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**.

# VAPOR INTRUSION PREFERENTIAL PATHWAYS FACT SHEET

## Introduction

The purpose of this fact sheet is to describe what may be considered a potential preferential pathway in the context of a vapor intrusion (VI) assessment and to summarize the role preferential pathways play in VI sampling, VI data evaluation, and VI mitigation.

Since around 2010, there has been an increase in understanding of vapor transport in the subsurface and within subsurface features. This fact sheet captures this updated understanding of the science and better defines terms used to describe vapor transport. In the past, the term *preferential pathway* had been used generically to apply to most ways in which vapors traveled near and into a building (for example calling an expansion joint in a building slab a preferential pathway). Being more specific with the terminology related to preferential pathways, however, will support a clearer VI conceptual site model (CSM) and help focus investigation, sampling, and mitigation resources more effectively.

This fact sheet introduces useful definitions including the term vapor intrusion preferential pathway (VIPP). It also includes descriptions of two of the most common types of features that could be considered VIPPs: conduit VIPPs and vertical VIPPs. It discusses why it is important to distinguish between VIPPs and typical potential vapor entry points (i.e., cracks, drains, expansion joints, etc.), lists common types of conduits that may be potential VIPPs and may need to be considered, and provides CSM scenarios where VIPPs may need further consideration during the VI assessment or mitigation stages of a project. In this fact sheet, the terms conduit VIPP, vertical VIPP, and vapor entry point will be used to refer to certain building and subsurface features. It should be noted, however, that these terms are referring only to potential VIPPs and potential vapor entry points. Not all of these building and subsurface features are going to transport vapor to and through a building. The word *potential* may not be used in front of each of these terms but is implied throughout the fact sheet.

Proper identification and evaluation of the potential influence of VIPPs is also important as they may act as precluding factors in distance-based screening or other site screening; this means that, if present, additional evaluations for VI will be warranted.

## Definition of VIPPs

VIPPs are pathways that intersect both the vapor source and the building foundation and provide for an increased flow of vapors that is higher than expected under typical conditions (i.e., typical vapor transport through vadose zone soils).

To focus the concept of VIPPs, the term explicitly excludes common features present in almost all buildings, such as typical subsurface utility penetrations, building foundation cracks, expansion joints, floor drains, etc. In this guidance document, these common features are known as vapor entry points and do not meet the definition of a VIPP. Vapor entry points (and vapor transport pathways within the interiors of buildings) are defined separately in the VIPPs versus Typical Building Features section of this fact sheet.

More detailed definitions of VIPPs are provided below:

- **Conduit VIPP:** Features that could potentially connect distal subsurface vapor-forming chemical (VFC) sources to the target building. They are high-permeability or high-capacity (e.g., the void space inside of a pipe) transport pathways that operate via advection and can be natural or anthropogenic. These commonly are outside, or extend outside, of the building footprint enhancing transport toward the building. Examples include sanitary sewers, utility tunnels or other subgrade pipes, and karst geology. A conduit VIPP can allow vapors to migrate from a VFC source area to or near a building via advection at a higher rate compared to transport through bulk soil.

- **Vertical VIPP:** Features that are within the building footprint and could potentially enhance vertical transport into the building that may not have happened under typical building construction or operating conditions. Vertical VIPPs include features such as elevator sumps and dry wells. They allow vapors to migrate into a building from the subsurface more easily than other typical vapor entry points.

Further detail on conduit VIPPS and vertical VIPPS are presented in subsequent sections of this fact sheet. **Figure 1** is a graphical summary illustrating VIPPs and vapor entry points. This figure shows examples that have been documented in literature and is not intended to be comprehensive. See Beckley and McHugh (2020) and Loll (2025) for more information on VIPP scenarios.

