Vapor Intrusion: A Growing Environmental Challenge

Sandra Gaurin, ERM
BEM Systems, Inc.
Chatham, NJ

Eugene P. Wingert, CHMM
Chubb Group of Insurance Companies
Whitehouse Station, NJ

Introduction

The potential for Vapor Intrusion (VI) to migrate into structures is an important environmental issue with more than 500,000 suspected contaminated sites. Background contamination, preferential pathways, the invasive nature of sampling and other factors make Vapor Intrusion difficult to evaluate. The variability of screening criteria developed by state, regional and federal agencies also contribute to the complexity of an assessment. VI screening criteria can be designed for groundwater, sub-slab (shallow) soil gas, exterior (deep) soil gas, indoor air, emergency action or notification. These categories can be further divided into residential, non-residential, industrial and occupational.

Significant differences exist between the occupational exposure standards, such as the OSHA Permissive Exposure Limits (PELs) and action levels or guidance adopted by state or federal environmental and health regulatory agencies to address exposures resulting from VI. The assumptions used to formulate occupational standards are very different from those used in developing VI standards or guidance, yielding radically different criteria for acceptable exposures and the need for mitigation. A significant lack of consensus also exists between regulatory agencies. Each agency has its own set of parameters and procedures to develop screening criteria, some based on policy, others promulgated in law. Finally, even within a particular agency, the application of VI criteria can vary given the situation, depending if the contaminant concentrations represent an acute exposure risk requiring immediate action such as building evacuation or a chronic exposure risk requiring long term mitigation.

The development of adequate VI screening criteria represents a challenge for regulators trying to focus resources on the protection of the public health. It is becoming increasingly apparent that not all No Further Action (NFA) decisions provide the same level of confidence through time. Some NFAs will likely need to be revisited, even where VI was previously addressed. The increase of third party purchasers and landowners interested in protecting themselves, coupled with the increasing role of for-profit environmental insurance, VI assessments are no longer only for regulators and the responsible parties. There is a need for protection of innocent purchasers of properties that were not the source of the contamination for VI but located near contaminated properties that are potential sources of VI. The recently formed

ASTM VI Task Group (E50.02.06) is evaluating the need to include some level of VI assessment into the due diligence requirements for property transfer.

Because of the complexity and uncertainties associated with this evolving issue, engineering review including VI assessment has become critical in the underwriting process for environmental insurance.

Understanding the Degree of Risk from Vapor Intrusion and Current Risk Management Approaches

Vapor Intrusion is defined by the United States Environmental Protection Agency as "the migration of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals in buried wastes or contaminated groundwater emit vapors that may migrate through subsurface soil and into air spaces of overlying buildings. The vapors may accumulate in dwellings or occupied buildings to levels that pose safety hazards (e.g., explosion), acute health effects or odors. In residences with low concentrations, chronic, long-term exposure may also present a risk. In most cases, chemical concentrations are low or not detectable." In many situations, historical uses at a property may have impacted soils and groundwater. The confirmed or suspected presence of residual or free-product contaminants may be the result of operations such as:

- Dry cleaners
- Service stations or auto body shops
- Metal works
- Landfills
- Large industrial sites
- Wood treaters

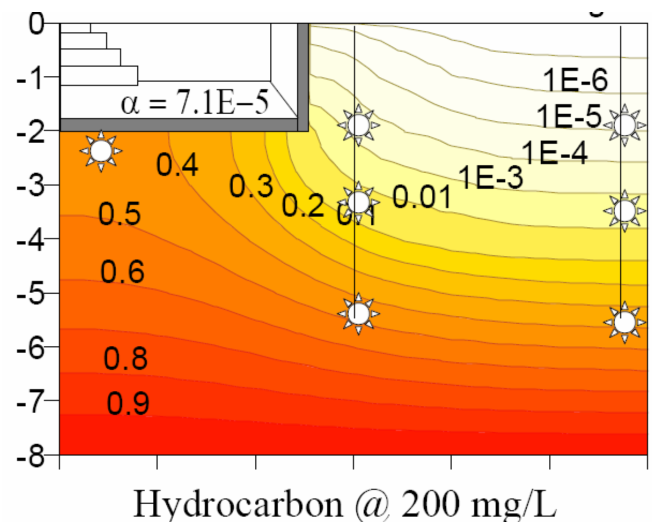
Contaminants that are commonly found at VI impacted properties include:

