Vapor Intrusion

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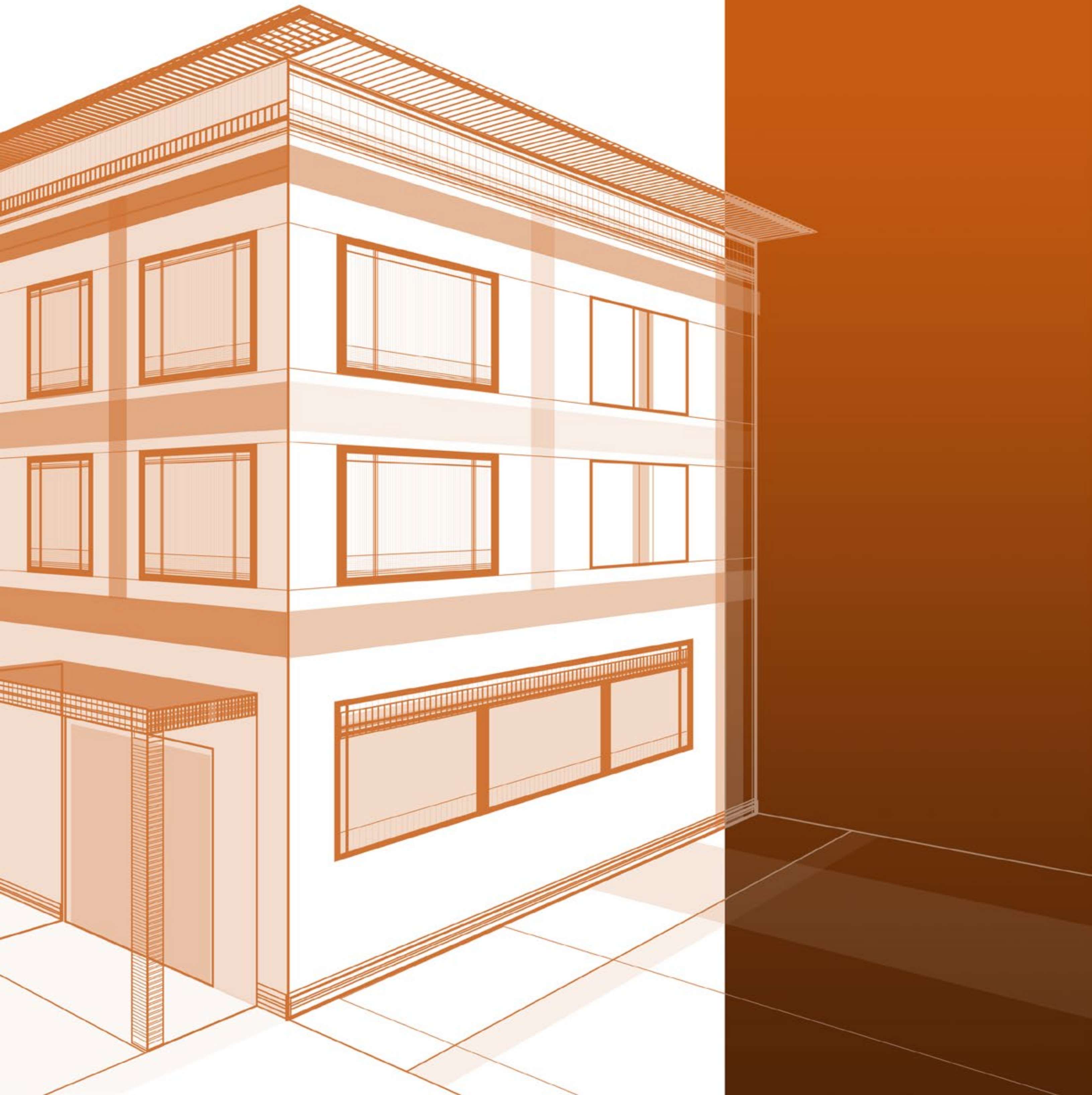