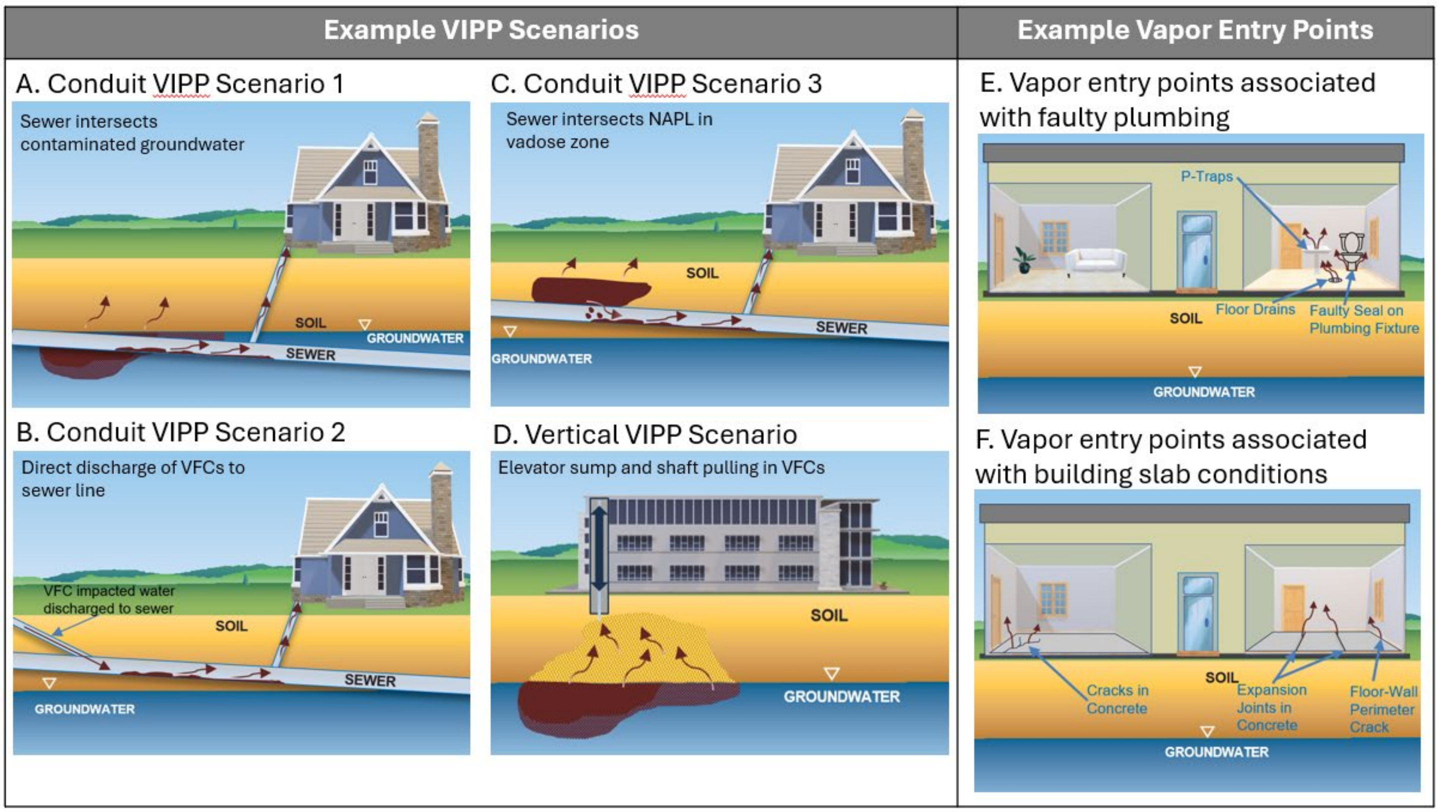


**Figure 1. Example vapor intrusion preferential pathways and vapor entry points.**

*Source: Laura Trozzolo, Lila Beckley, and Catherine Regan. Used with permission.*

## Conduit VIPPs

Conduit VIPPs enhance transport beyond what we would normally have considered based on the standard CSM for VI (see **Chapter 4: Conceptual Site Model**). The VFC flux is through the interior of the conduit. It is important to note that not all subsurface conduits present at or near a site/building will present as conduit VIPPs. A conduit VIPP is more likely to occur if all of the following are present:

1. There is a subsurface source of VFCs (e.g., nonaqueous-phase liquid [NAPL], soil contamination, groundwater plume).
2. There is a conduit connecting the source to a building.
3. The conduit is breached such that the VFCs can enter the conduit.
4. There is a mechanism to bring VFCs in the conduit to the building envelope. The VFC entry into the building would then occur and would typically be through vapor entry points.

A conduit VIPP may also be more likely to occur if, instead of a breach in the conduit as presented above, the VFCs have been disposed of directly into the conduit (**Figure 1**, Panel B). This may occur if, for example, dry-cleaning VFCs (such as tetrachloroethene [PCE, also called perchloroethene and tetrachloroethylene]) are put directly into the sanitary sewer or there is a permitted discharge of impacted recovered groundwater directly into the sewer. A conduit VIPP may increase the potential for VI for multiple buildings connected to the impacted conduit. Examples are shown in **Figure 1**, Panels A, B, and C. An example of a natural conduit VIPP is shown in **Figure 2**.

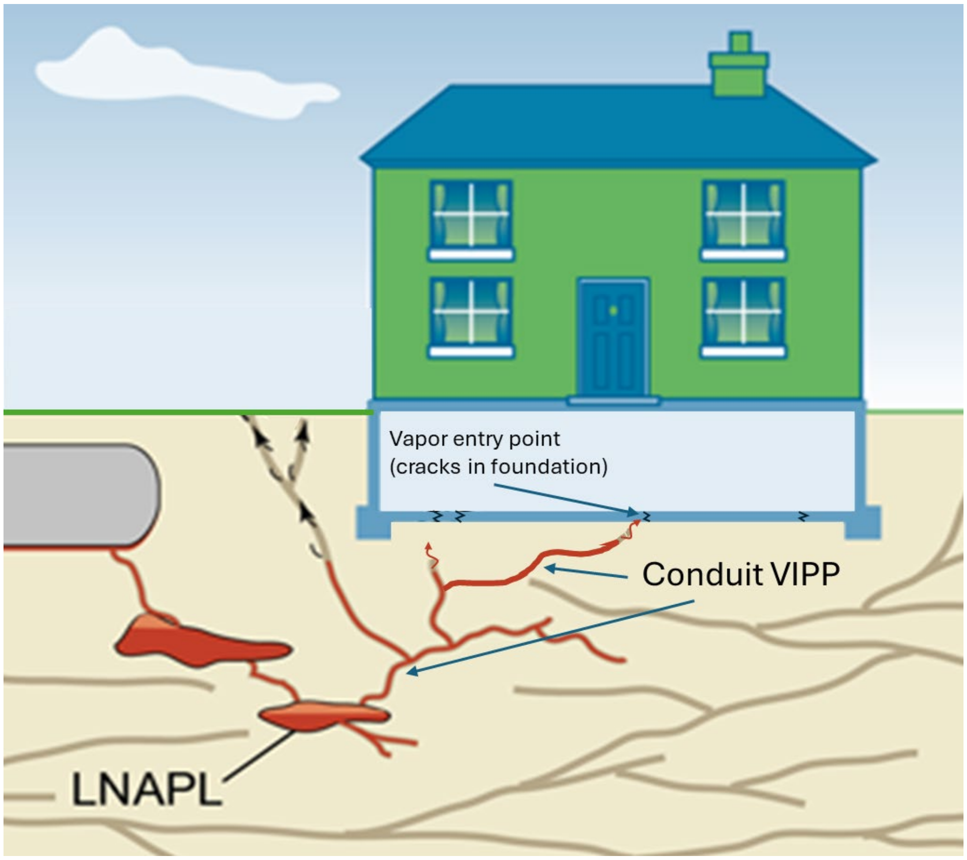


**Figure 2. Example of a natural conduit vapor intrusion preferential pathway.**

## Vertical VIPPs

Vertical VIPPs include features such as elevator sumps and dry wells. For example, an elevator sump may constitute a vertical VIPP into a building because it may be constructed with subbasement perforations to allow water to drain. Vapor may be drawn in via advection through these perforations by the upward movement of the elevator at a higher rate than the movement of vapors in other areas of the building slab. See **Figure 3**, which is an expanded version of **Figure 1**, Panel D. A building sump (e.g., basement sumps) that may be designed for water collection can act to introduce impacted vapors or groundwater directly into the building but is not a vertical VIPP. This is considered a direct volatilization pathway. See the **Direct Volatilization to Indoor Air Fact Sheet** for more information on this type of vapor transport.

