This document references Chapters and Sections from the ITRC Vapor Intrusion Technical and Regulatory Guidance, and Fact Sheets and Technology Information Sheets from the ITRC Vapor Intrusion Toolkit, published January 2026. These resources can be accessed at: **https://itrcweb.org/vapor-intrusion-toolkit**.

DIRECT VOLATILIZATION TO INDOOR AIR FACT SHEET

Introduction

Direct volatilization to indoor air occurs when vapor-forming chemicals (VFCs) have been released into the environment and migrated through groundwater or directly into a building where they can off-gas directly into indoor air without first migrating through subsurface soils and across a concrete building foundation.

A key assumption in vapor intrusion (VI) is that a reduction in chemical concentration (i.e., attenuation) occurs as VFCs migrate upward from their source, through the subsurface, and across the building foundation. In the case of direct volatilization to indoor air, this attenuation does not occur. Direct volatilization refers to the process by which VFCs vaporize or migrate directly into a building's breathing space without first traveling through the vadose zone. This poses a separate exposure pathway that differs from traditional VI.

Direct volatilization to indoor air is commonly associated with very shallow sources of groundwater containing VFCs that may have entered or is in direct contact with a building (e.g., through a sump). Please note that VFCs can readily enter a building in situations where groundwater is being used as a potable water source; however, this situation can result in multiple exposure pathways (e.g., drinking water ingestion, dermal contact, etc.) and, therefore, is outside the scope of this document. For additional information on evaluating risk from potable water use, please see the U.S. Environmental Protection Agency's (USEPA's) **Risk Assessment Guidance for Superfund, Volume I Human Health Evaluation Manual (Part A)** (USEPA 1989).

Figure 1 depicts common scenarios that may be encountered for the direct volatilization.

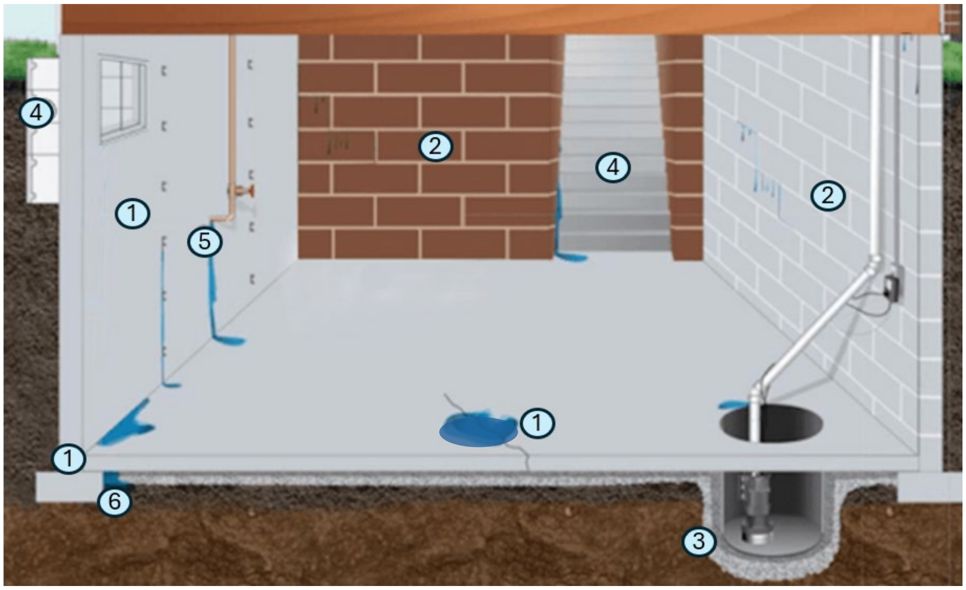

Figure 1. Common direct volatilization scenarios. Direct volatilization can occur when groundwater containing VFCs or the release enters through: (1) cracks in the foundation and floor; (2) mortar joints; (3) sump(s), vault(s) or penetration(s); (4) window wells and walk-up basement bulkheads; and (5) pipe penetrations; or (6) the foundation where it is in contact with foundation soil, including drain tile.

Because of the lack of subsurface attenuation, it is inappropriate to identify sites or buildings unlikely to pose a health concern through VI through the use of sub-slab, groundwater, and soil vapor screening values. Under these circumstances, further evaluation of the inhalation pathway is warranted if VFCs are present in groundwater or have directly entered into a building, as these vapors may pose a health risk to building occupants. Determining whether VFCs are present above a concentration may pose a challenge given the lack of published subsurface screening levels available for direct volatilization scenarios; therefore, some regulatory agencies may default to the presence or absence of a VFC.

It is common to conflate direct volatilization with soil VI for at least three reasons: (1) direct volatilization is sometimes discovered because of a VI investigation, (2) some buildings experience both VI and direct volatilization, and (3) direct volatilization site contaminants may enter living spaces as vapors. Regardless of the terminology used, it is important to explain that direct volatilization requires a different approach to mitigation than VI.

Conceptual Site Model Considerations

The value of a conceptual site model (CSM) in evaluating the potential for VI is well established by sources such as USEPA (USEPA OUST 2015; USEPA 2015) and the Department of Defense (USDOD 2009). The VI CSM helps practitioners assess the potential for a complete VI pathway, identify data gaps, and communicate findings to stakeholders. A VI CSM plays an equally critical role when evaluating whether direct volatilization to indoor air is a potential exposure pathway instead of, or in addition to, traditional VI.

When evaluating direct volatilization, the VI CSM should provide an overview of the inhalation pathway (including the location and types of VFCs), subsurface vapor transport mechanisms, building conditions (e.g., foundation), openings within the building, and potential receptors. This information will be similar to what is typically addressed in a CSM for VI.