- Total Petroleum Hydrocarbons (TPH), including benzene
- Chlorinated Volatile Organic Compounds (CVOCs) such as Perchloroethylene (PCE), Trichloroethylene (TCE), 1,1,1 –Trichloroethane (1,1,1-TCA) and Vinyl Chloride
- Landfill gas (methane)

The most significant concern with the VI issue is the uncertainty associated with the actual risk involved. For example, there are no clear standards for toxicity standards for compounds, VI models, or exposure assumptions. Although most properties with VI concerns are addressed under the Resource Conservation and Recovery Act (RCRA), CERCLA, or state cleanup programs, guidance from regulatory agencies is inconsistent. There are several federal guidance documents available from different agencies, such as EPA or the Department of Defense (DoD). Over thirteen state agencies documents have or are being developed to address the VI issues.

In addition, the physical considerations of a property contribute to the risk uncertainty. Exposure to a vapor intrusion condition from the migration of the contaminants of concern is a function of several factors, including the type of building, the exposure setting, hydrogeologic conditions, and atmospheric conditions. The challenge faced by property owners, regulators, and insurance carriers is to determine the relative risk posed by a vapor intrusion condition.

Measuring the impact of VI at a property is also an uncertain undertaking. A VI investigation and assessment can be complex and difficult to resolve. For VI investigations, the sampling requirements may be applied inconsistently within EPA Regions or between state agencies. For example, some agencies disagree on the sampling point locations – indoor breathing spaces, under slab, or exterior locations. Depending on the location of the samples or other influences (including other VOC sources), the concentrations of contaminants will vary. As depicted in the diagram below, a certain petroleum contamination will result in different soil gas contaminant concentrations depending on the depth and distance from the building to the collection point.



Source: Abreu & Johnson, 2005

Exhibit 1. Different soil gas contaminant concentrations form the collection point

In addition, the use of certain VI screening models in the risk assessment may also skew the actual VI risk. Thus, the inconsistent application of sampling protocol and screening tools can result in a poorly managed risk reduction program. With respect to the risk reduction or cleanup at a VI site, a wide range of active or passive measures can be utilized to mitigate the risk. Depending on the complexity of the subsurface, exposure assumptions, and the VI screening models used, a property owner or risk manager can control remediation costs. However, for an owner of many properties or facilities, the inconsistent application of sampling and cleanup protocols by state makes it difficult to manage budgets for environmental programs.

Potential Claim Issues Associated with VI

Provided below is a short discussion of some common potential claims or loss issues associated with VI conditions at properties. Depending on the locations of the VI-impacted properties, the impact of the VI claim will vary. In order to adequately manage or anticipate the impact of the potential VI claims issues, a corporate risk manager can seek advice from a variety of sources, including environmental consulting firms, professional groups (such as Interstate Technology & Regulatory Council) or regulatory agencies.

Re-openers for CERCLA Sites

EPA and state environmental agencies have regulatory requirements to perform post-remediation inspections to determine whether a site which was granted a 'No Further Action" or completion remains protective of human health and the environment. In many cases, vapor intrusion was not considered in the original risk assessment and remediation planning. However, after all the remediation work is complete, the environmental agencies must review all aspects of the remedy's effectiveness, including vapor intrusion. The number of sites requiring this type of review is large, more than 1,500 NPL site are currently in this pipeline. Most states have dozens, if not hundreds of sites that will be re-examined. New York State alone has 421 legacy sites known to have been contaminated with VOCs currently going through this review. The costs associated with VI screenings, investigations, and remediation will most likely become the responsibility of the property owner or operator if the regulatory agency exercises its authority to "re-open" what were once "closed cases."