VAPOR INTRUSION PRIMER

For a site with contaminated air, water, or soil, arriving at the milestone of site closure can seem daunting without a plan. There are numerous hazards that may prevent a site from reaching closure, but for many, the issue is related to volatile organic compounds (VOCs) contaminating indoor air, otherwise known as vapor intrusion. Sites deemed a risk to the environment or human health due to the presence of VOCs at unsafe levels in indoor air could benefit from using a risk-based strategy that considers both interior, or background, sources and the level of acceptable risk as defined by the relevant regulatory agencies. This approach can be used to accomplish the objectives of identifying the chemicals of potential concern (COPCs), selecting the areas of the site that require mitigation, and carrying out cleanup.

Discovering the source of the problem should be at the top of the list of priorities, which can be achieved by collecting data on the site's groundwater, air, and soil. Open communication with community members or residents that might be affected by these environmental hazards is an integral part of the assessment process and mitigation efforts, whatever they may be. By continuing to monitor the conditions after remediation has been carried out, and comparing data from before and after corrective action, sites can demonstrate attainment of cleanup standards and, ultimately, obtain closure.

INTRODUCTION

Considering adults ordinarily breathe over 3,000 gallons of air each day, inhalation of indoor air can be a pathway of serious concern for sites with VOCs. Vapor intrusion is a growing issue, as it's increasingly becoming a larger focus of both state and federal regulatory programs across the country. Some programs involve United States Environmental Protection Agency (EPA) or Interstate Technology & Regulatory Council (ITRC) guidance, while others only enforce state regulations and guidance or state voluntary programs where more decisions are left up to the site owner.

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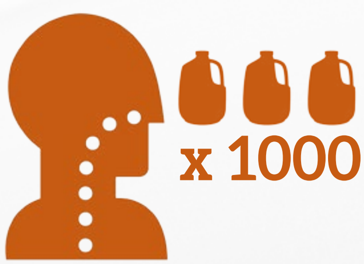

Action levels, the levels of exposure at which the EPA or other agencies require mitigation or remediation, for VOCs in indoor air are typically quite low, especially for chlorinate compounds such as trichloroethylene (TCE). Additionally, the standard of care has developed such that practically all properties with VOC contamination now are being evaluated for vapor intrusion potential, and the standards for many key chemicals are continuing to evolve. The reliability of prior work done at many sites regarding data quality and conceptual site model (CSM) development is also being called into question.

One site faced with the issue of vapor intrusion, which will be used as an example here, was a former jewelry manufacturing facility that operated for more than a century, beginning in the mid-1800s. Since then, the site has been turned into a residential condominium complex. Multiple waste streams containing VOCs, primarily solvents and metal sludge, were discharged into lagoons or otherwise released at the facility historically. The site was contaminated by these legacy pollutants, which resulted in the release of harmful chemicals into the air. VOCs were later detected in the indoor air of several condominium units and in groundwater at several locations of the site above regulatory thresholds. The developer of the site had stopped the assessment process due to financial constraints, so the former owner of the manufacturing facility was required to step in and perform the necessary work. The presence of VOCs above the state's vapor intrusion guidelines required an immediate response from the former facility owner with short-term regulatory deadlines to mitigate the vapor intrusion pathway.

The objectives at this site helped to create a plan of action that can be useful to other facilities in similar situations. These actions included using historical data to identify information gaps and collect the data needed to build a comprehensive "Conceptual Site Model" (CSM), a framework for conceptualizing the relationship between contaminant sources and receptors through the consideration of potential or actual migration and exposure pathways. It was also important to identify the site's structures that had complete vapor intrusion pathways. Once determined, it was then necessary to mitigate that vapor intrusion and reduce groundwater VOC concentrations to a level below the regulatory threshold. Throughout this remediation process, maintaining open communication and a strong rapport with the condominium complex residents and state regulators was crucial in efficiently and successfully reaching these objectives.

