Liberty Mutual INSURANCE

Vapor intrusion is one of the main drivers of risk to indoor receptors and can be a significant cause for contaminant evaluation and remediation at a variety of properties.

Vapor intrusion

What is vapor intrusion?

Vapor intrusion is the process which involves the vapor phase migration of volatile Oil or Hazardous Materials (OHM) from the subsurface into the indoor air of a structure. When these contaminants have been released or have migrated near buildings, they can present a risk of exposure to building occupants via inhalation. This route of human exposure is defined as the "vapor intrusion pathway."

Vapor intrusion is one of the main drivers of risk to indoor receptors and can be a significant cause for contaminant evaluation and remediation at a variety of properties. Contamination source areas can also present both on-site and off-site vapor intrusion concerns via migration to nearby indoor receptors through soil gas and groundwater. State agencies (e.g., California DTSC as recently as February 2023) and the U.S. Environmental Protection Agency (EPA) are continuously updating their vapor intrusion guidance and strategies to help address and mitigate vapor intrusion.

Vapor intrusion can present significant risks to sensitive receptors, including pregnant women and young children inside residences, schools, and daycare facilities. Vapor intrusion can also pose a risk to workers in commercial and/or industrial buildings. When vapor intrusion threatens human health or safety, a response action is warranted. Depending on the chemical involved, a buildup of vapors in indoor air can cause acute health effects such as eye and respiratory irritation, headache, or nausea. The chemical concentrations in indoor air can also be relatively low and the primary concern is the potential for nonacute health effects associated with longer-term exposures.

Sources of vapor intrusion

Vapor intrusion into buildings was recognized in the 1980s with concerns over radon intrusion. Current or former facilities at or near a subject property which released volatile oil or hazardous materials (e.g., chlorinated volatile organic compounds [VOCs] and volatile petroleum hydrocarbons) can be sources. Common operations related to vapor intrusion include dry cleaning and industrial degreasing, petroleum storage, and petroleum dispensing.

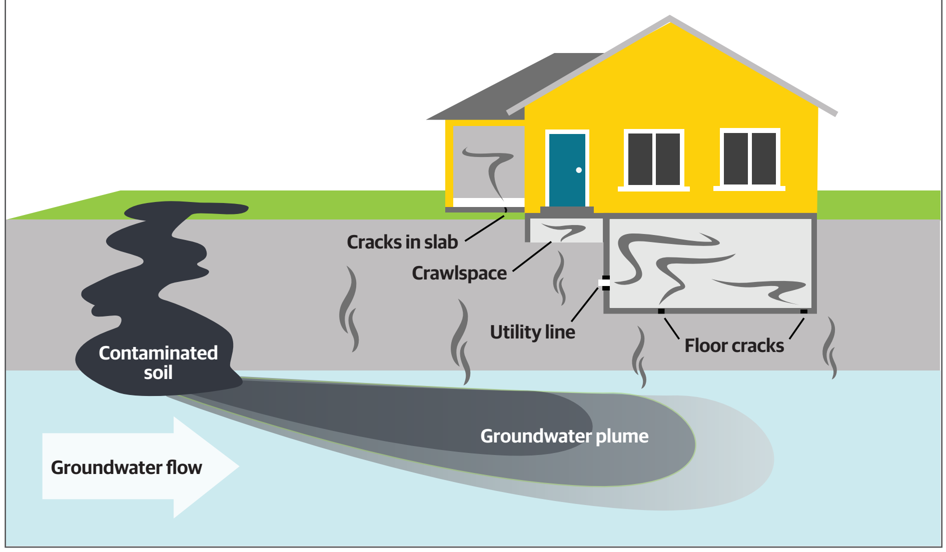
Specific sources of contamination include, but are not limited to, leaking underground or aboveground storage tanks or vessels, piping and conduits, floor drains, dry wells, industrial waste storage, contaminated groundwater plumes, and spills. Methane and certain vapor-forming chemicals can pose an explosion hazard and may pose imminent and substantial danger to human health and public welfare.

