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Is It a REC? – Vapor Intrusion Confusion

Back in 2008 the American Society for Testing and Materials (now ASTM International) released its guidance for what was then described as an emerging environmental risk – vapor intrusion. The consensus among Environmental Professionals conducting a Phase I ESA under the E1527-2005 Standard Practice for Environmental Site Assessments was that vapor impacts to a property should be designated as a "non-scope" item. Instead of being a true *recognized environmental condition (REC),* the suggested designation would lump vapor intrusion into the category of *business environmental risk* in much the same way that asbestos, lead-based paint, or mold issues would be addressed.

The clouds of confusion began to gather, as EPA quickly asserted that it had always considered vapor intrusion or migration to be on equal ground with other contaminant pathways such as soil, water and groundwater. The new ASTM E1527-13 Standard now specifically requires assessing the potential for hazardous vapors to migrate onto a subject property, clarifying the definition of "migrate/migration" as "the movement of hazardous substances or petroleum products in any form, including, for example, solid and liquid at the surface or subsurface, and vapor in the subsurface." ASTM 1527-13 stops short of instructing how to assess for vapor, leaving that to ASTM E2600-10 Standard Guide for Vapor Encroachment Screening on Property Involved in Real Estate Transactions, which was updated again in 2015 (E2600-15).

Did anyone notice that the term *encroachment* was slipped in to replace *intrusion*? Other questions, and guidance, have emerged, as well.

This white paper will attempt to clarify some of the lingering confusion by first going over some important definitions, introducing key guidance documents, and hopefully sorting through the main requirements in determining if vapor intrusion (or encroachment?) is a REC.

VEC or VI?

Any EP involved in vapor studies needs to understand the following definitions and at least be familiar with some key guidance documents.

Vapor Encroachment Condition (VEC)—The ASTM Guidance defines a VEC as "the presence or likely presence of COC (contaminant of concern) vapors in the vadose zone of the target property (TP) caused by the release of vapors from contaminated soil and/or groundwater either on or near the TP as identified by Tier 1 or Tier 2 procedures."

See Page 2 for ASTM's Guidance which further describes the tiered screening approach, and Page 4 for a definition of the Vadose Zone.

Vapor Intrusion (VI) or Vapor Intrusion Condition (VIC) – As defined by EPA, vapor intrusion occurs when volatile chemicals migrate from contaminated soil and/or groundwater into an overlying building. Vapor intrusion can be considered as an on-site condition whereas VEC also takes into account off-site sources. The term "Vapor Intrusion Condition" was included in the original ASTM guidance (2008) but was replaced by "Vapor Encroachment Condition" in 2010. There is currently no specific definition for "Vapor Intrusion Condition".

Vapor investigations can be a simple desktop exercise or require specific testing methods.

Tier I screening for a VEC is the initial evaluation of the likely presence of hazardous vapors, and relies on state and federal database records to identify sites within a certain radius of the target property that have the potential to affect subsurface vapor conditions.

If Tier 1 screening identifies sites that cannot be ruled out for a VEC, then **Tier 2 screening** allows further study through non-invasive or invasive techniques. Non-invasive screening is accomplished by reviewing existing regulatory files and reports for sites within the search radius of the target property. The information should allow the EP to examine such clues as contaminant plume size and direction, behavior in the subsurface, and ability to affect the target property. If such insight is not available or a VEC still cannot be ruled out, then invasive screening allows for the collection of soil, soil gas and/or groundwater samples to determine actual conditions at the property. Sampling often begins as a quick assessment, without regulatory oversight, and able to fit within the time constraints of a property transaction.

The VEC exercise conducted according to the ASTM guidance will allow a Phase I ESA to conclude that there is, or is not, a VEC. This two-option outcome then must make the jump to whether a VEC will actually impact the property, for example if the condition is causing vapor intrusion (VI). One bright spot in the cloud of confusion is that there are now only two conclusions to reach about VEC – yes or no. This is a change from previous ASTM guidance that required the EP to select from one of four conclusions following a VEC assessment: a VEC exists; a VEC is likely to exist; a VEC cannot be ruled out; or a VEC can be ruled out. These multiple scenarios were considered too confusing and arbitrary, and were therefore simplified.