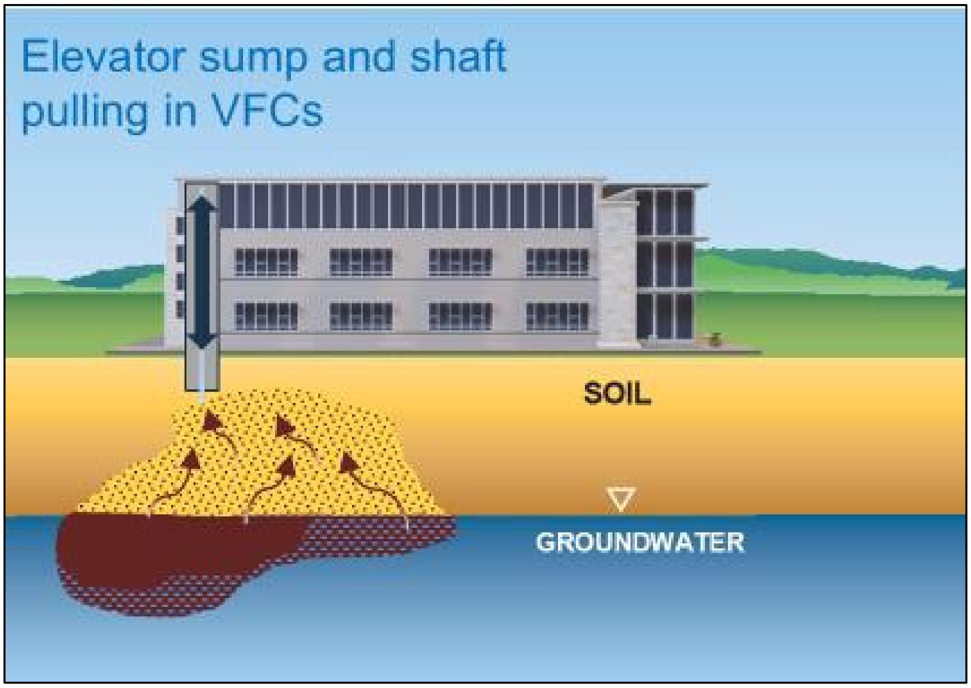


**Figure 3. Example of a vertical vapor intrusion preferential pathway—elevator sump and elevator shaft.**

*Source: Laura Trozzolo, Lila Beckley, and Catherine Regan, used with permission.*

The term *vertical VIPP* is not intended to apply to foundation penetrations, such as openings around a utility penetration, moderate slab cracking, or expansion joints, as these are present in a large percentage of all buildings (see the vapor entry point bullet item in the VIPPS versus Typical Building Features section below for this category). It also would not apply to plumbing features such as dry p-traps, defective/cracked piping, or defective seals. These are also considered vapor entry points. Although a conduit VIPP may allow vapors to travel farther than previously expected and may affect multiple buildings, a vertical VIPP increases the potential for VI within a single building.

## Preferential Pathway Terminology—Reason for Change

Historically, the term preferential pathway has been used very broadly to define a feature that may enhance subsurface migration of vapors (VFC flux) into a building. In 2015, U.S. Environmental Protection Agency (USEPA) VI guidance defined a preferential pathway (called a preferential migration pathway) as exhibiting “little resistance to vapor flow in the vadose zone (i.e., exhibits a relatively high gas permeability)…thereby facilitating the migration of vapor-forming chemicals in the subsurface and/or into buildings” (USEPA 2015).

USEPA’s term included natural features, constructed features confined within the footprint of a building, and constructed features such as sewer lines that extend beyond the footprint of a building (USEPA 2015). It is important to note that USEPA clarified that preferential migration pathways are different from intentional and common openings present in most buildings such as cracks, seams, gaps in basement floors, walls or foundations, or perforations due to utility conduits. USEPA did not define terminology to distinguish between these common openings and preferential pathways.

Used generically, the term preferential pathways is broad and makes it difficult to focus on specific features that are more likely to enhance the migration of VFCs toward a building relative to migration through a soil matrix or migration through normal, common vapor entry points. In addition, the term preferential pathway can mean multiple different things depending on the regulatory agency or practitioner. Given this, some have proposed avoiding confusion by replacing that term with language that more accurately indicates the particular transport mechanism for VI (Kapuscinski 2021).

Clear terminology is required for accurate and comprehensive CSMs. Such CSMs yield more focused assessments and mitigation because clearer terminology helps stakeholders more accurately visualize and document the source-transport-receptor components necessary for the VI pathway to be complete or potentially complete.

For example, historically, preferential pathways were not typically tested during initial VI site investigations. By the mid-2010s, a number of sites with VI through conduits were documented in published literature (McHugh et al. 2017). In many cases, the importance of the VIPP was not identified until late in the VI investigation process; in other cases, the VIPP was not identified until after conventional mitigation failed. If we understand which VIPPs, vapor entry points, and vapor transport pathways may be important at a given site during the initial VI CSM development stage, then sampling and analysis can be planned accordingly.

