	0.16	Not Detected	0.40	Not Detected
1,3-Butadiene	0.16	0.44	0.35	0.96
Bromomethane	0.16	Not Detected	0.61	Not Detected
Chloroethane	0.16	Not Detected	0.42	Not Detected
Freon 11	0.16	0.27	0.89	1.5
Ethanol	0.79	390 E	1.5	740 E
Freon 113	0.16	Not Detected	1.2	Not Detected
1,1-Dichloroethene	0.16	Not Detected	0.63	Not Detected
Acetone	0.79	6.0	1.9	14
2-Propanol	0.79	Not Detected	1.9	Not Detected
Carbon Disulfide	0.79	Not Detected	2.5	Not Detected
Methylene Chloride	0.32	Not Detected	1.1	Not Detected
Methyl tert-butyl ether	0.16	Not Detected	0.57	Not Detected
trans-1,2-Dichloroethene	0.16	Not Detected	0.63	Not Detected
Hexane	0.16	0.92	0.56	3.2
1,1-Dichloroethane	0.16	Not Detected	0.64	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.16	1.3	0.46	3.8
cis-1,2-Dichloroethene	0.16	Not Detected	0.63	Not Detected
Tetrahydrofuran	0.79	Not Detected	2.3	Not Detected
Chloroform	0.16	Not Detected	0.77	Not Detected
1,1,1-Trichloroethane	0.16	Not Detected	0.86	Not Detected
Cyclohexane	0.16	Not Detected	0.54	Not Detected
Carbon Tetrachloride	0.16	Not Detected	0.99	Not Detected
Benzene	0.16	1.1	0.50	3.4
1,2-Dichloroethane	0.16	Not Detected	0.64	Not Detected
Heptane	0.16	0.70	0.65	2.9
Trichloroethene	0.16	Not Detected	0.85	Not Detected
1,2-Dichloropropane	0.16	Not Detected	0.73	Not Detected
1,4-Dioxane	0.16	Not Detected	0.57	Not Detected
Bromodichloromethane	0.16	Not Detected	1.0	Not Detected
cis-1,3-Dichloropropene	0.16	Not Detected	0.72	Not Detected
4-Methyl-2-pentanone	0.16	0.23	0.65	0.93
Toluene	0.16	3.0	0.60	11
trans-1,3-Dichloropropene	0.16	Not Detected	0.72	Not Detected
1,1,2-Trichloroethane	0.16	Not Detected	0.86	Not Detected
Tetrachloroethene	0.16	Not Detected	1.1	Not Detected

Client Sample ID: [redacted]A012108

Lab ID#: 0801377B-05A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**s012416**	**Date of Collection: 1/21/08**
Dil. Factor:	**1.58**	**Date of Analysis: 1/24/08 07:06 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
2-Hexanone	0.79	Not Detected	3.2	Not Detected
Dibromochloromethane	0.16	Not Detected	1.3	Not Detected
1,2-Dibromoethane (EDB)	0.16	Not Detected	1.2	Not Detected
Chlorobenzene	0.16	Not Detected	0.73	Not Detected
Ethyl Benzene	0.16	0.48	0.69	2.1
m,p-Xylene	0.16	1.6	0.69	6.8
o-Xylene	0.16	0.50	0.69	2.2
Styrene	0.16	Not Detected	0.67	Not Detected
Bromoform	0.16	Not Detected	1.6	Not Detected
Cumene	0.16	Not Detected	0.78	Not Detected
1,1,2,2-Tetrachloroethane	0.16	Not Detected	1.1	Not Detected
Propylbenzene	0.16	Not Detected	0.78	Not Detected
4-Ethyltoluene	0.16	0.47	0.78	2.3
1,3,5-Trimethylbenzene	0.16	0.16	0.78	0.78
1,2,4-Trimethylbenzene	0.16	0.56	0.78	2.8
1,3-Dichlorobenzene	0.16	Not Detected	0.95	Not Detected
1,4-Dichlorobenzene	0.16	Not Detected	0.95	Not Detected
alpha-Chlorotoluene	0.16	Not Detected	0.82	Not Detected
1,2-Dichlorobenzene	0.16	Not Detected	0.95	Not Detected
1,2,4-Trichlorobenzene	0.79	Not Detected	5.9	Not Detected
Hexachlorobutadiene	0.79	Not Detected	8.4	Not Detected

E = Exceeds instrument calibration range.