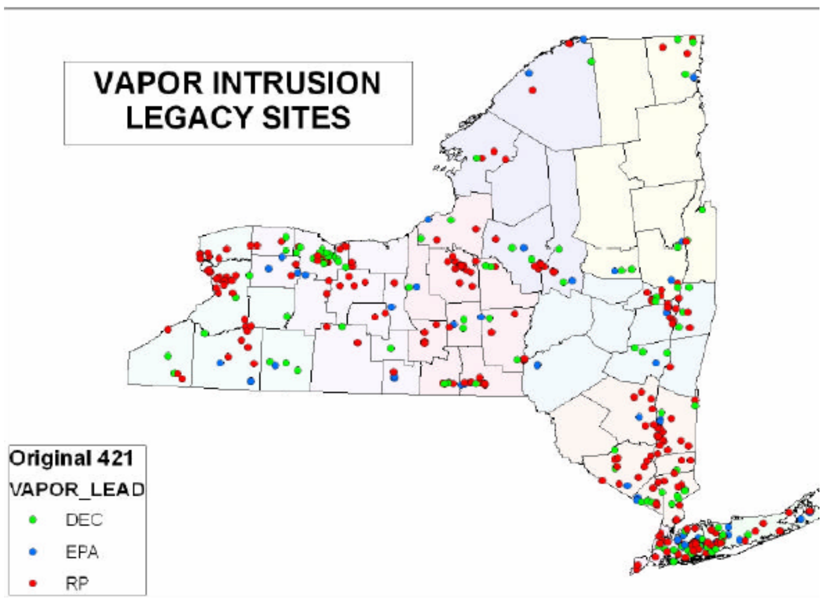


Exhibit 2. New York vapor intrusion legacy sites

Uncertainty of Personal Injury or Property Damage claims

Vapor Intrusion can pose a greater probability of direct exposure health risk than groundwater. For contaminated groundwater actions, it is not uncommon to see a regulatory agency require Institutional Controls (ICs) for groundwater to limit the direct exposure from ingestion of or dermal contact with contaminated groundwater. ICs, coupled with provisions for alternate water supplies, greatly reduce any claims exposure for personal injury caused by exposure to contaminated groundwater. Conversely, the exposure scenarios for VI cannot be as easily contained or controlled by ICs or alternate air supplies. Rather, the VI exposure must be dealt with through engineering controls, such as vapor barriers, venting systems, or a combination of both. As a result of a possible VI exposure, potentially affected individuals may require or demand costly health monitoring, or even will sue based on real or perceived bodily injury. For example, in the *City of San Antonio vs. Pollock*, the Pollock family moved in a home abutting a landfill owned by the City of San Antonio, who assured them that the house was safe to live in. Mrs. Pollock later gave birth to a daughter diagnosed with acute leukemia. The Pollock family alleged that benzene from the landfill leaked in the house and backyard while Mrs. Pollack was pregnant, and sued the City of San Antonio for trespass, negligence and nuisance. During the trial, the correlation between exposure to potential vapors from the landfill and the girl's leukemia could not be scientifically sustained; however, the jury awarded $23.1 million in damages including $10 millions in exemplaries (similar to punitive damages).

Worker Health and Safety

In addition to their operational risks associated with jobs functions, workers – including those in office, retail, or industrial settings, may be exposed to VI conditions caused by historical releases of contaminant sources. OSHA regulations dictate the degree of safety protocol necessary to protect workers during the course of a workday. However, there is considerable disagreement between OSHA and EPA as to which agency has jurisdictional control over addressing a VI condition from outside a workspace. A corporate risk manager may believe that he or she is managing all worker safety issues according to OSHA standards; however additional worker safety issues may be present if the VI conditions are not addressed.

Property Damage or DIV claims

Property Damage claims could result due to the reduction in value due to a real or perceived "sick building." Additional remediation costs may be incurred to reduce the vapor concentrations to an acceptable level. Additional cost for groundwater treatment may also be incurred to reduce the vapor concentrations in the unsaturated zone. The uncertainty of a DIV claim is especially true at sites where contamination impacts are already known, yet incentives are given by regulators, local redevelopment authorities, etc. to stimulate economic growth.

Disclosure of VI concerns to tenants or buyers

Under Common Law, the seller of a property may have a duty to disclose its knowledge of a release located beneath a property. Generally the due diligence standards require that a known or potential "Recognized Environmental Condition" be disclosed by the seller or landlord. Failure to disclose known VI conditions at a site can lead to contractual issues and/or negligence claims against a seller. However, as many states do not have any VI cleanup or risk-based standards, the obligation to report a known environmental condition that *exceeds regulatory standards* becomes an issue. If the VI condition is not recognized as a known Recognized Environmental Condition, then the clarity of the disclosure requirement no longer exists. Current actions by regulators, professional groups, and the ASTM VI Task Group (E50.02.06) will eventually more clearly define the level of VI assessment into the due diligence requirements for property transfer. However, it is not likely that any resolution to the disclosure standards will occur within the next year.

Acceptable concentrations of VI contaminants are a moving target"

There is no consensus between environmental or health agencies on the determination of an acceptable concentration of VI contaminants. For example, the indoor air screening level for 1,1 dichloroethene (1,1-DCE) is 200 $\mu g/m^3$ based on the EPA standards and 5.0 $\mu g/m^3$ based on the Colorado Department of Public Health and the Environment (CDPHE), demonstrating the discrepancy between the Federal and State Environmental Agencies with regard to VI screening levels. In many cases, the regulatory standards for an acceptable VI contaminant concentration are becoming more stringent. These stricter requirements will likely result in higher investigation and remediation costs, as well as increase the potential for personal injury and property damage claims.

