Urban Infrastructure and the Challenges Posed for Assessing and Mitigating Vapor Intrusion Adjacent to a Former Dry Cleaner: A Case Study

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1. Abstract

Assessment and mitigation of the subsurface vapor intrusion-to-indoor air pathway near a former dry cleaner in a densely settled urban site in Massachusetts generated interesting information regarding the influence of urban infrastructure on tetrachloroethene (PCE) migration and management. A case study will be discussed in which developing a conceptual site model (CSM) was integral to planning and executing a targeted investigation and optimizing the mitigation system design.

Initial site investigations identified a leaky sewer lateral as a likely pathway for PCE releases. Shallow groundwater flow and PCE migration were influenced by utilities, historic fill and a marine clay layer that inhibited downward migration. Sub-slab ventilation (SSV) systems were installed in multi-unit residential structures across the street from the former Dry Cleaner, which reduced PCE concentrations in indoor air; however, persistent PCE in the indoor air of one building required an innovative solution. The extent of the PCE plume was only partially defined because of constraints imposed by the existing building, so a targeted groundwater investigation adjacent to and through the basement slab was used to refine the CSM. Based on the updated CSM, the SSV system was modified to utilize horizontal extraction wells beneath the foundation slab. Subsequent monitoring showed reduced indoor air PCE concentrations and SSV vacuum propagation throughout the building footprint overlying the PCE plume, after which regulators concurred with the effectiveness of the mitigation system and agreed to reduce indoor air monitoring frequency from monthly to annually. Based on the understanding of system performance, the SSV blower was optimized to reduce electrical consumption while maintaining mitigation effectiveness. Monitoring systems were configured to nearly eliminate the need for remediation workers to enter occupied spaces, which dramatically reduced operating costs and minimized public relations concerns. Understanding the influence of urban infrastructure was critical for effective and efficient management of vapor intrusion risks.

2. Problem

1. PCE measured in indoor air exceeded regulatory criteria persistently despite an operating SSV system.
2. The SSV system imposed only a very small differential pressure across the slab (<5 Pascals or 0.02 inches of water, where the ASHRAE standard for radon mitigation systems is 0.6 Pa) and
3. The distribution of PCE in groundwater beneath the structure, the presumed source of PCE to indoor air, was unknown.

3. Refining the Conceptual Site Model

• Former dry cleaner off the figure to the right; subject structure off the left.
• PCE condensate leaked through cracks in sewer lateral causing ≥10,000 ng/L in groundwater over right half of Figure 1.
• The SSV system induced a differential of 1 to 3 Pa across the foundation slab nearest the plume.
• Prior to study the distribution of PCE in groundwater under the apartment building was presumed to extend westward under the slab.
• Following installation of groundwater monitoring wells through the slab and near the footer, a clearer picture emerged and a targeted modification of the SSV system was planned.

4. Sub-slab Ventilation System Modification

The original SSV system used two vertically-installed extraction points, but due to limited access, the nearest extraction point was not installed on the plume-facing side of the building. The modified system included two horizontal trenches installed directly over the footprint of the PCE plume in groundwater, and connected to the original system/blower via overhead vacuum lines installed above the drop ceiling.

5. Sub-slab Ventilation System Testing

Modifications to the SSV system resulted in several benefits:

1. Improved and targeted vacuum propagation (Figure 5)
2. Reduced PCE concentrations in indoor air (Figure 6)
3. Reduced monitoring frequency
4. Reduced costs to operate
5. Successfully achieved maintaining pressure differential, measured monthly, demonstrated system functionality without frequent indoor air sampling.

Summary and Next Steps

• Constructing a CSM and performing a data gap analysis facilitated significant and targeted improvements to the mitigation system.
• Cost and intangible savings were realized through reductions in laboratory analysis needs, consulting labor for sampling and occupant disturbance.
• The modified extraction lines used the same blower and off-gas treatment system as the original SSV system.
• The existing blower will be replaced with a smaller one to reduce electrical costs by an estimated $3000 to $5000 per year while maintaining adequate vacuum propagation and other associated benefits.
• PCE in the saturated zone is being treated with in situ bioaugmentation, which is anticipated to reduce the time frame over which the SSV system must operate.