Common volatile petroleum and organic compounds in vapor intrusion include:

- Chlorinated VOCs — trichloroethylene (TCE), perchloroethylene (PCE), vinyl chloride, 1,1,1-trichloroethane (1,1,1-TCA)
- Petroleum VOCs — benzene, toluene, ethylbenzene, xylenes, air-phase petroleum hydrocarbons
- Radon and methane gas

Specific sources of contamination include, but are not limited to, leaking underground or aboveground storage tanks or vessels, piping and conduits, floor drains, dry wells, industrial waste storage, contaminated groundwater plumes, and spills.

Example vapor intrusion pathways



Source: State of Washington Department of Ecology. 2022. Guidance for Evaluating Vapor Intrusion

To help ensure a site and inhabitants are properly protected against the potential effects of vapor intrusion, an evaluation should occur when:

- There is a volatile OHM release to the subsurface near occupied buildings.
- Concentrations in groundwater exceed standards or criteria developed to be protective of the volatilization of OHM from groundwater to indoor air.
- Indoor air contamination is detected, or odors are present inside an occupied building.
- An acute exposure concern exists.
- Light or dense nonaqueous phase liquid was released near an occupied building.

It's also good to think about site vulnerabilities that can potentially enable vapor to enter a premises. When evaluating a location, consider the following:

- Building uses — is there a presence of sensitive receptors (e.g., school, daycare, residence, office building)?
- Basement conditions — evaluate dirt floors, cracked concrete floors, sumps, and utility entry locations
- Is enough site characterization data available to evaluate the vapor intrusion pathway?
- Are screening levels exceeded?

A conceptual site model is a tool that characterizes the sources of OHM in the environment, shows potential migration and exposure pathways, and identifies the location of potential indoor air receptors.

Conceptual site model

A conceptual site model is a tool that characterizes the sources of OHM in the environment, shows potential migration and exposure pathways, and identifies the location of potential indoor air receptors. It can be used to guide the evaluation of vapor intrusion pathways by identifying: potential and known sources of OHM (including storage and releases); the nature and extent of OHM impacts; known or suspected migration and preferential pathways; and the distribution and concentrations of volatile contaminants in soil, groundwater, soil gas, indoor air, and outdoor air. The conceptual site model can be modified to add new data and information during vapor intrusion evaluation, risk characterization, and remediation activities.

Vapor intrusion lines of evidence can be uncovered through the following:

- Volatile contaminants detected in soil, sub-slab, and exterior soil gas and groundwater
- Volatile contaminants detected in indoor air from known or suspected sources
- Volatile contaminants in indoor air from confounding/indoor sources of OHM
- Volatile contaminants in outdoor air from confounding/outdoor sources of OHM
- Preferential pathways for groundwater and vapor migration
- The presence of light or dense nonaqueous phase liquid in the subsurface

Mitigation efforts

Measures can be taken to help prepare against the potential intrusion of harmful vapors.

- Perform due diligence. Evaluate site history and locate where volatile contaminants were stored, used, or released relative to the subject property.
- Assess preferential pathways, including sumps, floor drains, utility entry points, elevator shafts, and floor or foundation cracks.
- Document and remove potential sources of on-site indoor air contamination including products used or stored containing VOCs at least 24 to 72 hours before sampling.
- Conduct site investigations to evaluate the presence and extent of volatile contaminants in soil, groundwater, exterior soil gas, interior sub-slab soil gas, indoor air, and outdoor air. Compare data to standards/threshold values.
- Conduct seasonal indoor air sampling, including during the most conservative conditions in late winter/early spring. Greater sampling frequency is recommended for more sensitive receptors.
- If subsurface conditions have been adequately characterized, only those chemicals and their breakdown products should be considered as contaminants of concern for indoor air.

> Sufficient and appropriate lines of evidence should support whether or not a vapor intrusion pathway is complete.

Complete vs. incomplete vapor intrusion pathway

Sufficient and appropriate lines of evidence should support whether or not a vapor intrusion pathway is complete. Groundwater, sub-slab soil gas, and indoor air should be representative of site conditions and account for seasonal variability.

Incomplete vapor intrusion pathway.