Interpretation of sampling, analytical and modeling approaches currently used to perform VI assessments

As mentioned, there is no consensus on where and how to collect representative samples of a potential vapor exposure inside a building. However, to evaluate a potential VI risk associated with the site contamination, either sampling results or modeling results have to be collected and interpreted. Empirical results at the site consist of groundwater samples (soil samples are not recommended to screen VI exposure), soil vapor samples, sub slab samples or indoor air samples. It has been demonstrated that soil vapor samples are highly variable throughout sites and therefore would not appropriately depict the vapor concentrations beneath the building. Even though indoor air samples represent a direct assessment method, they are usually collected after evaluating either the groundwater or sub slab samples. The collection of indoor air samples represents a challenge because of the disruption of the site occupants (especially in residential settings), because of temporal and spatial variability of the samples collected but mostly because of the impact of potential background sources such as dry cleaned clothes, regular household detergents etc. that may contribute to the indoor air results.

To ensure the sampling results are relevant to evaluate potential VI exposure at a site, the analytical method used to screen the samples also has to be evaluated. There are few analytical methods accepted by the environmental regulatory agencies: USEPA TO-15 is usually recommended for sub slab and indoor air samples collected in Summa Canisters that provide a time controlled sampling method as well as a low detection limit, and a modified SW846 8260 is usually used for samples collected in Tedlar bags or syringes that provide near real-time data and allow for field adjustments.

Predictive models can be used as an alternative where sampling is impractical due to background contributions or restricted access and can be used to assess VI risk using site-specific parameters. The Johnson & Ettinger (J&E) Model is one of the simple models commonly used to assess VI exposure at sites. EPA also established a variant of the J&E Model to be used to evaluate VI risk at EPA -lead sites. The J&E Model or its EPA variant use data commonly collected during the site investigation phase (site specific geologic conditions) as well as data established in the literature with regard to contaminant behavior in the site subsurface. More sophisticated models such as Abreu & Johnson factor in biological degradation of contaminants, account for building characteristics and generally require additional sampling or measurement of site-specific conditions.

When the empirical sampling results are deemed relevant based on the sampling technique and analytical method used, they need to be compared to the regulatory guidance values, usually based on a 10^{-6} risk factor. Predictive results obtained through modeling also need to be compared screening levels established by the regulatory agencies. However, State and Federal guidance values are updated regularly based on recent contaminant toxicity data and/or analytical method improvements. Therefore, these values have to be confirmed prior to completion of any VI assessment.

Application of Engineering and Institutional Controls

Engineering Controls, also referred to as Mitigation Systems, are generally installed to reduce a VI risk, real or perceived, of direct exposure to vapors and vary depending on the site use, residential, commercial or industrial.

Mitigation systems in residential buildings typically consist of the installation of a passive or active mitigation system that prevent vapor build-up beneath the building and vents vapors to the outside. These systems cost between $1 and $2 per square foot and are more cost effective if installed during the construction stage. Their efficiency in removing the vapors is approximately 99.5%.