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	89	70-130
Toluene-d8	94	70-130
4-Bromofluorobenzene	112	70-130

SECTION 5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

April 18, 2008

John Smith
123 Main Street
Dayton, Ohio 45404

Dear Mr. Smith:

The purpose of this letter is to inform you of the 90-day proficiency sample results of the sub-slab (the space under your basement floor) and indoor air samples collected from your property on April 2, 2008. The samples were collected approximately 90 days following U.S. EPA installing a vapor abatement mitigation system at your property. The sample results are reviewed by U.S. EPA to determine the effectiveness of the system. We are specifically testing for the presence of trichloroethylene (also known as TCE), which has been detected in the groundwater under the neighborhood.

TCE is known as a volatile organic compound (VOC), which means it can easily evaporate (turn from a liquid to a gas) when it is exposed to the soil or air. TCE has the potential, as vapors, to move through the soils and work their way into building substructures, such as basements, where it can accumulate in the indoor air.

The results for the sub-slab and indoor air samples collected at your property are presented below and are identified as “Detected” where TCE was found in the samples. “ND” (no detection) is used when there is a chemical concentration less than the laboratory’s minimum detection limit (the laboratory’s minimum detection limit is written below in parentheses). The air samples are measured in units called parts per billion by volume (ppbv). Following the result for each sample is the “screening level” for the chemical. The Ohio Department of Health (ODH) has recommended the screening levels for sub-slab and indoor air.

Sub-Slab Sampling Results:
TCE: **3.8 ppbv**, ODH recommended screening level: 4 ppbv

The results from the **sub-slab air sample** collected at your property show that the chemical TCE was detected at 3.8 ppbv, which is less than the sub-slab screening level recommended by the ODH.

Indoor Air Sampling Results:
TCE: **ND (0.14) ppbv**, ODH recommended screening level: 0.4 ppbv

The results from the **indoor air sample** collected at your property show that the chemical TCE was not detected (ND) greater than 0.14 ppbv, which is less than the indoor air screening level recommended by the ODH.

The sub-slab and indoor air results are both beneath the TCE screening levels recommended by the ODH. The results show that the vapor abatement mitigation system is working properly and effectively reducing the vapors beneath your property. Because 90-day indoor air results are beneath the TCE screening levels recommended by the ODH, no further action is necessary. U.S. EPA would like to take this opportunity to thank you for participating in this mitigation program.

If you have health-related questions concerning this matter, please contact Dr. Bob Frey at the Ohio Department of Health at 614-466-1069. If you have questions related to the sampling or on-going site investigation, please feel free to contact me at 513-569-7539.

Sincerely,

Steven L. Renninger
On-Scene Coordinator
U.S. EPA Region 5

Attachments: Analytical Results

cc: Site File

SUB-SLAB AIR SAMPLE RESULTS

Client Sample ID: [redacted]S040208

Lab ID#: 0804121A-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**7040730**	**Date of Collection:**	**4/2/08**
Dil. Factor:	**1.58**	**Date of Analysis:**	**4/8/08 07:33 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.79	Not Detected	3.9	Not Detected
Freon 114	0.79	Not Detected	5.5	Not Detected
Chloromethane	3.2	Not Detected	6.5	Not Detected
Vinyl Chloride	0.79	Not Detected	2.0	Not Detected
1,3-Butadiene	0.79	Not Detected	1.7	Not Detected
Bromomethane	0.79	Not Detected	3.1	Not Detected
Chloroethane	0.79	Not Detected	2.1	Not Detected
Freon 11	0.79	Not Detected	4.4	Not Detected
Ethanol	3.2	Not Detected	6.0	Not Detected
Freon 113	0.79	Not Detected	6.0	Not Detected
1,1-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Acetone	3.2	Not Detected	7.5	Not Detected
2-Propanol	3.2	Not Detected	7.8	Not Detected
Carbon Disulfide	0.79	Not Detected	2.5	Not Detected
3-Chloropropene	3.2	Not Detected	9.9	Not Detected
Methylene Chloride	0.79	Not Detected	2.7	Not Detected
Methyl tert-butyl ether	0.79	Not Detected	2.8	Not Detected
trans-1,2-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Hexane	0.79	Not Detected	2.8	Not Detected
1,1-Dichloroethane	0.79	Not Detected	3.2	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.79	Not Detected	2.3	Not Detected
cis-1,2-Dichloroethene	0.79	Not Detected	3.1	Not Detected
Tetrahydrofuran	0.79	Not Detected	2.3	Not Detected
Chloroform	0.79	Not Detected	3.8	Not Detected
1,1,1-Trichloroethane	0.79	Not Detected	4.3	Not Detected
Cyclohexane	0.79	Not Detected	2.7	Not Detected
Carbon Tetrachloride	0.79	Not Detected	5.0	Not Detected
2,2,4-Trimethylpentane	0.79	Not Detected	3.7	Not Detected
Benzene	0.79	Not Detected	2.5	Not Detected
1,2-Dichloroethane	0.79	Not Detected	3.2	Not Detected
Heptane	0.79	Not Detected	3.2	Not Detected
Trichloroethene	0.79	3.8	4.2	20
1,2-Dichloropropane	0.79	Not Detected	3.6	Not Detected
1,4-Dioxane	3.2	Not Detected	11	Not Detected
Bromodichloromethane	0.79	Not Detected	5.3	Not Detected
cis-1,3-Dichloropropene	0.79	Not Detected	3.6	Not Detected
4-Methyl-2-pentanone	0.79	Not Detected	3.2	Not Detected
Toluene	0.79	Not Detected	3.0	Not Detected
trans-1,3-Dichloropropene	0.79	Not Detected	3.6	Not Detected