To fully screen a property for potential RECs, it is important to acknowledge that confirmed migration and/or encroachment of COC vapors onto a property with a building fits the definition of a REC, similar to conditions where a leaking UST, former dry cleaner, solvent spill or other source has impacted, or may impact, soil and groundwater. Can we then figure out if, for example, a VEC is deep enough or far enough away to not likely be a REC?

Current Guidance

ASTM E2600-15 - The aforementioned guidance considers vapor migration as a VEC, but applies some distances from the target property to allow exclusion as a source area. For example, the Guidance allows source areas with releases of chlorinated hydrocarbons to be excluded from further consideration as a VEC if they are more and 1/3 mile (1728 ft) from the target property. For what often can be less volatile and mobile petroleum hydrocarbons, the exclusion zone for considering offsite releases is reduced to 1/10 mile (528 ft). A full copy of the guidance is available for a fee from ASTM https://www.astm.org/Standards/E2600.htm

EPA Guidance – OSWER (Office of Solid Waste & Emergency Response) published its "Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, OSWER Publication 9200.2-154" in June 2015. This 268-page document available on EPA's website (https://www.epa.gov/vaporintrusion/technical-guide-assessing-and-mitigating-vapor-intrusion-pathway-subsurface-vapor) is a technical guidance, not a regulation and describes methods to test for vapor COCs on a site. This guidance prefers to measure soil gas concentrations near the source, but also considers Attenuation Factors to account for the expected decrease in concentration when moving from subsurface source to indoor air. EPA's default Attenuation Factors for contaminant concentrations in the area immediately below a building (subslab), in deep soil gas (> 5 feet below floor level), and groundwater are 0.03, 0.03, and 0.001, respectively. This means that concentrations of a particular compound that was present in indoor air entirely as a result of vapor intrusion would equal $1/30^{th}$ of the measured subslab levels, or $1/30^{th}$ of deep soil gas levels, or $1/1000^{th}$ of groundwater levels.
The guidance also recommends longer sampling periods, but this approach can pick up VOCs and hydrocarbons from other common indoor products/sources, and concentrations offered for regulatory comparison may be lower than what OSHA allows for indoor air in non-residential, business locations. Where this guidance may not be the best choice for cases of quick assessments for property transactions, it can be a good source when needing regulatory approvals.

EPA's "Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites, EPA 510-R-15-001" was published in June 2015 by OUST (Office of Underground Storage Tanks) and focuses solely on vapor intrusion at sites where petroleum hydrocarbons have been released from petroleum storage tanks. Like the ASTM guidance, the OUST guide also provides exclusion criteria for groundwater and soil. For example, considering concentrations of select VOCs such as benzene and TPH, if the source area concentrations are less than recommended screening levels (RSLs) and have a vertical separation distance of 6 feet, or 15 feet when source area concentrations exceed the RSLs, then the vapor intrusion pathway can be eliminated in many cases. The OUST guidance allows for sampling close to the building slab and not just at the source area. However, some screening levels are inconsistent with, and often much higher when compared to, the OSWER guidance.

ITRC PVI Guidance – The Interstate Technology Regulatory Council released its guidance for Petroleum Vapor Intrusion investigations in October 2014. This web-based guidance available at http://www.itrcweb.org/PetroleumVI-Guidance/ provides good details on site screening and prioritizing vapor pathways for petroleum sites and discusses use of models as well as methods of mitigation. In addition ITRC offers frequent web-based and classroom training to focus on the methods. Such training can go a long way to clear up confusion or at the very least help the EP to select the best approach for a particular site.

Modeling – Numerical simulation methods are available to supplement field screening of vapor sites and aid in decision making. The Johnson and Ettinger spreadsheet input model has been used for years to estimate indoor air concentrations and associated health risks from subsurface vapor intrusion into buildings, and is now in Version 6.0. An enhanced and perhaps more widely accepted model is EPA's **VISL (Vapor Intrusion Screening Level)** calculator (https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-levels-visls). According to EPA, the VISL provides generally recommended, media-specific, risk-based screening-level concentrations for ground water, near-source soil gas, sub-slab soil gas, and indoor air to come up with the applicable screening levels for your site.