Based on a number of research studies since the mid-2010s (Guo et al. 2015; McHugh et al. 2017; Nielsen et al. 2014; Riis et al. 2010), the primary transport mechanism for VI through conduits is vapor migration through the interior of sewers and underground utilities. If the site or building VI CSM indicates the potential for VI through conduits, samples should be collected from inside the pipe (see **Section 7.6.4 Sewer and Other Utility Conduits** for sewer and utility conduit sampling) rather than collecting soil vapor within utility backfill surrounding the pipe.

## VIPPs versus Typical Building Features

As described above, VIPPs are features that may enhance the process of bringing subsurface VFCs to/into buildings. The following terminology describes other types of vapor movement into or within a building as part of the VI CSM. These potential pathways do not constitute VIPPs, per se, but are important VI processes.

- **Vapor entry point**: This is a term that would be used to describe penetrations through the building foundation such as cracks, expansion joints, plumbing (e.g., defective plumbing or dry p-traps), and passages for heating, ventilation, and air conditioning (HVAC) systems and electrical conduits that, if not properly sealed, could potentially enhance airflow into the building. These are not considered VIPPs because they are common construction features that are included in the standard CSM. Although vapor entry points are not VIPPs, they may have important influences on localized vapor entry into the building and could potentially be the primary mechanism for VI under a standard VI scenario. See **Figure 4** and **Figure 5**, which are expanded versions of **Figure 1**, Panels E and F.
- **Interior vapor transport pathway:** This is enhanced airflow within a given building, which can sometimes be driven by HVAC systems. Once inside the building, VFCs may migrate within wall cavities, stair wells, open attic spaces, and other construction features. Interior vapor transport pathways can result in an unexpected distribution of VFCs within the building.

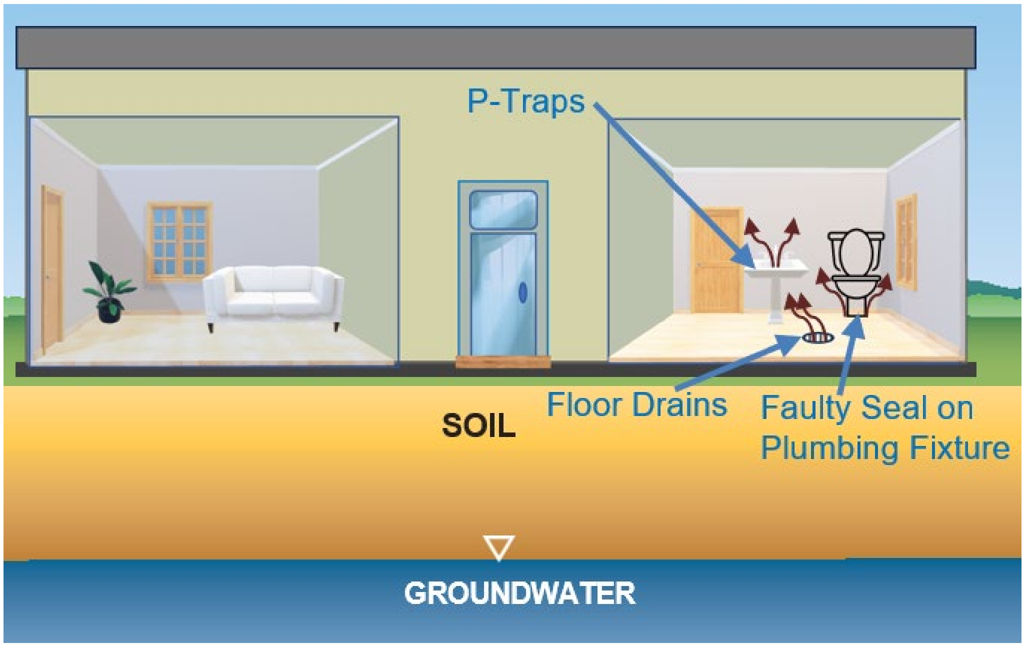


**Figure 4. Example of faulty plumbing features that may be vapor entry points.**

*Source: Laura Trozzolo, Lila Beckley, and Catherine Regan, used with permission.*

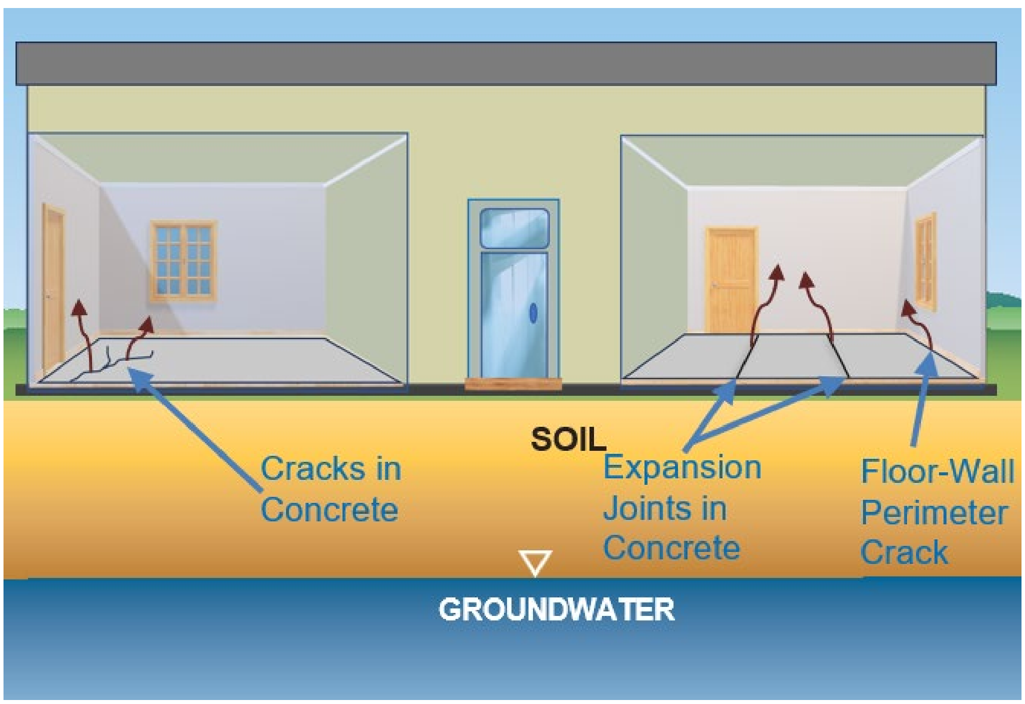


**Figure 5. Example of slab cracks and expansion joints that may be vapor entry points.**

*Source: Laura Trozzolo, Lila Beckley, and Catherine Regan, used with permission.*