Client Sample ID: [redacted]S040208

Lab ID#: 0804121A-04A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name: 7040730		**Date of Collection: 4/2/08**
Dil. Factor: 1.58		**Date of Analysis: 4/8/08 07:33 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
1,1,2-Trichloroethane	0.79	Not Detected	4.3	Not Detected
Tetrachloroethene	0.79	1.3	5.4	9.1
2-Hexanone	3.2	Not Detected	13	Not Detected
Dibromochloromethane	0.79	Not Detected	6.7	Not Detected
1,2-Dibromoethane (EDB)	0.79	Not Detected	6.1	Not Detected
Chlorobenzene	0.79	Not Detected	3.6	Not Detected
Ethyl Benzene	0.79	Not Detected	3.4	Not Detected
m,p-Xylene	0.79	Not Detected	3.4	Not Detected
o-Xylene	0.79	Not Detected	3.4	Not Detected
Styrene	0.79	Not Detected	3.4	Not Detected
Bromoform	0.79	Not Detected	8.2	Not Detected
Cumene	0.79	Not Detected	3.9	Not Detected
1,1,2,2-Tetrachloroethane	0.79	Not Detected	5.4	Not Detected
Propylbenzene	0.79	Not Detected	3.9	Not Detected
4-Ethyltoluene	0.79	Not Detected	3.9	Not Detected
1,3,5-Trimethylbenzene	0.79	Not Detected	3.9	Not Detected
1,2,4-Trimethylbenzene	0.79	Not Detected	3.9	Not Detected
1,3-Dichlorobenzene	0.79	Not Detected	4.8	Not Detected
1,4-Dichlorobenzene	0.79	Not Detected	4.8	Not Detected
alpha-Chlorotoluene	0.79	Not Detected	4.1	Not Detected
1,2-Dichlorobenzene	0.79	Not Detected	4.7	Not Detected
1,2,4-Trichlorobenzene	3.2	Not Detected	23	Not Detected
Hexachlorobutadiene	3.2	Not Detected	34	Not Detected

Container Type: 6 Liter Summa Canister

Surrogates	%Recovery	Method Limits
Toluene-d8	89	70-130
1,2-Dichloroethane-d4	107	70-130
4-Bromofluorobenzene	100	70-130

INDOOR AIR SAMPLE RESULTS

Client Sample ID: [redacted]A040208

Lab ID#: 0804121B-09A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**y040725**	**Date of Collection: 4/2/08**
Dil. Factor:	**1.44**	**Date of Analysis: 4/8/08 04:58 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
Freon 12	0.14	0.44	0.71	2.2
Freon 114	0.14	Not Detected	1.0	Not Detected
Chloromethane	0.14	0.88	0.30	1.8
Vinyl Chloride	0.14	Not Detected	0.37	Not Detected
1,3-Butadiene	0.14	0.36	0.32	0.80
Bromomethane	0.14	Not Detected	0.56	Not Detected
Chloroethane	0.14	Not Detected	0.38	Not Detected
Freon 11	0.14	0.19	0.81	1.1
Ethanol	0.72	280 E	1.4	520 E
Freon 113	0.14	Not Detected	1.1	Not Detected
1,1-Dichloroethene	0.14	Not Detected	0.57	Not Detected
Acetone	0.72	7.1	1.7	17
2-Propanol	0.72	12	1.8	30
Carbon Disulfide	0.72	Not Detected	2.2	Not Detected
Methylene Chloride	0.29	Not Detected	1.0	Not Detected
Methyl tert-butyl ether	0.14	Not Detected	0.52	Not Detected
trans-1,2-Dichloroethene	0.14	Not Detected	0.57	Not Detected
Hexane	0.14	0.89	0.51	3.1
1,1-Dichloroethane	0.14	Not Detected	0.58	Not Detected
2-Butanone (Methyl Ethyl Ketone)	0.14	0.82	0.42	2.4
cis-1,2-Dichloroethene	0.14	Not Detected	0.57	Not Detected
Tetrahydrofuran	0.72	Not Detected	2.1	Not Detected
Chloroform	0.14	Not Detected	0.70	Not Detected
1,1,1-Trichloroethane	0.14	Not Detected	0.78	Not Detected
Cyclohexane	0.14	0.18	0.50	0.61
Carbon Tetrachloride	0.14	Not Detected	0.91	Not Detected
Benzene	0.14	1.0	0.46	3.3
1,2-Dichloroethane	0.14	Not Detected	0.58	Not Detected
Heptane	0.14	0.29	0.59	1.2
Trichloroethene	0.14	Not Detected	0.77	Not Detected
1,2-Dichloropropane	0.14	Not Detected	0.66	Not Detected
1,4-Dioxane	0.14	Not Detected	0.52	Not Detected
Bromodichloromethane	0.14	Not Detected	0.96	Not Detected
cis-1,3-Dichloropropene	0.14	Not Detected	0.65	Not Detected
4-Methyl-2-pentanone	0.14	Not Detected	0.59	Not Detected
Toluene	0.14	3.1	0.54	12
trans-1,3-Dichloropropene	0.14	Not Detected	0.65	Not Detected
1,1,2-Trichloroethane	0.14	Not Detected	0.78	Not Detected
Tetrachloroethene	0.14	Not Detected	0.98	Not Detected