With an incomplete pathway, volatile contaminants detected in sub-slab soil gas or groundwater exceed threshold values/groundwater standards but are at levels below the threshold values in indoor air. Similarly, contaminants can be detected in indoor air above screening or threshold values, but undetected in sub-slab soil gas or groundwater (potential indoor air source).

Potentially complete vapor intrusion pathway.

In a potentially complete VI pathway, volatile contaminants are present beneath or near an existing building or a building that is proposed for construction in the future, there is a vapor migration route, and the building has potential soil gas entry.

Complete vapor intrusion pathway.

A complete pathway exists when volatile contaminants are detected in soil gas and/or groundwater and in indoor air above threshold or screening values/standards and building occupants are present. There is a potential opportunity for human exposures and further evaluation or response actions are warranted.

Vapor intrusion mitigation considerations

- Consider an exposure assessment to characterize whether any imminent hazards exist or if a risk to human health exists.
- Site-wide remedies include source area removal as well as contaminated soil and groundwater remediation (e.g., soil vapor extraction, in-situ bioremediation).
- Implement institutional controls (e.g., activity and use limitations) to help protect human health or to require the maintenance of vapor mitigation systems or barriers. Ensure that the vapor intrusion pathway is addressed in the future.

Mitigation measures and systems

- **Vapor barriers.** These are installed above a permeable layer where soil vapors can migrate to the building perimeter or into passive or active vents. Vapor barriers include sprayed-on rubber asphalt emulsion or epoxy (e.g., Liquid Boot), or high-, low-, or very-low density polyethylene materials.
- **Passive venting.** This intercepts sub-slab soil gas with perforated pipes installed below the slab within a permeable layer. Vapors are directed to vent piping to the building exterior above the roof line. Passive venting relies on wind speed and temperature and pressure differences and should be designed to include an active sub-slab depressurization system if the passive technology is ineffective at VOC reduction. It is typically used in conjunction with a vapor barrier.
- **Aerated floor systems.** These systems include prefabricated, plastic interlocking forms installed in a permeable sub-base material below a concrete floor. A void space beneath the forms may include air inlets and vent piping to direct sub-slab soil vapor to the building exterior. Aerated floor systems may be passive or active with a fan or blower and can include a variety of sizes and areas.

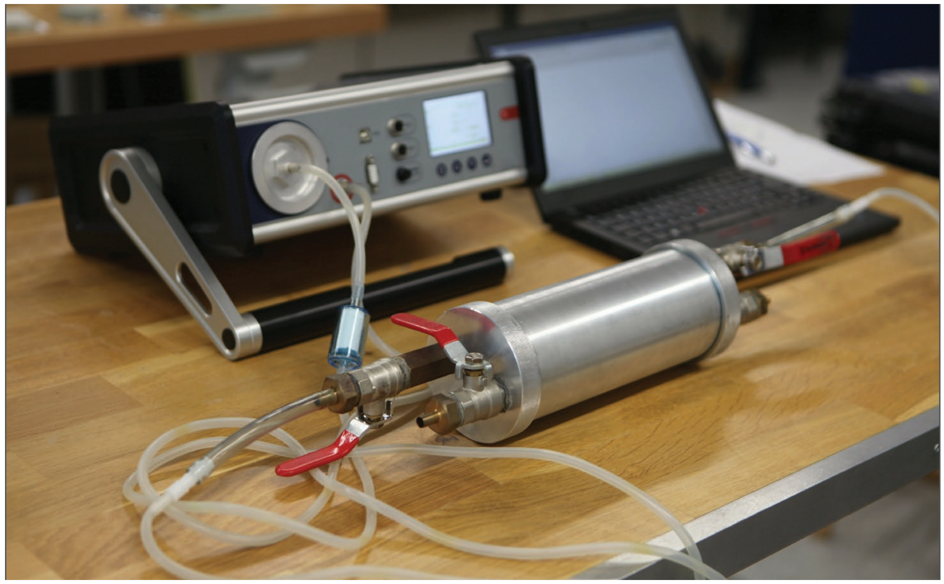
> According to the U.S. EPA, a sub-slab depressurization system is the most reliable, cost effective, and efficient way to help control vapor intrusion.