The term preferential pathway has, in the past, been applied to the permeable material or construction fill surrounding a subsurface conduit with the assumption that VFCs might be transported more readily through this material than through less permeable porous materials in the adjacent vadose zone

(Kapuscinski 2021). Although in zones like this (e.g., gravel surrounding a sewer) the ability for movement of vapors may be easier, there still needs to be a driving force applied to those vapors to make them move. In the absence of a significant advective force (e.g., pressure differential), movement of vapors in this more permeable material will closely match the movement via diffusion in the surrounding bulk soil. Transport will not occur preferentially through higher permeability backfill (McHugh and Beckley 2018). The exception to this may occur if the backfill was isolated within an impermeable matrix and a pressure gradient or strong driving force was present—for example, in a landfill with landfill methane generation (McHugh and Beckley 2018). Backfill around utility corridors is not likely a VIPP for lateral soil vapor migration.

## Significance of VIPPs Through the Project Life Cycle

At the beginning of a project, assessment of the VI pathway typically focuses on the nature and extent of VFC impacts in soil and groundwater. Screening distances (see **Section 5.1 in Chapter 5: Site Screening**) are typically used consistent with the idea that the closer the potential receptor is to impacted soil or groundwater, the higher the potential for VI. For that reason, VI pathway evaluations typically take place over the footprint of impacted areas, plus a conservative buffer. If, however, a sanitary sewer, or other conduit, intersects a source in groundwater or impacts are introduced directly to the conduit, there is the potential that a conduit VIPP, in which contaminants enter the conduit, will allow vapors to flow in a direction outside the typical area of VI assessment. **Figure 1**, Panels A and B show VI CSMs where vapor sources are directly in the path of a conduit or the vapor source is discarded directly into the conduit and then intersects the building. In these scenarios, there is a higher chance that the conduit VIPPs may increase the potential for VI both close to the vapor source and farther from the source area.

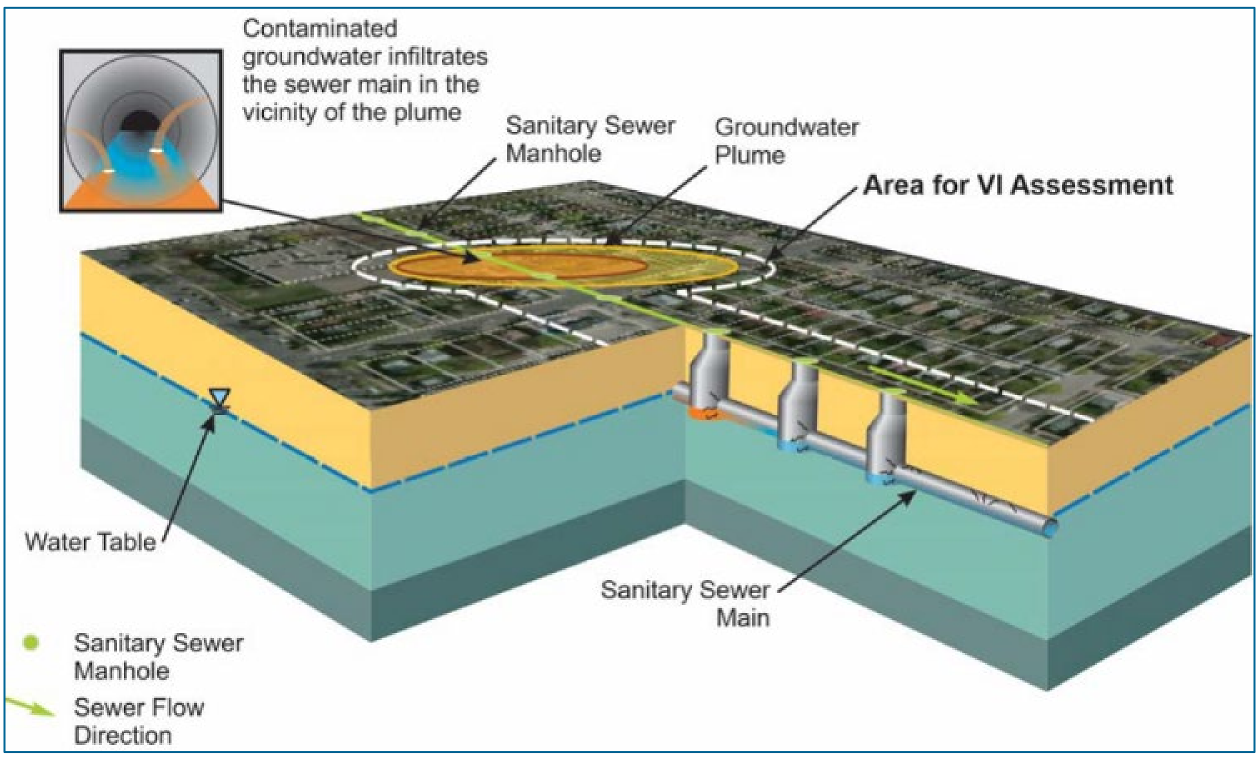


**Figure 6. Conceptual model of conduit vapor intrusion preferential pathway expanding the area of vapor intrusion assessment.**

*Source: Department of Defense,* Vapor Intrusion Handbook Fact Sheet *(USDOD 2020, Figure 3), used with permission.*

Figure 6 shows an example of how the area for VI assessment may expand down the length of, in this example, a sewer, due to the presence of the sewer at or below the water table and the sewer's intersection with the contaminant source area. If information as detailed here is known based on the VI CSM, it is recommended that the potential presence of VIPPS be evaluated early in the site screening or investigation process to confirm that the VI assessment area is appropriate (McHugh and Beckley 2018). Approaches for identifying VIPPs are discussed in the Approaches for Identifying and Sampling VIPPs section below.