Client Sample ID: [redacted]A040208

Lab ID#: 0804121B-09A

MODIFIED EPA METHOD TO-15 GC/MS FULL SCAN

File Name:	**y040725**	**Date of Collection: 4/2/08**
Dil. Factor:	**1.44**	**Date of Analysis: 4/8/08 04:58 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (uG/m3)	Amount (uG/m3)
2-Hexanone	0.72	Not Detected	2.9	Not Detected
Dibromochloromethane	0.14	Not Detected	1.2	Not Detected
1,2-Dibromoethane (EDB)	0.14	Not Detected	1.1	Not Detected
Chlorobenzene	0.14	Not Detected	0.66	Not Detected
Ethyl Benzene	0.14	0.43	0.62	1.9
m,p-Xylene	0.14	1.4	0.62	5.9
o-Xylene	0.14	0.34	0.62	1.4
Styrene	0.14	Not Detected	0.61	Not Detected
Bromoform	0.14	Not Detected	1.5	Not Detected
Cumene	0.14	Not Detected	0.71	Not Detected
1,1,2,2-Tetrachloroethane	0.14	Not Detected	0.99	Not Detected
Propylbenzene	0.14	Not Detected	0.71	Not Detected
4-Ethyltoluene	0.14	0.23	0.71	1.1
1,3,5-Trimethylbenzene	0.14	Not Detected	0.71	Not Detected
1,2,4-Trimethylbenzene	0.14	0.24	0.71	1.2
1,3-Dichlorobenzene	0.14	Not Detected	0.86	Not Detected
1,4-Dichlorobenzene	0.14	Not Detected	0.86	Not Detected
alpha-Chlorotoluene	0.14	Not Detected	0.74	Not Detected
1,2-Dichlorobenzene	0.14	Not Detected	0.86	Not Detected
1,2,4-Trichlorobenzene	0.72	Not Detected	5.3	Not Detected
Hexachlorobutadiene	0.72	Not Detected	7.7	Not Detected

E = Exceeds instrument calibration range.

Container Type: 6 Liter Summa Canister (100% Certified)

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	93	70-130
Toluene-d8	95	70-130
4-Bromofluorobenzene	104	70-130

SECTION 6

U.S. EPA Website for the Behr VOC Site

The U.S. EPA has created a website to provide residents with important information concerning this project. The web address is listed at the bottom of the page. The following information may be found at this website:

- Information on the current status of this project;
- Ohio Department of Health Fact Sheets related to Vapor Intrusion, TCE, and Exposure to Toxic Chemicals;
- Maps showing the project status;
- Photo images of various events that have occurred during the project; and
- Contact information for the U.S. EPA, Ohio Department of Health, Ohio EPA and other members of the project team.

Site Profile

Page 1 of 3

Behr VOC Plume - EPA Fund Lead Removal

Dayton, OH - EPA Region V

Site Contact:
Steven Renninger
On-Scene Coordinator
renninger.steven@epa.gov

epaosc.net/behrvocplumeepafundleadremoval

919 North Keowee Street
Dayton, OH 45404

Latitude: 39.773925
Longitude: -84.181406

site map | area map | weather | bookmark

The EPA Command Post Phone Number is **937-262-7919** and is located at 919 North Keowee Street, Dayton, Ohio.