SITE EVALUATION AND COMPARISON

The first step of creating a mitigation strategy is to conduct a primary screening of the site, familiarizing yourself with the chemicals suspected or known to be present there. This step allows you to determine quickly whether there is a potential for a complete vapor intrusion pathway that might warrant immediate remediation action. This includes knowing how volatile the chemicals onsite are and how dangerous they are for inhalation in indoor air. If it has already been determined that remediation at the site will be necessary, a more in-depth evaluation should take place in which samples are taken from indoor air, groundwater, soil gas, and/or soil. The levels of VOCs present should then be compared to the target concentrations required by state or federal regulations. By conducting these tests, it should become apparent whether a complete vapor intrusion pathway exists.

To then begin the development of an initial CSM, compile and review both the current and historical environmental data. Collecting samples from various media is certainly important at any site facing environmental concerns, but evaluating the data from these samples collectively, along with any available historical data, helps bring the full picture of the site into focus. This review of historical data should include available reports as well as discussions with former facility employees who were familiar with the types of operations and processes taking place on the site. In addition, it is important to understand not only the current but proposed uses and activities at the site. It is relatively commonplace now that former industrial facilities are repurposed for mixed or residential uses, as was the case at this site. After sampling and researching, a comprehensive CSM can be developed out of this data composite.

> Closing data gaps and analyzing the results will help narrow your scope of response actions.
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For example, at the former jewelry manufacturing facility, the assessment revealed that the groundwater wasn't necessarily the source of contamination, as the VOCs were only found in a select number of monitoring wells. Interestingly, there wasn't a strong correlation between the presence of contaminant levels in groundwater and the levels in soil vapor or air. There was also very little historical information on how the soil had been treated in the redevelopment of the site from manufacturing facility to condos, which made it difficult to determine the extent of the vapor intrusion across the property. Ultimately, sampling a peat layer that was only present in certain sections of the property revealed some clues as to why the contaminant level of the groundwater wasn't corresponding directly with that of the vapor in the same areas. In this case, it was determined that the presence of vapor intrusion was correlated with the placement of impacted soil beneath the condominiums as part of the site grading and redevelopment activities. This research and discovery process was critical in developing a CSM for this site.

REMEDIATION

With a comprehensive CSM in place, the next step is to establish a remediation plan. The primary goals of this plan should include identifying sections of the site that will or will not require mitigation for vapor intrusion, mitigating vapor intrusion at the locations that VOCs are posing a health risk, and diminishing pollutant concentrations in source areas. Focusing on closing any gaps in data and analyzing the results of your environmental samples will help in both narrowing the scope of response actions and assisting the remedial design process.

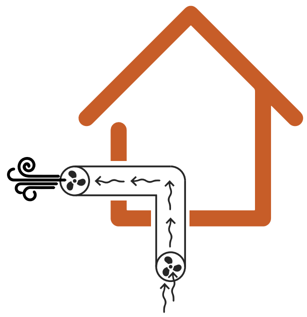
Vapor intrusion is most often caused by contaminants from the groundwater or soil migrating upward into the fill material underneath a building's slab. A difference in pressure, due to heated air for instance, will cause the VOCs from groundwater or soil to move into a structure, especially through cracks or other permeable conduits (e.g., utility lines), which are termed "preferential pathways." Understanding this makes remediation simpler in that three things need to be present for the vapor intrusion to take place: contaminants in the groundwater, soil, or other sub-slab fill material; a difference in pressure or some other gradient causing VOCs to relocate from underneath a building into the building itself; and a pathway for those VOCs to relocate. Tackling any one of these factors will effectively lessen vapor intrusion.