Conduit VIPPs can also intersect an NAPL vadose zone source as shown in Figure 1, Panel C. These VIPPs will likely be located within the typical VI assessment area and can be identified during the normal course of site investigation.

VIPPs may be precluding factors that prevent use of distance-based screening. VIPPs that represent a precluding factor may not allow a site to be screened out at early stages of the VI life cycle. Conduit VIPPs that represent precluding factors may be more significant at sites with petroleum hydrocarbon (PHC) impacts, as these VIPPs do not allow for the screening distances and the environmental conditions needed for PHC biodegradation to take place. See **Section 5.3.1 Precluding Factors Assessment** and **Appendix E: Application of Precluding Factors** for more information on precluding factors and screening distances and **Section 2.2.6 How Is Petroleum Vapor Intrusion Different from Nonpetroleum Vapor Intrusion?** for more information on PHCs and petroleum VI.

During the VI investigation phase (see **Chapter 6: Iterative Investigation Process**), awareness of how VIPPs, vapor entry points, and potential interior vapor transport pathways fit in the site-specific VI CSM becomes even more important so that VI-specific sampling programs can be designed to test hypotheses, such as the following: Does the elevator shaft need to be sampled to confirm that a vertical VIPP is or is not present? and Do vapors in the sanitary sewer need to be sampled to rule out conduit VIPP? A VI CSM that includes VIPPs can also be used to aid in data interpretation (see **Chapter 8: Data Evaluation and Vapor Intrusion Risk Assessment**) and be part of the multiple lines of evidence (MLE) approach as noted in the Approaches for Identifying and Sampling VIPPs section of this fact sheet and in the **Multiple Lines of Evidence Fact Sheet**. For example, unexpected VFC concentrations in an upper floor could be explained by VFC transport (vertical VIPP) via an elevator sump and advective transport via the movement up and down of the elevator. In a few states, screening levels and attenuation factors have been provided in guidance to support evaluation of the influence a known VIPP may have on a building. See the **Screening Levels Fact Sheet** for more information.

A detailed understanding of VIPPs, vapor entry points, and interior vapor transport pathways is also critical during the mitigation phase of a VI project, as it may guide the selection and implementation of mitigation technologies that include addressing these features. For example, one may line a sanitary sewer to stop the conduit VIPP from occurring, or a vapor entry point like a plumbing feature (such as p-taps or toilet seals) may need to be fixed or sealed within a house. Sealing or fixing plumbing features would not stop the conduit VIPP from occurring, but it would mitigate the impact of the conduit VIPP to the interior of the building. See **Chapter 10: Vapor Intrusion Mitigation** and the **Preferential Pathway Sealing and Ad Hoc Ventilation Technology Information Sheet** for considerations on incorporating VIPPs into the mitigation CSM and design plans.

The examples listed in this section have been documented in literature but are not intended to be a comprehensive list of scenarios. Literature, such as Beckley and McHugh (2020), should be reviewed for more detailed information. The influence of enhanced VFC-flux-related VIPPs should be considered within the full VI project life cycle. By updating the VI CSM during the project life cycle with information gained about VIPPs, practitioners can incorporate progressively more complex information to more efficiently drive decision-making.

# Approaches for Identifying and Sampling VIPPs

## Approaches

Approaches for early identification of VIPPs include review of the VI CSM to identify whether indicating factors for VIPPs are present in the vicinity of the site. For example, for conduit VIPPs, are sanitary sewers below the depth of impacted groundwater? Do subsurface conduits intersect NAPL in the vadose zone and then intersect the target building? If indicating factors exist, sampling may need to be conducted to confirm whether VIPPs are a concern. Example investigation strategies are described in McHugh and Beckley (2018) and Loll (2025) as well as in some state guidance documents such as those from Wisconsin (WI DNR 2021) and Indiana (IDEM 2022). The decision to investigate for, or sample from, potential VIPPs should be supported by evidence suggesting the likelihood of their presence. This determination should be guided by the VI CSM, which integrates site-specific data to identify conditions favorable to conduit VIPPs or vertical VIPPs. It is not required to sample all subsurface conduits at a site; rather, a targeted approach based on the VI CSM (which guides decisions on whether or where sampling is necessary) is sufficient.

## Sampling Methods

If the site CSM suggests that VIPPs could reasonably contribute to VI, samples can be collected to test the hypothesis. Early identification of conduit VIPPs is particularly important because the presence of conduit VIPPs could potentially alter the area considered for VI investigation, as discussed in the Significance of VIPPs Through the Project Life Cycle section above. Conduit vapor sampling methods are discussed in **Section 7.6.4. Sewer and Other Utility Conduits**. Some state guidance documents also describe procedures to sample this pathway (e.g., WI DNR 2021).

Forensic testing approaches such as on-site analysis, real-time monitoring, or building pressure control testing can also be used to identify VIPPs as well as vapor entry points in specific buildings. For more information on these methods see the **Approaches for Vapor-Forming Chemical Source Determination Fact Sheet**, the **Real-Time Monitoring Fact Sheet**, and the **Pressure Monitoring and Building Pressure Control Fact Sheet**.