The Behr VOC Plume (EPA Fund Lead Removal) and the Behr VOC Plume Site (funded by Chrysler) are simultaneous removal actions at the same site. This website is for the Behr VOC Plume (EPA Fund Lead Removal). For further information on the Behr VOC Plume Site (Chrysler funded) see the following link:

"http://www.epaosc.net/behrvocplume"

The Behr Dayton Thermal Products Facility (Behr-Dayton facility) is located at 1600 Webster Street, Dayton, Montgomery County, Ohio. The Behr-Dayton facility manufactures vehicle air conditioning and engine cooling systems at the facility. Chrysler Corporation owned and operated the Behr-Dayton facility from at least 1937 until April of 2002.

The groundwater beneath the Behr-Dayton facility is contaminated with volatile organic compounds, including trichloroethene (TCE). Chrysler contracted Earth Tech to design, install, and operate two systems for the remediation of soil and groundwater contamination under the Behr-Dayton facility, with TCE as the main contaminant of concern. Earth Tech installed a Soil Vapor Extraction (SVE) system on the Behr-Dayton facility

www.epaosc.net\behrvocplumeepafundleadremoval

SECTION 7

U.S. EPA and its vapor abatement mitigation system installation team installed one of the following two fans at your property.

If warranty service is required or if you have any questions regarding your mitigation system, please call AtHomeRadon at 513.561.8378.

Thank you.

Five (5) Year Warranty

FANTECH HP220

This warranty supersedes all prior warranties

Installation that will result in condensate forming in the outlet ducting should have a condensate bypass installed to route the condensate outside of the fan housing. Conditions that are likely to produce condensate include but are not limited to: outdoor installations in cold climates, long lengths of outlet duction, high moisture content in soil and thin wall or aluminum outlet ducting. Failure to install a proper condensate bypass may void any warranty claims.

DURING ENTIRE WARRANTY PERIOD:

FANTECH will repair or replace any part which has a factory defect in workmanship or material. Product may ~~need~~ to be returned to the fantech factory, together with a copy of the bill of sale and identified with RMA number.

FOR FACTORY RETURN YOU MUST:

- Have a Return Materials Authorization (RMA) number. This may be obtained by calling FANTECH either in the USA at 1.800.747.1762 or in CANADA at 1.800.565.3548. Please have bill of sale available.
- The RMA number must be clearly written on the outside of the carton, or the carton will be refused.
- All parts and/or product will be repaired/replaced and shipped back to buyer; no credit will be issued.

OR

The Distributor may place an order for the warranty part and/or product and is invoiced. The Distributor will receive a credit equal to the invoice only after product is returned prepaid and verified to be defective.

FANTECH WARRANTY TERMS DO NOT PROVIDE FOR REPLACEMENT WITHOUT CHARGE PRIOR TO INSPECTION FOR A DEFECT. REPLACEMENTS ISSUED IN ADVANCE OF DEFECT INSPECTION ARE INVOICED, AND CREDIT IS PENDING INSPECTION OF RETURNED MATERIAL. DEFECTIVE MATERIAL RETURNED BY END USERS SHOULD NOT BE REPLACED BY THE DISTRIBUTOR WITHOUT CHARGE TO THE END USER, AS CREDIT TO DISTRIBUTOR'S ACCOUNT WILL BE PENDING INSPECTION AND VERIFICATION OF ACTUAL DEFECT BY FANTECH.

THE FOLLOWING WARRANTIES DO NOT APPLY:

- Damages from shipping, either concealed or visible. Claim must be filed with freight company.
- Damages resulting from improper wiring or installation.
- Damages or failure caused by acts of God, or resulting from improper consumer procedures, such as:
  1. Improper maintenance
  2. Misuse, abuse, abnormal use, or accident, and
  3. Incorrect electrical voltage or current.
- Removal or any alteration made on the FANTECH label control number or date of manufacture.
- Any other warranty, expressed, implied or written, and to any consequential or incidental damages, loss or property, revenues, or profit, or costs of removal, installation or reinstallation, for any breach of warranty.

WARRANTY VALIDATION

- The user must keep a copy of the bill of sale to verify purchase date.
- These warranties give you specific legal rights, and are subject to an applicable consumer protection legislation. You may have additional rights which vary from state to state.

United States
1712 Northgate Blvd.,
Sarasota, FL. 34234
Phone: 800.747.1762; 941.309.6000
Fax: 800.487.9915; 941.309.6099
www.fantech.net; info@fantech.net

Canada
50 Kanalflakt Way,
Bouctouche, NB E4S 3M5
Phone: 800.565.3548; 506.743.9500
Fax: 877.747.8116; 506.743.9600
www.fantech.ca; info@fantech.ca

Article #: 301077
Item #: 401443
Rev Date: 010307

RADON AWAY XP-201

IMPORTANT INSTRUCTIONS TO INSTALLER

Inspect the GPx01/XP/XR Series Fan for shipping damage within 15 days of receipt. Notify RadonAway of any damages immediately. Radonaway is not responsible for damages incurred during shipping. However, for your benefit, Radonaway does insure shipments.