With direct volatilization, VFCs released into the subsurface may enter a building through the direct intrusion of VFC containing groundwater or directly without attenuation or dispersion occurring in the subsurface or across the building foundation. Therefore, a VI CSM adequate for evaluating VI may not provide sufficient information for evaluating direct volatilization. For example, more detailed information about slab and sub-slab conditions, as well as building openings, may be necessary.

Since CSMs are evolving documents, additional information related to direct volatilization should be incorporated to enhance the VI CSM and inform the selection of appropriate vapor control strategies when required.

Vapor Source and Concentration

Direct volatilization to indoor air can occur when VFCs are present from any subsurface source, similar to the VI pathway. VFCs may include the following:

- Volatile organic compounds, such as trichloroethylene and benzene
- Certain semivolatile organic compounds, such as naphthalene
- Elemental mercury
- Some polychlorinated biphenyls and pesticides

The key distinction is that for unacceptable human health risks to arise from direct volatilization, the VFCs must be in direct contact with, or capable of entering, a building and volatilizing directly into its indoor air without attenuation in the subsurface or across a concrete building foundation. Consequently, determining whether VFCs are present at a sufficiently high concentration to pose potential human health risks is challenged by the absence of published screening levels available for this scenario.

Building Conditions

Understanding the building's construction, openings, and utilities is essential for evaluating the potential for unacceptable risk from direct volatilization. Below is a brief description of the key factors:

- **Direct entry into a building:** This is typically associated with sites where shallow groundwater containing VFCs comes into contact with a building and enters it. This allows vapors to directly off-gas into the building's indoor air, often identified through sumps or conduits in direct communication with groundwater.
- **Direct contact:** In cases where VFCs are present near a building but there is no visible indication that groundwater has entered into it, this can often be identified through the presence of a lower level of a building, vault, or elevator pit, or sumps that may be occasionally or seasonably below the hydrostatic level of the groundwater. Vapors can still enter the building with minimal or no attenuation. This typically occurs when there is little or no soil between the VFCs and the building.

Investigation and Evaluation

VI investigations commonly involve collecting vapor samples from areas between the vapor source and the building. Evaluating this data typically includes an initial comparison of the resulting data to appropriate published risk-based screening levels. Published screening levels generally include the incorporation of some sort of subsurface attenuation factor, either based on modeling or on empirical data from published studies. Since direct volatilization occurs without much, if any, attenuation in the subsurface, existing published screening levels are not generally available. The challenges this creates in determining whether VFCs are present in the source medium at concentrations sufficient to warrant further evaluation leaves limited options for evaluating the pathway.

The most straightforward investigation/evaluation option involves air sampling within the building. Indoor air samples may contain VFCs from various sources, complicating the assessment of contributions from different sources. To better understand the source of the VFCs, it may be helpful to identify where the vapors enter the building and sample the water at that location. Detailed guidance on collecting indoor air samples is available in **Section 7.5.1**, and information on background sources is available in **Background Sources to Indoor Air Fact Sheet**. Similarly, the sump could be temporarily capped and an air sample collected from within the sump. The methodology for evaluating the contributions of different vapor sources is outside the scope of this document.

In cases where impacted water is directly exposed to indoor air, such as when sumps are present in areas with shallow groundwater, there may be a benefit to conducting a simple calculation to estimate the potential associated vapor concentration. This can be done by multiplying the concentration in the exposed water source by the chemical-specific dimensionless Henry's Law. This will provide a conservative estimate of the vapor concentration that could potentially occur at the location of the water source (USEPA 1994). Vapor concentrations are likely to decrease over distance as one moves away from the exposed water source. As multiple methods are available to estimate vapor dispersion in indoor air, practitioners should consult with their regulatory agency to agree upon an appropriate dispersion model.

Mitigation

Mitigating the risk from VFCs due to direct volatilization typically involves the following strategies:

- Removing or reducing VFCs in contact with the building.
- Preventing VFCs from entering the building (e.g., sealing and venting of a sump).
- Addressing any off-gassing of VFCs or preventing vapors from entering.

Many mitigation strategies for VI are discussed in **Chapter 10**, but those effective for direct volatilization are a smaller subset. Some common VI mitigation strategies, such as sub-slab depressurization, may not be effective to address direct volatilization by itself. Careful consideration of the VFCs, their location, and the rate at which they can enter the building is essential for selecting appropriate mitigation measures.

REFERENCES

USDOD. 2009. *DoD Vapor Intrusion Handbook*. Tri-Service Environmental Risk Assessment Workgroup. U.S. Department of Defense. **https://clu-in.org/download/char/dodvihdbk200901.pdf**.

USEPA. 1989. *Risk Assessment: Guidance for Superfund Volume 1 Human Health Evaluation Manual (Part A)*. United States Environmental Protection Agency. **https://www.epa.gov/system/files/documents/2024-10/rags_a_508.pdf**.

USEPA. 1994. *Air Emissions Models for Waste and Wastewater*. EPA-453/R-94-080A. United States Environmental Protection Agency. **https://www.epa.gov/sites/default/files/2020-08/documents/air_emission_models_waste_wastewater.pdf**.

USEPA. 2015. *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. **https://www.epa.gov/sites/default/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf**.

USEPA OUST. 2015. *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites*. U.S. Environmental Protection Agency, Office of Underground Storage Tanks. **https://www.epa.gov/sites/default/files/2015-06/documents/pvi-guide-final-6-10-15.pdf**.