ELIMINATING VAPOR INTRUSION

Ideally, to mitigate the vapor intrusion for good, the source should be removed from the site, but there are some cases, especially for sources that may be present under existing buildings, in which that isn't feasible. There are then two main alternative strategies in preventing vapor intrusion. The first is to remove the pathways serving as entry routes to the building, and the second is to remove the force encouraging the contaminants to travel into the structure. As mentioned above, this is most often a difference in pressure, but can also be due to the process of diffusion if the material between the contamination source and the interior of a building happens to be very porous or if the concentration of VOCs in the source material is extremely high.

If possible, one mitigation strategy for vapor intrusion would be to block all the entry pathways from the source into the building. This could be done either by sealing entry points or by installing some type of barrier that would prevent the gas from moving beyond the slab layer. These points of entry are most commonly cracks in a building's slab, expansion joints, sumps, or pathways of utility lines (i.e., preferential pathways). If the entry points are too numerous or a barrier installation is out of the question, another popular technique is to "break the pathway" by extracting the sub slab vapors and consequently prevent the vapor from moving into the indoor space. Doing this typically requires either the installation of a pipe(s) below the building slab or using vertical pipes that extract through the slab, and using a fan to "suck" out and blow the contaminated air away from, rather than into, the building's interior. This is called a sub-slab depressurization system (SSDS) or a sub-slab ventilation system.

Sub-Slab Depressurization System



The vapor intrusion mitigation conducted at the condominiums included the installation of SSDS in the affected condominium units. Six of the seven buildings located at the site had high enough concentrations of VOCs in soil, gas, and indoor air to call for mitigation. Pilot tests were initially conducted in one building, which consisted of drilling holes through the concrete floor slab of garages and living spaces, connecting fans to the holes, and testing sub slab pressure with a digital manometer. The results of the pilot testing indicated that the design would be useful at the other units too. Two-story units benefited from having an extraction point in two locations, both connected to a single fan mounted in the attic.

GROUNDWATER REMEDIATION DESIGN AND RESULTS

Ex-situ remediation involves physically removing material from the subsurface and either disposing of that material or cleaning it and returning it to its original location. In-situ remediation refers to a method where contaminated material is cleaned up in place through a physical or chemical processes. There are various in-situ methods that can be used in groundwater and soil cleanup, such as pump systems, biostimulation with chemicals to encourage certain chemical processes, and vapor extraction, among others. One of the more popular in-situ technologies is bioremediation, which is a process of injecting naturally occurring substances into a contaminated subsurface to detoxify hazardous material.

At the former manufacturing facility, a type of bioremediation was used for the groundwater remediation in which certain microbes were introduced to the impacted media that encouraged the degradation and, ultimately, the destruction of VOCs. This approach was more cost-effective for this particular site than the alternatives, and it worked in conjunction with the chemical balance that was already present in the groundwater and soil.

Soil Vapor Extraction (SVE) is another popular method for groundwater and soil remediation. While SVE was not used at the condominium site, it can work well for sites that have contaminated soil located above the water table with VOCs that evaporate easily, like many found in solvents. SVE requires wells to be drilled into the soil above the water table; then a pump or vacuum is put into the wells to pull vapors and air from the soil aboveground. Air sparging can be used in combination with SVE if contaminated soil is below the water table, which involves using an air compressor to pump air into the soil. The bubbles this process produces rise to the surface, carrying contaminants. Once the vapor has been extracted from the soil, it is typically pumped through a container of activated carbon, which captures the chemicals and releases clean air back into the atmosphere.

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Lastly, another popular process for soil and groundwater remediation is called "monitored natural attenuation," often referred to as "MNA." Basically, this approach involves monitoring the clean-up process as nature runs its course, and it usually comes after the physical removal of the pollution source. Natural attenuation can work in a few different ways: some VOCs, after evaporating and escaping into the air are destroyed by sunlight; tiny bugs or microorganisms living in soil or groundwater use VOCs as food and digestion renders them harmless; or contaminated material mixes with clean water, which can dilute the pollution to a much lower level. This is considered a very passive form of remediation, and should only be utilized if the conditions within the soil or groundwater are suitable for this approach. Many sites will require more aggressive methods of remediation, such as those mentioned previously.