There are no user serviceable parts inside the fan. **Do not attempt to open.** Return unit to factory for service.

Install the GPx01/XP/XR Series Fan in accordance with all EPA standard practices, and state and local building codes and state regulations.

WARRANTY

Subject to any applicable consumer protection legislation, RadonAway warrants that the GPX01/XP/XR/RP Series Fan (the "Fan") will be free from defects in materials and workmanship for a period of 90 days from the date of purchase (the "Warranty Term").

RadonAway will replace any Fan which fails due to defects in materials or workmanship. The Fan must be returned (at Owner's cost) to the RadonAway factory. Any Fan returned to the factory will be discarded unless the Owner provides specific instructions along with the Fan when it is returned regardless of whether or not the Fan is actually replaced under this warranty. Proof of purchase must be supplied upon request for service under this Warranty.

This Warranty is contingent on installation of the Fan in accordance with the instructions provided. This Warranty does not apply where any repairs or alterations have been made or attempted by others, or if the unit has been abused or misused. Warranty does not cover damage in shipment unless the damage is due to the negligence of RadonAway.

5 YEAR EXTENDED WARRANTY WITH PROFESSIONAL INSTALLATION.

RadonAway will extend the Warranty Term of the fan to 5 years from date of manufacture if the Fan is installed in a professionally designed and professionally installed radon system or installed as a replacement fan in a professionally designed and professionally installed radon system. Proof of purchase and/or proof of professional installation may be required for service under this warranty. Outside the Continental United States and Canada the extended Warranty Term is limited to one (1) year from the date of manufacture.

RadonAway is not responsible for installation, removal or delivery costs associated with this Warranty.

EXCEPT AS STATED ABOVE, THE GPx01/XP/XR/RP SERIES FANS ARE PROVIDED WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

IN NO EVENT SHALL RADONAWAY BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES ARISING OUT OF, OR RELATING TO, THE FAN OR THE PERFORMANCE THEREOF. RADONAWAY'S AGGREGATE LIABILITY HEREUNDER SHALL NOT IN ANY EVENT EXCEED THE AMOUNT OF THE PURCHASE PRICE OF SAID PRODUCT. THE SOLE AND EXCLUSIVE REMEDY UNDER THIS WARRANTY SHALL BE THE REPAIR OR REPLACEMENT OF THE PRODUCT, TO THE EXTENT THE SAME DOES NOT MEET WITH RADONAWAY'S WARRANTY AS PROVIDED ABOVE.

For service under this Warranty, contact RadonAway for a Return Material Authorization (RMA) number and shipping information. No returns can be accepted without an RMA. If factory return is required, the customer assumes all shipping cost to and from factory.

RadonAway
3 Saber Way
Ward Hill, MA 01835
TEL. (978) 521-3703
FAX (978) 521-3964

Record the following information for your records:

Serial No.____________________________________

Purchase Date___________________________

ATTACHMENT V

O&M MANUAL ACCEPTANCE FORM

Vapor Abatement Mitigation System Operations and Maintenance Informational Manual Acceptance Form

Date: ___________________

Address: ____

By signing below, I acknowledge that I have received the U.S. EPA Operations and Maintenance Informational Manual.

______________________________	______________________________
PRINTED NAME	**SIGNATURE**

ATTACHMENT W

QUICK GUIDE

VAPOR ABATEMENT SYSTEM

QUICK GUIDE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPA

EMERGENCY RESPONSE

VAPOR ABATEMENT SYSTEM
“QUICK GUIDE”

SITE BACKGROUND

The United States Environmental Protection Agency (U.S. EPA) has prepared this “Quick Guide” to inform occupants of this property that a vapor abatement system was installed at this property to address chlorinated volatile organic compounds (VOCs) migrating into the basements of residential and commercial properties south of the Behr Dayton Thermal Products Facility located at 1600 Webster Street in Dayton, Ohio (Behr-Dayton facility). The scientific term for the migration of chemicals into overlying homes is called “vapor intrusion”. This work is being performed pursuant to a Unilateral Administrative Order dated July 31, 2009, issued by U.S. EPA to Behr America, Inc. (Behr). The vapor abatement system was installed in response to a trichloroethylene (TCE) contaminated groundwater plume which has migrated south-southwest of the Behr-Dayton facility and beneath the residential and commercial properties in the McCook Field neighborhood.

WHAT IS VAPOR INTRUSION?