Preferential Pathways – just as with soil and groundwater investigations, a thorough vapor study should consider site specific conditions that can cause expected exclusion zones to become smaller than what is suggested in the guidance, such as variations in geology and presence of subsurface utilities.

Preemptive Vapor Mitigation (PVM)

Another method for eliminating a VEC as a REC is to preemptively mitigate the vapor intrusion potential. This method is often more cost effective than performing extensive testing and re-testing, especially when vapor sources have been confirmed within exclusion zones. PVM works well for new construction, where designing the mitigation system into the foundation or under the slab can be most cost effective. Costs for PVM include labor and capital expenses for installation of an active or passive venting system and minimal maintenance and electrical usage over time. These costs have seen reductions due to widespread use and refinements for similar systems used to control radon entry into buildings. In addition, sub-slab vapor barriers, membranes, and spray-applied coatings are available to block vapor intrusion in new and existing buildings.

Some Recommended Separation Distances When Considering Vapor Encroachment Conditions and Potential for Vapor Intrusion*

Guidance	Volatile Organics	Petroleum
ASTM, 2015	0.3 mi (1,728 ft)	0.1 mi (528 ft)
EPA OSWER & OUST, 2015	15 ft 100 ft lateral	6 ft if <RSL; 15 ft if >RSL; 100 ft lateral
ITRC PVI, 2014	Not applied	5 ft dissolved; 15-18 ft LNAPL; 30 ft lateral

*may not apply for all site specific conditions
RSL = Recommended Screening Levels
LNAPL = Light Non-Aqueous Phase Liquid, often observed as free product on and above the water table

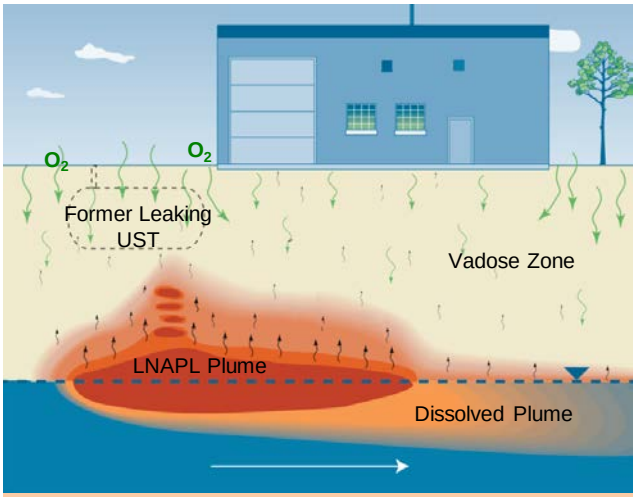
Other Important Considerations – Vapor intrusion continues to be an evolving issue. Where appropriate, many sites will fit into a neat screening determination or sampling exercise to exclude VEC from further consideration. However, it would be a risky venture to try to force fit every site into the same conclusion. Situations that will continue to add complexity to the vapor issue are as follows:

- **TCE and Pregnancy** - EPA has recommended that it establish heath protective response actions to address inhalation exposures to trichloroethylene (TCE) in indoor air resulting from the vapor intrusion pathway, especially for women in the first trimester of pregnancy due to potential for cardiac malformations to the developing fetus. EPA is proposing short-term exposure limits for TCE. While awaiting final outcome of this controversial issue, several states (CA, CT, MA, NJ, NH, OH) have begun using or are considering developing short-term exposure limits for TCE.

- **Don't Forget State Requirements** - Individual state regulations and guidance should be consulted to identify applicability of their own screening levels and exclusion criteria. An example of differing requirements from the EPA guidance is requiring a 6-foot horizontal and 10-foot vertical exclusion zone for vapor contamination in soil, and a specific evaluation of VI if the structure of concern has an earthen floor, fieldstone or concrete block wall foundation, significant cracks, and/or a groundwater sump. Many states use a 100-foot horizontal buffer from a vapor source area that exceeds screening levels to consider VI as a potential threat to all current and future buildings, and some states require that an evaluation of the VI pathway, in particular when applying a sampling program, be conducted by an experienced EP who is licensed as a Professional Engineer or Geologist.