# Multiple Lines of Evidence Used to Evaluate VIPPs

Identifying the presence of VIPPs and the impact of these VIPPs on a site or building can often be difficult. An MLE approach (see the **Multiple Lines of Evidence Fact Sheet**) is often needed to show that multiple pieces of information align with the CSM and indicate the influence of a VIPP. The following example illustrates data collected at a site/building that was used to determine the presence of a conduit VIPP and how that conduit VIPP was then influencing the indoor air in a residential building via vapor entry points. The MLE approach used in this example scenario follows the MLE approach discussed in "What Does an MLE Approach Look Like?" section of the **Multiple Lines of Evidence Fact Sheet**.

## Example Scenario: Multiple Lines of Evidence in the Identification of VIPPs

The following scenario includes data collected by Pennell et.al (2013; 2016). This example has been simplified to highlight a targeted MLE approach for VIPPs; therefore, not all site data or CSM components available from the project or from the example building were used in this example scenario.

### *Example Building Summary*

The scenario building is a three-story multifamily home situated in a residential community near a former chemical-handling facility in the Greater Boston area. A graphical display of relevant building data for the example scenario is provided in [Figure 7](#).

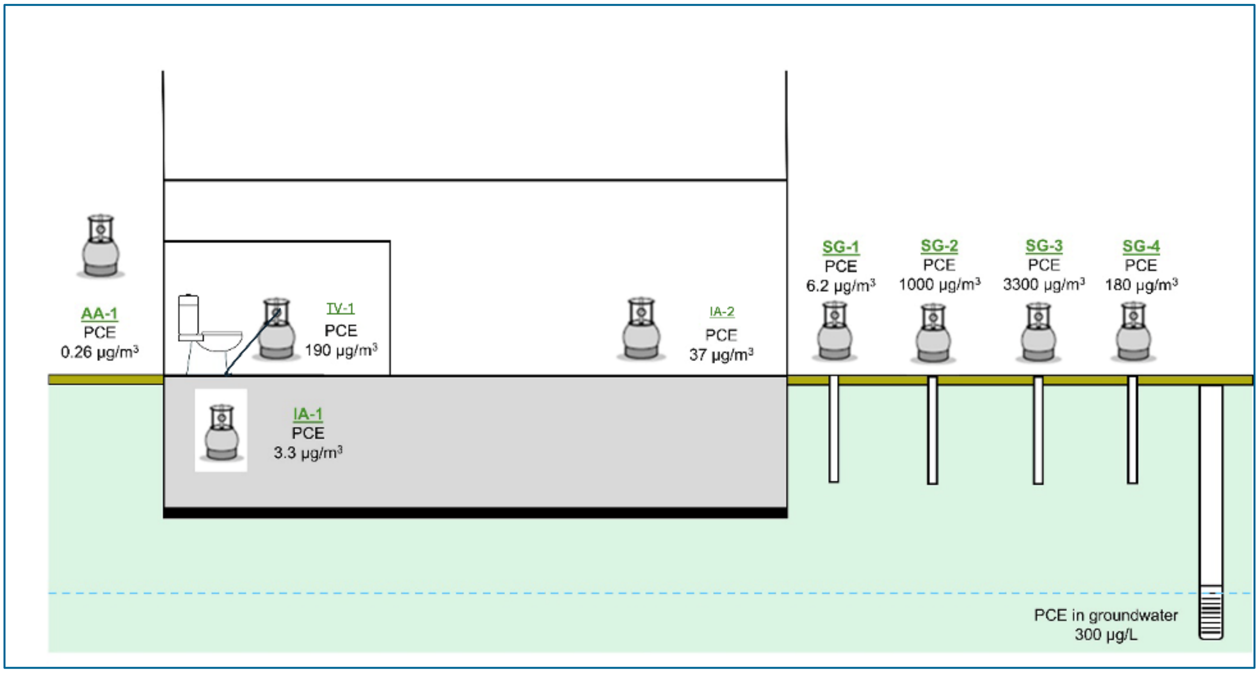


**Figure 7. Example scenario building/site data.**

*Source: Kelly Pennell and Herman Tay, used with permission. Adapted from* Sewer Gas: An Indoor Air Source of PCE to Consider During Vapor Intrusion Investigations *(Pennell et al. 2013).*

General site information is described by Pennell et al. (2013; 2016) and includes the following details:

- Depth to water is approximately 10–13 feet below the ground surface.
- The site has a two-layer geological system; the top layer is a loamy sand, and the bottom layer is sandy clay.
- Chlorinated VFCs are present in groundwater as a result of decades of handling and transporting bulk PCE to dry cleaners and other businesses.
- The basement walls had been previously sealed, and a sub-slab depressurization (SSD) system was operational during sampling.
- A sewer main is adjacent to the site and in proximity to the VFC groundwater plume.

### *Example Site Data*

The information in [Figure 7](#) shows maximum PCE concentrations for indoor air (living space), vapor from toilet connection, outdoor air, soil vapor, and groundwater. PCE was the only consistent VFC that exceeded target risk values at this site.

## Multiple Lines of Evidence Approach

**Step 1:** Define a target question: Are the site data consistent with a conduit VIPP?

**Step 2:** Pull together applicable data and data evaluations. For this example, the lines of evidence (LOE) used are listed below, and more details are provided in **Table 1**. In this example, these LOE are developed under conditions where VI has already been identified at the site. This assessment is aimed at determining the primary drivers of VI—for example, whether it is occurring through subsurface soil diffusion or conduit VIPPs or a combination of both. The MLE approach described below only focuses on assessing whether there is evidence of conduit VI.

