State of Vermont
VT Department of Environmental Conservation
Waste Management & Prevention Division
1 National Life Drive – Davis 1
Montpelier, VT 05620-3704

Vapor Intrusion Background

Last Update: July 11, 2017

Vapor Intrusion (VI), the intrusion of contaminated soil vapors into buildings may be the most common route of human exposure to environmental contamination. It is therefore necessary to assess the potential for VI to be an existing or potential future issue for sites contaminated with volatile and semi-volatile organic compounds.

This document provides guidance on how vapor intrusion occurs, how to measure it, and VI measurement and monitoring Standard Operating Procedures (SOPs).

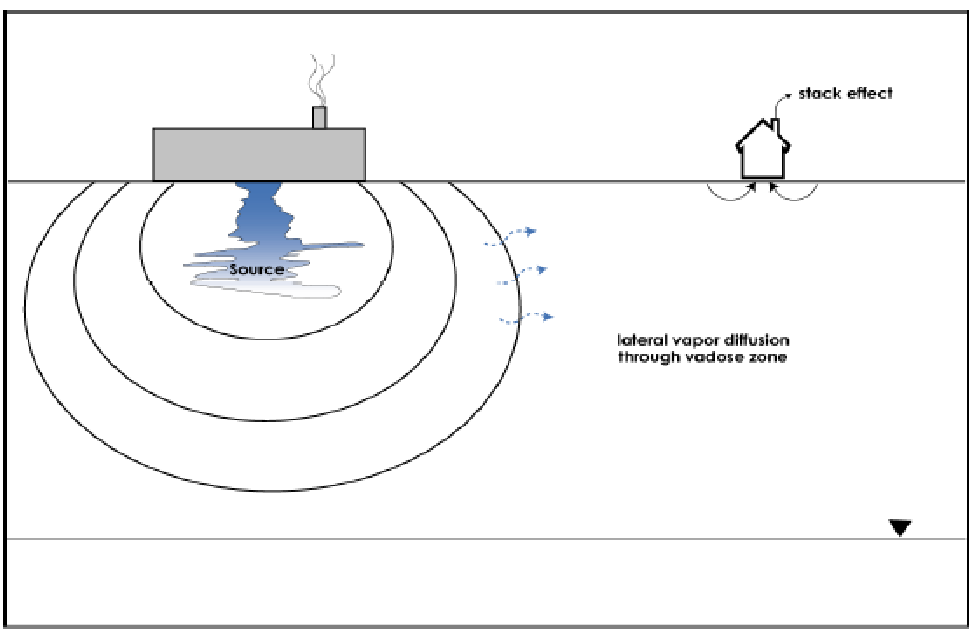
How Vapor Intrusion Occurs

When volatile and semi-volatile organic compound vapors are present in the subsurface, many factors relating to air movement, environmental conditions, geology, anthropogenic subsurface conditions, and building types influence how vapors will affect a particular area. This section describes several air movement patterns and site conditions that may reduce or increase the risk of vapor intrusion.

Diffusion

Diffusion occurs as a result of a concentration gradient between the source and the surrounding area; in the example provided below, the source is NAPL. This can result in the migration of vapors through the vadose (unsaturated) zone above the groundwater table (see Figure 1). Soil vapors can also be produced by dissolved contamination in groundwater, and by contamination in dry soils. Depending on the soil permeability and heterogeneity, the time since chemicals were released, and natural attenuation processes, the distribution of volatile chemicals in soil vapor may extend considerable distances.

Figure 1: Vapor Diffusion



Diffusion is a function of concentration gradients. Soil vapor molecules will follow a diffusion gradient of high to low concentration. Diffusion is not a mechanical process.