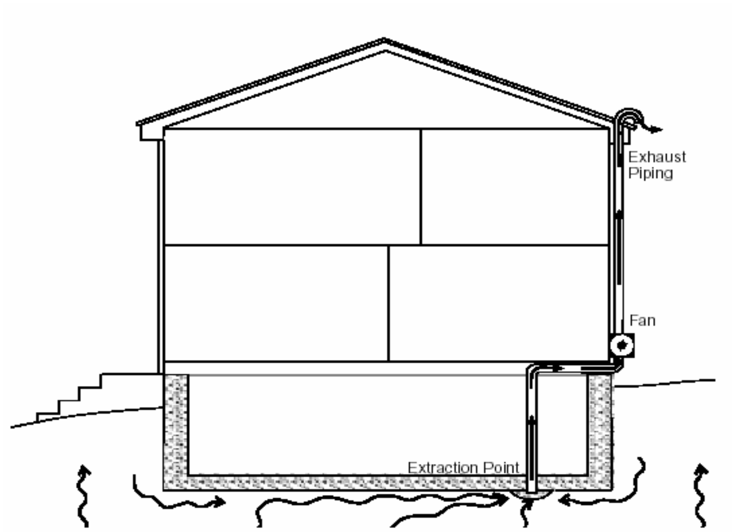


Exhibit 3. A subsurface depressurization system prevents VI

The mitigation systems for commercial buildings consist of depressurization and venting system as well but, face several challenges: a larger footprint to be covered by the mitigation system, difficulty to access to the sub-slab to install the system and an uncertain suction field coverage (presence of cracks, utilities, foundation walls, varying slab elevations). Additionally, the system installation may require an expensive horizontal drilling and potentially deal with the encounter of asbestos and lead-based paint material. Costs for installing a mitigation system in commercial buildings are estimated at approximately $5 per square foot.

The mitigation of VI in industrial campuses faces complex infrastructure, with different onsite uses, different occupational programs, and with potential property transactions. A strategic approach consisting of a tier screening is recommended to reduce the costs of the mitigation system in industrial complexes, estimated at between $5 million and $10 million per site. Tier 1 consists of eliminating the onsite buildings falling under OSHA regulations, unoccupied or scheduled for demolition. Tier 2 consists of installing institutional controls (to limit the building access, restrict the building use). Tier 3 uses the HVAC system as a mitigation system to extract vapors from beneath the building and vent them to the outside. Tier 4, uses creative systems such as combining the mitigation system with an existing soil vapor extraction (SVE) system or depressurizing utility drains adjacent to the building.

Institutional Controls (IC) represent another mitigation system to prevent the potential exposure to vapors and consist of restrictive covenants, zoning restriction, excavation prohibition, groundwater use restriction and requirement for installation of VI mitigation system in future buildings. Any institutional controls are difficult to implement and require the involvement of the regulatory agencies to make sure they are maintained and enforced in the future.

Case Studies of VI Risk Management Strategies

Redfield Rifle Scope site – Redfield, Colorado

The Redfield Rifle Scope site, located near Denver, Colorado, had been used since the 1950s for manufacturing computer parts, rifle scopes and binoculars. Chlorinated solvents were used as vapor degreaser until 1993. During the first phase of an EPA-required site investigation, it was estimated that a limited groundwater impact had occurred. EPA had determined that low concentrations (i.e., parts per billion (ppb) range) of 1,1 dichloroethene (1,1 DCE) had been detected at this site. However, additional environmental investigations including groundwater and indoor air sampling were performed, and the groundwater plume was found to actually extend over two miles, beneath residential properties and near the Cherry Creek. A total of 800 residential homes were sampled for indoor air quality. Based on this sampling, EPA had determined that 500 were impacted by 1,1-DCE vapor at levels that exceeded the acceptable screening level of 0.49 $\mu g/m^3$. The vapor intrusion was subsequently remediated through the installation of extraction systems in the impacted residences' basement, periodic monitoring of the indoor air quality and the installation of a groundwater pump and treatment system to remediate the sources of the vapors.

The Redfield Rifle Scope site represents several environmental insurance risks. First, this site represents a moderate risk for future bodily injury claim. Even though mitigation systems have been installed in the impacted residences basements, residents could still be exposed to the contaminated vapors if these systems are not maintained appropriately or if the systems fail. Additionally, because of the known offsite impact to residences more than two miles from the source, this site poses a significant risk for future property damage claims for property diminution value. Defense costs related to these claims would also be a significant concern.

In fact, about 2,000 residents sued for the 2-mile long “sea of toxic chemicals” under their homes and sought $200 million in loss of property value and loss of enjoyment, and $181 million in punitive damages for delay, concealment and failure to inform officials. The jury found that only 1,000 residents suffered damages in the amount of $2 million. However, based on a real estate survey, it was determined that the property value of houses with mitigation system installed was similar than the one of houses without any mitigation systems therefore the jury did not recognize the loss of property value claim from the plaintiffs.

To further complicate the claims issues at the Redfield Rifle Scope site, in late 2004, the Colorado Department of Public Health and the Environment (CDPHE) changed the cleanup standards for VI. CDPHE increased the indoor air action level for 1,1 DCE from 0.49 $\mu g/m^3$ to 5.0 $\mu g/m^3$ but decreased the action level for TCE from 1.6 $\mu g/m^3$ to 0.8 $\mu g/m^3$. As a result of CDPHE's actions, additional surveys and indoor air testing were completed to determine houses with existing mitigation systems where the systems could be turned off based on a less stringent 1,1 DCE standard and houses without current mitigation systems that would need remediation based on the new TCE standard. As of March 2007, CDPHE determined that 86 homes no longer require mitigation system for either DCE or TCE. CDPHE's actions had a significant impact on the remediation costs, and more importantly –skewed the community's perception of protected. These environmental conditions, coupled with the perceived uncertainty in the community, presents a high risk scenario for third party claims.