- Groundwater data
- Soil vapor data
- Groundwater to soil vapor constituent ratios
- Basement air data
- First-floor data
- First floor to basement vapor concentration ratios
- Sewer odor assessment during sampling
- Discussions with building occupants
- Bathroom data
- Concentration data (indoor air) compared to applicable screening levels
- First floor to bathroom concentration ratio analysis
- Building conditions assessment

**Steps 4 and 5:** Evaluate data for uncertainty and weight of importance of each LOE.

- In this scenario, data uncertainty was decreased by changing the building conditions (i.e., the building conditions assessment LOE) by closing the bathroom door, sampling the toilet connection, and replacing the toilet (data not shown is included in the publications by Pennell et al. (2013; 2016). Changing the conditions for sampling provided increased weight to the LOEs supporting the occurrence of and influence of the conduit VIPP. Additionally, uncertainty can be decreased by collecting data over multiple sampling events across different times and locations within the building.
- More weight could also be given to LOE that more strongly link the data to the source of the pathway—for instance, the higher vapor concentration ratios between the first floor and basement. These concentrations were not subtly different—they were significantly different (3.3 μg/m$^3$ in the basement versus 37 μg/m$^3$ on the first floor). This suggests a stronger connection to the sewer gas pathway than to the soil vapor pathway since the first floor is farther from the soil vapor and yet has a higher concentration than the basement, which has more direct contact with soil vapor.

**Step 6:** Summarize the MLE results.

- In the above scenario, the MLE evaluation supports the conclusion that VI is primarily driven by (1) sewer gas and the conduit VIPP followed by (2) vapor entry at the faulty toilet seal, rather than conventional VI. With the operation of an active VI mitigation system (the current SSD system), as well as the repair of plumbing connections, indoor air PCE concentration decreased.

**Table 1. Multiple lines of evidence approach to assess a potential conduit VIPP.**

| Line(s) of Evidence | Are the Site Data Consistent with a Conduit VIPP? | Comment |
|---|---|---|
| Groundwater data, soil vapor data, groundwater to soil vapor constituent ratios | Neutral | These LOE support the initial phase of VI assessment. Impacts of VFCs found in soil vapor and groundwater indicate the presence of contamination that could influence a subsurface conduit and that VFC vapors are likely migrating from groundwater to soil vapor, but this does not help answer the target question. Additional evaluation is warranted to understand the intrusion pathway. |
| Basement air data | Supporting | Impacts of VFCs found in the basement indicate the presence of contamination; additional evaluation is warranted to understand the intrusion pathway (i.e., conduit VIPP or other). |
| First-floor data | Supporting | Impacts of VFCs found in the first-floor indoor air indicates the presence of contamination; additional evaluation is warranted to understand the intrusion pathway (i.e., conduit VIPP or other). |
| First floor to basement vapor concentration ratios analysis | Yes | Maximum first-floor concentrations are greater than basement concentrations. This is an indication that the site conceptual model is inconsistent with upward migration of vapors from below the building. Additionally, at this site, the basement had an operational SSD system, so higher concentrations on the first floor versus the basement indicates influence of either a VIPP or a background indoor air source and likely not conventional vapor intrusion. |
| Concentration data (indoor air) compared to applicable screening levels | Supporting | Based on USEPA screening levels, the indoor air data collected from both the bathroom and living space exceeds the established screening levels. These data support the need to look at VIPPs for vapor migration but do not specifically answer the target question. |
| Sewer odor assessment | Yes | The presence of sewer odors within the building can indicate the potential for the intrusion of vapors from VIPPs. The absence of sewer odors does not indicate the absence of VIPPs. At the example site, strong sewer odors were noted during sampling events, especially on the first floor (Pennell et al. 2013). |
| Discussions with building occupants | Yes | Building occupants are often knowledgeable about plumbing fixtures that may be faulty and/or are in disrepair. At the example site, the building owner noted that the toilet connection was poor and in need of maintenance, which was useful information for subsequent sampling efforts. |
| In-conduit vapor data from the toilet connection | Yes | The vapor concentration detected inside the conduit connected to the toilet (TV-1) is greater than the indoor air concentrations in the house, indicating a conduit VIPP for the sewer and subsequent migration of PCE into indoor air via the poor plumbing connection as the vapor entry point. The toilet was improperly connected to the floor in the bathroom. |
| First floor to bathroom concentration ratio analysis | Yes | The maximum first-floor indoor air concentration is lower than the concentration in the bathroom, where piping and conduits are prevalent. This is an important indication that vapors are preferentially migrating through a sewer as a conduit VIPP and then into indoor air through a vapor entry point rather than via conventional vapor intrusion. |
| Building conditions assessment | Yes | The building differential condition assessment documented an increase in indoor air PCE concentrations when the bathroom door remained open across multiple sampling events. PCE concentrations decreased when the bathroom door was closed. Bathroom concentrations increased after homeowner removed the toilet.<br>Confirmatory sampling once the toilet was properly sealed indicated indoor air concentrations in the house decreased. |

## Other VIPP Investigation Examples

Other examples of the use of MLE to identify conduit VIPPs can be found in the scientific literature. These studies include, but are not limited to, Riis et al. (2010), Guo et al. (2015), and McHugh et al. (2017).

# Management of VIPPs

Several mitigation options are available to address VIPPs, depending on site-specific details. For example, if VFC migration through conduits (e.g., sanitary sewers) is an issue, these conduits can be lined to minimize influx of contaminants into the system. Conduit VIPPs can also be addressed by rerouting the lines away from the groundwater plume or contaminant source area, installing gas siphons in the line, depressurizing or venting the line to remove VFC vapors, installing check valves within sewer laterals to prevent migration of VFCs into buildings, or other measures (Nielsen and Hvidberg 2017; Tay et al. 2024).

Vertical VIPPS such as elevator sumps can be sealed. Although not VIPPs, the influence of VIPPs can be managed at the vapor entry points in the building envelope by, for example, sealing floors (see the **Preferential Pathway Sealing and Ad Hoc Ventilation Technology Information Sheet**) or conducting plumbing repairs.

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