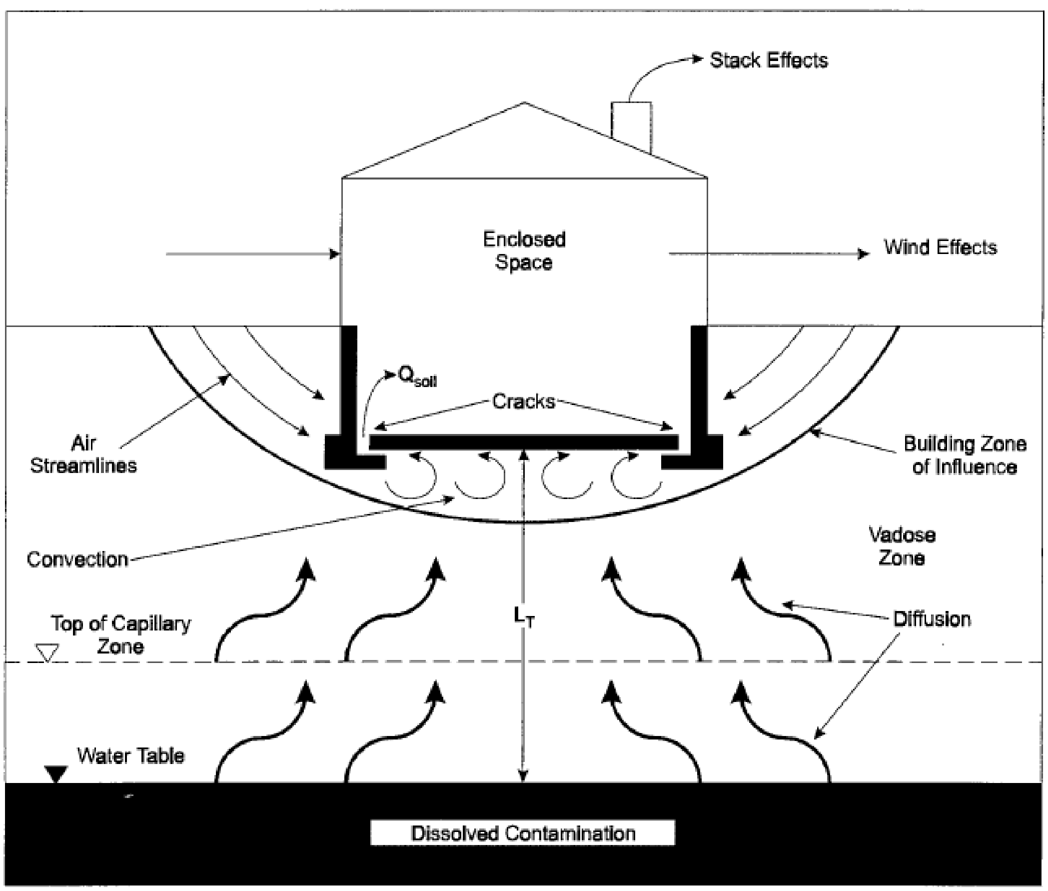
Advection/Convection

Contaminated soil vapors can also be moved "mechanically" when air pressure gradients force the vapor cloud to move from higher to lower pressure. The horizontal and vertical movement of vapors located near a building foundation is often affected by activities within the building that create a negative pressure within the building relative to the outdoors and the surrounding soil. This pressure gradient will "pull" vapors from the soil into the building.

Examples of actions within a building that can create advective transport include the use of heating systems in basements that need air in order for the fuel to burn. When the heating system is operating, air will be pulled into the furnace or firebox. This air can be drawn into a basement through cracks in the slab, utility entrances into buildings, etc. Commercial kitchen ventilation hoods and pizza ovens also create a significant amount of air movement out of a building that will need to be replaced, often at least partially through intrusion of vapors into the basement or through the slab if no basement is present. Outdoor wind can also create a negative pressure gradient causing soil vapor to enter a building.

The area where vapors in the subsurface an affected by activities within a building is referred to as the "zone of influence" (see Figure 2).

Figure 2: Advective/Convective Transport of Vapors



Factors that Affect Vapor Intrusion

The following list describes factors which should be taken into account when assessing the potential for vapor intrusion:

- **Construction style** – Vapor intrusion occurs in structures with or without basements. Investigation of sites has demonstrated that slab-on-grade construction can be affected by vapor intrusion. The condition and construction of the foundation and presence/absence of an adequate vapor barrier are important factors to consider. A simple polyethylene vapor barrier installed during construction below the concrete is often effective at reducing or eliminating vapor migration into the house. Positive pressure heating, ventilation and air conditioning systems can prevent vapor intrusion. Low wattage sub-slab vacuum systems (similar to radon remediation systems) have also proven effective at remediating vapor intrusion.

- **Structure age** – Older structures are less likely to have adequate vapor barriers incorporated into the foundation construction, and the foundation itself is more likely to have developed cracks. However, newer structures generally are more airtight and have less air exchange, and therefore may have higher differential pressures between the building and the soil vapor.

- **Dirt floors and stone foundations** - Earthen floors or field stone foundations are more porous and provide increased opportunity for vapor intrusion.

- **Drain tile/sumps** - If the building has a foundation drain tile or sump, VOC concentrations in the water can contribute to indoor air problems.

- **Wet basement** - If the building has groundwater infiltrating into the basement, dissolved VOCs can volatilize into indoor air. Wet basements can indicate a shallow water table (which could increase vapor intrusion in the event of contaminated groundwater), or be related to surface water drainage problems (which are less likely to cause indoor air quality issues).

- **Utility lines** - Gaps or cracks around piping or other utility lines that enter a building can be important preferential migration paths for vapors. Permeable soil in a utility trench can also provide a conduit for contaminants to migrate to a building.

- **Proximity of contamination to buildings** - Vapor intrusion should be a concern when buildings are close to the source of VOC contamination.

- **Shallow groundwater** - The potential for vapor intrusion typically decreases with increasing groundwater depth for many chemicals, particularly those that are known to biodegrade such as petroleum hydrocarbons.

- **Soil type** - Soil type greatly influences the transport of contaminants in soil vapor and groundwater. Coarse-grained soil types can promote contaminant migration over long distances, but also provide easier venting to the atmosphere if paving is not present and the ground surface is open to the atmosphere. Fine grained or lower permeable “tight soils” will tend to inhibit vapor transport. The soil stratigraphy is also important in developing a conceptual model of soil gas migration. Variations in soil structure and composition can create preferential pathways for vapors to migrate through and may need to be assessed as part of a site investigation.

- **Anthropogenic subsurface structures** – The presence of subsurface utility lines, foundation drains, drainage tiles, or other anthropogenic activities can create preferential pathways or barriers to vapor migration**.**

- **Fractured bedrock** - Shallow fractured bedrock connected to a subsurface source of VOC vapors can increase vapor intrusion potential by allowing soil gas migration. This becomes a greater concern when the bedrock is at or near the base of a building foundation.

- **Degradation** - Petroleum hydrocarbons can biodegrade in unsaturated soils which can reduce or eliminating some vapor intrusion of VOCs. Nevertheless, the degradation of gasoline containing ethanol can result in the production of explosive levels of methane. In contrast, chlorinated solvents will likely undergo limited aerobic biodegradation and, therefore, may have the ability to cause a vapor intrusion impact a longer distance away from the VOC source than petroleum compounds.