After remediation has been successfully carried out, it's important to conduct appropriate monitoring at the site to confirm its longer-term effectiveness and that a "rebound" does not occur. Sampling of the affected media should take place at multiple intervals, such as two, six, and nine months after initial remediation/mitigation efforts are finished. Supplemental groundwater samples should also be collected from areas outside of and downgradient from the main treatment area to check for possible mobilization of VOCs. Collecting this data will reveal whether conditions are either stable or continuously improving through natural attenuation or if additional cleanup efforts are required.

RISK COMMUNICATION

One crucial component to the remediation process at large is communication with the project's stakeholders. Without it, implementing efficient and effective sampling and analysis is very difficult. Not only can the stakeholders help to provide necessary background information, but maintaining a strong working relationship decreases the amount of obstacles that crop up in the site closure process. In the example of the condominium site, the developer had neglected the site for some time, causing many of the residents to be distrustful of the party that took over (the owner of the former industrial facility) and their consultant. It was then very important to establish a good rapport with the residents before any work began, so they would more likely be agreeable to the assessment process and mitigation plans.

Anticipating stakeholders' needs or concerns is valuable, but a willingness to communicate and maintain transparency during the process facilitates trust and confidence with all those involved. Prior to assessment activities, letters should be sent to all those affected, explaining why collecting samples or remediation is necessary. When concerns or questions arise, the matter can be discussed via phone conversations or in-person visits, or as in this case study, meetings. This process can take several months and is a common challenge for site owners where multiple concerned parties are involved.

Explaining air-monitoring results to stakeholders that are unfamiliar with environmental data can be a challenge. For simplicity, it is often best during the early phases of the project to compare results with the state regulatory thresholds. Similarly, a level of “acceptable” risk can be difficult to convey to those not accustomed to the term. Therefore, exercise caution when communicating results in a public forum, and be prepared to help the audience understand what these thresholds actually mean, and what exceeding a threshold signifies from a safety perspective. Every reasonable effort should be made to be available to listen to stakeholders’ concerns and address their questions openly and respectfully.

KEY POINTS

Vapor intrusion can be a serious issue for many sites, particularly if VOCs are present above levels that may pose short term or long term health risks. For those facing the obstacle of legacy pollutants present in their site’s groundwater, air, or soil, a thoughtful remediation plan might be the only way for a site to obtain closure. Others might find that more passive cleanup strategies will be all that is required to address a vapor intrusion problem. The first step to identifying what will be necessary in a site cleanup is to do a thorough site assessment, compiling historical and current data to create a CSM. Evaluating the site’s structures and potential preferential pathways and determining whether complete vapor intrusion pathways exist will determine what type of remediation action is needed.

If possible, eliminate the entry points to the structure allowing VOCs to pollute indoor air. Filling cracks and holes or installing some type of barrier can do this effectively. Otherwise, remediating groundwater or soil through in-situ or ex-situ methods will be the next course of action to remove the source of pollution. After remediation has been effectively carried out, groundwater, soil, and/or indoor air will need to be tested at a number of intervals to ensure that the mitigation was successful. It is important for site owners to determine who will be responsible for keeping up with this monitoring process.

Throughout the entire process, communication is of the utmost importance. Working closely with environmental officials and regulators will ensure compliance, put the project on the right track to obtaining closure, and keep site owners aware of any relevant changes in regulations or standards. To help the whole process move along smoothly, maintain a steady line of open and honest communication with stakeholders and regulators.

Though it might not be easy, site closure is attainable with the right approach. Develop an understanding of vapor intrusion and the VOCs present on your site to narrow down the options for remediation, forge strong relationships with agencies and impacted individuals to avoid unnecessary obstacles, and put a remediation plan into effect that will make for a healthier environment and community.