<u>IBM – Endicott NY</u>

Since the 1940's, IBM has used industrial solvents in its manufacturing operations at the Endicott facility, a 140-acre industrial facility formerly owned by IBM, located on North Street in the Village of Endicott and the Town of Union. Historically, as a result of leaks and spills, these solvents entered the soil and groundwater located 18 feet to 30 feet below the ground surface. These solvents are no longer used at the facility and since 1980, IBM has been cleaning up and monitoring the contaminants that entered the groundwater. IBM continues to operate a groundwater cleanup program as required by its cleanup agreement with the New York State Department of Environmental Conservation (NYSDEC).

In the spring of 2002, NYSDEC and the New York State Department of Health (NYSDOH) required IBM to assess the possibility that vapors from the contaminants in the groundwater might be moving upward through the soil toward buildings. Results provided to the State in September 2002 indicated that vapors were present eight feet below the ground in the IBM parking lots north of Monroe Street where samples were collected.

Since the autumn of 2002, there has been an extensive effort to assess impacts associated with migration of contaminant vapors from the groundwater through the soil and into buildings in the Village of Endicott and the Town of Union. As part of that assessment, IBM implemented the agencies' approved work plan; collecting vapor samples from within, beneath and outside of 233 buildings throughout the study area. IBM has notified affected parties of the presence, or likely presence, of the vapors in building basements and has been installing mitigation systems beneath the buildings where appropriate. The mitigation systems are designed to intercept contaminant vapors before they enter the building. To date, more than 314 mitigation systems have been installed. Most of the buildings impacted by IBM-related contaminant vapors have now been identified.

Soil vapor and groundwater collected also suggest that there are additional sources of soil gas contaminants to those associated with the IBM groundwater plume and these are being addressed by NYSDEC with the other potential Responsible Parties (PRPs).

<u>Former Gasoline Station/Dry Cleaner, New Jersey</u>

Residential properties in New Jersey were built on a location with known soil and groundwater contamination (TPH and VOC) associated with former gasoline station and dry cleaning operations. Vapor intrusion has been identified at this site and is being remediated in the residences using a venting system in the basement or crawlspace.

The New Jersey Department of Environmental Protection (NJDEP) issued a no further action (NFA) covenant not to sue only for the vapor intrusion in the residences already built; the site is still an active case with the NDJEP with regard to soil and groundwater contamination. A potential purchaser or this property is planning additional development including new housing and playground and is seeking environmental coverage for the existing residences and for the future redevelopment of the currently undeveloped portion of the site.

As part of the engineering review for an insurance carrier, soil gas results from samples collected on the undeveloped portion of the site indicated high concentrations of VOCs, representing a risk for evaporation of VOCs from shallow soils and exposure of workers to both contaminated soil and groundwater during site redevelopment activities. Additionally, the future capping of the site will most likely create preferential pathways for the vapors in portions of the site that remain undeveloped such as the proposed playground and create a potential exposure for future residents. Further, this property is located within a flood plain and represents a potential direct exposure to contaminated saturated soils during flooding events. These environmental conditions represent a high risk for future bodily injury claims.

Finally, because the site was issued an NFA only for the vapor intrusion on the residences already built, the active regulatory status of the site represents a risk for additional investigation and future cleanup costs for the insurance carrier.

Conclusion

Vapor Intrusion issues associated with subsurface contamination continue to be a growing concern with property owners, safety professionals, business managers, local communities, regulators, and insurance carriers. While many parties – including regulators, community activists, private industry, and the scientific community – work to determine acceptable protocols, the need to reduce potential VI claims must be addressed by risk management professionals. Safety Professionals and Risk Managers should seek advice and training to help identify VI potential and mitigate the VI concerns. Suggested actions include:

- Become active in professional organizations and/or trade groups focusing on the VI issues (such as ASTM, ITRC, or ASSE)
- Identify properties or facilities under the Risk Manager's control that may have VI conditions
- Develop a VI screening protocol that: 1) identifies conditions (historical or current) at properties/facilities which may have resulted in contaminated subsurface, 2) evaluates actual or potential VI exposures, and 3) reduces the degree of VI impact