- **Re-opening Sites?** - In addition to its OSWER VI guidance, EPA has issued supplemental guidance to include vapor intrusion when confirming protectiveness of remedies at private and federal facility Superfund sites during the required five-year review process. EPA provides recommendations for assessing protectiveness at sites where a vapor intrusion remedy has not been implemented and where the vapor intrusion pathway was never adequately characterized. For future Superfund sites, EPA has added the subsurface intrusion pathway to the Hazard Ranking System (HRS). This means sites previously not eligible for the Superfund National Priorities List (NPL) based on other exposure or migration pathways may become eligible after evaluation of the threat posed by intrusion of contaminants into occupied structures from the subsurface. These two actions have further raised awareness of VI, as well as the concern of reopening closed sites to further scrutiny.

A note on Vadose Zone – ASTM and EPA are concerned with migration of COCs "into the vadose zone" rather than simply the "subsurface." Vadose is derived from the Latin word for "shallow." The ASTM guidance (and other sources) defines the vadose zone as "the zone between the land surface and the water table within which moisture content is less than saturation (except in the capillary fringe) and pressure is less than atmospheric." It is the soil pore space between soil particles and capillary fringe (the zone where water exists in surface tension with soil particles just above the saturated water bearing zone) that can provide a migration pathway for volatile and semi-volatile COCs. Variability within this zone, just as in differing sediments of an aquifer, can affect migration and impacts from vapor.



Typical Vapor conceptual site model (adapted from ITRC PVI Guidance, 2014)

Case Study Example

This case study allows a "glimpse into the future" when taken from the perspective of a site that begins with multiple identified RECs, to more than 3 years later when vapor intrusion ultimately became the main regulatory concern.

A Phase I ESA performed in 2014 at a former manufacturing facility identified multiple RECs including petroleum tanks and suspected releases of oil and solvents near floor drains at a former automotive shop building on the property. In keeping with the ASTM vapor investigation protocol in effect at the time, a Vapor Encroachment Condition could not be ruled out. A preliminary Phase II ESA was performed, and the conceptual site model called for a groundwater and soil investigation, which was performed under the state voluntary remediation program (VRP).

Monitoring well data from 2015 and 2016 delineated a groundwater contaminant plume emanating from beneath the former automotive shop building and migrating via the shallow water table aquifer. Six volatile organic compounds were detected in wells within the plume at concentrations that exceeded the applicable risk screening levels (RSLs) and which were further evaluated as contaminants of concern – 1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethylene, tetrachloroethylene (PCE), trichloroethylene (TCE), and naphthalene. Groundwater sampling confirmed that the plume was contained on-site and had not impacted deeper aquifers. Soil sampling confirmed that soils could be eliminated from further consideration as a contaminant source at the property. Results of subslab soil gas sampling and perimeter deep soil gas sampling showed that detected soil gas compounds did not exceed RSLs at any location except where TCE was detected in the subslab vapor sample collected below the automotive shop, nearest to the suspected source area.

A risk assessment determined that the exposure pathways from the groundwater plume were limited and could be managed with institutional controls, i.e., no lengthy and expensive groundwater remediation would be required by the regulators. It was the vapor inhalation pathway, however, where more attention was requested.

For an occupant in the automotive shop building, the risk from inhalation exceeded the target risk goal for only one compound – TCE. The state regulators asked for more subslab vapor sampling, which was conducted by deploying Summa canisters and analyzing vapor samples according to the EPA TO-15 procedures. Results showed consistent TCE levels below the slab. The U.S. EPA Vapor Intrusion Screening Level (VISL) calculator was then used to calculate a Target Indoor Air Concentration (Cia) for TCE, which employed very conservative assumptions. For example, the VISL default values for inhalation pathway exposure were used, which assume an exposure duration of 8 hours per day over a 250 day work year. This particular building was now used only for storage and for indoor parking of trucks, with no continuous occupancy. Therefore it was determined that actual exposure duration would never extend to an entire work day nor likely to be on consecutive days. Furthermore, it was demonstrated that the building has overhead bay doors on each end which increases air flow and diminishes potential for vapor accumulation compared to a normal office building or other enclosed space. And the 6-inch thick concrete floor slab was confirmed to be continuous and in good condition. By 2017, regulators agreed with the vapor assessment conclusions and the site was granted closure.