Active mitigation systems

- **Sub-slab depressurization system (SSDS).** The SSDS creates a pressure differential across the building slab, which transports indoor air downward into the subsurface while actively removing soil gas from beneath the building slab and venting to the building exterior. A fan is used to draw soil gas through the sub-slab permeable layer and into vent piping and to the exterior of the building. Perforated piping or aerated flooring is installed in a permeable layer over large areas or suction pits.

According to the U.S. EPA, a SSDS is the most reliable, cost effective, and efficient way to help control vapor intrusion. This system can reduce contaminant concentrations by 90 to 99 percent at vapor intrusion sites and is the most widely applied for new and existing construction. Soil gas movement may be limited in wet and low-permeability soils. A SSDS can also require periodic inspections and maintenance.

- **Sub-membrane depressurization.** A membrane is used as a surrogate for a slab, which allows depressurization of the soil and has been shown to be most effective in crawl spaces. This has similar effectiveness to the SSDS in reducing contaminant concentrations, is used in new and existing construction, and may be combined with SSDS. Membranes must be sealed and inspected periodically.
- **Sub-slab pressurization.** This is similar to a SSDS and includes fans that push air into the subsurface soil or venting layer below the building slab. Sub-slab pressurization increases sub-slab air pressure above ambient levels and is most effective in highly permeable soils. It can be applied to new and existing buildings. This type of active mitigation system can use more energy to operate than a SSDS and may be inappropriate for dense soil.



Post-mitigation system installation activities

- Conduct indoor air quality sampling to demonstrate the system's effectiveness. Sampling frequency and timing depends on the mitigation approach.
- For active systems, conduct annual checks for pressure drops and fan operation until the system is no longer needed.
- Conduct confirmatory sampling after an active system is shut down; several seasonal indoor air sampling events may be necessary to achieve regulatory closure. If a passive system is necessary to maintain a condition of no significant risk, an activity and use limitation/deed restriction will likely be required to maintain the passive system.

Regulatory information

- Existing policies, regulations, and guidance regarding the vapor intrusion pathway evaluation methods can vary widely among jurisdictional agencies.
- The U.S. EPA issued draft guidance in 2002 and released its final vapor intrusion technical guide in 2015.
- According to the ASTM 1257-21 standard, the presence of hazardous substances within a building, such as vapors that have migrated into a building from a "release to the environment," can result in liability under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).
- In 2022, the ASTM released its E2600-22 Standard Guide for Vapor Encroachment Screening on Property Involved with Real Estate Transactions for use on a voluntary basis.

Liberty is here for you.
Today. Tomorrow. Together.

For more information, please visit: **lmi.co/business.**

Follow us on LinkedIn and be in the know on emerging trends, legislative updates, and announcements.

References and resources

Vapor Intrusion Guidance: Site Assessment, Mitigation and Closure – Policy #WSC-16-435, Massachusetts Department of Environmental Protection, October 14, 2016.
https://www.mass.gov/files/documents/2016/10/nu/vapor-intrusion-guidance-10-14-2016.pdf (mass.gov)

OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Source to Indoor Air, OWSER Publication Number 9200.2-154, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, June 2015.
OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air (epa.gov)

U.S. Environmental Protection Agency Vapor Intrusion Guide, October 2015.
EPA's VAPOR INTRUSION GUIDE

Vapor Intrusion Pathway: A Practical Guideline, The Interstate Technology & Regulatory Council Vapor Intrusion Team, January 2007
http://itrcweb.org/Guidance/GetDocument?documentID=104

Vapor Intrusion Pathway: Investigative Approaches for Typical Scenarios, The Interstate Technology & Regulatory Council Vapor Intrusion Team, January 2007
https://www.partneresi.com/sites/default/files/vapor-intrusion-pathway-invesitgative-approaches-for-typical-scenarios.pdf

Guidance for Evaluating Vapor Intrusion in Washington State – Investigation and Remedial Action, Toxics Cleanup Program, Washington State Department of Ecology, March 2022.
https://apps.ecology.wa.gov/publications/documents/0909047.pdf