Vapor Intrusion is the migration of volatile chemicals (ie, TCE) from the subsurface into overlying buildings. TCE-contaminated groundwater can emit vapors that may migrate through subsurface soils and into indoor air spaces of overlying buildings in ways similar to that of radon gas seeping into homes, as shown in the illustration below. As Figure 1 illustrates, the vapor intrusion pathway may be important for buildings both with and without a basement.

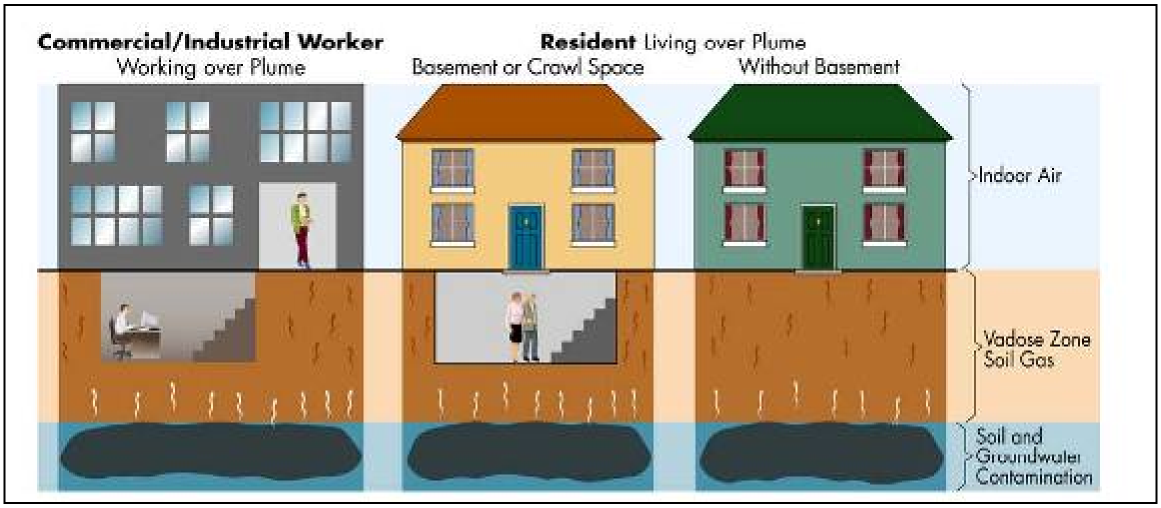


Figure 1 - Vapor Intrusion Pathway

WHAT IS A VAPOR ABATEMENT SYSTEM?

A vapor abatement system is similar to a “radon mitigation system”. The system removes TCE vapors that are accumulating beneath the property and venting the TCE vapors, where the chemical is then vented in the atmosphere. The system does not clean the air inside the property. The system prevents TCE vapors from entering the basement and into the breathing zone of the property. After the system was installed, indoor air sampling was conducted to confirm that the system was operational.

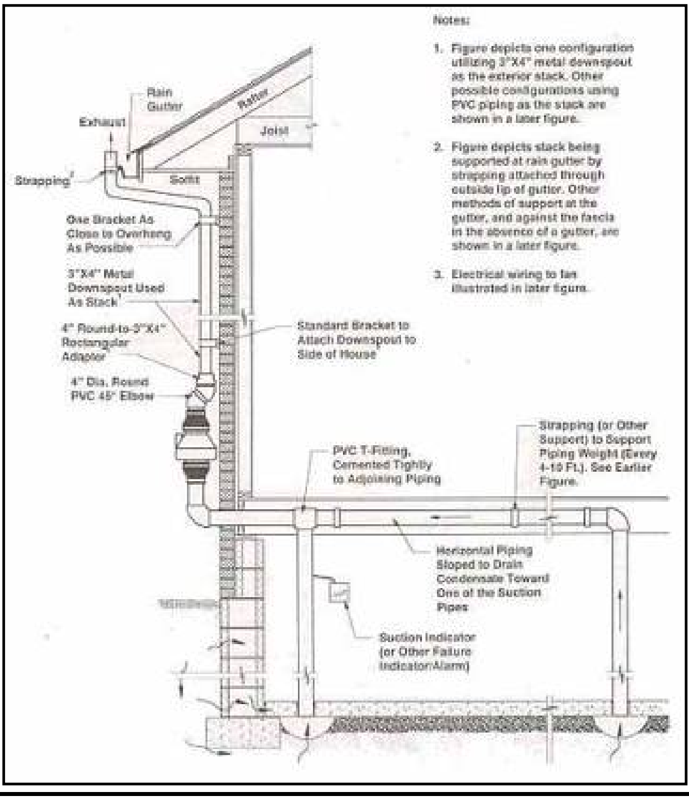
A portion of the basement slab was cored and a 3-inch diameter Schedule 40 polyvinyl chloride (PVC) piping was routed through the slab and then outside the basement through a wall penetration. The vertical PVC pipe through the slab floor is called an “extraction point”. The PVC pipe was then connected to an extraction fan and the exhaust piping was routed to the roof-line, taking care to exhaust the air above any nearby intake pipes or building windows. The system must remain ‘on’ at all times.

Since 2008, U.S. EPA has overseen the installation of approximately 240 vapor abatement systems in residential and commercial properties within the McCook Field neighborhood.

WHY WAS A VAPOR ABATEMENT SYSTEM INSTALLED AT THIS PROPERTY?

The Ohio Department of Health (ODH) established conservative action levels to determine if a property requires a vapor abatement system. When the subslab (air under your basement floor) and/or the indoor air were sampled by U.S. EPA/Behr, TCE concentrations were observed greater that the screening levels recommended by ODH. As a result, a vapor abatement system was installed. See Figure 2 for an illustration of a typical vapor abatement system.

Figure 2 – Illustration of a Typical Vapor Abatement System



Notes:

1. Figure depicts one configuration utilizing 3"X4" metal downspout as the exterior stack. Other possible configurations using PVC piping as the stack are shown in a later figure.
2. Figure depicts stack being supported at rain gutter by strapping attached through outside lip of gutter. Other methods of support at the gutter, and against the fascia in the absence of a gutter, are shown in a later figure.
3. Electrical wiring to fan illustrated in later figure.

This is called a U-tube manometer. It shows if the system is pulling vacuum.

View of the extraction well pipe inside the basement.

View of the outside fan and the piping which vents the vapors that accumulate beneath the property

What if the systems stops working or if I have questions about the vapor abatement system?

If you have any questions, please call either of the numbers below.

John Smith	(937) 123-4567
Mike Jones	(937) 234-5678

Where can I found out more information on the McCook Field neighborhood project?

If you still have questions, go to the following U.S. EPA project website: http://www.epaosc.org/site_profile.asp?site_id=2642

Site Profile

Page 1 of 3

Behr VOC Plume - EPA Fund Lead Removal

Dayton, OH - EPA Region V

Site Contact:
Steven Renninger
On-Scene Coordinator
renninger.steven@epa.gov

epaosc.net/behrvocplumeepafundleadremoval

919 North Keowee Street
Dayton, OH 45404

Latitude: 39.773925
Longitude: -84.181406

site map | area map | weather | bookmark

The EPA Command Post Phone Number is 937-262-7919 and is located at 919 North Keowee Street, Dayton, Ohio.

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http://epaosc.net/site_profile.asp?site_id=3677

5/20/2008

How do I know that my vapor abatement system is working properly?

The vapor abatement system will be inspected on an annual basis to ensure that it is working properly. A Behr contractor representative will contact the property owner for access to inspect the system. If anything is found to be wrong with the system, such as the fan not working or the fan making unusual noises, the problem will corrected at no cost to the property owner.

ATTACHMENT X

MITIGATION SYSTEM ANNUAL INSPECTION FORM

U.S. EPA

Sub-Slab and Sub-Membrane Depressurization System

Annual O&M Inspection Form

Property Address:		Temperature (Ambient)		F
Tenant's Name:		Temperature (House)		F
Owner's Name:		Barometric Pressure		"Hg
Owner's Address (If Different from Property)		Weather Conditions:		
Inspector Name:				
Date:				
Time:				

Exterior System Inspection

Is fan intact and operational?	yes	no	Any heaving or subsidence at suction point?	yes	no
Any unusual fan vibrations?	yes	no	Any whistling noises noted?	yes	no
Is vent piping/downspout intact?	yes	no	Caulk seals inspected?	yes	no
Any caulking required around fan and piping connections?	yes	no	Cracking or Separation of piping joints?	yes	no

Interior System Inspection

Tenant Observations

Any change in fan noise or vibration?	yes	no	
Any lack of differential pressure in the manometer?	yes	no	
Have you turned the fan off for any period of time?	yes	no	Reason?
Have you or the owner made any changes to the basement?	yes	no	

If so, what were the changes:

Measurements

System Manometer Reading		"H_2O	Initial System Manometer Reading		"H_2O
Vacuum Point 1		"H_2O	Vacuum Point 1		"H_2O
Vacuum Point 2		"H_2O	Vacuum Point 2		"H_2O
Vacuum Point 3		"H_2O	Vacuum Point 3		"H_2O
Vacuum Point 4		"H_2O	Vacuum Point 4		"H_2O

Is the System Manometer Steady? yes no

Comments (any repairs made while visiting, etc…):